



Terraprobe

Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

FOUNDATION INVESTIGATION REPORT
WOODLAWN ROAD OVERPASS, HIGHWAY 406 NBL
HIGHWAY 406 TWINNING
PORT ROBINSON ROAD TO EAST MAIN STREET
AGREEMENT No. 2008-E-0016, W.P. 280-99-00, SITE: 34-463/1
GEOCRES NO. 30M3-259

PREPARED FOR: Giffels Associates Ltd./IBI Group
30 International Blvd.
Toronto, Ontario M9W 5P3

Attention: Mr. Stephen Chiu, P.Eng.
Manager, Transportation Engineering

File No. 1-09-4135
September 29, 2010

Terraprobe Inc.
10 Bram Court
Brampton, Ontario
L6W 3R6
Phone: (905) 796 2650
Fax: (905) 796 2250

Distribution:

2 Copies	-	MTO Project Manager (Central Region)
1 Copy	-	Giffels Associates Limited
1 Copy	-	Terraprobe Inc., Brampton

Terraprobe Inc.

Greater Toronto
10 Bram Court
Brampton, Ontario L6W 3R6
(905) 796-2650 Fax 796-2250
brampton@terraprobe.ca

Hamilton - Niagara
903 Barton Street, Unit 22
Stoney Creek, Ontario L8E 5P5
(905) 643-7560 Fax 643-7559
stoneycreek@terraprobe.ca

Central Ontario
220 Bayview Drive, Unit 25
Barrie, Ontario L4N 4Y8
(705) 739-8355 Fax 739-8369
barrie@terraprobe.ca

Northern Ontario
1012 Kelly Lake Rd.
Sudbury, Ontario P3E 5P4
(705) 670-0460 Fax 670-0558
sudbury@terraprobe.ca

www.terraprobe.ca

TABLE OF CONTENTS

Part 1

1	INTRODUCTION.....	1
2	SITE DESCRIPTION & PHYSIOGRAPHY.....	1
3	SITE INVESTIGATION AND FIELD TESTING	2
4	LABORATORY TESTING	3
5	DESCRIPTION OF SUBSURFACE CONDITIONS.....	3
5.1	Topsoil	4
5.2	Fill – Sand and Gravel	4
5.3	Fill – Silty Clay.....	4
5.4	Silty Clay	5
5.5	Silt.....	6
5.6	Silty Clay to Clayey Silt Till	6
5.7	Sandy Silt to Silty Sand Till	7
5.8	Bedrock (Salina Formation)	7
5.9	Water Levels.....	8
5.10	Miscellaneous	8

Appendices

Appendix A	Record of Borehole Sheets, Core Logs and Core Photos
Appendix B	Laboratory Test Results
Appendix C	Drawings titled “Borehole Locations and Soil Strata”



FOUNDATION INVESTIGATION REPORT
WOODLAWN ROAD OVERPASS, HIGHWAY 406 NBL
HIGHWAY 406 TWINNING
ONTARIO
AGREEMENT No. 2008-E-0016, W.P. 280-99-00, SITE: 34-463/1
GEOCRES NO. 30M3-259

PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual findings obtained from a foundation investigation conducted at the Woodlawn Overpass bridge site on the proposed Highway 406 NBL in the City of Welland, Ontario.

The purpose of this investigation was to explore the subsurface conditions at the site and based on the data obtained, to provide a borehole location plan, records of boreholes, stratigraphic profile and cross-sections, laboratory test results and a written description of the subsurface conditions. A model of the subsurface conditions was developed from the data obtained.

Terraprobe conducted the investigation as a sub-consultant to Giffels Associates Ltd./IBI Group, under the Ministry of Transportation Ontario (MTO) Agreement Number 2008-E-0016.

2 SITE DESCRIPTION & PHYSIOGRAPHY

The site is located approximately 50 m north of the existing at grade intersection of Highway 406 and Woodlawn Road/Daimler Parkway in the City of Welland, Regional Municipality of Niagara, Ontario. At this location Highway 406 is a two-lane highway with gravel shoulders carrying both north and south bound traffic.

The topography is generally flat and vegetation at this site consists primarily of deciduous trees and wild bush. Areas of groomed grass can be found at some locations along the existing roadways.

The site is located between the Niagara Escarpment and Lake Erie in the physiographic region of Southern Ontario referred to as the Haldimand Clay Plain. The Haldimand Clay Plain is best described as falling into a series of parallel belts with the highest ground adjacent to the Escarpment. Generally this region is flat and poorly drained although it includes several distinctive landforms such as dunes, cobble, clay and sand beaches, limestone pavements and back-shore wetland basins¹.

The Niagara Region is underlain by a sequence of very gently south-dipping dolostones, limestones, shales and sandstones overlying Precambrian basement rock. The key elements in the

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



bedrock geology of the region are the multiple layers of softer sedimentary limestones, shale, sandstone and dolostone.

The bedrock unit at this site is the Salina Formation of Upper Silurian Age². This unit consists essentially of easily weathered, grey, very finely crystalline, laminated argillaceous dolostone with grey, calcareous shale partings and gypsum veins and lenses of varying thicknesses.

3 SITE INVESTIGATION AND FIELD TESTING

The site investigation and field testing for this project were carried out between November 18, 2009 and February 22, 2010 and consisted of drilling and sampling six boreholes to depths ranging from 13.7 m to 31.2 m. The boreholes were numbered NBL 12+695Lt, NBL 12+750Rt, WN1, WN2, WN3 and WN4 and their approximate locations are shown on the attached Borehole Locations and Soil Strata Drawing in Appendix C.

The borehole locations were marked in the field by surveyors from Callon Dietz Inc. who also provided Terraprobe with their coordinates and geodetic elevations. Access to some specific borehole locations was difficult due to locally steep slopes. Borehole WN3 was also moved because of traffic concerns and safety issues. The locations of these boreholes were selected to be as close as feasible to the staked out location while allowing safe operation of the drill rig. Terraprobe obtained utility clearances and permits prior to drilling.

Samples of the overburden soils were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT), as specified in ASTM Method D1586. In the cohesive (clayey) deposits the undrained shear strength of the soil was measured in-situ by means of field vane tests using an MTO type field vane. Relatively undisturbed soil samples were also collected with thin-walled Shelby Tube samplers. The boreholes at the abutments were also advanced into bedrock by NQ size diamond coring techniques.

Ground water conditions in the open boreholes were observed throughout the drilling operations and standpipe piezometers consisting of 19 mm diameter PVC pipe with a slotted screen enclosed in sand were installed in selected boreholes to permit longer term ground water level monitoring. The remaining boreholes were abandoned in accordance with MOE Regulation 903 by sealing/grouting with a bentonite slurry mixture after drilling was complete.

² Ontario Division of Mines, "Quaternary Geology Of The Welland Area", Preliminary Map P.796, 1972.



The locations and completion details of the piezometers are shown in Table 3.1.

Table 3.1 – Piezometer Installation Details

Piezometer Location	Piezometer Details	
	Tip Depth/ Elevation (m)	Completion Details
NBL 12+695Lt	12.2/170.7	Piezometer with 3.0 m slotted screen installed with filter sand to 8.5 m, bentonite seal from 8.5 m to 7.9 m, drill cuttings from 7.9 m to 0.3 m and bentonite seal from 0.3 m to ground surface.
NBL 12+750Rt	12.6/170.2	Piezometer with 3.0 m slotted screen installed with filter sand to 9.0 m, bentonite seal from 9.0 m to 8.4 m, drill cuttings from 8.4 m to 0.6 m and bentonite seal from 0.6 m to ground surface.
WN2	25.9/155.3	Hole sealed to 25.9 m with bentonite, piezometer with 1.8 m slotted screen installed with filter sand to 24.1 m, bentonite seal from 24.1 m to ground surface.
WN3	22.6/159.5	Hole sealed to 22.6 m with bentonite, piezometer with 1.5 m slotted screen installed with filter sand to 20.7 m, bentonite seal from 20.7 m to ground surface with a flush mounted casing installation.

The drilling, sampling and coring operations were observed on a full time basis by members of Terraprobe's technical staff who logged the boreholes and rock cores and processed the recovered soil and rock samples for transport to Terraprobe's Brampton laboratory for further examination and testing.

4 LABORATORY TESTING

The recovered soil samples were subjected to Visual Identification (VI) and natural moisture content determination. Select samples were also subjected to a laboratory testing programme consisting of gradation analysis, Atterberg Limits tests, consolidation tests, unit weight, unconfined compression tests and undrained shear strength testing with a laboratory vane. The results of this testing program are shown on the Record of Borehole sheets in Appendix A and the figures in Appendix B.

5 DESCRIPTION OF SUBSURFACE CONDITIONS

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

In general, the site is underlain by 25.9 m to 27.4 m of overburden soils consisting of topsoil, fill material (sand and gravel and silty clay) and native deposits of silty clay, silt, silty clay to clayey silt till and sandy silt to silty sand till. These soils are underlain by bedrock of the Salina Formation.



5.1 Topsoil

Topsoil ranging from 60 mm to 150 mm in thickness was encountered at this site. Topsoil thickness may vary between and beyond the boreholes.

5.2 Fill – Sand and Gravel

Borehole WN3 was drilled on the gravel shoulder of the highway and encountered a layer of sand and gravel fill (approximately 700 mm thick) that extends to a depth of 0.7 m (Elev. 181.4 m) below ground surface.

A sample of this fill material was subjected to a grain size analysis and the results are presented in Figure B1. These results show a grain size distribution consisting of 41% gravel, 44% sand, 13% silt and 2% clay size particles.

A Standard Penetration test in the sand and gravel fill gave an ‘N’ value of 48 blows for 0.3 m penetration. Based on this result the fill is considered to have a dense relative density. The moisture content of a sample of this fill was 6% by weight.

5.3 Fill – Silty Clay

Silty clay fill material was encountered at this site generally extending to depths ranging from 0.7 m to 2.1 m or to elevations ranging between 182.2 m and 181.0 m. Borehole WN4 was drilled in close proximity to an existing sanitary sewer and this borehole encountered silty clay fill that extends to a depth of 3.7 m (Elev. 178.8 m) below ground surface.

Samples of this fill were subjected to grain size analysis and the results are presented in Figure B2. These results show a grain size distribution consisting of 0-5% gravel, 2-4% sand, 35-67% silt and 31-63% clay size particles.

The fill material was also subjected to Atterberg Limits tests and the results are presented in Figure B3. The index values from these tests are summarized below:

Liquid Limit:	27-49%
Plastic Limit:	16-23%
Plasticity Index:	11-26%
Natural Moisture Content:	16-21%

These values are characteristic of clayey soils of low to intermediate plasticity.

Standard Penetration tests in the silty clay fill gave ‘N’ values that ranged from 3 to 24 blows for 0.3 m penetration. Based on these results the fill is considered to have a soft to very stiff consistency. The moisture content of samples of this fill ranged from 16% to 26% by weight.



5.4 Silty Clay

A major silty clay deposit was encountered across the site. This deposit was fully penetrated in some of the boreholes where it was found to extend to depths ranging from 13.2 m (Elev. 168.4 m) to 14.7 m (Elev. 167.8 m) below ground surface. The approach boreholes were terminated in this deposit at depths of 13.7 m or elevations of 169.2 m and 169.1 m.

The grain size distribution plots of tested samples of the silty clay are presented in Figures B4 to B9 inclusive. These results show a grain size distribution consisting of 0-17% gravel, 1-10% sand, 37-74% silt and 21-60% clay size particles.

Samples were also subjected to Atterberg Limits tests and the results are illustrated on the plasticity charts, Figures B10 to B13 inclusive. The index values from these tests are summarized below:

Liquid Limit:	24-48%
Plastic Limit:	14-21%
Plasticity Index:	9-27%
Natural Moisture Content:	16-24%

These values indicate that the silty clay has a generally low to intermediate plasticity.

Standard Penetration tests in this stratum gave 'N' values that ranged from 1 to 60 blows for 0.3 m penetration. Field vane tests gave in-situ undrained shear strengths ranging from 48 kPa to in excess of 100 kPa. An unconfined compression test gave an undrained shear strength of 36 kPa and laboratory vane tests on relatively undisturbed Shelby tube samples gave undrained shear strengths ranging from 58 kPa to 60 kPa. These values indicate that the consistency of the silty clay is generally firm to hard with infrequent very soft to soft zones. The moisture content of samples of the silty clay range from 13% to 24% by weight and the unit weight of selected samples ranged from 20.6 to 20.8 kN/m³.

The variation of undrained shear strength with elevation is depicted in Figure B19. The plot illustrates a wide scatter in the data with no obvious trend with depth. An interpreted dashed line is shown representing a lower bound trend with depth, for the data. The upper portion of this deposit up to about Elev. 177.0 m is estimated to have relatively high undrained shear strength i.e. in excess of 100 kPa. Below Elev. 177.0 m the undrained shear strength decreases with depth and is about 50 kPa at elevations ranging between 175.0 m and about 173.0 m. Below Elev. 173.0 m the trend indicates increasing undrained shear strength with depth.

The Atterberg Limits tests results are also plotted against elevation, Figure B20. These results illustrate that the natural moisture contents are generally below the plastic limit up to about Elev. 180.0 m. Below Elev. 180.0 m the natural moisture content is generally above the plastic limit.

Consolidation tests were also performed on Shelby tube samples retrieved from Boreholes NBL 12+695Lt and NBL 12+750Rt and the results are presented in Figures B21 to B26 inclusive. These results indicate estimated preconsolidation pressures ranging between 320 kPa and 450 kPa.



5.5 Silt

A native silt deposit was encountered at this site in Boreholes WN1, WN2, WN3 and WN4. The deposit is approximately 0.8 m to 1.2 m thick and extends to depths ranging from 3.5 m to 5.2 m below ground surface or to elevations ranging from 178.1 m to 177.4 m. Based on visual and tactile examinations of the retrieved samples, the unit is essentially a cohesionless silt with frequent cohesive silty clay seams and partings.

The grain size distribution plots of tested samples of the silt are presented in Figure B14. These results show a grain size distribution consisting of 0% gravel, 0-1% sand, 80-84% silt and 15-20% clay size particles.

The deposit is considered to have a generally compact relative density based on SPT 'N' values that ranged from 12 to 26 blows for 0.3 m penetration. The moisture content of samples from this deposit ranged from 17% to 21% by weight.

5.6 Silty Clay to Clayey Silt Till

A native deposit of silty clay to clayey silt till was encountered across the site extending to depths ranging from 16.2 m (Elev. 165.4 m) to 17.8 m (Elev. 164.3 m) below ground surface.

The grain size distribution plots of tested samples from this unit are depicted in Figure B15. These results show a grain size distribution consisting of 5-8% gravel, 17-25% sand, 53-57% silt and 15-21% clay size particles. Till soils will also contain random cobble and boulder inclusions.

Samples were also subjected to Atterberg Limits tests and the results are plotted on the plasticity chart, Figure B16. The index values from these tests are summarized below:

Liquid Limit:	19-23%
Plastic Limit:	13-14%
Plasticity Index:	6-10%
Natural Moisture Content:	9-19%

These values are typical of clayey soils of low plasticity.

Standard Penetration tests in this stratum yielded 'N' values ranging from 18 to 62 blows per 0.3 m penetration. A field vane test was also attempted in this deposit and the results indicate an undrained shear strength more than 100 kPa. Based on these results the silty clay till is considered to have a very stiff to hard consistency. The moisture content of samples from this deposit varies from 7% to 19% by weight.



5.7 Sandy Silt to Silty Sand Till

The site is underlain by a granular till deposit with a soil matrix that ranges from sandy silty to silty sand. These units extend to depths ranging from 25.9 m to 27.4 m or to elevations ranging from 156.5 m to 155.7 m.

The grain size distribution plots of tested samples from this stratum are depicted in Figures B17 and B18. These results show a grain size distribution consisting of 3-21% gravel, 23-48% sand, 31-61% silt and 4-13% clay size particles. Till soils will also contain random cobble and boulder inclusions.

Standard Penetration tests in the till yielded 'N' values ranging from 28 to more than 100 blows per 0.3 m penetration. Based on these results the unit is considered to have a compact to very dense relative density. The moisture content of samples from this stratum varies from 4% to 12% by weight.

5.8 Bedrock (Salina Formation)

The overburden soils described above are underlain by the Salina Formation. Bedrock was proved by coring at the abutment locations. Table 5.1 summarizes the bedrock depth and the elevations to the top of bedrock.

Table 5.1 – Depth to Bedrock

Location	BH Number	Depth to Bedrock (m)	Top of Bedrock Elevation (m)
South Abutment	WN1	27.4	155.7
	WN2	25.9	155.7
North Abutment	WN3	26.4	155.7
	WN4	26.0	156.5

The bedrock is described as unweathered dolostone and shale and its colour is generally grey. It is thinly laminated with white unweathered gypsum and calcite veins. Total core recovery in the bedrock generally ranged from 50% to 100%. The RQD values ranged widely from 29% to 70% and an RQD of 0% was obtained in Run 1 of Borehole WN3. The core data also reveals that there is no trend of improving rock quality with depth. Based on these results the rock quality is considered to be very poor to poor with occasional zones of fair quality rock.



5.9 Water Levels

A standpipe piezometer was installed in selected boreholes. The water level readings measured on separate visits made after the completion of drilling are presented in Table 5.2.

Table 5.2 – Water Level Measurements

Borehole	Date	Water Levels	
		Depth (m)	Elevation (m)
NBL 12+695Lt	November 30, 2009	9.3	173.6
	December 15, 2009	3.4	179.5
	January 04, 2010	3.2	179.7
	January 11, 2010	3.3	179.6
	January 19, 2010	3.4	179.5
NBL 12+750Rt	December 15, 2009	5.1	177.7
	January 04, 2010	2.7	180.1
	January 11, 2010	2.7	180.1
	January 19, 2010	2.8	180.0
WN2	January 04, 2010	5.2	176.4
	January 11, 2010	4.2	177.4
	January 19, 2010	5.2	176.4
	January 27, 2010	5.2	176.4
WN3	April 16, 2010	7.7	174.4
	April 29, 2010	3.9	178.2
	May 04, 2010	5.2	176.9
	May 06, 2010	4.8	177.3

The ground water table was estimated based on the recorded water levels in the standpipe piezometers and our review of moisture contents of the retrieved samples. Based on these observations, the local ground water level is estimated at approximately Elev. ± 180.0 m.

All ground water observations at this site are short term and the levels are expected to fluctuate seasonally and after severe weather events.

5.10 Miscellaneous

The drilling, sampling and in-situ testing operations were conducted with track and truck mounted drill rigs owned and operated by Groundworks Drilling Limited of Toronto, Ontario and Determination Drilling & Soil Investigations of Hamilton, Ontario.

Hollow-stem auger drilling techniques and casing and washboring methods were used to advance the boreholes. NQ size rock cores of the bedrock were obtained using diamond drilling techniques.

Messrs. Alexander Winkelmann, E.I.T., Marc Paoliello, E.I.T, and Phil Khuu, B.A.T, carried out the field work. The laboratory testing was performed at Terraprobe's Brampton laboratory and the Mississauga laboratory of Golder Associates. The report was written by Rehman Abdul, P.Eng. and reviewed by Michael Tanos, P.Eng.



R. Abdul

Prepared by:
R. Abdul, P.Eng.,
Senior Geotechnical Engineer



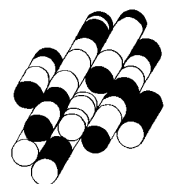
Michael Tanos

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



APPENDICES

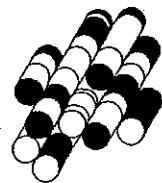
TERRAPROBE INC.



APPENDIX A

Record of Borehole Sheets, Core Logs and Core Photos

Terraprobe Inc.



LIMITATIONS AND RISK

Procedures

The soil conditions were confirmed at the borehole and test pit locations only and conditions may vary between and beyond the boreholes. The boundaries between the various strata as shown on the logs are based on non-continuous sampling. These boundaries represent an inferred transition between the various strata, rather than a precise plane of stratigraphic change.

This investigation has been carried out using investigation techniques and engineering analysis methods consistent with those ordinarily exercised by Terraprobe and other engineering practitioners, working under similar conditions and subject to the time, financial and physical constraints applicable to this project. The discussions and recommendations that have been presented are based on the factual data obtained.

It must be recognized that there are special risks whenever engineering or related disciplines are applied to identify subsurface conditions. Even a comprehensive sampling and testing programme implemented in accordance with the most stringent level of care may fail to detect certain conditions. Terraprobe has assumed for the purposes of providing design parameters and advice, that the conditions that exist between sampling points are similar to those found at the sample locations. The conditions that Terraprobe has interpreted to exist between sampling points can differ from those that actually exist.

It may not be possible to drill a sufficient number of boreholes or sample and report them in a way that would provide all the subsurface information that could affect construction costs, techniques, equipment and scheduling. Contractors bidding on or undertaking work on the project should be directed to draw their own conclusions as to how the subsurface conditions may affect them, based on their own investigations and their own interpretations of the factual investigation results, cognizant of the risks implicit in the subsurface investigation activities.

Changes In Site And Scope

It must be recognized that the passage of time, natural occurrences, and direct or indirect human intervention at or near the site have the potential to alter subsurface conditions. Groundwater levels are particularly susceptible to seasonal fluctuations.

The design advice is based on the factual data obtained from this investigation made at the site by Terraprobe and are intended for use by the owner and its retained designers in the design phase of the project. If there are changes to the project scope and development features, or there is any additional information relevant to the interpretations made of the subsurface information, the geotechnical design parameters and comments relating to constructibility issues and quality control may not be relevant or complete for the revised project. Terraprobe should be retained to review the implications of such changes with respect to the contents of this report.

This report was prepared for the express use of the Ministry of Transportation, its retained design consultants and Giffels Associates Ltd./IBI Group. It is not for use by others. This report is copyright of Terraprobe Inc. and no part of this report may be reproduced by any means, in any form, without the prior written permission of Terraprobe Inc. The Ministry of Transportation, its retained design consultants and Giffels Associates Ltd./IBI Group, are authorized users.

EXPLANATION OF TERMS USED IN REPORT

N VALUE: THE STANDARD PENETRATION TEST (SPT) N VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D. SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N VALUE IS DENOTED THUS N.

DYNAMIC CONE PENETRATION TEST: CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D. 60° CONE ANGLE) DRIVEN BY 475J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

CONSISTENCY: COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH (c_u) AS FOLLOWS:

c_u (kPa)	0 - 12	12 - 25	25 - 50	50 - 100	100 - 200	> 200
	VERY SOFT	SOFT	FIRM	STIFF	VERY STIFF	HARD

DENSENESS: COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF DENSENESS AS INDICATED BY SPT N VALUES AS FOLLOWS:

N (BLOWS/0.3m)	0 - 5	5 - 10	10 - 30	30 - 50	> 50
	VERY LOOSE	LOOSE	COMPACT	DENSE	VERY DENSE

ROCKS ARE DESCRIBED BY THEIR COMPOSITION AND STRUCTURAL FEATURES AND/OR STRENGTH.

RECOVERY: SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH OF THE CORING RUN.

MODIFIED RECOVERY: SUM OF THOSE INTACT CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (RQD), FOR MODIFIED RECOVERY IS:

RQD (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	POOR	FAIR	GOOD	EXCELLENT

JOINTING AND BEDDING:

SPACING	50mm	50 - 300mm	0.3m - 1m	1m - 3m	> 3m
JOINTING	VERY CLOSE	CLOSE	MOD. CLOSE	WIDE	VERY WIDE
BEDDING	VERY THIN	THIN	MEDIUM	THICK	VERY THICK

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

SS	SPLIT SPOON	TP	THINWALL PISTON
WS	WASH SAMPLE	OS	OSTERBERG SAMPLE
ST	SLOTTED TUBE SAMPLE	RC	ROCK CORE
BS	BLOCK SAMPLE	PH	TW ADVANCED HYDRAULICALLY
CS	CHUNK SAMPLE	PM	TW ADVANCED MANUALLY
TW	THINWALL OPEN	FS	FOIL SAMPLE

STRESS AND STRAIN

u	kPa	PORE WATER PRESSURE
r_u	1	PORE PRESSURE RATIO
σ	kPa	TOTAL NORMAL STRESS
σ'	kPa	EFFECTIVE NORMAL STRESS
τ	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
ϵ	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
μ	1	COEFFICIENT OF FRICTION

MECHANICAL PROPERTIES OF SOIL

m_v	kPa ⁻¹	COEFFICIENT OF VOLUME CHANGE
C_c	1	COMPRESSION INDEX
C_s	1	SWELLING INDEX
C_α	1	RATE OF SECONDARY CONSOLIDATION
C_v	m ² /s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{vo}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
τ_r	kPa	SHEAR STRENGTH
c'	kPa	EFFECTIVE COHESION INTERCEPT
ϕ'	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u	kPa	APPARENT COHESION INTERCEPT
ϕ_u	-°	APPARENT ANGLE OF INTERNAL FRICTION
τ_R	kPa	RESIDUAL SHEAR STRENGTH
τ_r	kPa	REMOULDED SHEAR STRENGTH
S	1	SENSITIVITY = c_u / τ_r

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m ³	DENSITY OF SOLID PARTICLES	e	1%	VOID RATIO	e_{min}	1%	VOID RATIO IN DENSEST STATE
γ_s	kN/m ³	UNIT WEIGHT OF SOLID PARTICLES	n	1%	POROSITY	I_b	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
ρ_w	kg/m ³	DENSITY OF WATER	w	1%	WATER CONTENT	D	mm	GRAIN DIAMETER
γ_w	kN/m ³	UNIT WEIGHT OF WATER	S_r	%	DEGREE OF SATURATION	D_n	mm	n PERCENT - DIAMETER
ρ	kg/m ³	DENSITY OF SOIL	w_L	%	LIQUID LIMIT	C_u	1	UNIFORMITY COEFFICIENT
γ	kN/m ³	UNIT WEIGHT OF SOIL	w_p	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
ρ_d	kg/m ³	DENSITY OF DRY SOIL	w_s	%	SHRINKAGE LIMIT	q	m ² /s	RATE OF DISCHARGE
γ_d	kN/m ³	UNIT WEIGHT OF DRY SOIL	I_p	%	PLASTICITY INDEX = $(w_L - w_p)$	v	m/s	DISCHARGE VELOCITY
ρ_{sat}	kg/m ³	DENSITY OF SATURATED SOIL	L	1	LIQUIDITY INDEX = $(w - w_p)/I_p$	i	1	HYDRAULIC GRADIENT
γ_{sat}	kN/m ³	UNIT WEIGHT OF SATURATED SOIL	I_c	1	CONSISTENCY INDEX = $(w_L - w)/I_p$	k	n/s	HYDRAULIC CONDUCTIVITY
ρ'	kg/m ³	DENSITY OF SUBMERGED SOIL	e_{max}	1%	VOID RATIO IN LOOSEST STATE	j	kN/m ²	SEEPAGE FORCE
γ'	kN/m ³	UNIT WEIGHT OF SUBMERGED SOIL						

EXPLANATORY SHEET FOR CORE LOG

Column Number

1. Elevation of borehole collar.
2. Depth of geotechnical boundary in borehole
3. Geologic symbol for rock or soil material
4. General description of geotechnical unit - qualitative description, including rock type(s), percentage rock types, frequency and sizes of interbeds, colour, texture.

Joint (discontinuity) Characteristics

5. Number of joint sets: a rock mass can be intersected by a number of joint sets of varying orientations.
6. Joint type: B = Bedding joint C = Cross joint
7. Orientation: only variations in dip can be identified in core; dip direction is from field mapping or oriented core:
F = Flat = 0 - 20° D = Dipping = 20 - 50° V = Vertical = 50 - 90°
8. Joint spacing: this is an approximate measure of spacing between joints in specific joint sets.

SPACING	> 3 m	1 m - 3 m	0.3 m - 1 m	50 mm - 300 mm	< 50 mm
	VERY WIDE	WIDE	MODERATE	CLOSE	VERY CLOSE

9. Roughness:

RU = Rough Undulating
SU = Smooth Undulating
LU = Slickensided Undulating
RP = Rough Planar
SP = Smooth Planar
LP = Slickensided Planar

10. Filling:

Approximate ϕ

T = Tight, hard, non-softened
O = Oxidation surface staining only
SA = Slightly altered; clay-free
S = Sandy particles; clay-free
Si = Sandy and silty, minor clay
NC = Non-softening Clays; 5mm
SC = Swelling Clay fillings; 5mm

25 - 35
25 - 30
25 - 30
20 - 25
16 - 24
6 - 12

11. Aperture: estimated size of joint opening.

12. Degree of weathered rock material:

DEGREE	DESCRIPTION	
UNWEATHERED	NO SIGNS OF DISCOLOURATION OR OXIDIZATION	
SLIGHTLY WEATHERED	PARTIAL DISCOLOURATION; FRACTURES (JOINTS), TYPICALLY OXIDIZED	
MODERATELY WEATHERED	TOTAL DISCOLOURATION	
HIGHLY WEATHERED	TOTAL DISCOLOURATION; TYPICALLY FRIABLE AND PITTED	
COMPLETELY WEATHERED	RESEMBLE A SOIL; ROCK STRUCTURE - USUALLY PRESERVED	

13. Strength of rock material:

		MPa	
VERY HIGH STRENGTH	SPECIMEN CAN ONLY BE CHIPPED BY GEOLOGICAL HAMMER	> 200	
HIGH STRENGTH	SPECIMEN REQUIRES A NUMBER OF BLOWS OF A GEOLOGICAL HAMMER TO FRACTURE IT; CANNOT BE SCRAPPED WITH POCKET KNIFE	50 - 200	
MEDIUM STRENGTH	SPECIMEN CANNOT BE FRACTURED BY A SINGLE, FIRM BLOW OF GEOLOGICAL HAMMER; CAN BE SCRAPPED WITH POCKET KNIFE, NOT PEELED	15 - 50	
LOW STRENGTH	SHALLOW INDENTATIONS MADE BY FIRM BLOW WITH POINT OF GEOLOGICAL HAMMER; CAN BE PEELED WITH POCKET KNIFE WITH DIFFICULTY	4 - 15	
VERY LOW STRENGTH	CRUMBLES UNDER FIRM BLOW WITH POINT OF GEOLOGICAL HAMMER; CAN BE PEELED	1 - 4	

14. Fracture frequency: number of natural joints occurring over a meter length of core. All natural joints are counted irrespective of the number of joint sets.

FRACTURE FREQUENCY	JOINT SPACING	LENGTH	
0.3 m	VERY WIDE	> 3 m	
0.3 - 1 m	WIDE	1 m - 3 m	
1 - 3 m	MODERATE	0.03 m - 1 m	
3 - 20 m	CLOSE	0.005 m - 0.03 m	
20 m	VERY CLOSE	< 0.005 m	

15. Run number and Core Recovery

- (i) Drill run number

- (ii) Total Core Recovery is the total length of core pieces, irrespective of their individual lengths obtained in a core run, and expressed as a percentage of the length of that core run.

16. Rock Quantity Designation (RQD): The total length of those pieces of sound core which are 0.01 metres or greater in length in a core run, expressed as a percentage of the total length of that core run. Sound pieces of rock are those pieces separated by natural breaks and not machine breaks or subsequent artificial breaks.

Rock Mass Classification (after Deare)					
RQD (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
DESCRIPTION	VERY POOR	POOR	FAIR	GOOD	EXCELLENT

17. Core and Casing sizes: changes of core and casing sizes are indicated.

18. Water recovery, level and tests:

- (i) percentage drill water recovery

- (ii) water level depth

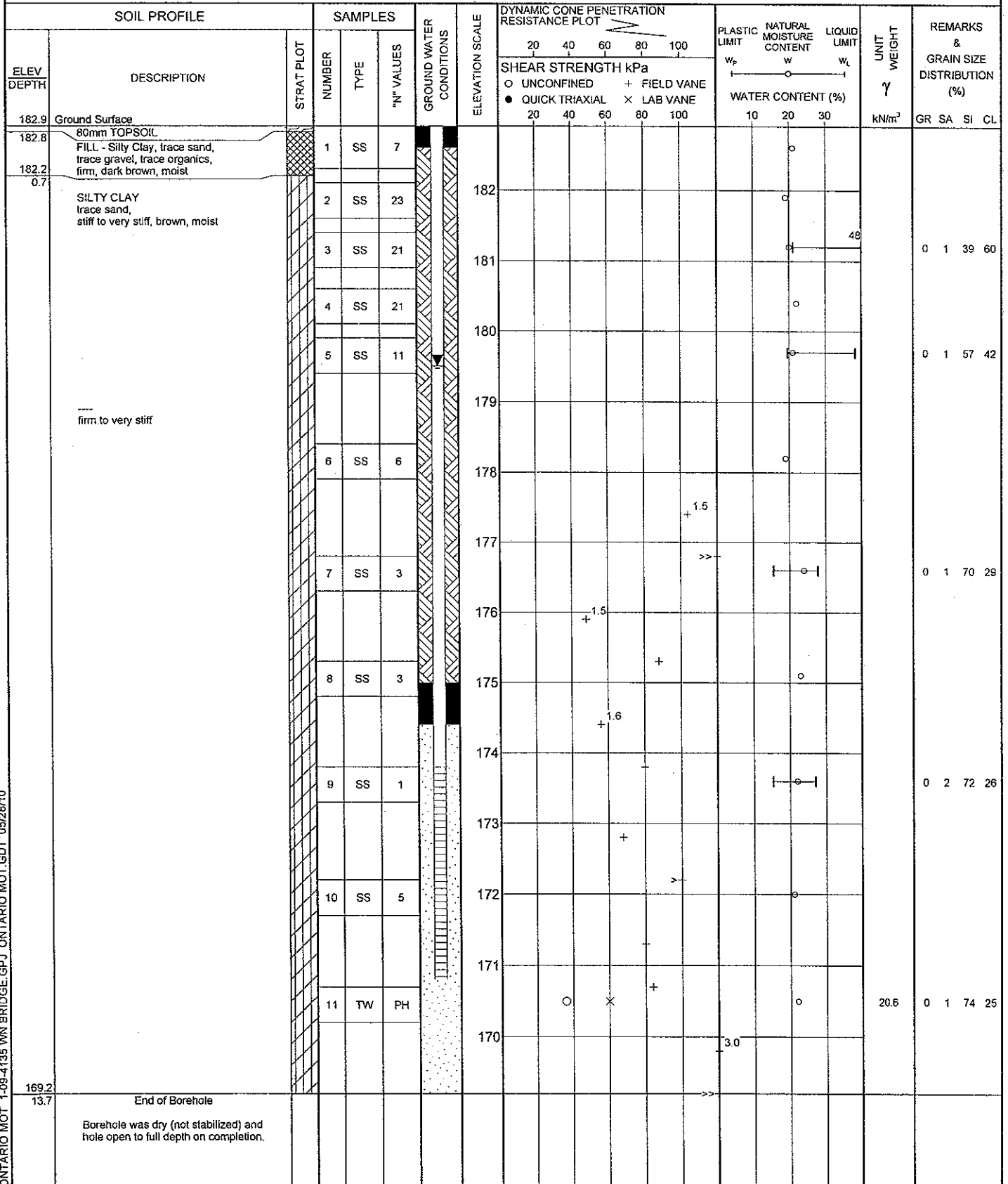
- (iii) positions and results of tests, e.g., permeability and packer tests

RECORD OF BOREHOLE No NBL 12+695Lt

1 OF 2

METRIC

W.P. 280-99-00 LOCATION Coords: N:4764175.1 E:327333.0 ORIGINATED BY MP
DIST HWY 406 BOREHOLE TYPE Hollow Stem Augers COMPILED BY DB
DATUM Geodetic DATE 11.18.09 CHECKED BY RA



ONTARIO MOT 1-09-4135 WN BRIDGE.GPJ ONTARIO MOT.GDT 05/28/10

Continued Next Page

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

RECORD OF BOREHOLE No NBL 12+695Lt

2 OF 2

METRIC

W.P. 280-99-00 LOCATION Coords: N:4764175.1 E:327333.0 ORIGINATED BY MP
DIST HWY 406 BOREHOLE TYPE Hollow Stem Augers COMPILED BY DB
DATUM Geodetic DATE 11.18.09 CHECKED BY RA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
						○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					WATER CONTENT (%)						
						20	40	60	80	100		10	20	30			
	Piezometer installation consists of a 19mm diameter, Schedule 40 PVC pipe with a 3.0m slotted screen. Water Level Readings: Date Depth(m) Elevation(m) Nov.30.09 9.3 173.6 Dec.15.09 3.4 179.5 Jan.04.10 3.2 179.7 Jan.11.10 3.3 179.6 Jan.19.10 3.4 179.5 Consolidation test performed on TW 11.																

ONTARIO MOT 1-09-4135 WN BRIDGE GPJ ONTARIO MOT.GDT 05/28/10

RECORD OF BOREHOLE No WN1

1 OF 3

METRIC

W.P. 280-99-00 LOCATION Coords: N:4764187.0 E:327332.0 ORIGINATED BY AW
DIST HWY 406 BOREHOLE TYPE Hollow Stem Augers / NQ Rock Coring COMPILED BY DB
DATUM Geodetic DATE 02.16.10 - 02.18.10 CHECKED BY RA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
183.1	Ground Surface							20 40 60 80 100						
183.0	80mm TOPSOIL		1	SS	13		183	○ UNCONFINED + FIELD VANE						
	FILL - Silty Clay, trace sand, trace organics, stiff to very stiff, brown, moist		2	SS	23		182	● QUICK TRIAXIAL × LAB VANE						
			3	SS	24		181							
181.0			4	SS	25		180							
2.1	SILTY CLAY trace sand, stiff to very stiff, brown, moist		5	SS	14		179							
			6	SS	15		178							
178.7			7	SS	16		177							
4.4	SILT frequent silty clay seams and partings, compact, brown, moist		8	SS	11		176							
			9	SS	11		175							
177.9			10	SS	11		174							
5.2	SILTY CLAY trace sand, stiff to very stiff, brown, damp to moist		11	TW	PH		173							
			12	SS	8		172							
			13	SS	9		171							
			14	SS	10		170							
							169							
168.4														
14.7														

ONTARIO MOT 1-09-4135 WN BRIDGE.GPJ ONTARIO MOT.GDT 06/28/10

Continued Next Page

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

METRIC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT w_p	NATURAL MOISTURE CONTENT w	LIMIT w_L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE		WATER CONTENT (%)			
							20 40 60 80 100						
165.3 17.8	SILTY CLAY TO CLAYEY SILT some sand, trace gravel, very stiff to hard, brown, moist (GLACIAL TILL)		15	SS	18		168	>>		10	20	30	5 17 57 2
			16	SS	32		167						
			17	SS	42		166						14 33 42 1
			18	SS	28		165						Feb.16
			19	SS	172/ 23cm		164						Feb.17
			20	SS	167/ 25cm		163						
			21	SS	138		162						
			22	SS	100/ 15cm		161						
			23	SS	100/ 2.5cm		160						
155.7 27.4	BEDROCK - INTERBEDDED DOLOSTONE AND SHALE Unweathered, thinly laminated, grey, medium strength, argillaceous with unweathered, laminated, white, very low strength gypsum and calcite layers / veins and frequent unweathered, white, low strength, coarse grained calcitic vugs.		1	RUN	NQ		159						8 39 41 1
							158						
							157						
							156						Feb.17
							155						Feb.18
							154						RUN#1 TCR=72% SCR=67% RQD=34%

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

RECORD OF BOREHOLE No WN1

3 OF 3

METRIC

W.P. 280-99-00 LOCATION Coords: N:4764187.0 E:327332.0 ORIGINATED BY AW
DIST HWY 406 BOREHOLE TYPE Hollow Stem Augers / NQ Rock Coring COMPILED BY DB
DATUM Geodetic DATE 02.16.10 - 02.18.10 CHECKED BY RA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL						
							20	40	60	80	100					GR SA SI CL
			2	RUN	NQ											RUN#2 TCR=75% SCR=57% RQD=29%
151.9 31.2	End of Borehole															
	Sampler wet at 19.8m.															
	Borehole open to full depth and filled with drill water upon completion of drilling.															
	Borehole sealed with bentonite slurry to ground surface.															

ONTARIO MOT. 1-09-4135 WN BRIDGE.GPJ ONTARIO MOT.GDT 05/28/10

CORE LOG



Terraprobe

Project	Highway 406 Twinning	Orientation	Vertical	Ground Elevation	183.1m	Datum	Geodetic	Borehole No.	WN1
Location	Welland, Ontario	Date Started	February 16, 2010	Completed	February 16, 2010	Logged By	AW	Sheet	1 of 1
W.P.:	280-99-00	Drilling Agency	DDSI	Drill Type	Track-Mount	Core Barrel & Bit Design	NQ	Project No.	1-09-4135

ELEVATION (m)	DEPTH (m)	SYMBOL	GENERAL DESCRIPTION	Joint Characteristics								STRENGTH	FRACTURE FREQUENCY	RUN NO. CORE RECOVERY %	R Q D %	CORE SIZE/CASING	MPa UNCONFINED COMPRESSIVE STRENGTH	UNIT WEIGHT (KN/m³)
				NO. OF SETS	JOINT TYPE	ORIENTATION	SPACING	ROUGHNESS	FILLING	APERTURE	WEATHERING							
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
156.1	27.0		Overburden, refer to Borehole Log WN1															
155.6	27.5		SALINA FORMATION BEDROCK															
155.1	28.0		INTERBEDDED DOLOSTONE AND SHALE Unweathered, thinly laminated, grey, medium strength, argillaceous with unweathered, laminated, white, very low strength gypsum and calcite layers / veins and frequent unweathered, white, low strength, coarse grained calcitic vugs.	1	B	F	C	SP	T									
154.6	28.5			1	B	F	VC	RP	T	0.50				#1 TCR 72 SCR 67	34	NQ		
154.1	29.0			1	B	F	C	SP	T									
153.6	29.5																	
153.1	30.0			1	B	F	C	SP	T									
152.6	30.5			1	B	F	VC	SP	T	0.41				#2 TCR 75 SCR 57	29	NQ		
152.1	31.0			1	B	F	C	SP	T									
152.1	31.0			1	B	F	VC	SP	T									
151.6	31.5		End of Core Log															
151.6	31.5		<u>Rubble zone at:</u> 28.50-28.55m.															
151.1	32.0		Rubble indicated by 'a'.															
151.1	32.0		<u>Highly fractured zones at:</u> 30.20-30.40m; 31.00-31.20m.															
150.6	32.5																	
150.1	33.0																	

Remarks:

LEGEND:

- Interbedded Dolostone and Shale
- Rubble

RECORD OF BOREHOLE No WN2

1 OF 3

METRIC

W.P. 280-99-00 LOCATION Coords: N:4764202.3 E:327354.1 ORIGINATED BY PK
DIST HWY 406 BOREHOLE TYPE Hollow Stem Augers / NQ Rock Coring COMPILED BY DB
DATUM Geodetic DATE 12.10.09 - 12.14.09 CHECKED BY RA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × LAB VANE						
181.6	Ground Surface						20 40 60 80 100								
181.5	150mm TOPSOIL						20 40 60 80 100								
0.2	SILTY CLAY trace sand, stiff to very stiff, brown, damp to moist		1	SS	8										
			2	SS	16									0 2 55 43	
			3	SS	16										
179.3	SILT trace sand, frequent silty clay seams and partings, compact, brown, moist		4	SS	19									0 1 80 19	
2.3			5	SS	12										
178.1	SILTY CLAY trace sand, trace gravel, firm to very stiff, brown, moist		6	SS	6									0 3 64 33	
3.5			7	SS	7										
			8	SS	6									1 5 65 29	
			9	SS	2										
			10	TW	PH										
			11	SS	8									Dec.10 Dec.11 1 2 73 24	
			12	SS	9										
			13	SS	25									8 19 54 19	
168.4		SILTY CLAY TO CLAYEY SILT some sand, trace gravel, very stiff to hard, brown, damp (GLACIAL TILL)													
13.2															

Continued Next Page

+ 3, x 3. Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

ONTARIO MOT 1-09-4135 WN BRIDGE CPJ ONTARIO MOT.GDT 05/28/10

METRIC

Continued Next Page


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

CORE LOG



Terraprobe

Project	Highway 406 Twinning	Orientation	Vertical	Ground Elevation	181.6m	Datum	Geodetic	Borehole No.	WN2
Location	Welland, Ontario	Date Started	December 14, 2009	Completed	December 14, 2009	Logged By	AW	Sheet	1 of 1
W.P.:	280-99-00	Drilling Agency	DDSI	Drill Type	Truck Mount	Core Barrel & Bit Design	NQ	Project No.	1-09-4135

ELEVATION (m)	DEPTH (m)	SYMBOL	GENERAL DESCRIPTION	Joint Characteristics								WEATHERING	STRENGTH	FRACTURE FREQUENCY	RUN NO.	CORE RECOVERY %	R Q D %	CORE SIZE/CASING	MPa UNCONFINED COMPRESSIVE STRENGTH	UNIT WEIGHT (kN/m³)
				No. OF SETS	JOINT TYPE	ORIENTATION	SPACING	ROUGHNESS	FILLING	APERTURE										
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19		
156.1	25.5		Overburden, refer to Borehole Log WN2																	
155.6	26.0		SALINA FORMATION BEDROCK INTERBEDDED DOLOSTONE AND SHALE Unweathered, thinly laminated, grey, medium strength, argillaceous with unweathered, laminated, white, very low strength gypsum and calcite layers / veins and frequent unweathered, white, low strength, coarse grained calcitic vugs.	1	B	F	C	SP	T	0 to 1				#1 TCR 95 SCR 89	70	NQ				
155.1	26.5																			
154.6	27.0			1	B	F	C	SP	T											
154.1	27.5			1	B	F	VC	SP	T											
153.6	28.0			1	B	F	M	SP	T		0 to 1				#2 TCR 100 SCR 83	58	NQ			
153.1	28.5																			
152.6	29.0			1	B	F	M	SP	T											
152.1	29.5			1	B	F	VC	SP	T											
				1	B	F	C	SP	T											
				1	B	F	M	SP	T		0 to 1				#3 TCR 100 SCR 77	50	NQ			
				1	B	F	VC	SP	T											
151.6	30.0		End of Core Log																	
151.1	30.5		Highly fractured zones at: 27.10~27.30m; 28.60~28.70m; 29.60~29.80m.																	
150.6	31.0																			
150.1	31.5																			

Remarks:

LEGEND:

- Interbedded Dolostone and Shale
- Rubble

RECORD OF BOREHOLE No WN3

1 OF 3

METRIC

W.P. 280-99-00 LOCATION Coords: N:4764212.0 E:327314.7 ORIGINATED BY KB
DIST HWY 406 BOREHOLE TYPE Hollow Stem Augers / NQ Rock Coring COMPILED BY DB
DATUM Geodetic DATE 02.18.10 - 02.22.10 CHECKED BY RA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
182.1	Ground Surface																
0.0	FILL - Sand and Gravel, some silt, trace clay, dense, grey, damp		1	SS	48		182										41 44 13 2
181.4																	
0.7	fim		2	SS	6		181										

	SILTY CLAY trace sand, trace gravel, very stiff, brown, damp		3	SS	22		180										
			4	SS	14												
			5	SS	27		179										
178.4																	
3.7	SILT trace sand, frequent silty clay seams and partings, compact, brown, damp		6	SS	26		178										0 1 84 15
177.4			7	SS	9												
4.7	SILTY CLAY trace sand, trace gravel, stiff to hard, brown, damp		8	SS	12		177										
			9	SS	10		176										
			10	SS	11		175										
							174										0 3 70 27
			11	SS	8		173										1 3 69 27
							172										
			12	TW	PH												
							171										
							170										
			13	SS	17												1 2 72 25
							169										
							168										
167.8			14	SS	60												
14.3																	

Continued Next Page

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

ONTARIO MOT 1-09-4135 WN BRIDGE.GPJ ONTARIO MOT.GDT 05/28/10

RECORD OF BOREHOLE No WN3

2 OF 3

METRIC

W.P. 280-99-00 LOCATION Coords: N:4764212.0 E:327314.7 ORIGINATED BY KB
DIST HWY 406 BOREHOLE TYPE Hollow Stem Augers / NQ Rock Coring COMPILED BY DB
DATUM Geodetic DATE 02.18.10 - 02.22.10 CHECKED BY RA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)				
								20 40 60 80 100	20 40 60 80 100	10 20 30				
								○ UNCONFINED + FIELD VANE	○ UNCONFINED + FIELD VANE	○ UNCONFINED + FIELD VANE				
								● QUICK TRIAXIAL × LAB VANE	● QUICK TRIAXIAL × LAB VANE	● QUICK TRIAXIAL × LAB VANE				
								20 40 60 80 100	20 40 60 80 100	10 20 30				

Continued Next Page

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

ONTARIO MOT 1-09-4135 WN BRIDGE 3PJ ONTARIO MOT.GDT 05/28/10

RECORD OF BOREHOLE No WN3

3 OF 3

METRIC

W.P. 280-99-00 LOCATION Coords: N:4764212.0 E:327314.7 ORIGINATED BY KB
 DIST HWY 406 BOREHOLE TYPE Hollow Stem Augers / NQ Rock Coring COMPILED BY DB
 DATUM Geodetic DATE 02.18.10 - 02.22.10 CHECKED BY RA

SOIL PROFILE		SAMPLES				GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100					
30.0	End of Borehole Borehole open to full depth and filled with drill water upon completion of drilling. Piezometer installation consists of a 19mm diameter, Schedule 40 PVC pipe with a 1.52m slotted screen. Water Level Readings: Date Depth(m) Elevation(m) Apr.16.10 7.7 174.4 Apr.29.10 3.9 178.2 May.04.10 5.2 176.9 May.06.10 4.8 177.3						152										


ONTARIO MOT. 1-09-4135 WN BRIDGE.GPJ ONTARIO MOT.GDT 05/28/10

CORE LOG



Terraprobe

Project	Highway 406 Twinning	Orientation	Vertical	Ground Elevation	182.1m	Datum	Geodetic	Borehole No.	WN3
Location	Welland, Ontario	Date Started	February 22, 2010	Completed	February 22, 2010	Logged By	AW	Sheet	1 of 1
W.P.:	280-99-00	Drilling Agency	ODSI	Drill Type	Truck Mount	Core Barrel & Bit Design	NQ	Project No.	1-09-4135

ELEVATION (m)	DEPTH (m)	SYMBOL	GENERAL DESCRIPTION	Joint Characteristics							WEATHERING	STRENGTH	FRACTURE FREQUENCY	RUN NO. CORE RECOVERY %	R Q D %	CORE SIZE/CASING	UNCONFINED COMPRESSIVE STRENGTH MPa	UNIT WEIGHT (kN/m³)					
				No. OF SETS	JOINT TYPE	ORIENTATION	SPACING	ROUGHNESS	FILLING	APERTURE													
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19					
156.1	26.0		Overburden, refer to Borehole Log WN3																				
155.6	26.5		SALINA FORMATION BEDROCK INTERBEDDED DOLOSTONE AND SHALE Unweathered, thinly laminated, grey, medium strength, argillaceous with unweathered, laminated, white, very low strength gypsum and calcite layers / veins and frequent unweathered, white, low strength, coarse grained calcitic vugs.	1	B	F	VC	SU	T	0 to 1							#1 TCR 38 SCR 11	0	NQ				
155.1	27.0			1	B	F	VC	SU	T														
154.6	27.5			1	B	F	C	SP	T		0 to 1								#2 TCR 100 SCR 95	51	NQ		
154.1	28.0			1	B	F	VC	SP	T														
				1	B	F	M	SP	T														
153.6	28.5																						
153.1	29.0			1	B	F	C	SP	T	0 to 1								#3 TCR 97 SCR 92	60	NQ			
152.6	29.5			1	B	F	M	SP	T														
152.1	30.0		End of Core Log																				
151.6	30.5		Rubblelized zones of: 26.40-27.20m; 27.95-28.00m. Rubble indicated by 'a'.																				
151.1	31.0																						
150.6	31.5																						
150.1	32.0																						

Remarks:

LEGEND:

- Interbedded Dolostone and Shale
- Rubble

RECORD OF BOREHOLE No WN4

1 OF 3

METRIC

W.P. 280-99-00 LOCATION Coords: N:4764228.4 E:327343.4 ORIGINATED BY PK
 DIST HWY 406 BOREHOLE TYPE Hollow Stem Augers / NQ Rock Coring COMPILED BY DB
 DATUM Geodetic DATE 12.14.09 - 12.15.09 CHECKED BY RA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
182.5	Ground Surface							20 40 60 80 100						
182.4	150mm TOPSOIL							20 40 60 80 100						
0.2	soft		1	SS	3		182							
	FILL - Silty Clay, trace sand, trace gravel, firm to stiff, brown, damp		2	SS	6		181							0 2 67 31
			3	SS	9		180							5 3 56 36
			4	SS	8		179							
			5	SS	5		178							
178.8	SILT trace clay, trace sand, frequent silty clay seams and partings, compact, brown, damp		6	SS	16		177							
3.7			7	SS	22		176							
177.6	SILTY CLAY trace to some gravel, trace sand, stiff to very stiff, brown, damp		8	SS	5		175							17 10 37 36
4.9			9	SS	10		174							
			10	TW	PH		173							
			11	SS	9		172							1 2 72 25
			12	SS	8		171							1 3 73 23
			13	SS	12		170							Dec.14 Dec.15
			14	SS	12		169							1 8 68 23
167.8							168							
14.7														

Continued Next Page

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

ONTARIO MOT. 1-09-4135 WN BRIDGE GPJ ONTARIO MOT.GDT 05/28/10

METRIC

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

RECORD OF BOREHOLE No WN4

3 OF 3

METRIC

W.P. 280-99-00 LOCATION Coords: N:4764228.4 E:327343.4 ORIGINATED BY PK
DIST HWY 406 BOREHOLE TYPE Hollow Stem Augers / NQ Rock Coring COMPILED BY DB
DATUM Geodetic DATE 12.14.09 - 12.15.09 CHECKED BY RA

SOIL PROFILE		SAMPLES				GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100	W _p	W	W _L		
	<p>Borehole open to full depth and filled with drill water upon completion of drilling.</p> <p>Borehole sealed with bentonite slurry to ground surface.</p> <p>Resistance to augering at 22.9m and 24.3m.</p> <p>Unable to push vane beyond 13.1m and 14.2m.</p>																

ONTARIO MOT 1-09-4135 WN BRIDGE.CPJ ONTARIO MOT GDT 05/28/10

CORE LOG



Terraprobe

Project	Highway 406 Twinning	Orientation	Vertical	Ground Elevation	182.5m	Datum	Geodetic	Borehole No.	WN4
Location	Welland, Ontario	Date Started	December 15, 2009	Completed	December 15, 2009	Logged By	AW	Sheet	1 of 1
W.P.:	280-99-00	Drilling Agency	DDSI	Drill Type	Truck Mount	Core Barrel & Bit Design	NQ	Project No.	1-09-4135

ELEVATION (m)	DEPTH (m)	SYMBOL	GENERAL DESCRIPTION	Joint Characteristics							WEATHERING	STRENGTH	FRACTURE FREQUENCY	RUN NO.	CORE RECOVERY %	R Q D %	CORE SIZE/CASING	UNCONFINED COMPRESSIVE STRENGTH MPa	UNIT WEIGHT (kN/m³)
				No. OF SETS	JOINT TYPE	ORIENTATION	SPACING	ROUGHNESS	FILLING	APERTURE									
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	
157.0	25.5		Overburden, refer to Borehole Log WN4																
156.5	26.0		Silty Sand to Sandy Silt TILL, refer to Borehole Log WN4																
			SALINA FORMATION BEDROCK																
156.0	26.5		INTERBEDDED DOLOSTONE AND SHALE Unweathered, thinly laminated, grey, medium strength, argillaceous with unweathered, laminated, white, very low strength gypsum and calcite layers / veins and frequent unweathered, white, low strength, coarse grained calcitic vugs.	1	B	F	C	SU	T	0 to 1					#1 TCR 92 SCR 77	44	NQ		
				1	B	F	VC	SP	T										
				2	BC	PV	C	SP	T										
155.5	27.0			1	B	F	C	SP	T										
				1	B	F	VC	RP	T										
155.0	27.5			1	B	F	C	SP	T	0 to 1					#2 TCR 100 SCR 90	35	NQ		
				1	B	F	VC	SP	T										
				1	B	F	C	SP	T										
154.5	28.0			1	B	F	VC	SP	T										
				1	B	F	C	SP	T										
				1	B	F	VC	SP	T										
				1	B	F	C	RU	T										
154.0	28.5			1	B	F	C	SP	T	0 to 1					#3 TCR 98 SCR 95	36	NQ		
153.5	29.0		End of Core Log																
153.0	29.5		<u>Rubblelized zones at:</u> 26.40-26.50m; 27.70-27.75m; 27.90-27.95; 28.00-28.05m. Rubble indicated by 'a'.																
152.5	30.0																		
152.0	30.5		<u>Highly fractured zone at:</u> 26.95-27.00m.																
151.5	31.0																		
151.0	31.5																		

Remarks:

LEGEND:

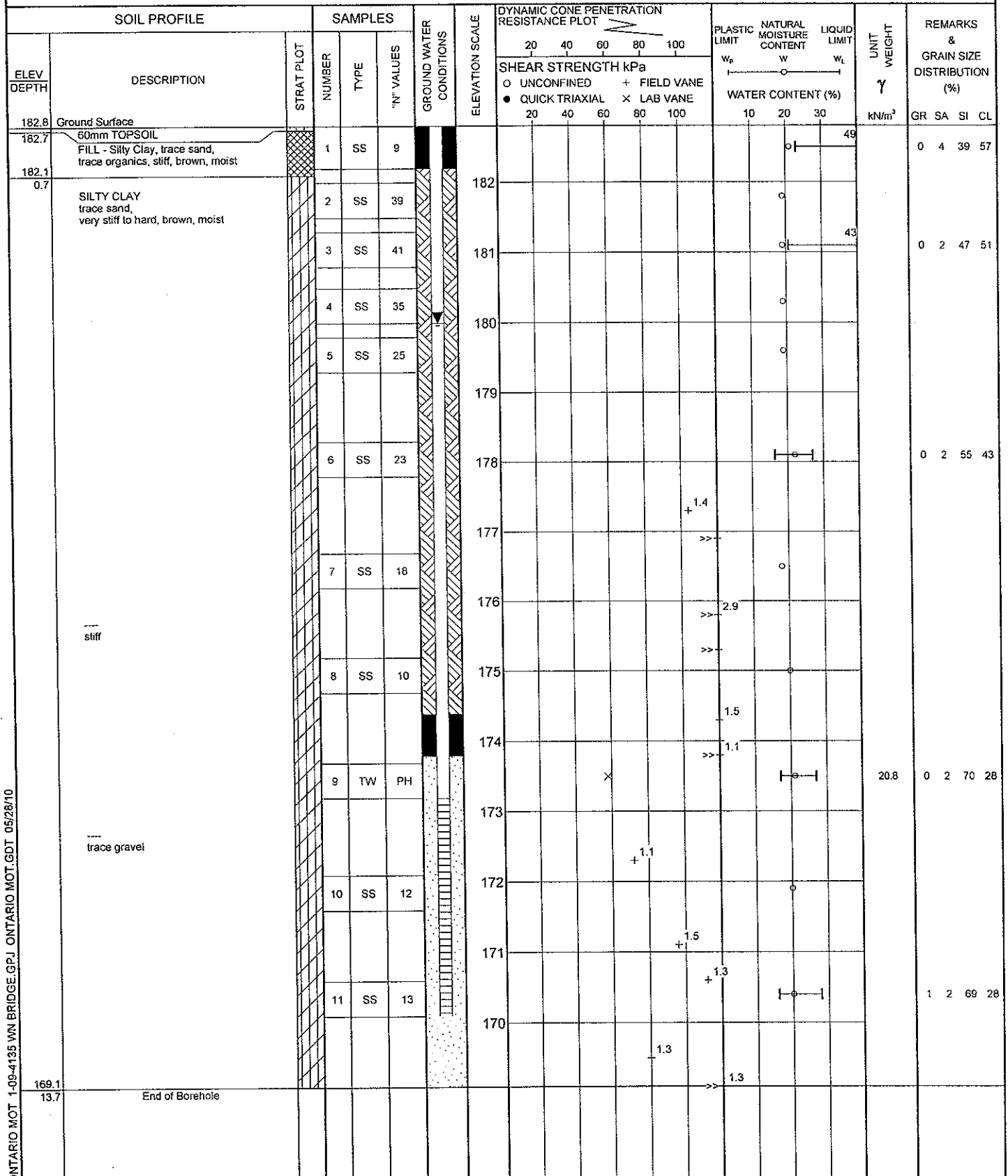
	Interbedded Dolostone and Shale
	Rubble
	Silly Sand to Sandy Silt TILL

RECORD OF BOREHOLE No NBL 12+750Rt

1 OF 2

METRIC

W.P. 280-99-00 LOCATION Coords: N:4764237.5 E:327341.9 ORIGINATED BY AW
 DIST HWY 406 BOREHOLE TYPE Hollow Stem Augers COMPILED BY KL
 DATUM Geodetic DATE 12.02.09 CHECKED BY RA



ONTARIO MOT 1-09-4135 WN BRIDGE.GPJ ONTARIO MOT.GDT 05/28/10

Continued Next Page

+ 3, x 3. Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

RECORD OF BOREHOLE No NBL 12+750Rt

2 OF 2

METRIC

W.P. 280-99-00 LOCATION Coords: N:4764237.5 E:327341.9 ORIGINATED BY AW
DIST HWY 406 BOREHOLE TYPE Hollow Stem Augers COMPILED BY KL
DATUM Geodetic DATE 12.02.09 CHECKED BY RA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL														
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100	w _p	w	w _L																
	<p>Borehole was dry (not stabilized) and hole open to full depth on completion.</p> <p>Piezometer installation consists of a 19mm diameter, Schedule 40 PVC pipe with a 3.0m slotted screen.</p> <p>Water Level Readings:</p> <table border="1"> <thead> <tr> <th>Date</th> <th>Depth(m)</th> <th>Elevation(m)</th> </tr> </thead> <tbody> <tr> <td>Dec.15.09</td> <td>5.1</td> <td>177.7</td> </tr> <tr> <td>Jan.04.10</td> <td>2.7</td> <td>180.1</td> </tr> <tr> <td>Jan.11.10</td> <td>2.7</td> <td>180.1</td> </tr> <tr> <td>Jan.19.10</td> <td>2.8</td> <td>180.0</td> </tr> </tbody> </table> <p>Consolidation test performed on TW9.</p>	Date	Depth(m)	Elevation(m)	Dec.15.09	5.1	177.7	Jan.04.10	2.7	180.1	Jan.11.10	2.7	180.1	Jan.19.10	2.8	180.0															
Date	Depth(m)	Elevation(m)																													
Dec.15.09	5.1	177.7																													
Jan.04.10	2.7	180.1																													
Jan.11.10	2.7	180.1																													
Jan.19.10	2.8	180.0																													

Foundation Investigation Report
Highway 406 Twinning - Port Robinson Road to East Main Street
Agreement No.: 2008-E-0016; W.P. 280-99-00



Bedrock Core Sample
Borehole: WN1
Runs: 1 & 2
Depth: 27.4m – 31.2m



Foundation Investigation Report
Highway 406 Twinning - Port Robinson Road to East Main Street
Agreement No.: 2008-E-0016; W.P. 280-99-00



Bedrock Core Sample

Borehole: WN2

Runs: 1, 2 & 3

Depth: 25.9m – 29.8m



Foundation Investigation Report
Highway 406 Twinning - Port Robinson Road to East Main Street
Agreement No.: 2008-E-0016; W.P. 280-99-00



Bedrock Core Sample
Borehole: WN3
Runs 1, 2 & 3
Depth: 26.4m – 30.0m



Foundation Investigation Report
Highway 406 Twinning - Port Robinson Road to East Main Street
Agreement No.: 2008-E-0016; W.P. 280-99-00



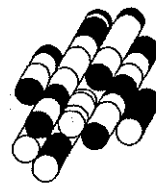
Bedrock Core Sample
Borehole: WN4
Runs: 1, 2 & 3
Depth: 25.8m – 28.9m



APPENDIX B

Laboratory Test Results

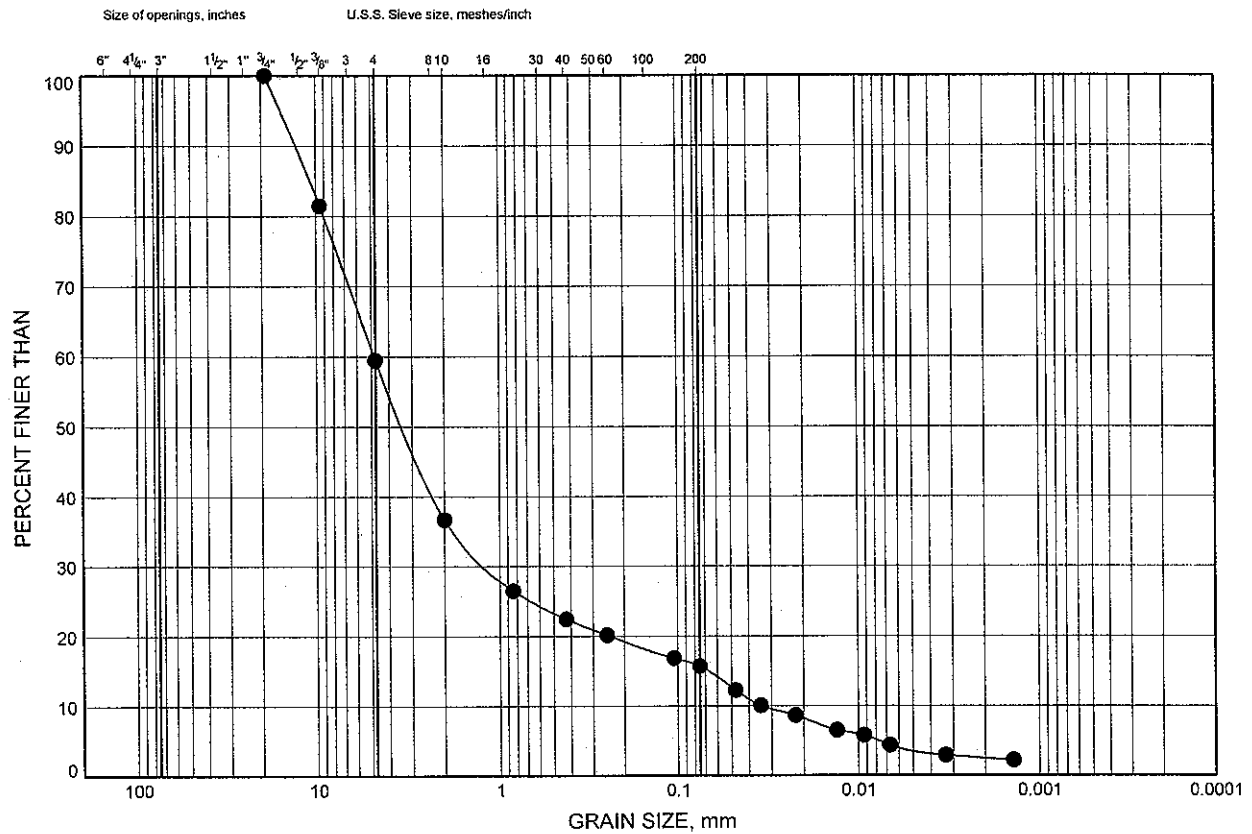
Terraprobe Inc.



GRAIN SIZE DISTRIBUTION

FIGURE B1

FILL - Sand and Gravel

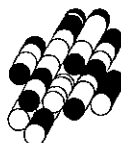


COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT and CLAY
	GRAVEL		SAND			FINE GRAINED

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	WN3	0.3	181.8

Date May 2010

Project 1-09-4135



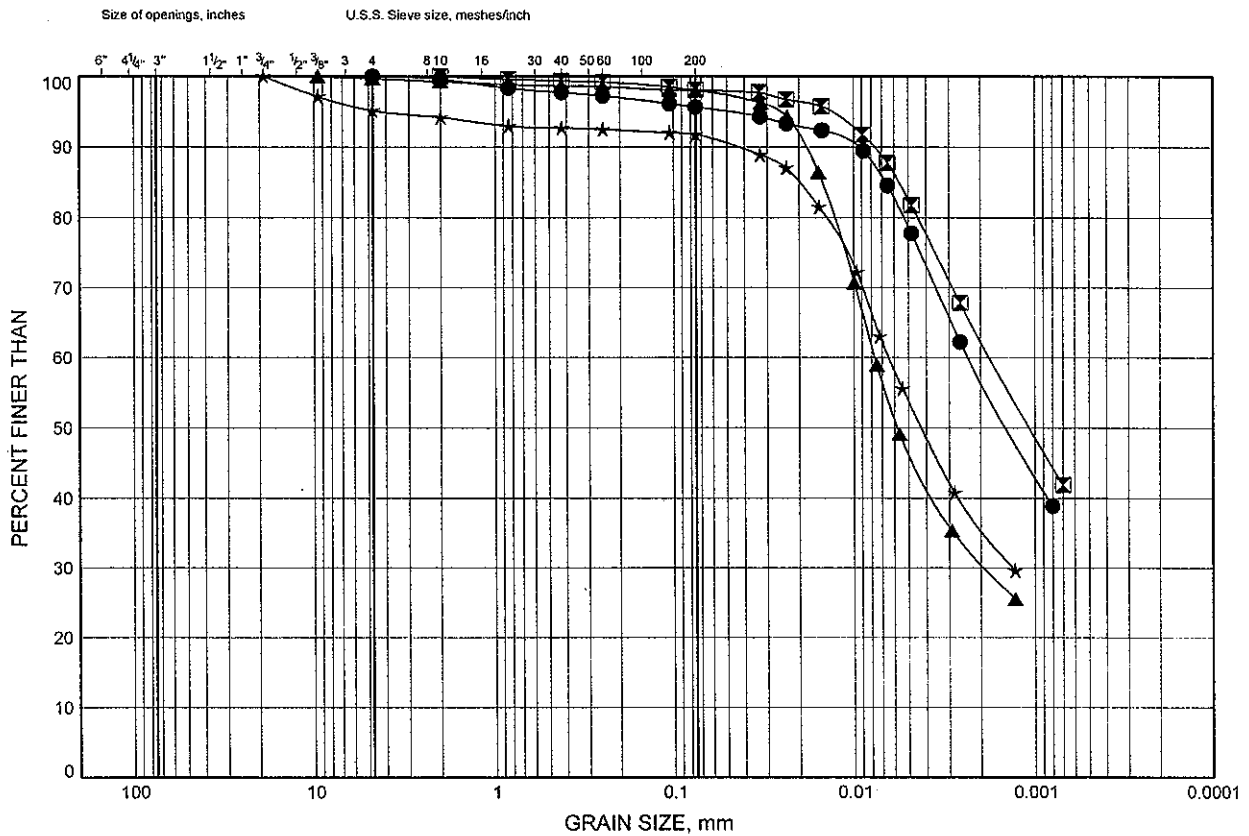
Prep'd DB

Chkd. MP

GRAIN SIZE DISTRIBUTION

FIGURE B2

FILL - Silty Clay

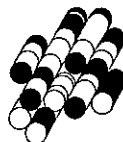


COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT and CLAY
	GRAVEL		SAND			FINE GRAINED

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	NBL 12+750Rt	0.3	182.5
⊠	WN1	1.0	182.1
▲	WN4	1.0	181.5
★	WN4	2.5	180.0

Date May 2010

Project 1-09-4135



Prep'd DB

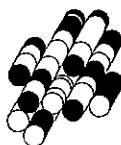
Chkd. MP

FIGURE B3

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	NBL 12+750Rt	0.3	182.5
⊠	WN1	1.0	182.1
▲	WN4	1.0	181.5

Prep'dDB.....

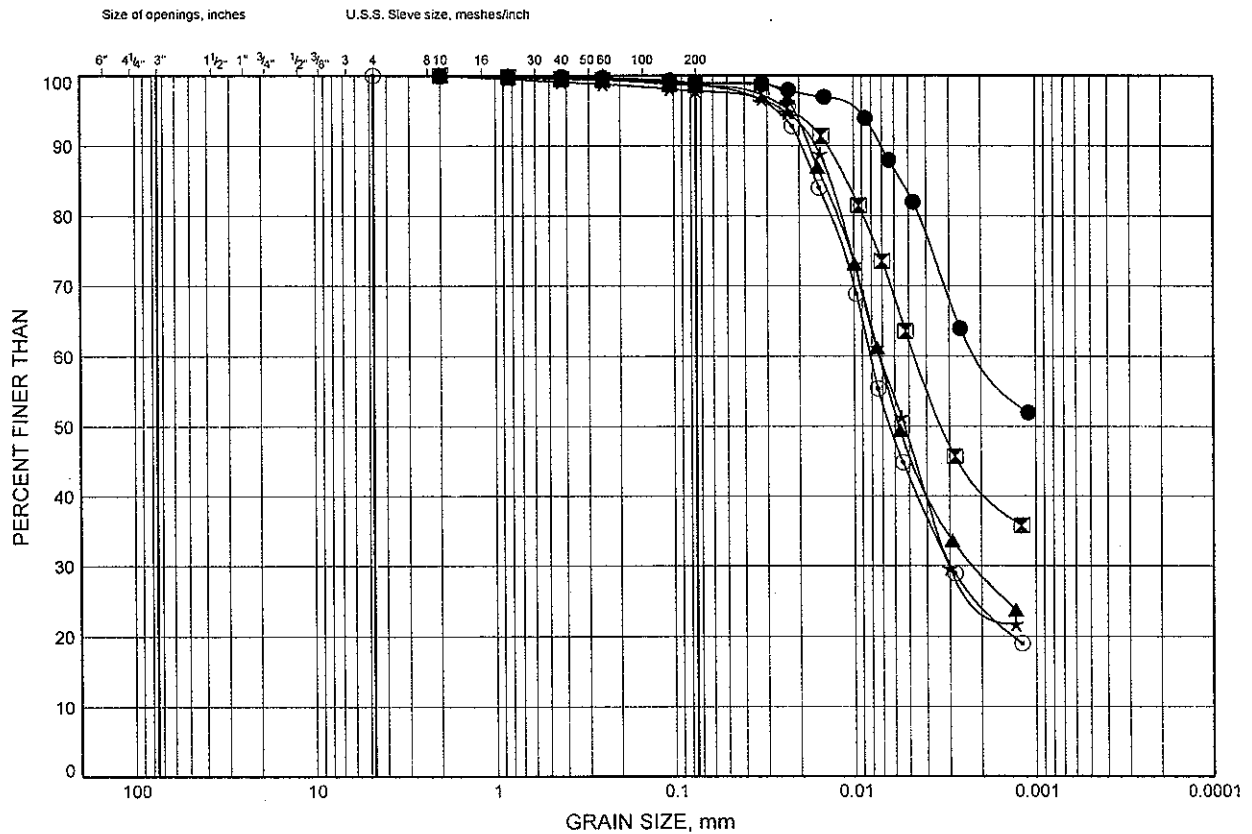
Chkd.MP.....



GRAIN SIZE DISTRIBUTION

FIGURE B4

SILTY CLAY

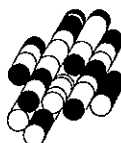


COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT and CLAY
	GRAVEL		SAND			FINE GRAINED

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	NBL 12+695Lt	1.7	181.2
⊠	NBL 12+695Lt	3.2	179.7
▲	NBL 12+695Lt	6.3	176.6
★	NBL 12+695Lt	9.3	173.6
⊙	NBL 12+695Lt	12.4	170.5

Date May 2010

Project 1-09-4135



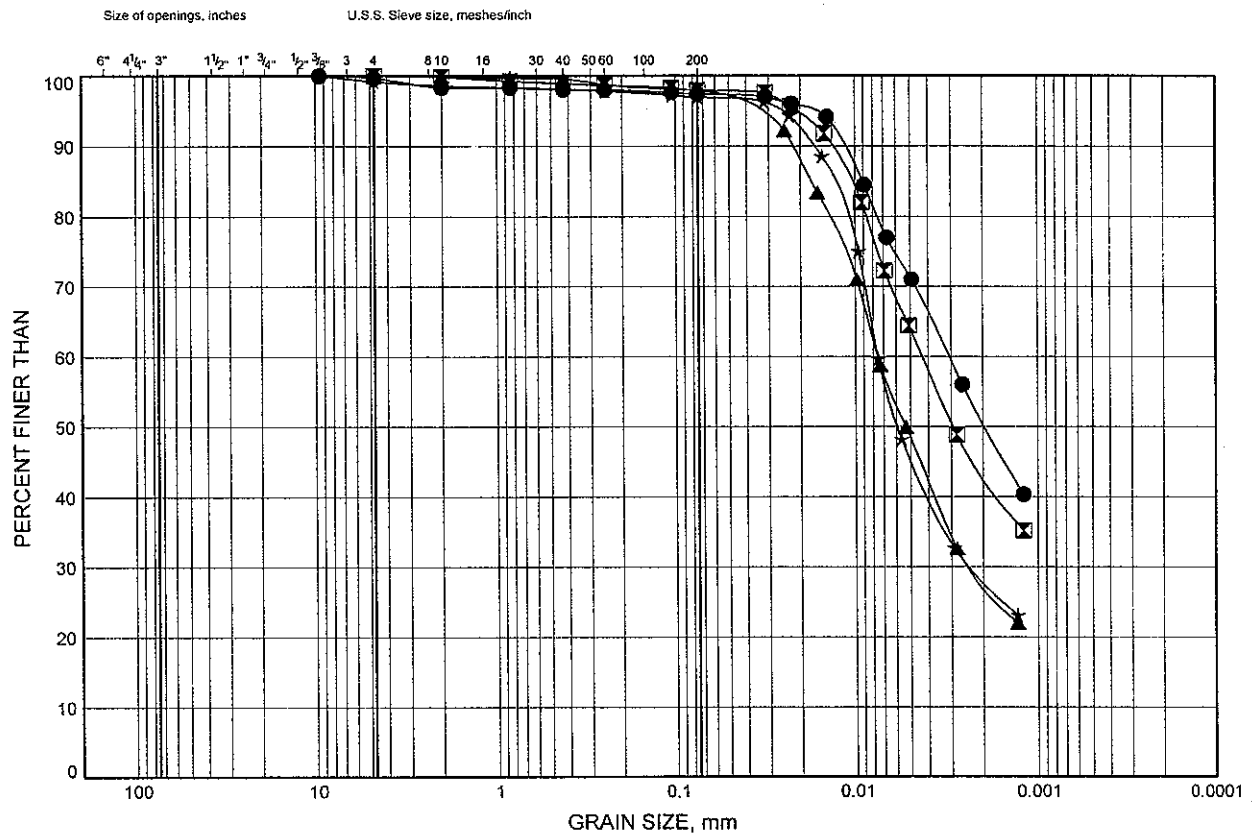
Prep'd DB

Chkd. MP

GRAIN SIZE DISTRIBUTION

FIGURE B5

SILTY CLAY



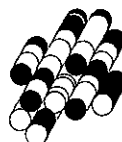
COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT and CLAY
	GRAVEL		SAND			FINE GRAINED

SYMBOL BOREHOLE DEPTH (m) ELEVATION (m)

●	NBL 12+750Rt	1.7	181.1
⊠	NBL 12+750Rt	4.7	178.1
▲	NBL 12+750Rt	9.3	173.5
★	NBL 12+750Rt	12.4	170.4

Date May 2010

Project 1-09-4135



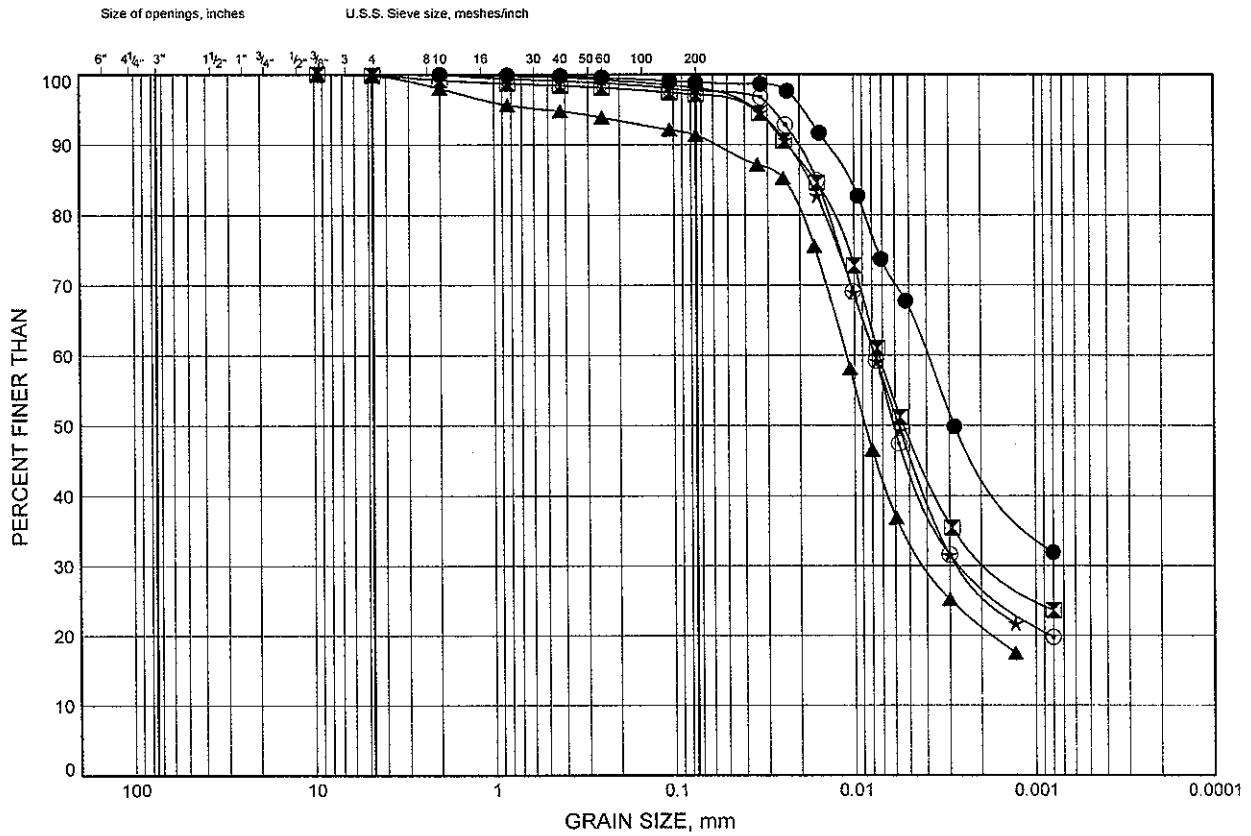
Prep'd DB

Chkd. MP

GRAIN SIZE DISTRIBUTION

FIGURE B6

SILTY CLAY

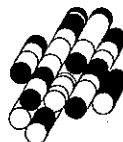


COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT and CLAY
	GRAVEL		SAND			FINE GRAINED

SYMBOL BOREHOLE DEPTH (m) ELEVATION (m)

●	WN1	3.2	179.9
⊠	WN1	6.3	176.8
▲	WN1	7.8	175.3
★	WN1	10.9	172.2
⊙	WN1	13.9	169.2

Date May 2010
Project 1-09-4135

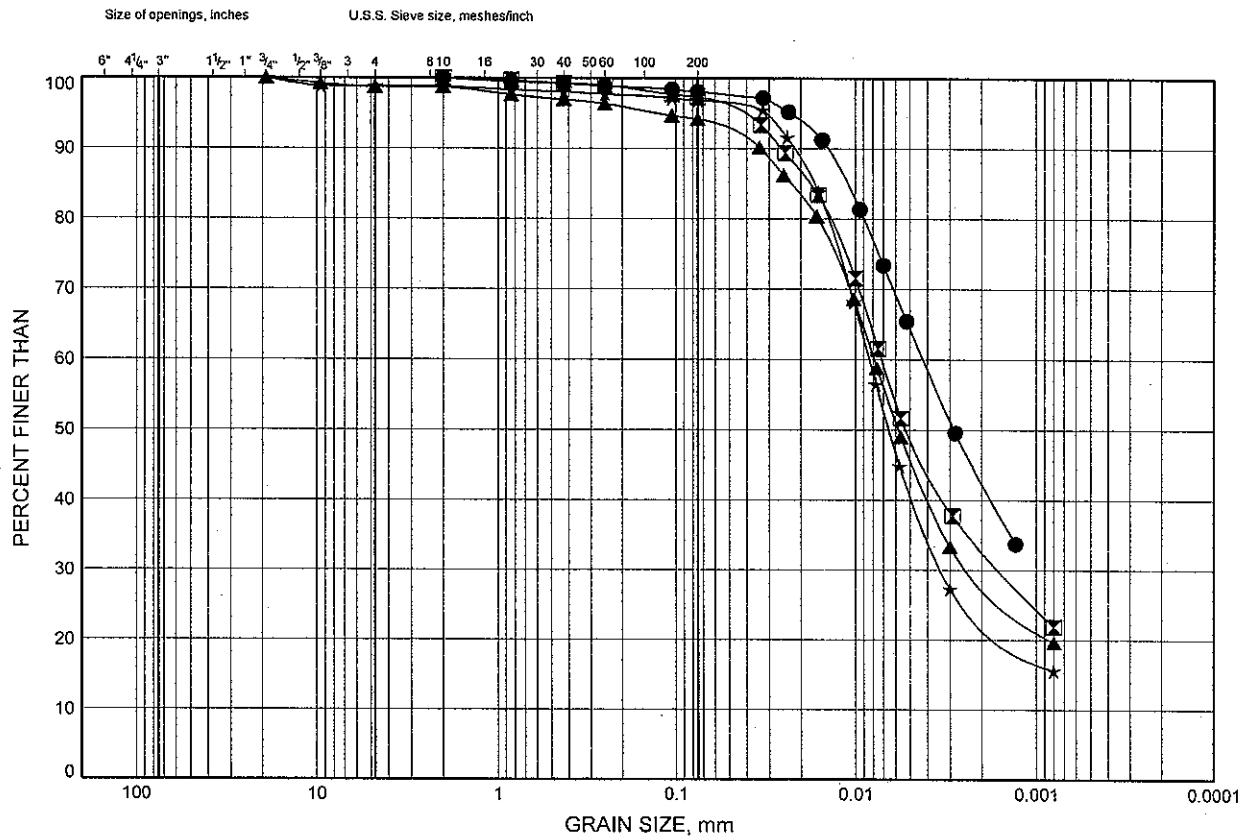


Prep'd DB
Chkd. MP

GRAIN SIZE DISTRIBUTION

FIGURE B7

SILTY CLAY

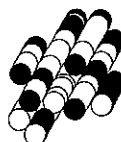


COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT and CLAY
	GRAVEL		SAND			FINE GRAINED

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	WN2	1.0	180.6
⊠	WN2	4.0	177.6
▲	WN2	6.3	175.3
★	WN2	10.9	170.7

Date May 2010

Project 1-09-4135



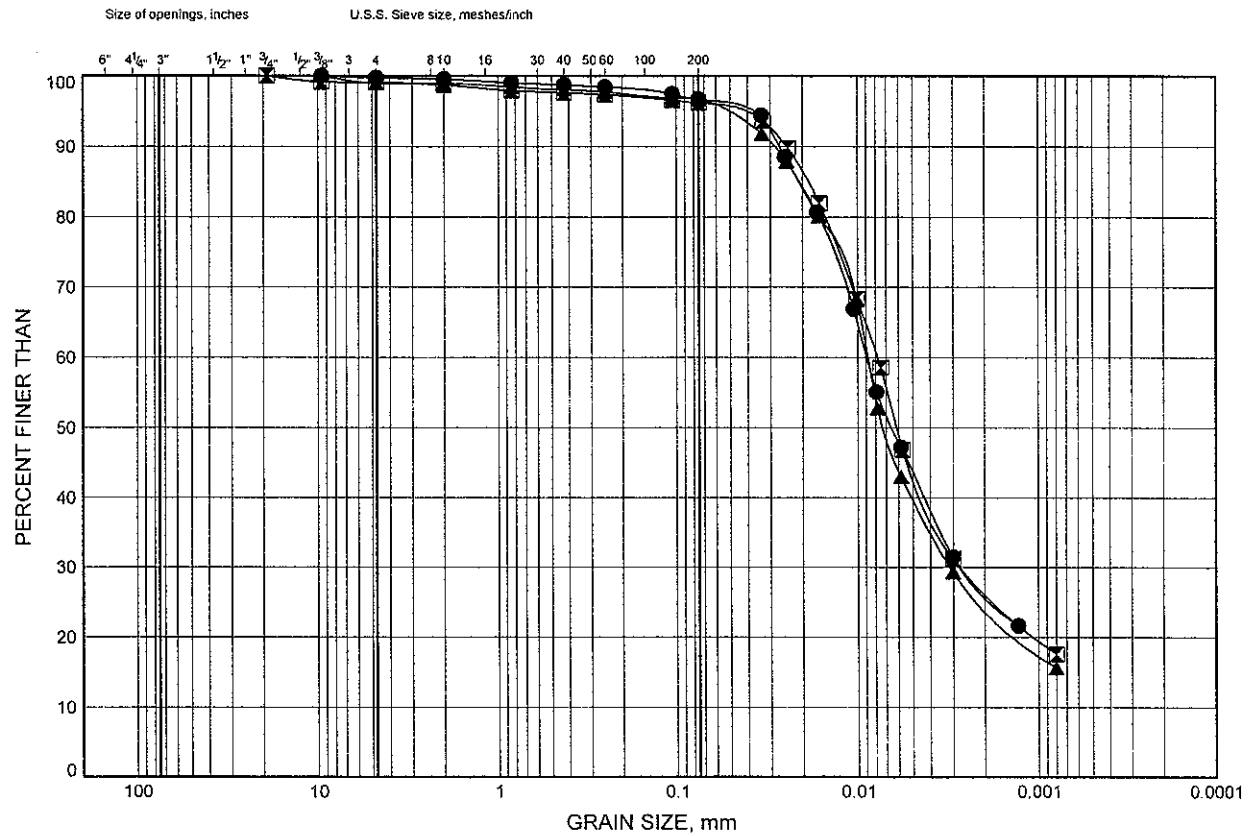
Prep'd DB

Chkd. MP

GRAIN SIZE DISTRIBUTION

FIGURE B8

SILTY CLAY

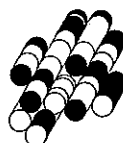


SYMBOL BOREHOLE DEPTH (m) ELEVATION (m)

● WN3 7.8 174.3
 ☒ WN3 9.3 172.8
 ▲ WN3 12.4 169.7

Date May 2010

Project 1-09-4135



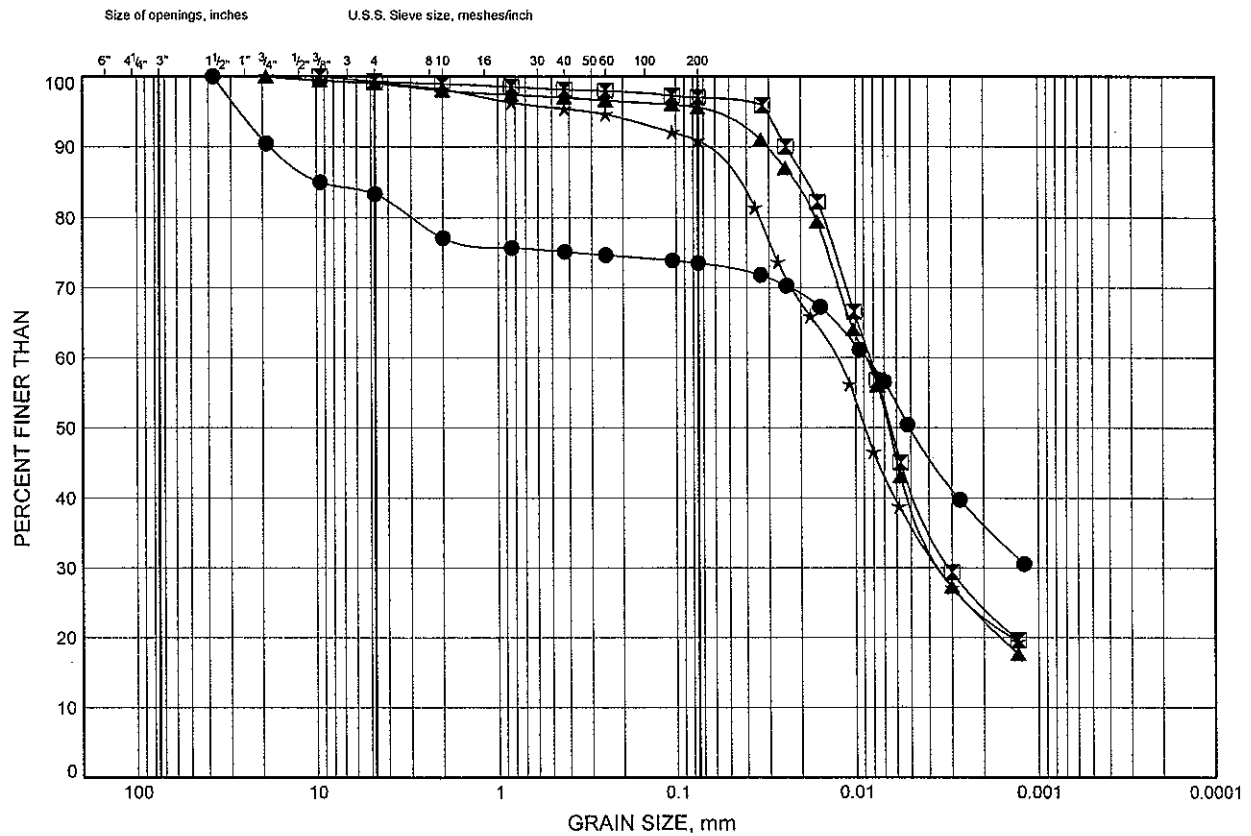
Prep'd DB

Chkd. MP

GRAIN SIZE DISTRIBUTION

FIGURE B9

SILTY CLAY

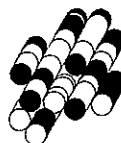


COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT and CLAY
	GRAVEL		SAND			FINE GRAINED

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	WN4	5.5	177.0
⊠	WN4	9.3	173.2
▲	WN4	10.9	171.6
★	WN4	13.9	168.6

Date May 2010

Project 1-09-4135



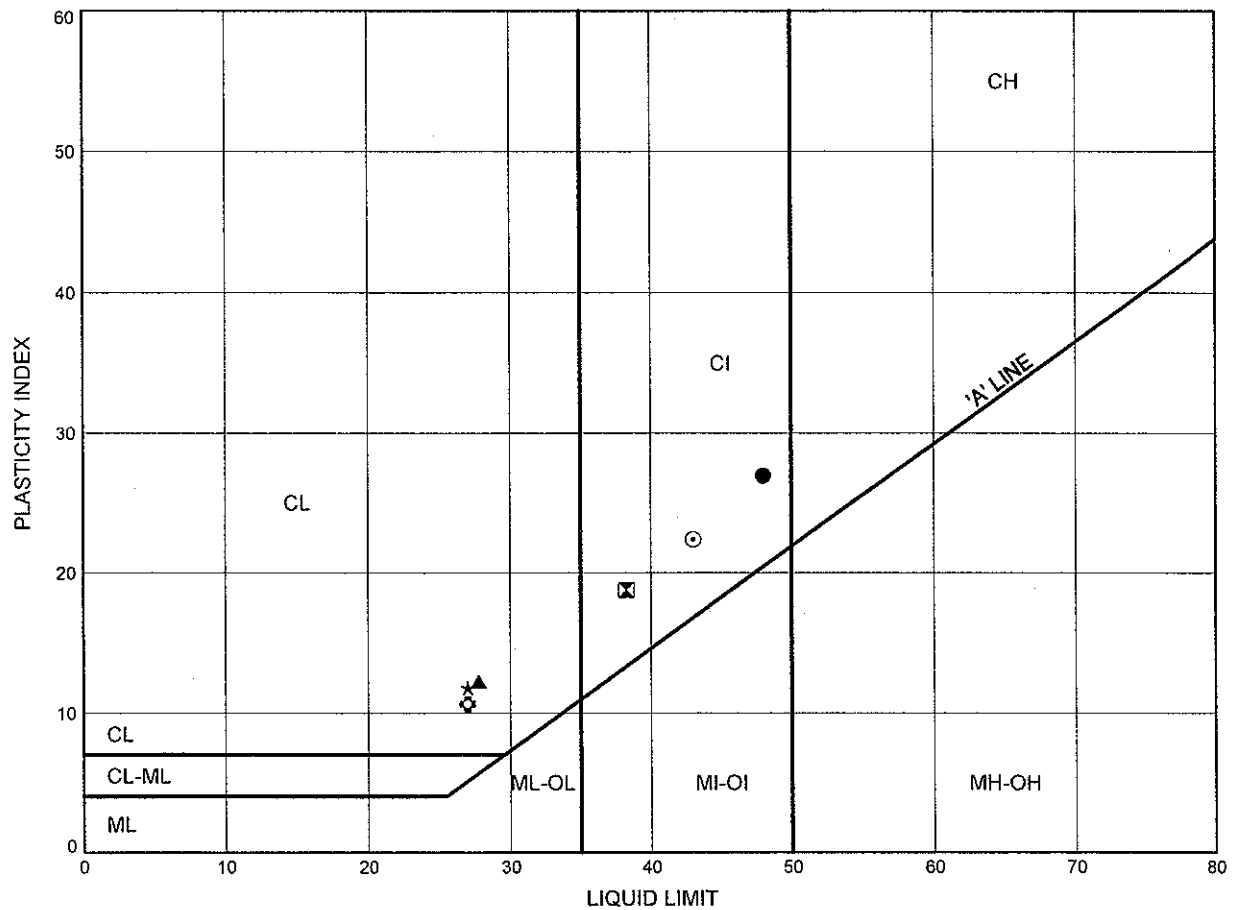
Prep'd DB

Chkd. MP

ATTERBERG LIMITS TEST RESULTS

FIGURE B10

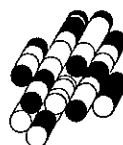
SILTY CLAY



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	NBL 12+695Lt	1.7	181.2
⊠	NBL 12+695Lt	3.2	179.7
▲	NBL 12+695Lt	6.3	176.6
★	NBL 12+695Lt	9.3	173.6
⊙	NBL 12+750Rt	1.7	181.1
⊛	NBL 12+750Rt	4.7	178.1

Date May 2010

Project 1-09-4135



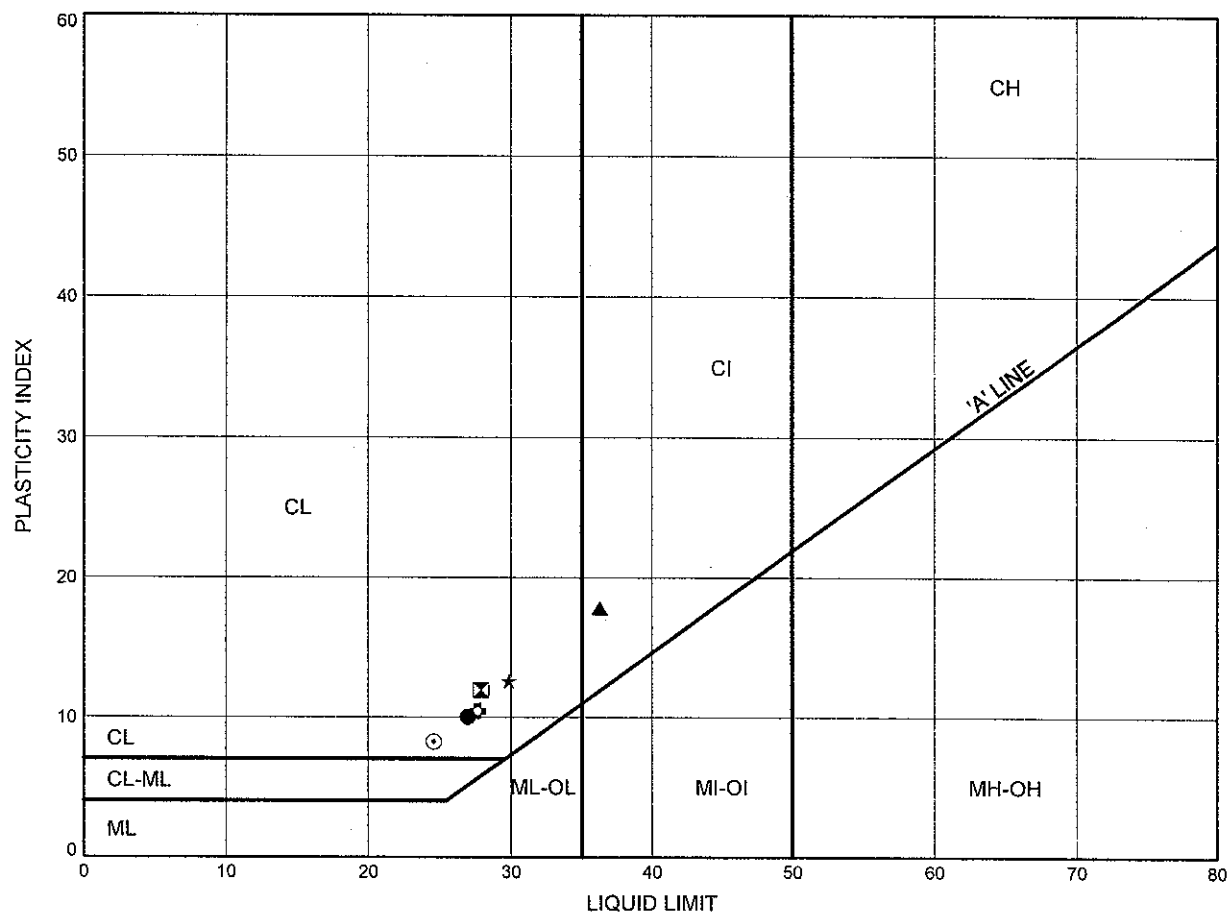
Prep'd DB

Chkd. MP

ATTERBERG LIMITS TEST RESULTS

FIGURE B11

SILTY CLAY

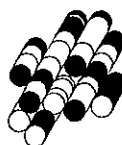


SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	NBL 12+750Rt	9.3	173.5
⊠	NBL 12+750Rt	12.4	170.4
▲	WN1	3.2	179.9
★	WN1	6.3	176.8
⊙	WN1	7.8	175.3
⊛	WN1	10.9	172.2

ALTR 1-09-4135 WN BRIDGE.GPJ 05/28/10

Date May 2010

Project 1-09-4135



Prep'd DB

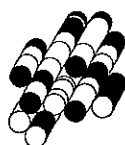
Chkd. MP

FIGURE B12

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	WN1	13.9	169.2
⊗	WN2	1.0	180.6
▲	WN2	4.0	177.6
★	WN2	6.3	175.3
⊙	WN2	10.9	170.7
⊕	WN3	7.8	174.3

Prep'dDB.....

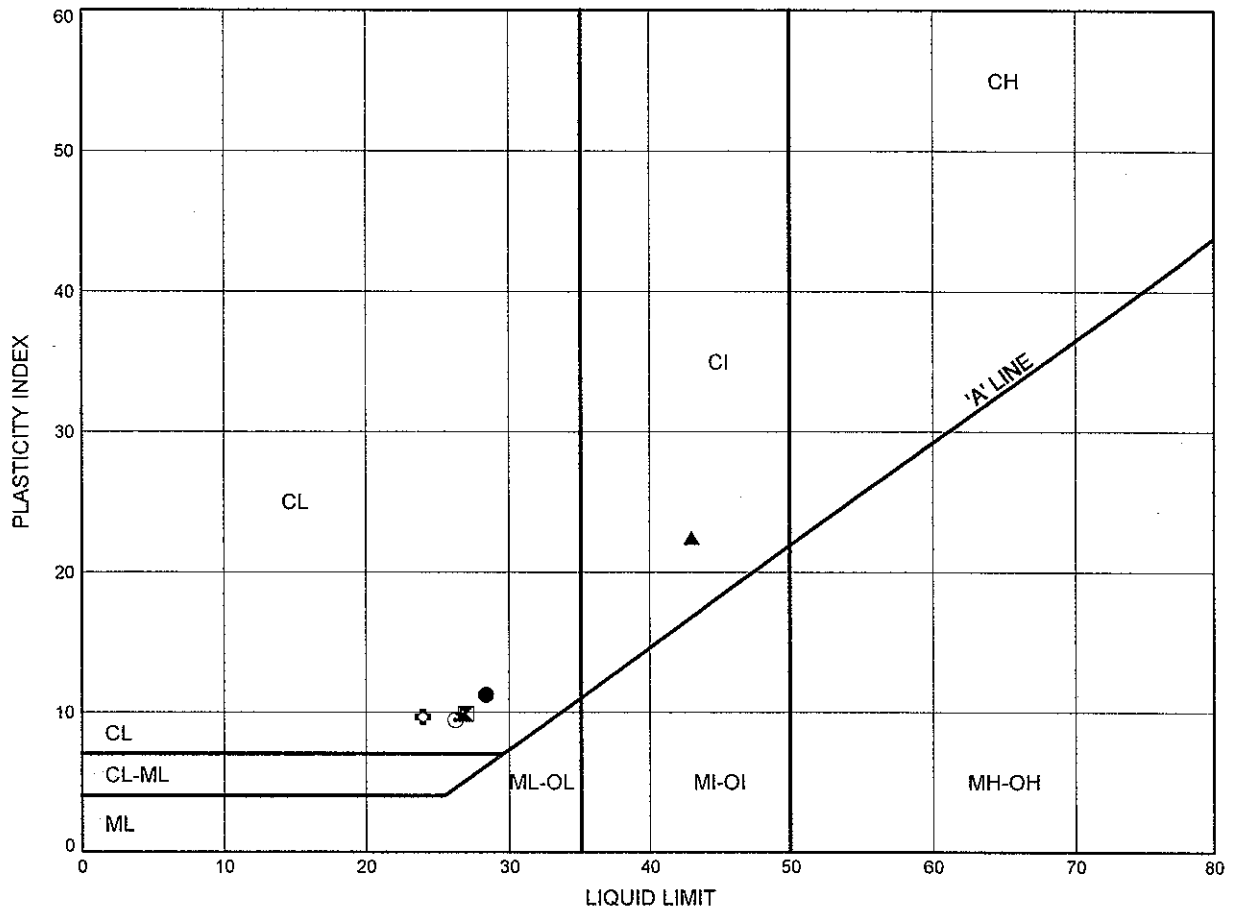
Chkd.MP.....



ATTERBERG LIMITS TEST RESULTS

FIGURE B13

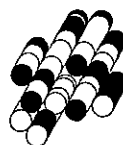
SILTY CLAY



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	WN3	9.3	172.8
⊠	WN3	12.4	169.7
▲	WN4	5.5	177.0
★	WN4	9.3	173.2
⊙	WN4	10.9	171.6
⊛	WN4	13.9	168.6

Date May 2010

Project 1-09-4135



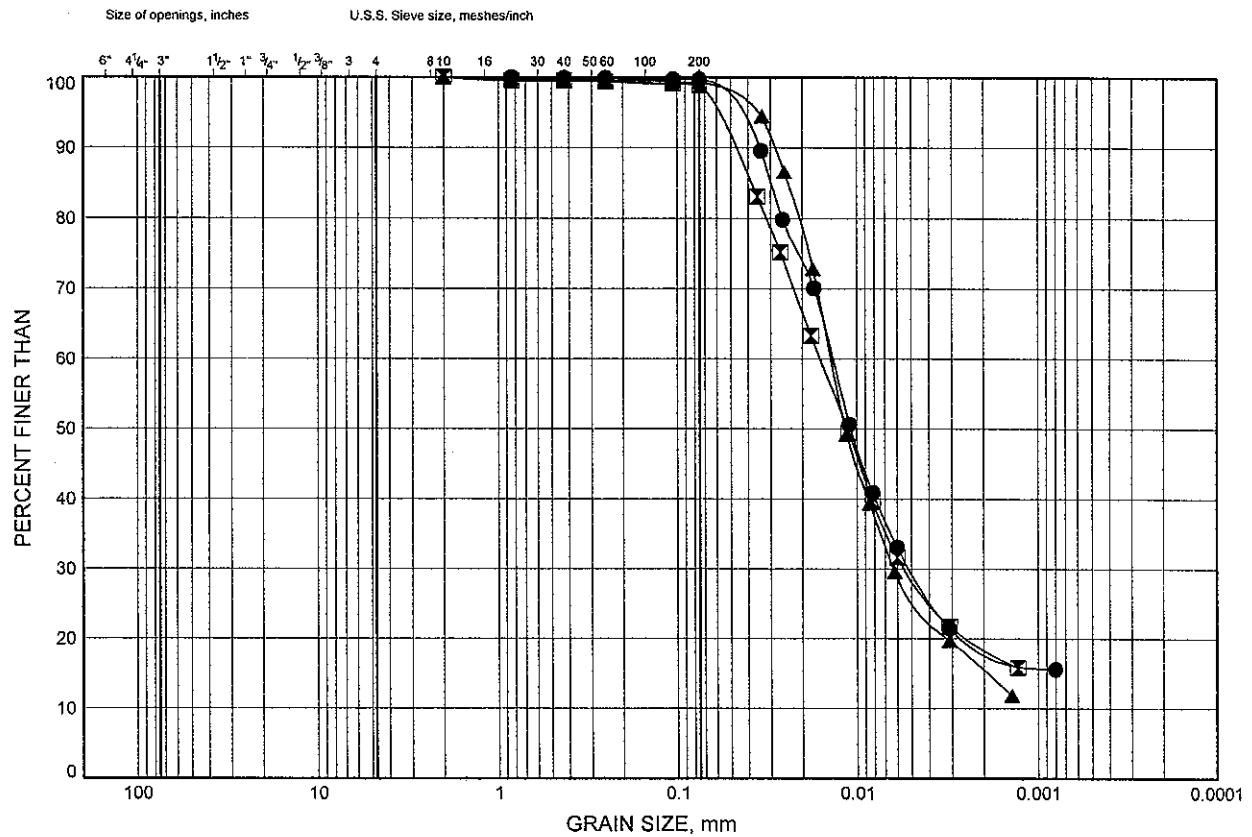
Prep'd DB

Chkd. MP

GRAIN SIZE DISTRIBUTION

FIGURE B14

SILT



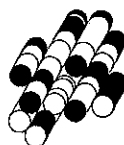
COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT and CLAY
	GRAVEL		SAND			FINE GRAINED

SYMBOL BOREHOLE DEPTH (m) ELEVATION (m)

●	WN1	4.7	178.4
⊠	WN2	2.5	179.1
▲	WN3	4.0	178.1

Date May 2010

Project 1-09-4135



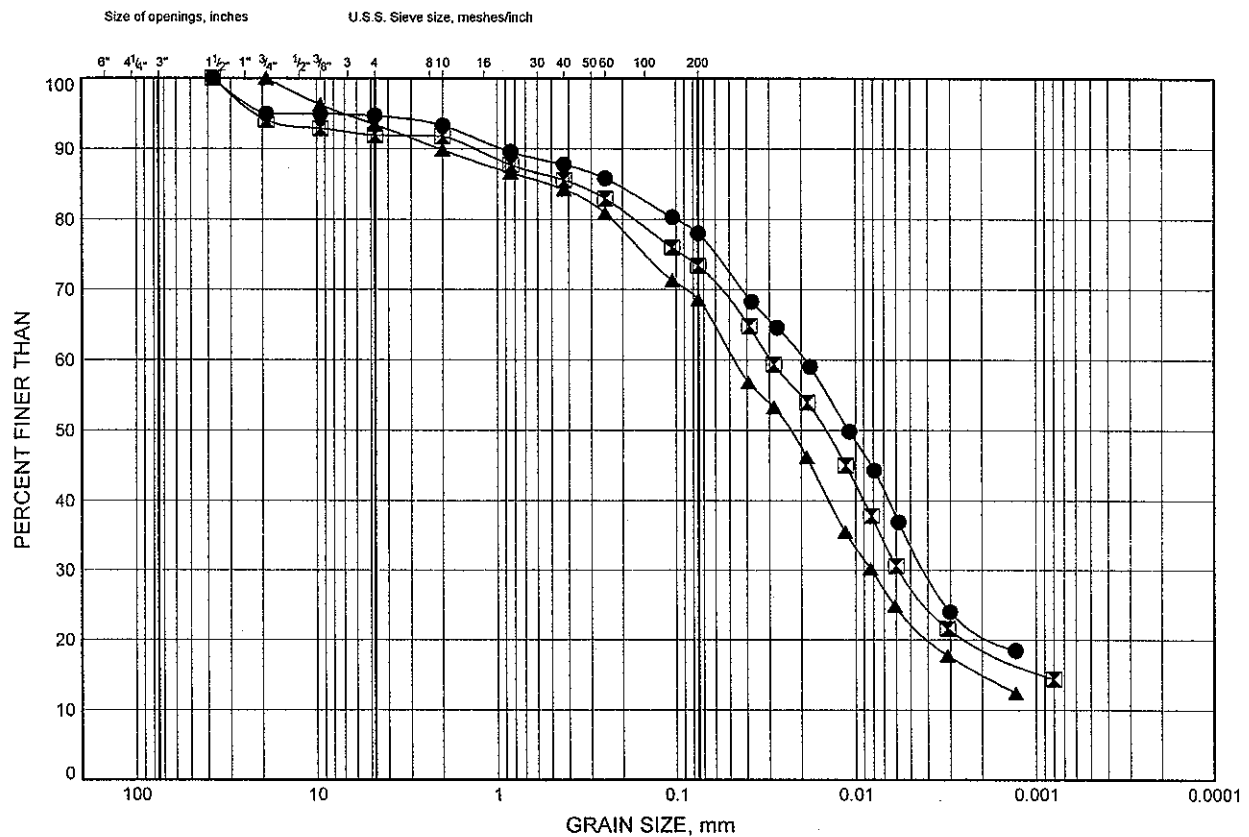
Prep'd DB

Chkd. MP

GRAIN SIZE DISTRIBUTION

FIGURE B15

SILTY CLAY TO CLAYEY SILT TILL

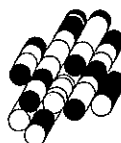


COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT and CLAY
	GRAVEL		SAND			FINE GRAINED

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	WN1	15.4	167.7
⊠	WN2	13.9	167.7
▲	WN3	15.4	166.7

Date May 2010

Project 1-09-4135



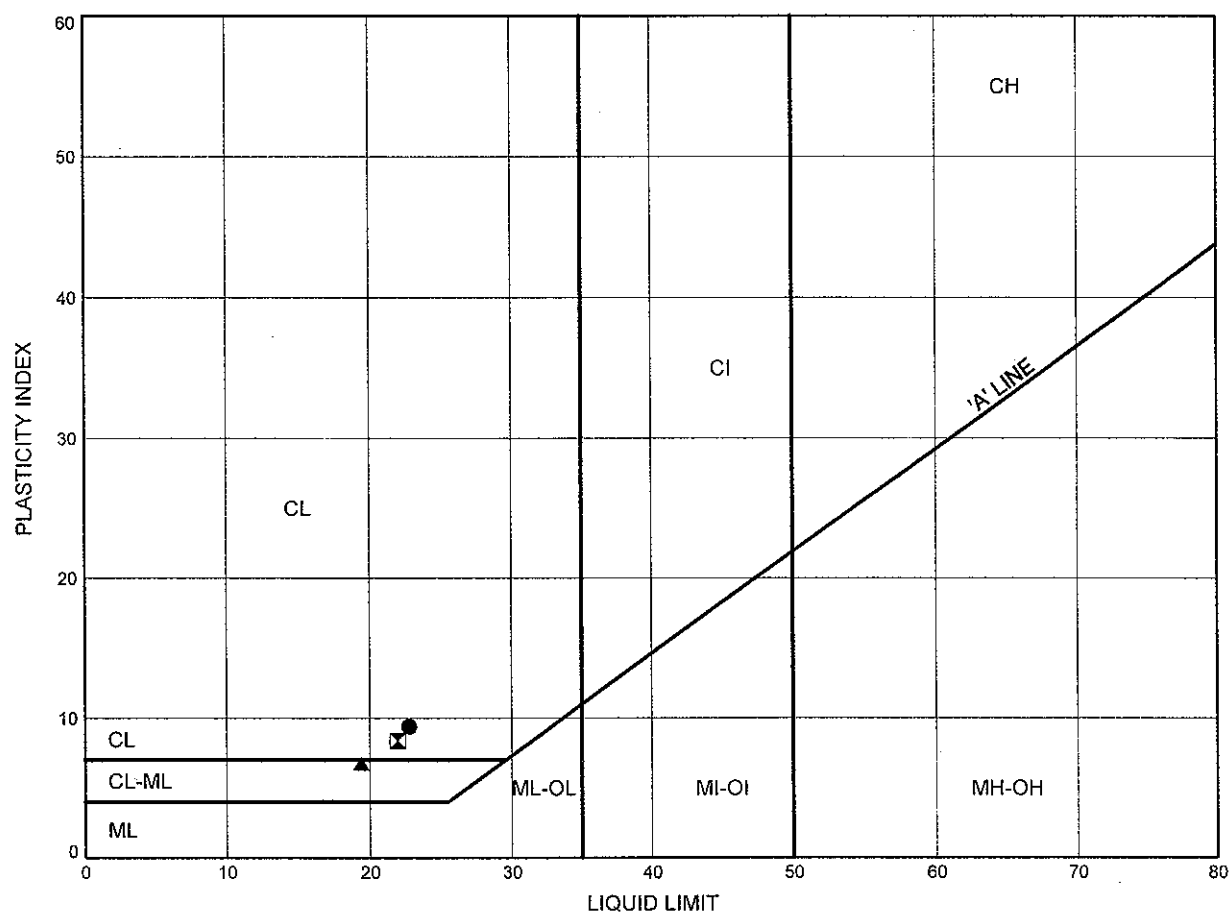
Prep'd DB

Chkd. MP

ATTERBERG LIMITS TEST RESULTS

FIGURE B16

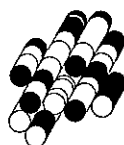
SILTY CLAY TO CLAYEY SILT TILL



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	WN1	15.4	167.7
⊠	WN2	13.9	167.7
▲	WN3	15.4	166.7

Date May 2010

Project 1-09-4135



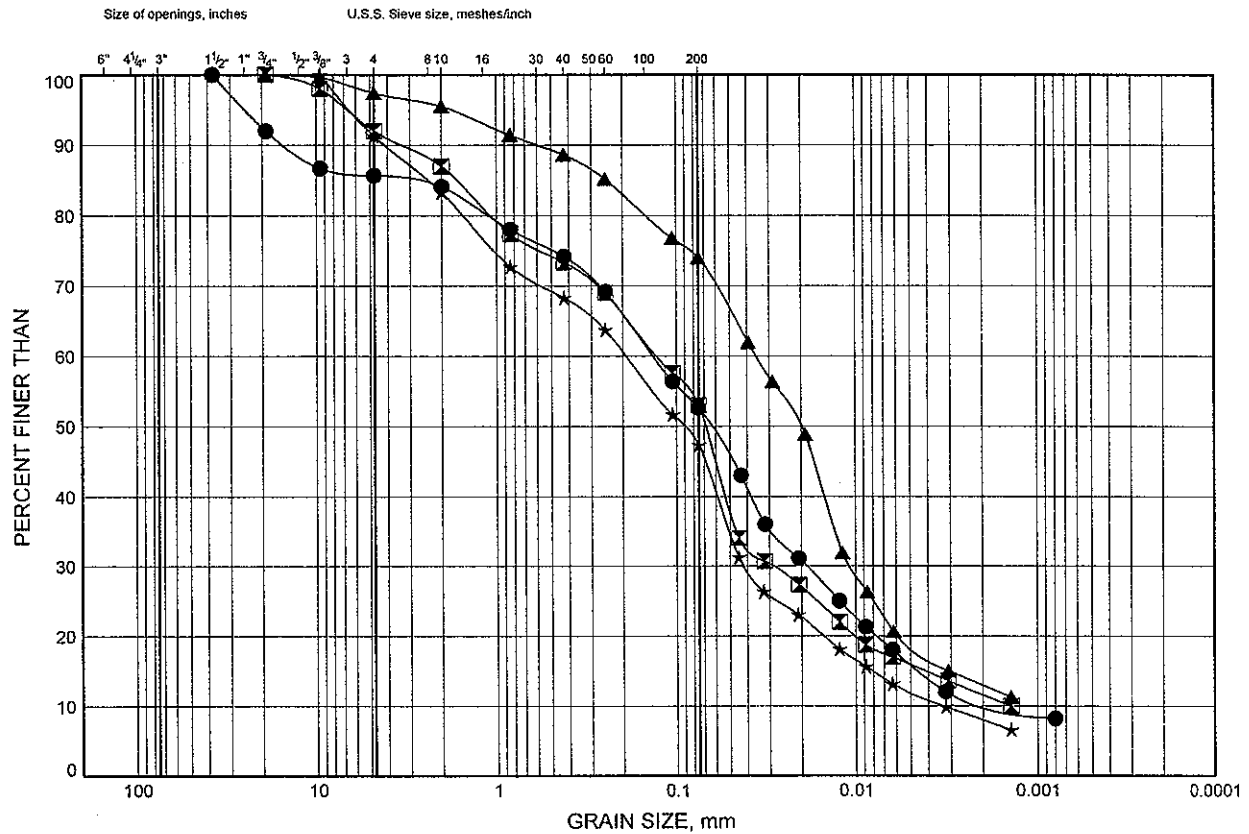
Prep'd DB

Chkd. MP

GRAIN SIZE DISTRIBUTION

FIGURE B17

SILTY SAND TO SANDY SILT TILL

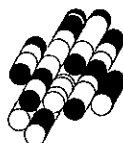


COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT and CLAY
	GRAVEL		SAND			FINE GRAINED

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	WN1	18.5	164.6
⊠	WN1	24.6	158.5
▲	WN2	17.0	164.6
★	WN2	20.0	161.6

Date May 2010

Project 1-09-4135



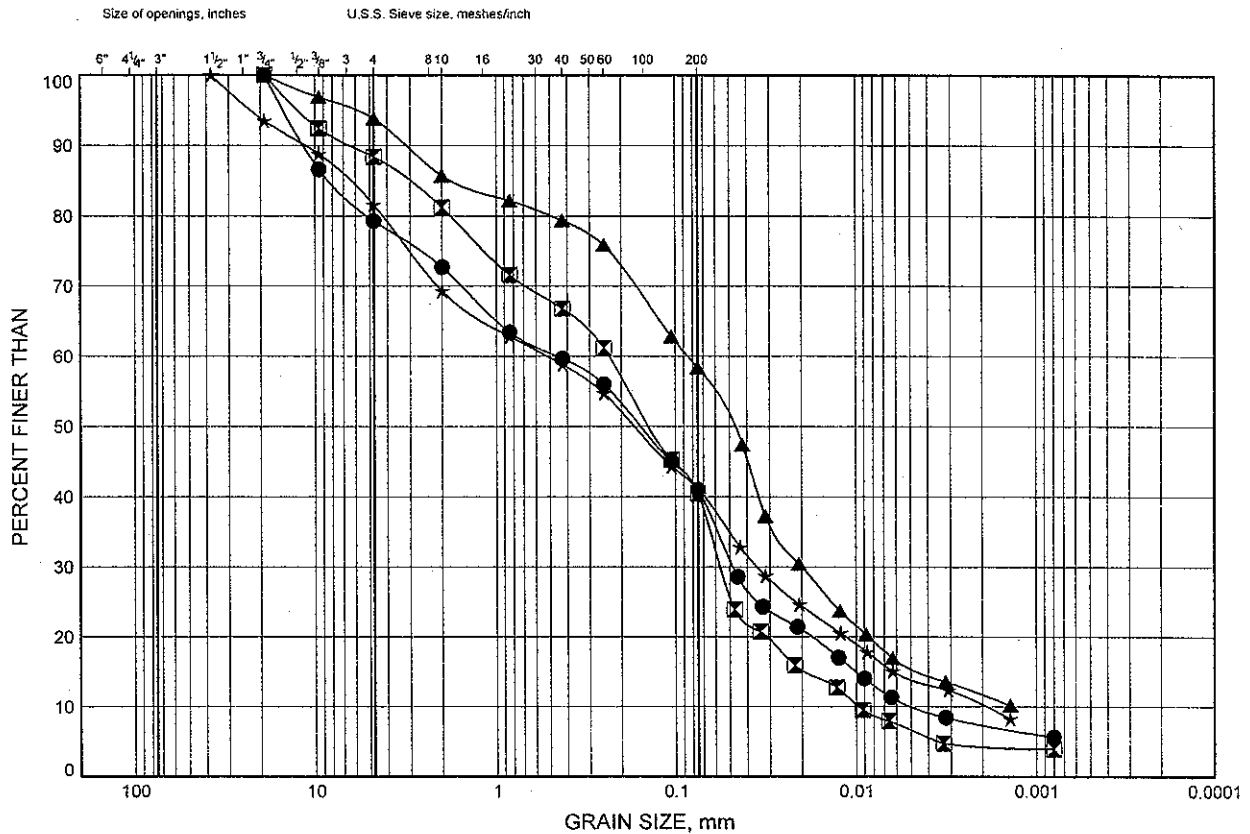
Prep'd DB

Chkd. MP

GRAIN SIZE DISTRIBUTION

FIGURE B18

SANDY SILT TO SILTY SAND TILL



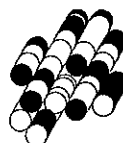
COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT and CLAY
	GRAVEL		SAND			FINE GRAINED

SYMBOL BOREHOLE DEPTH (m) ELEVATION (m)

●	WN2	21.5	160.1
⊠	WN3	18.5	163.6
▲	WN4	18.5	164.0
★	WN4	23.1	159.4

Date May 2010

Project 1-09-4135



Prep'd DB

Chkd. MP

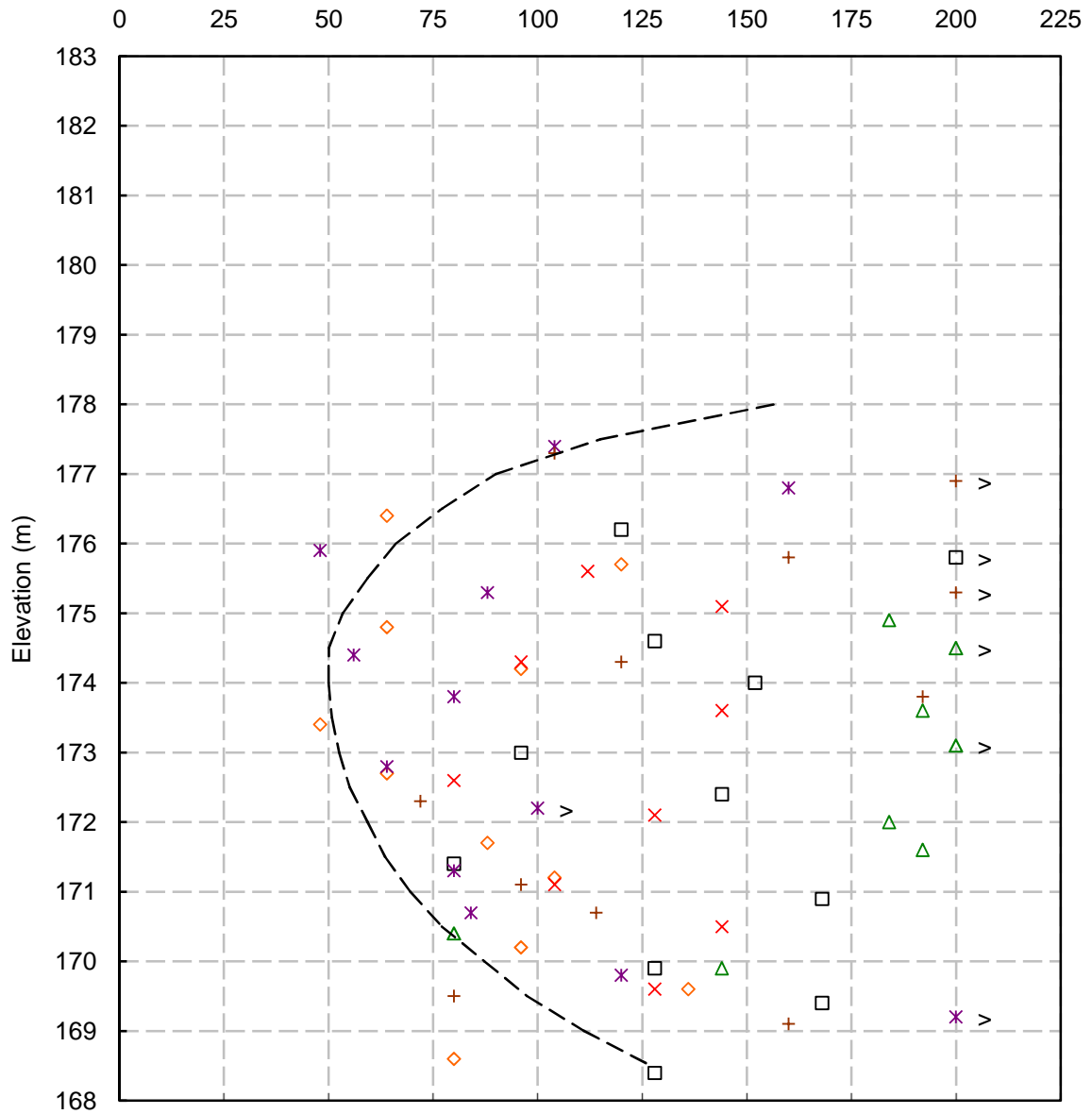
CORRECTED UNDRAINED SHEAR STRENGTH

FIGURE B19

HWY 406 TWINNING - WOODLAWN OVERPASS (NBL)

Silty Clay

Corrected Cu (kPa)



□ WN1

◇ WN2

△ WN3

× WN4

× NBL 12+695 LT

+ NBL 12+750 RT

Field Shear Vane Correction

Morris & Williams (1994)

$(\mu = 1.18 \text{ EXP}(-0.08 I_p) + 0.57)$

Applied Correction Factors

0.84 (Elev.>178m)

1.00 (Elev.<178m)

Project No. : 1-09-4135

Date : September, 2010



Terraprobe Inc.

Prepared By : HW

Checked By : RA

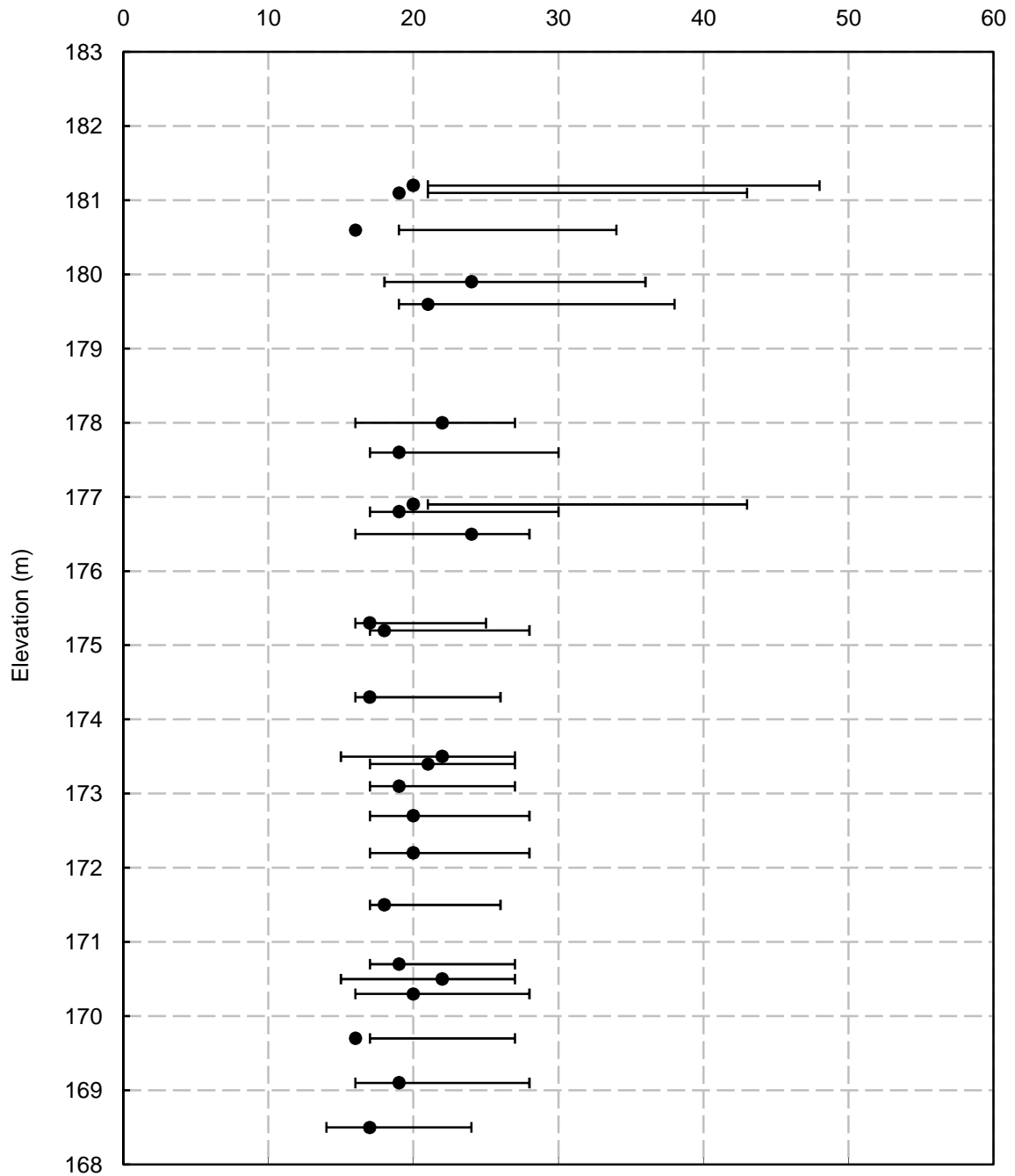
ATTERBERG LIMITS AND WATER CONTENTS

FIGURE B20

HWY 406 TWINNING - WOODLAWN OVERPASS (NBL)

Silty Clay

Atterberg Limits & Water Contents (%)



Project No. : 1-09-4135

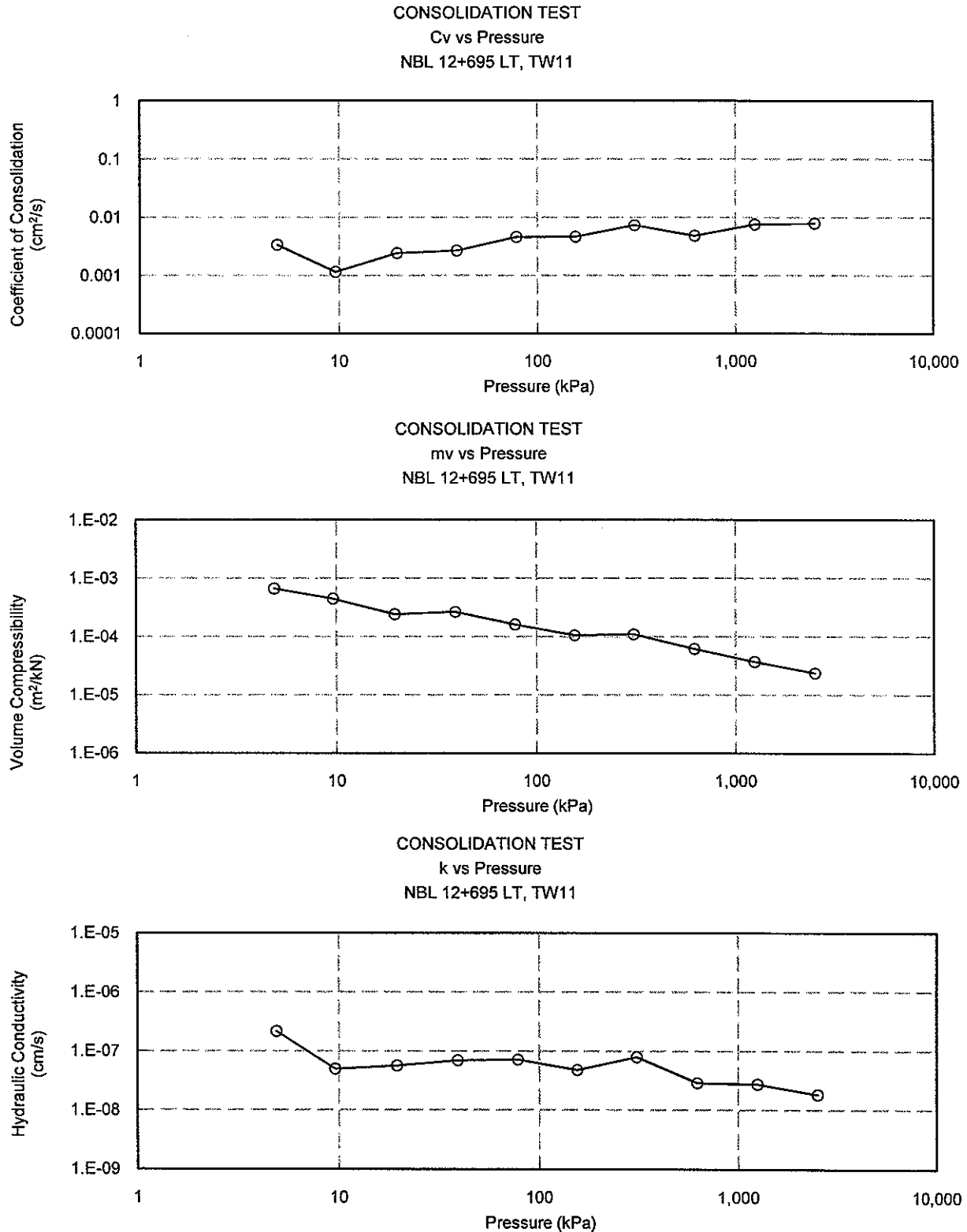
Date : September, 2010



Terraprobe Inc.

Prepared By : HW

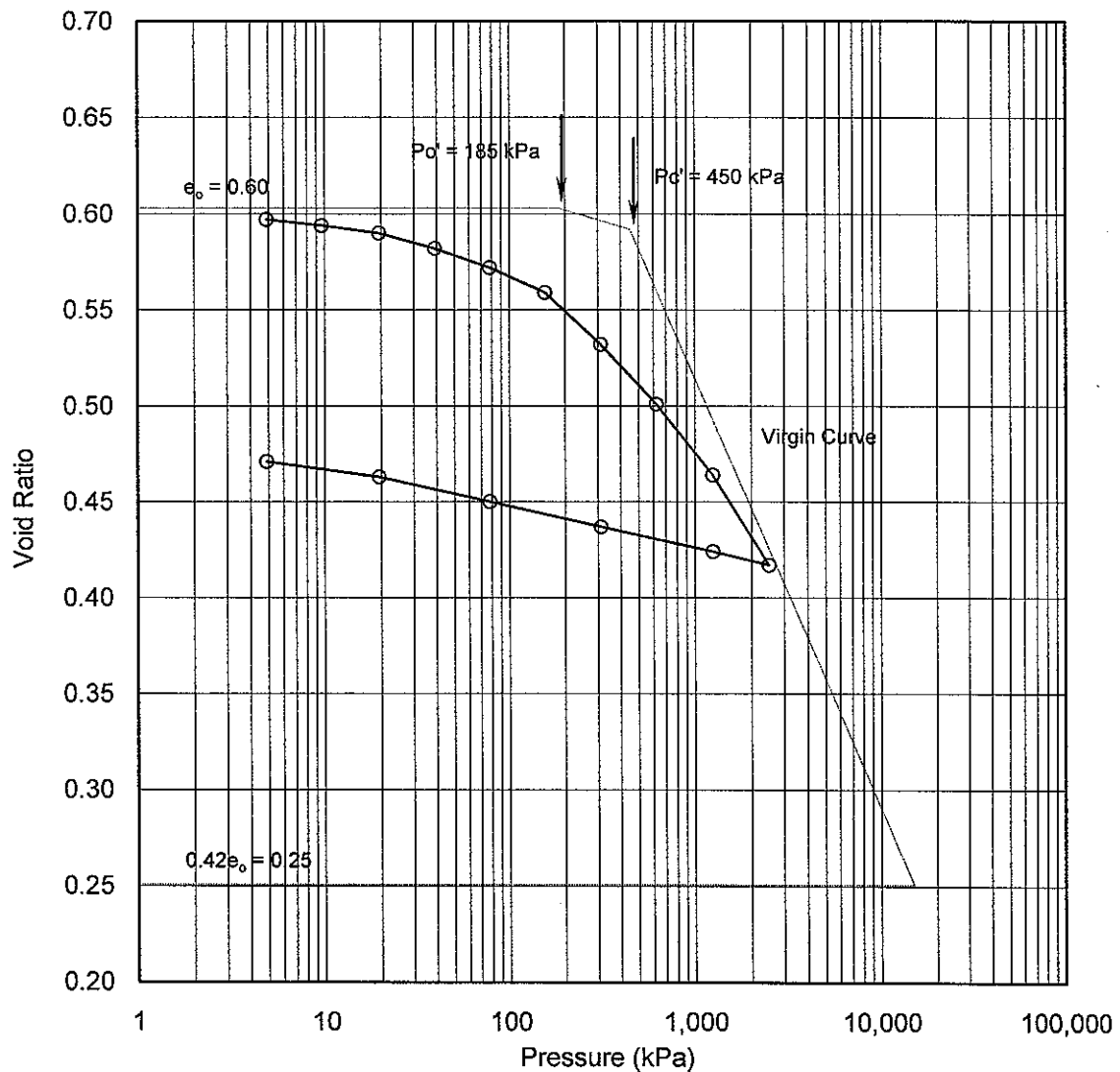
Checked By : RA



CONSOLIDATION TEST

e vs Pressure

NBL 12+695 LT, TW11



Soil Type : Silty Clay

e _o =	0.60	ω _L =	25%	P _{o'} =	185 kPa
ω =	22%	ω _p =	15%	P _{c'} =	450 kPa
γ =	20.6 kN/m ³	PI =	10%	C _c =	0.224
G _s =	2.76			Cr =	0.028

Project No. : 1-09-4135
 Date : September 2010



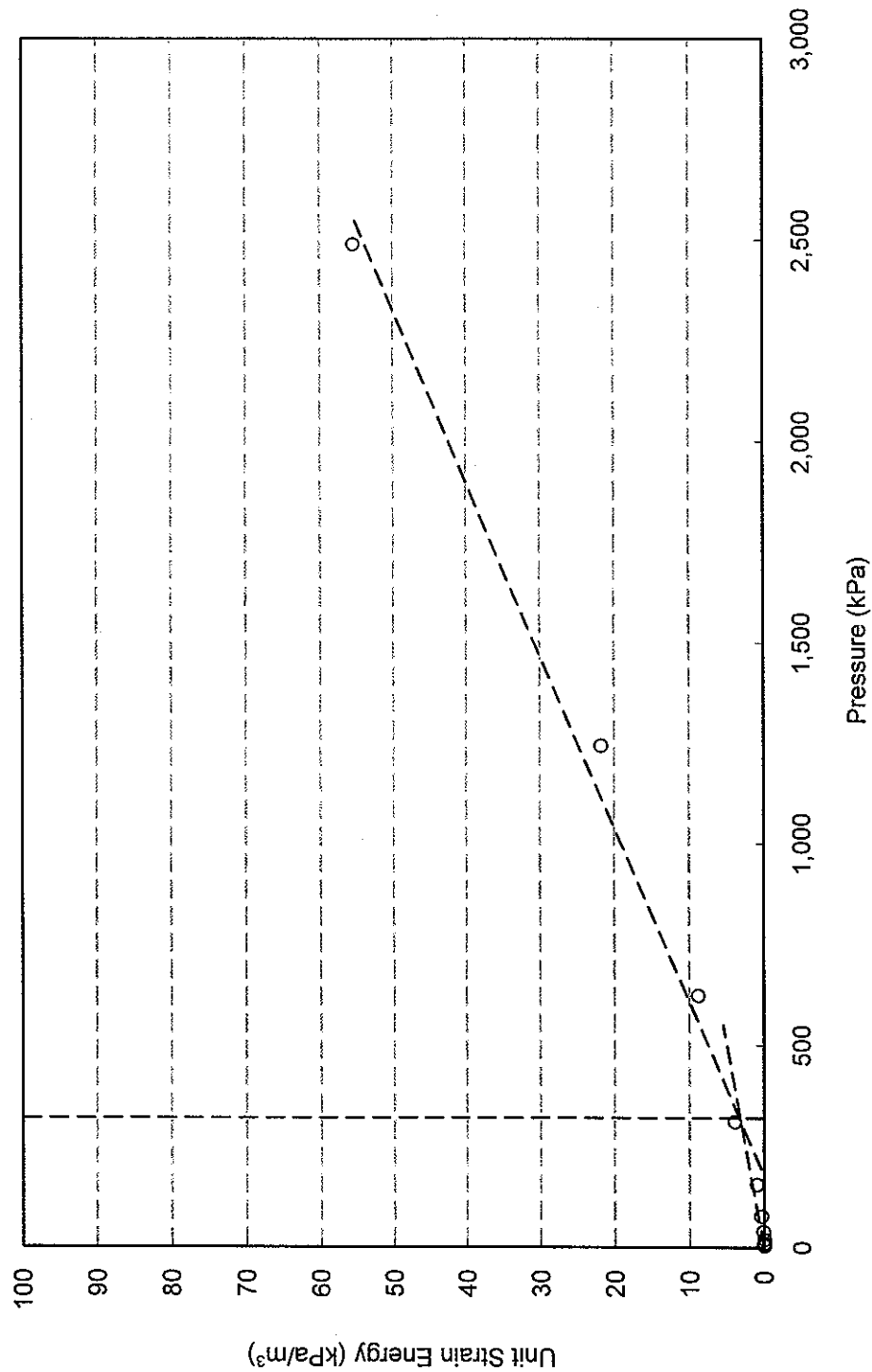
Terraprobe Inc.

Prepared By : HW
 Checked By : RA

HWY 406 TWINNING - WOODLAWN OVERPASS (NBL)

FIGURE B23

CONSOLIDATION TEST Unit Strain Energy vs Pressure NBL 12+695 LT, TW'11



Project No. : 1-09-4135

Date : September 2010



Terraprobe Inc.

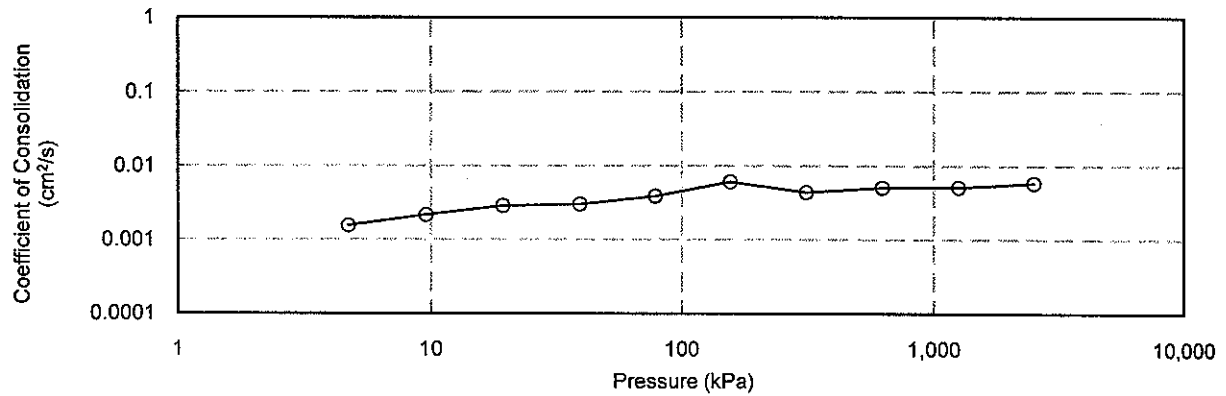
Prepared By : HW

Checked By : RA

CONSOLIDATION TEST

Cv vs Pressure

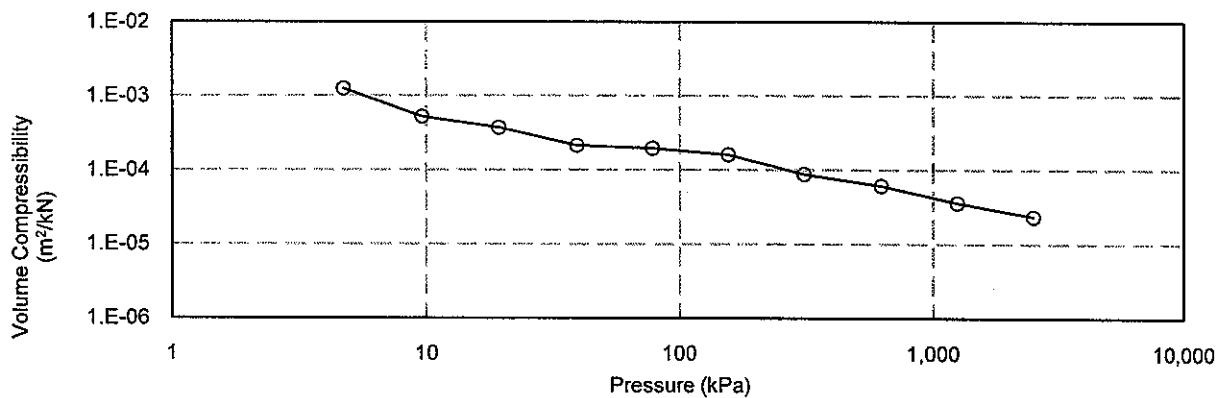
NBL 12+750 RT, TW9



CONSOLIDATION TEST

mv vs Pressure

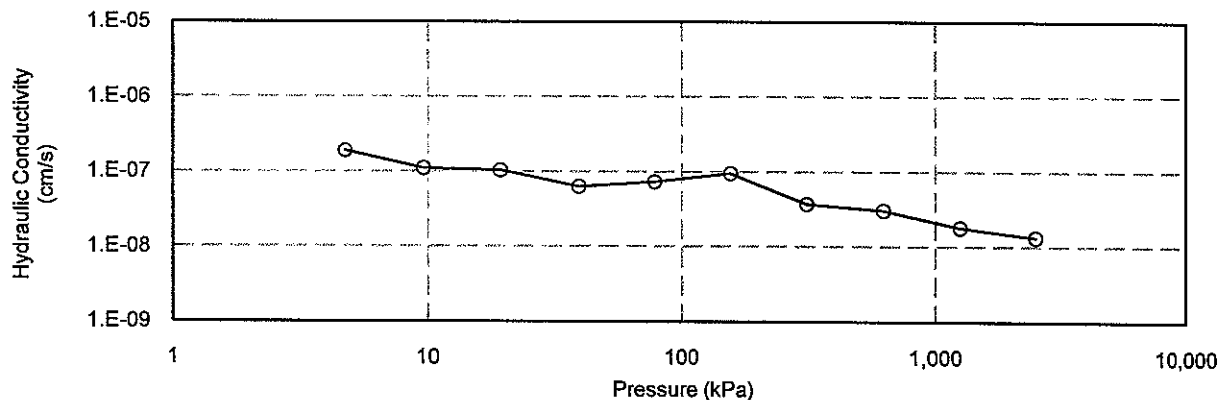
NBL 12+750 RT, TW9



CONSOLIDATION TEST

k vs Pressure

NBL 12+750 RT, TW9



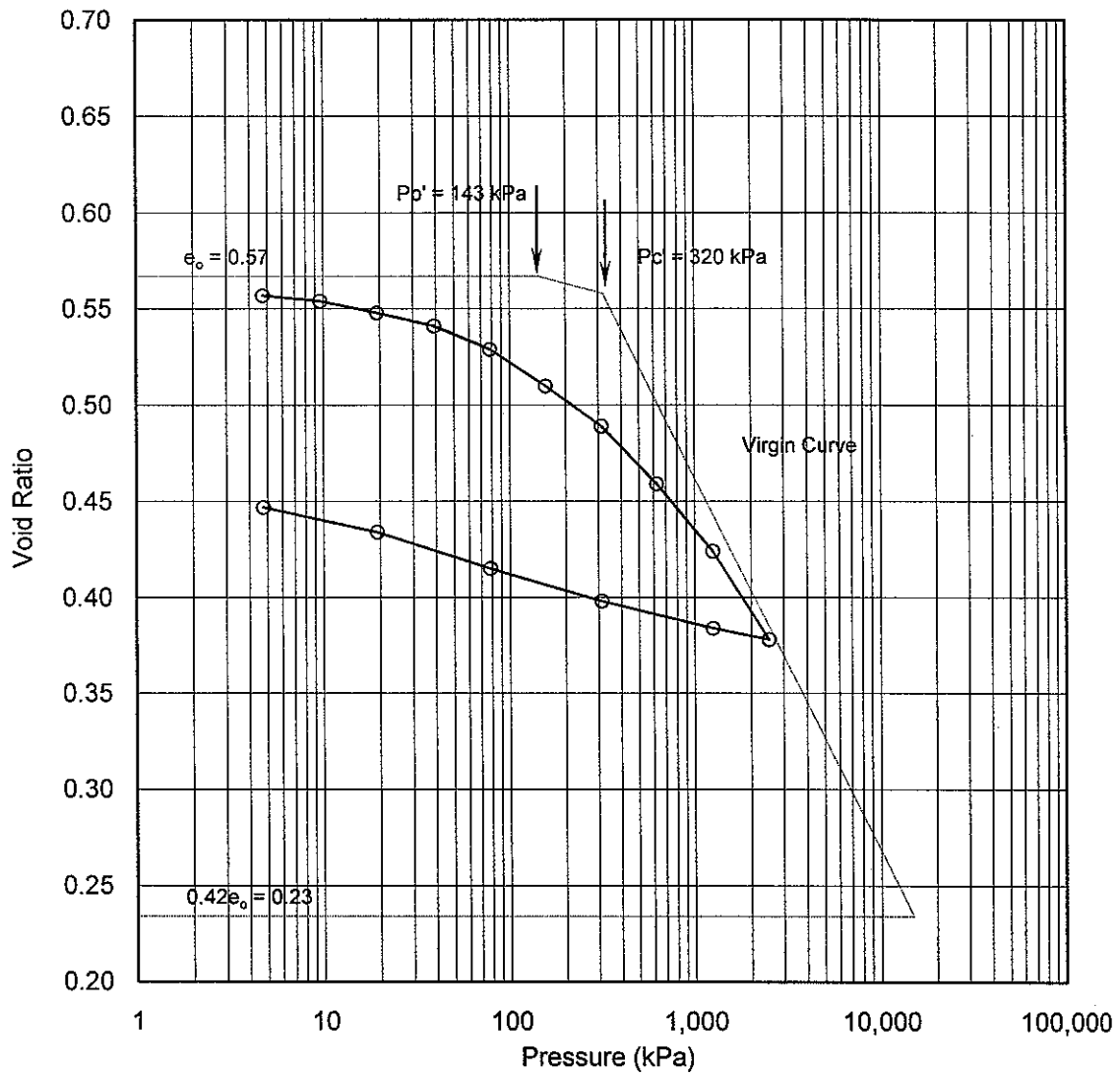
Project No. : 1-09-4135
Date : September 2010



Terraprobe Inc.

Prepared By : HW
Checked By : RA

CONSOLIDATION TEST
e vs Pressure
NBL 12+750 RT, TW9



Soil Type : Silty Clay

$e_0 =$	0.57	$\omega_L =$	27%	$P_{o'} =$	143 kPa
$\omega =$	21%	$\omega_P =$	17%	$P_{c'} =$	320 kPa
$\gamma =$	20.8 kN/m ³	PI =	10%	Cc =	0.194
Gs =	2.74			Cr =	0.026

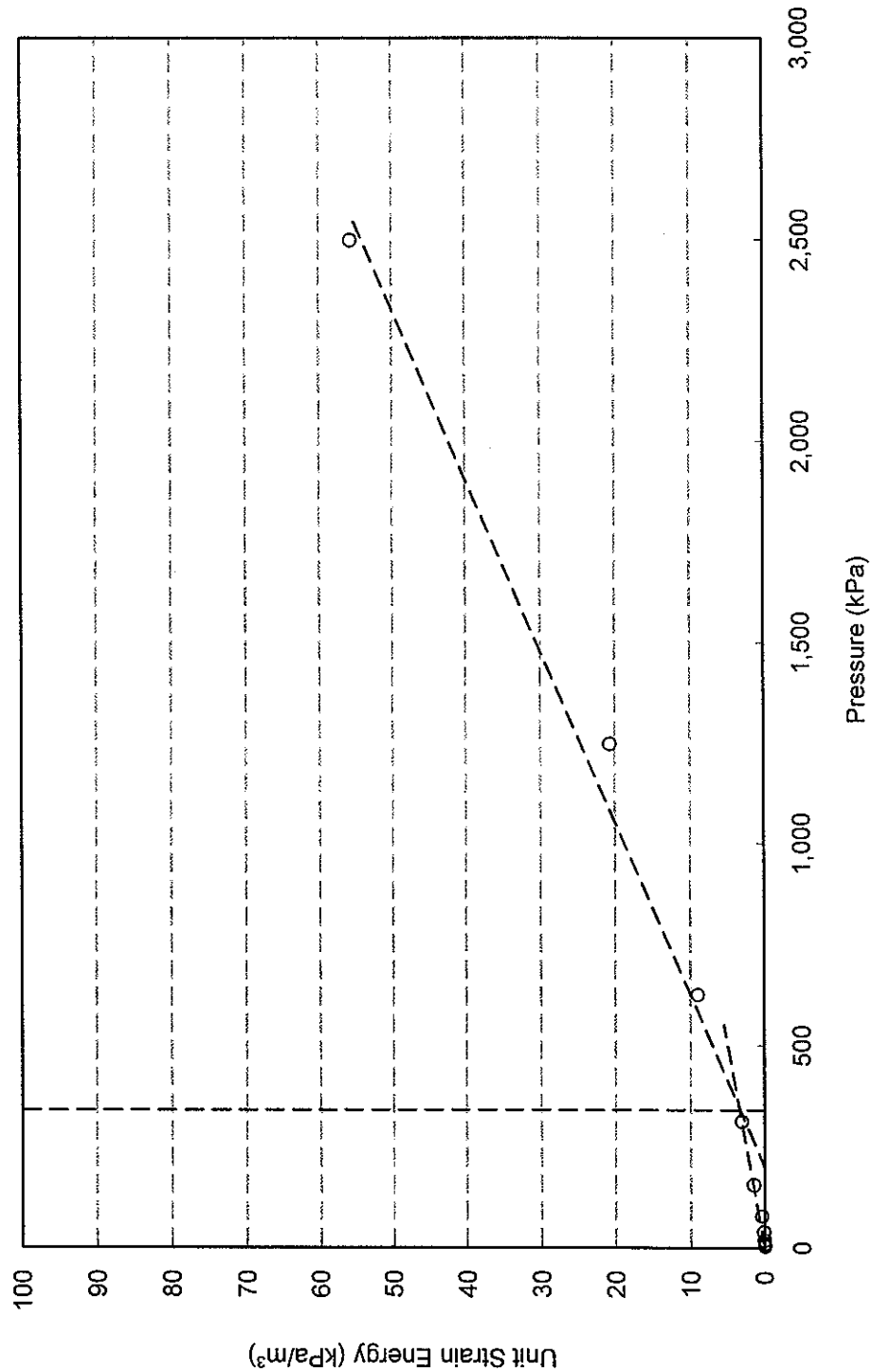
Project No. : 1-09-4135
Date : September 2010



Terraprobe Inc.

Prepared By : HW
Checked By : RA

CONSOLIDATION TEST
Unit Strain Energy vs Pressure
NBL 12+750 RT, TW9



Project No. : 1-09-4135

Date : September 2010



Terraprobe Inc.

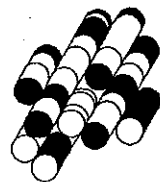
Prepared By : HW

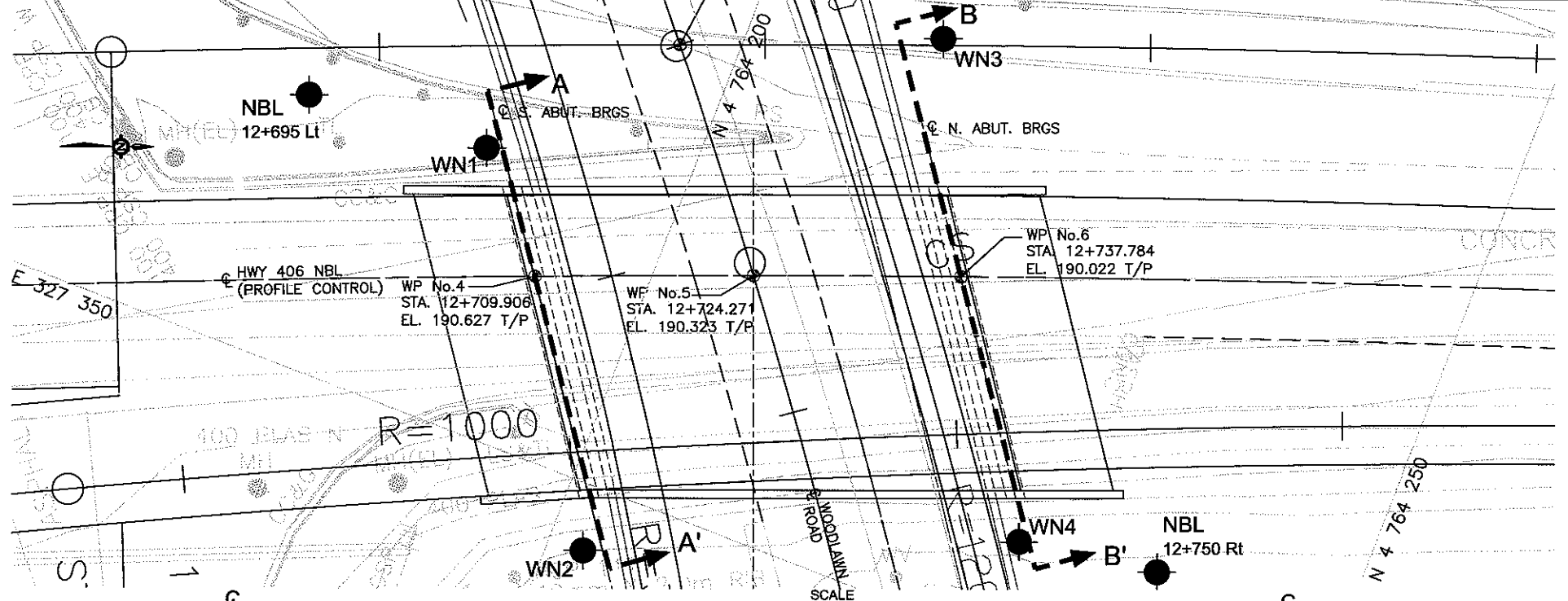
Checked By : RA

APPENDIX C

**Drawings titled “Borehole
Locations and Soil Strata”**

Terraprobe Inc.



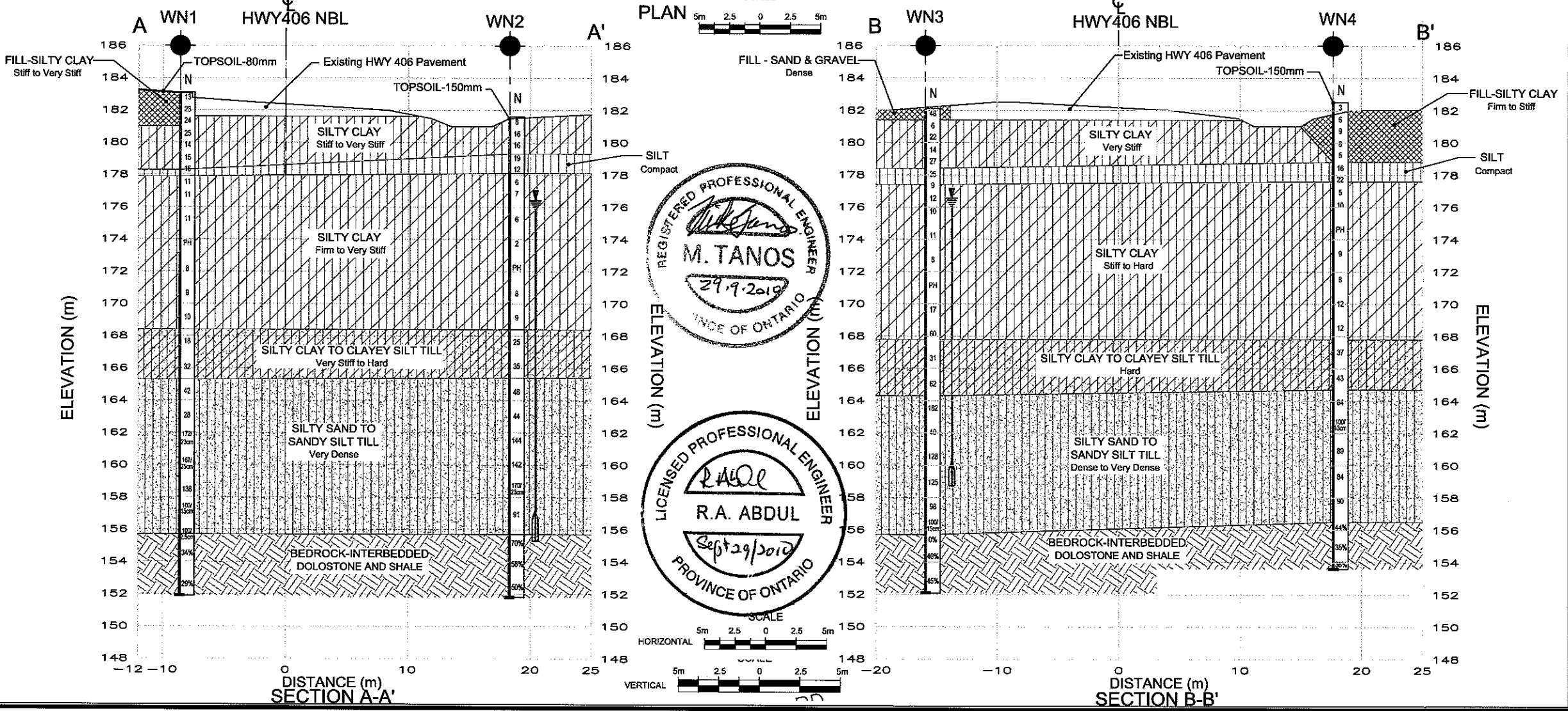


METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETERS
UNLESS OTHERWISE SHOWN

CONT No		SHEET 1 OF
WP No 280-99-00		
HIGHWAY 406 HIGHWAY 406 NBL WOODLAWN ROAD OVERPASS BOREHOLE LOCATIONS AND SOIL STRATA		
Giffels Associates Limited Consulting Engineers and Architects An IBI Group Company		



KEY PLAN



- LEGEND**
- Bore Hole
 - ⊕ Dynamic Cone Penetration Test
 - ⊕ Bore Hole And Cone
 - 'N' Blows/0.3m (Std Pen Test, 475 J/blow)
 - CONE Blows/0.3m (60° Cone, 475 J/blow)
 - ≡ WL at Time of Investigation
 - ≡ WL in Piezometer (MAY 2010)
 - ⊕ Piezometer
 - 90% Rock Quality Designation
 - A/R Auger Refusal

No	ELEV.	COORDINATES	
		NORTHING	EASTING
WN1	183.1	4 764 187.0	327 332.0
WN2	181.6	4 764 202.3	327 354.1
WN3	182.1	4 764 212.0	327 314.7
WN4	182.5	4 764 228.4	327 343.4
NBL 12+695Lt	182.9	4 764 175.1	327 333.0
NBL 12+750Rt	182.8	4 764 237.5	327 341.9

NOTE
The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.
This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

REVISIONS	DATE	BY	DESCRIPTION
DESIGN R.A.	CODE CHBDC2006	LOAD	DATE SEPT. 2010
DRAWN K.C.	CHK R.A.	STRUCT 34-463/1	GEORGES 30M3-259