# Terraprobe

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

**FOUNDATION INVESTIGATION REPORT**

**WOODLAWN ROAD OVERPASS, HIGHWAY 406 SBL**

**HIGHWAY 406 TWINNING**

**PORT ROBINSON ROAD TO EAST MAIN STREET**

**AGREEMENT No. 2008-E-0016, W.P. 280-99-00, SITE: 34-463/2**

**GEOCRES NO. 30M3-260**

**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 |

## TABLE OF CONTENTS

### Part 1



### Appendices

**FOUNDATION INVESTIGATION REPORT**
**WOODLAWN ROAD OVERPASS, HIGHWAY 406 SBL**
**HIGHWAY 406 TWINNING**
**ONTARIO**
**AGREEMENT No. 2008-E-0016, W.P. 280-99-00, SITE: 34-463/2**
**GEOCRES NO. 30M3-260**

## 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 SBL 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 basins[1].

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 Age[2]. 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 10, 2009 and April 29, 2010 and consisted of drilling and sampling six boreholes to depths ranging from 11.3 m to 32.2 m. The boreholes were numbered SBL 12+685CL, SBL 12+750CL, WS1, WS2, WS3 and WS4 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. 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 |
| SBL 12+685CL | 10.7/172.0 | Piezometer with 3.0 m slotted screen installed with filter sand to 7.0 m, bentonite seal from 7.0 m to 6.4 m, drill cuttings from 6.4 m to 0.3 m, bentonite seal from 0.3 m to 0.2 m and a flush mounted casing installation from 0.2 m to ground surface. |
| SBL 12+750CL | 10.5/172.4 | Piezometer with 3.0 m slotted screen installed with filter sand to 6.9 m, bentonite seal from 6.9 m to 6.6 m, drill cuttings from 6.6 m to 0.3 m and bentonite seal from 0.3 m to ground surface. |
| WS1 | 22.9/159.8 | Hole sealed to 22.9 m with bentonite, piezometer with 1.5 m slotted screen installed with filter sand to 20.4 m, bentonite seal from 20.4 m to ground surface. |
| WS4 | 24.4/158.3 | Hole sealed to 24.4 m with bentonite, piezometer with 1.5 m slotted screen installed with filter sand to 21.9 m, bentonite seal from 21.9 m to ground surface. |

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 topsoil and about 25.9 m to 27.5 m of overburden soils consisting of topsoil, fill material (sand and gravel and silty clay) and native deposits of silty clay, silt, silty clay till, sandy silt to sand and silt till, and clayey silt till. These soils are underlain by bedrock of the Salina Formation.

### 5.1 Topsoil

Topsoil ranging from 25 mm to 200 mm in thickness was encountered at this site. Topsoil thickness may vary between and beyond the boreholes.

### 5.2 Fill – Sand and Gravel

Borehole SBL 12+685CL was drilled on the gravel shoulder of the dedicated right turn lane that carries Highway 406 north bound traffic to Woodlawn Road. The sand and gravel fill is approximately 470 mm thick and extends to a depth of 0.5 m (Elev. 182.2 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, 42% sand, 13% silt and 4% clay size particles.

A Standard Penetration test in the sand and gravel fill gave an 'N' value of 11 blows for 0.3 m penetration indicating a compact relative density. The moisture content of a sample of this fill was 4% by weight.

### 5.3 Fill – Silty Clay

Silty clay fill material was encountered at this site extending to depths ranging from 0.7 m (Elev.182.2) to 2.9 m (Elev.180.1) below ground surface. Silty clay fill was not encountered in Boreholes SBL12+685CL and WS2.

Samples of this fill material were subjected to grain size analysis and the grain size distribution curves are illustrated in Figure B2. These results show a grain size distribution consisting of 0% gravel, 2-3% sand, 36% silt and 61-62% clay size particles.

Samples of the fill were also subjected to Atterberg Limits tests and the results are plotted on the plasticity chart, Figure B3. The index values from this test are summarized below:

| | |
|---|---|
| Liquid Limit: | 49-53% |
| Plastic Limit: | 23-24% |
| Plasticity Index: | 26-29% |
| Natural Moisture Content: | 18-22% |

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

Standard Penetration tests in the silty clay fill gave 'N' values that ranged from 7 to 43 blows for 0.3 m penetration but generally, the recorded 'N' values ranged from 17 to 43 blows for 0.3 m penetration. Based on these results the fill is considered to have a generally very stiff to hard consistency with occasional firm to stiff zones. The moisture content of samples of this fill ranged from 18% to 31% 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 of 14.7 m below ground surface or to elevations ranging from 168.4 m to 168.0 m. The approach boreholes were terminated in this deposit at depths of 11.3 m (Elev. 171.6 m) and 12.2 m (Elev. 170.5 m).

The grain size distribution plots of tested samples of the silty clay are presented in Figures B4 to B8 inclusive. These results show a grain size distribution consisting of 0-8% gravel, 0-6% sand, 37-83% silt and 12-58% clay size particles.

Samples of the silty clay were also subjected to Atterberg Limits tests and the results are illustrated on the plasticity charts, Figures B9 to B13 inclusive. The index values from these tests are summarized below:

| | |
|---|---|
| Liquid Limit: | 25-47% |
| Plastic Limit: | 15-23% |
| Plasticity Index: | 9-24% |
| 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 7 to 61 blows for 0.3 m penetration but generally the recorded 'N' values ranged from 15 to 46 blows for 0.3 m penetration. Field vane tests gave in-situ undrained shear strengths ranging from 64 kPa to in excess of 100 kPa. An unconfined compression test gave an undrained shear strength of 77 kPa and laboratory vane tests on relatively undisturbed Shelby tube samples gave undrained shear strengths ranging from 49 kPa to 126 kPa. These values indicate that the consistency of the silty clay is generally stiff to hard with infrequent firm zones. The moisture content of samples of the silty clay range from 12% to 27% by weight and the unit weight of selected samples ranged from 20.7 to 21.1 $kN/m^3$.

The variation of undrained shear strength with elevation is depicted in Figure B20. 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. 176.0 m is estimated to have relatively high undrained shear strength i.e. in excess of 125 kPa. Below Elev. 176.0 m the undrained shear strength decreases with depth and is about 50 kPa at Elev. 172.0 m. Below Elev. 172.0 m the trend indicates increasing undrained shear strength with depth.

The Atterberg Limits tests results are also plotted against elevation, Figure B21. These results illustrate that the natural moisture contents are generally at or below the plastic limit up to Elev. 177.0 m. Below Elev. 177.0 m the moisture content is generally slightly above the plastic limit.

Consolidation tests were also performed on Shelby tube samples retrieved from Boreholes SBL 12+685CL and SBL 12+750CL and the results are presented in Figures B22 to B27 inclusive. These results indicate estimated preconsolidation pressures ranging between 370 kPa and 550 kPa.

### 5.5 Silt

A native discontinuous silt deposit was encountered at this site in Boreholes WS1, WS2 and WS4. The deposit is approximately 0.9 m to 1.5 m thick and extends to depths of 5.9 m below ground surface or to elevations ranging from 177.2 m to 176.8 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 curves of tested samples of the silt deposit are presented in Figure B14. These results show a grain size distribution consisting of 0-1% gravel, 1-2% sand, 75-79% silt and 20-22% clay size particles.

The deposit is considered to have a dense to very dense relative density based on SPT 'N' values that ranged from 36 to 64 blows for 0.3 m penetration. The moisture content of samples from this deposit ranged from 16% to 22% by weight.

### 5.6 Silty Clay Till

A deposit of silty clay till was encountered across the site extending to depths ranging from 18.0 m to 18.7 m below ground surface or to elevations ranging from 165.1 m to 164.0 m.

The grain size distribution curves of tested samples from this unit are depicted in Figure B15. These results show a grain size distribution consisting of 4-17% gravel, 17-24% sand, 48-55% silt and 17-18% 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: | 21-23% |
| Plastic Limit: | 14% |
| Plasticity Index: | 7-9% |
| Natural Moisture Content: | 10-13% |

These values are characteristic of clayey soils of low plasticity.

Standard Penetration tests in this deposit yielded 'N' values ranging from 40 to more than 100 blows per 0.3 m penetration. A field vane test was also attempted in this deposit and the results (no-turn on vane) indicate undrained shear strengths more than 100 kPa. Based on these results the silty clay till is considered to have a hard consistency. The moisture content of samples retrieved from this stratum varies from 7% to 16% by weight.

### 5.7 Sandy Silt to Sand and Silt Till

The site is underlain by discontinuous deposits of sandy silt till and a deposit of sand and silt till. These units extend to depths ranging from 25.9 m (Elev. 157.1 m) to 27.5 m (Elev. 155.2 m) below ground surface.

The grain size distribution plots of tested samples from these till deposits are depicted in Figure B17. These results show a grain size distribution consisting of 2-26% gravel, 10-38% sand, 36-72% silt and 8-16% clay size particles. Till soils will also contain random cobble and boulder inclusions.

Standard Penetration tests in these deposits yielded 'N' values ranging from 65 to more than 100 blows per 0.3 m penetration. Based on these results these units are considered to have a very dense relative density. The moisture content of samples from these deposits varies from 3% to 13% by weight.

### 5.8 Clayey Silt Till

A deposit of clayey silt till was encountered at this site in Boreholes WS1, WS2 and WS3. The deposit is approximately 1.6 m to 2.5 m thick and extends to a depth of 22.3 m below ground surface or to elevations ranging from 160.8 m to 160.4 m.

The grain size distribution plots of tested samples from this till deposit are depicted in Figure B18. These results show a grain size distribution consisting of 2-15% gravel, 31-35% sand, 35-48% silt and 15-19% 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 B19. The index values from these tests are summarized below:

| | |
|---|---|
| Liquid Limit: | 15-17% |
| Plastic Limit: | 11-12% |
| Plasticity Index: | 4-5% |
| Natural Moisture Content: | 7-15% |

These values indicate a clayey silt matrix of low plasticity.

Standard Penetration tests conducted in this stratum yielded 'N' values ranging from 44 to more than 100 blows per 0.3 m penetration. Based on these results the silty clay till is considered to have a hard consistency. The moisture content of samples of this till varies from 7% to 15% by weight.

### 5.9 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 | WS1 | 27.5 | 155.2 |
| | WS2 | 27.3 | 155.8 |
| North Abutment | WS3 | 25.9 | 157.1 |
| | WS4 | 26.3 | 156.4 |

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 58% to 100% and one recorded TCR of 19% was obtained in Run 1 of Borehole WS1. The RQD values ranged widely from 12% to 49% and an RQD of 0% was obtained in Run 1 of Borehole WS1. Rubble and highly fractured zones were observed in the rock cores which contributed to the relatively low RQD values. The core data reveals that there is generally no trend of improving rock quality with depth. Based on these results the rock quality is considered to be very poor to poor.

### 5.10 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) |
| SBL 12+685CL | Piezometer destroyed | - | - |
| SBL 12+750CL | November 19, 2009 | 4.6 | 178.3 |
| | November 30, 2009 | 7.8 | 175.1 |
| | December 08, 2009 | 4.1 | 178.8 |
| | December 15, 2009 | 3.2 | 179.7 |
| | January 04, 2010 | 2.7 | 180.2 |
| | January 11, 2010 | 2.7 | 180.2 |
| | January 19, 2010 | 2.6 | 180.3 |
| WS1 | January 27, 2010 | 6.8 | 175.9 |
| | February 08, 2010 | 6.8 | 175.9 |
| WS4 | February 08, 2010 | 4.7 | 178.0 |
| | April 16, 2010 | 2.1 | 180.6 |
| | April 29, 2010 | 5.1 | 177.6 |
| | May 04, 2010 | 5.7 | 177.0 |
| | May 06, 2010 | 4.1 | 178.6 |
| | May 18, 2010 | 5.9 | 176.8 |

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. ±181.0 m.

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

### 5.11 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, DBW Drilling Limited of Ajax, Ontario and Determination Drilling & Soil Investigations of Hamilton, Ontario.

A combination of hollow-stem auger and solid 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.

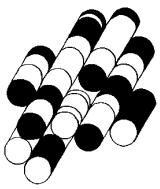
Messrs. Alexander Winkelmann, E.I.T., Marc Paoliello, E.I.T, and Phil Khuu, B.A.T, carried out the field work. The laboratory testing was performed at Terraprobe's Brampton laboratory and the Mississauga laboratory of Golder Associates. The report was written by Rehman Abdul, P.Eng. and reviewed by Michael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


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

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

# APPENDICES

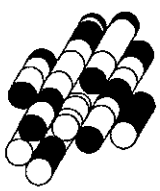
TERRAPROBE INC.



# 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

# 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 $\bar{N}$.

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

| | | |
|---|---|---|
| $u_w$ | kPa | PORE WATER PRESSURE |
| $r_u$ | 1 | PORE PRESSURE RATIO |
| $\sigma$ | kPa | TOTAL NORMAL STRESS |
| $\sigma'$ | kPa | EFFECTIVE NORMAL STRESS |
| $\tau$ | kPa | SHEAR STRESS |
| $\sigma_1, \sigma_2, \sigma_3$ | kPa | PRINCIPAL STRESSES |
| $\varepsilon$ | % | LINEAR STRAIN |
| $\varepsilon_1, \varepsilon_2, \varepsilon_3$ | % | PRINCIPAL STRAINS |
| E | kPa | MODULUS OF LINEAR DEFORMATION |
| G | kPa | MODULUS OF SHEAR DEFORMATION |
| $\mu$ | 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 |
| $C_\alpha$ | 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 |
| $\sigma'_{vo}$ | kPa | EFFECTIVE OVERBURDEN PRESSURE |
| $\sigma'_p$ | kPa | PRECONSOLIDATION PRESSURE |
| $\tau_f$ | kPa | SHEAR STRENGTH |
| c' | kPa | EFFECTIVE COHESION INTERCEPT |
| $\phi'$ | - ° | EFFECTIVE ANGLE OF INTERNAL FRICTION |
| $c_u$ | kPa | APPARENT COHESION INTERCEPT |
| $\phi_u$ | - ° | APPARENT ANGLE OF INTERNAL FRICTION |
| $\tau_R$ | kPa | RESIDUAL SHEAR STRENGTH |
| $\tau_r$ | kPa | REMOULDED SHEAR STRENGTH |
| $S_t$ | 1 | SENSITIVITY = $c_u / \tau_r$ |

# PHYSICAL PROPERTIES OF SOIL

| | | | | | |
|---|---|---|---|---|---|
| $\rho_s$ | $kg/m^3$ | DENSITY OF SOLID PARTICLES | e | 1,% | VOID RATIO |
| $\gamma_s$ | $kN/m^3$ | UNIT WEIGHT OF SOLID PARTICLES | n | 1,% | POROSITY |
| $\rho_w$ | $kg/m^3$ | DENSITY OF WATER | | | |
| $\gamma_w$ | $kN/m^3$ | UNIT WEIGHT OF WATER | w | 1,% | WATER CONTENT |
| $\rho$ | $kg/m^3$ | DENSITY OF SOIL | $S_r$ | % | DEGREE OF SATURATION |
| $\gamma$ | $kN/m^3$ | UNIT WEIGHT OF SOIL | $w_L$ | % | LIQUID LIMIT |
| $\rho_d$ | $kg/m^3$ | DENSITY OF DRY SOIL | $w_P$ | % | PLASTIC LIMIT |
| $\gamma_d$ | $kN/m^3$ | UNIT WEIGHT OF DRY SOIL | $w_S$ | % | SHRINKAGE LIMIT |
| $\rho_{sat}$ | $kg/m^3$ | DENSITY OF SATURATED SOIL | $I_P$ | % | PLASTICITY INDEX = $(w_L - w_P)$ |
| $\gamma_{sat}$ | $kN/m^3$ | UNIT WEIGHT OF SATURATED SOIL | $I_L$ | 1 | LIQUIDITY INDEX = $(w - w_P)/I_P$ |
| $\rho'$ | $kg/m^3$ | DENSITY OF SUBMERGED SOIL | $I_C$ | 1 | CONSISTENCY INDEX = $(w_L - w)/I_P$ |
| $\gamma'$ | $kN/m^3$ | UNIT WEIGHT OF SUBMERGED SOIL | $e_{max}$ | 1,% | VOID RATIO IN LOOSEST STATE |

| | | | |
|---|---|---|---|
| $e_{min}$ | 1,% | VOID RATIO IN DENSEST STATE | |
| $I_D$ | 1 | DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$ | |
| D | mm | GRAIN DIAMETER | |
| $D_n$ | mm | n PERCENT - DIAMETER | |
| $C_u$ | 1 | UNIFORMITY COEFFICIENT | |
| h | m | HYDRAULIC HEAD OR POTENTIAL | |
| q | $m^3/s$ | RATE OF DISCHARGE | |
| v | m/s | DISCHARGE VELOCITY | |
| i | 1 | HYDRAULIC GRADIENT | |
| k | m/s | HYDRAULIC CONDUCTIVITY | |
| j | $kN/m^3$ | SEEPAGE FORCE | |

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

10. Filling:

| | Approximate φ |
|---|---|
| T = Tight, hard, non-softened | |
| O = Oxidation surface staining only | 25 - 35 |
| SA = Slightly altered; clay-free | 25 - 30 |
| S = Sandy particles; clay-free | 25 - 30 |
| Si = Sandy and silty, minor clay | 20 - 25 |
| NC = Non-softening Clays; 5mm | 16 - 24 |
| SC = Swelling Clay fillings; 5mm | 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 SCRAPED WITH POCKET KNIFE | 50 - 200 |
| MEDIUM STRENGTH | SPECIMEN CANNOT BE FRACTURED BY A SINGLE, FIRM BLOW OF GEOLOGICAL HAMMER; CAN BE SCRAPED 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 SBL 12+685CL 1 OF 1 METRIC

W.P. 280-99-00 LOCATION Coords: N:4764160.4 E:327319.7 ORIGINATED BY MP

DIST HWY 406 BOREHOLE TYPE Hollow Stem Augers COMPILED BY DB

DATUM Geodetic DATE 11.17.09 CHECKED BY RA

| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | SAMPLES NUMBER | SAMPLES TYPE | SAMPLES "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100 | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ WATER CONTENT (%) 10 20 30 | UNIT WEIGHT $\gamma$ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 182.7 | Ground Surface | | | | | | | | | | |
| 0.0 / 182.2 | 470mm FILL - Sand and Gravel, some silt, trace clay, compact, grey, damp | | 1 | SS | 11 | | | | | | 41 42 13 4 |
| 0.5 | SILTY CLAY trace sand, occasional gravel inclusions, very stiff, brown, moist | | 2 | SS | 18 | | 182 | | | | |
| | | | 3 | SS | 15 | | 181 | | | | |
| | | | 4 | SS | 16 | | 180 | | 42 | | 0 1 50 49 |
| | | | 5 | SS | 19 | | 179 | | | | |
| | | | 6 | SS | 15 | | 178 | | | | |
| | ---- stiff | | | | | | 177 | | | | |
| | | | 7 | SS | 13 | | 176 | | | | 0 2 68 30 |
| | | | 8 | SS | 11 | | 175 | | | | |
| | | | 9 | SS | 8 | | 174 | 1.9 | | | 1 5 68 26 |
| | | | | | | | 173 | 1.2 | | | |
| | | | 10 | TW | PH | | 172 | × | | 20.7 | 0 3 70 27 |
| 170.5 / 12.2 | End of Borehole | | | | | | 171 | | | | |

Borehole was dry (not stabilized) and hole open to full depth on completion.

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)

Piezometer destroyed after drilling.

Consolidation test performed on TW 10.

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

ONTARIO MOT 1-09-4135 WS BRIDGE.GPJ ONTARIO MOT.GDT 05/26/10

# RECORD OF BOREHOLE No WS1 1 OF 3 METRIC

W.P. 280-99-00 LOCATION Coords: N:4764163.6 E:327303.9 ORIGINATED BY MP

DIST HWY 406 BOREHOLE TYPE Solid Stem Augers / Casing and Washboring / NQ Rock Coring COMPILED BY DB

DATUM Geodetic DATE 01.19.10 - 04.29.10 CHECKED BY RA

| 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 ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (20 40 60 80 100) | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ WATER CONTENT (%) (10 20 30) | UNIT WEIGHT $\gamma$ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 182.7 | Ground Surface | | | | | | | | | | |
| 182.6 | 80mm TOPSOIL | | | | | | | | | | |
| | FILL - Silty Clay, trace sand, firm to hard, brown, damp | | 1 | SS | 7 | | | | | | |
| | | | 2 | SS | 28 | | 182 | | 53 | | 0 2 36 62 |
| 180.6 | | | 3 | SS | 37 | | 181 | | | | |
| 2.1 | SILTY CLAY trace sand, trace gravel, hard, brown, damp | | 4 | SS | 32 | | 180 | | | | |
| | | | 5 | SS | 33 | | 179 | | | | |
| 178.3 | | | 6 | SS | 52 | | | | | | |
| 4.4 | SILT trace sand, trace gravel, frequent silty clay seams and partings, dense, brown, damp | | 7 | SS | 47 | | 178 | | | | 1 2 75 22 |
| 176.8 | | | 8 | SS | 39 | | 177 | | | | |
| 5.9 | SILTY CLAY trace sand, trace gravel, very stiff to hard, brown, damp to moist | | 9 | SS | 15 | ▽ | 176 | | >> 3.3 | | |
| | | | 10 | SS | 23 | ▼ | 175 | | >> | | 0 5 83 12 |
| | | | | | | | | | >> 1.8 | | |
| | | | 11 | SS | 25 | | 174 | | >> | | 0 4 62 34 |
| | | | | | | | 173 | | >> 1.4 | | |
| | | | 12 | TW | PH | | 172 | | >> | | |
| | | | | | | | 171 | | >> | | |
| | | | 13 | SS | 41 | | 170 | | | | |
| | | | | | | | 169 | | | | |
| | | | 14 | SS | 28 | | | | | | 1 3 72 24 |
| 168.0 | | | | | | | 168 | | | | |
| 14.7 | | | | | | | | | | | |

Continued Next Page

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

# RECORD OF BOREHOLE No WS1 2 OF 3 METRIC

W.P. 280-99-00 LOCATION Coords: N:4764163.6 E:327303.9 ORIGINATED BY MP

DIST HWY 406 BOREHOLE TYPE Solid Stem Augers / Casing and Washboring / NQ Rock Coring COMPILED BY DB

DATUM Geodetic DATE 01.19.10 - 04.29.10 CHECKED BY RA

| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | SAMPLES: NUMBER | SAMPLES: TYPE | SAMPLES: "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ (WATER CONTENT %) | UNIT WEIGHT $\gamma$ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | SILTY CLAY sandy, trace gravel, hard, brown, damp to moist (GLACIAL TILL) | | 15 | SS | 55 | | 167 | | | | 4 24 55 17 |
| | | | 16 | SS | 66 | | 166 | | | | |
| 164.1 | | | 17 | SS | 104 | | 165 | | | | |
| 18.6 | SANDY SILT some clay, trace gravel, very dense, brown, damp to moist (GLACIAL TILL) | | 18 | SS | 100/13cm | | 164 | | | | Jan.19 / Jan.20 |
| 162.1 | | | | | | | 163 | | | | |
| 20.6 | CLAYEY SILT sandy, trace gravel, hard, brown, damp (GLACIAL TILL) | | 19 | SS | 129 | | 162 | | | | 2 31 48 19 |
| 160.4 | | | | | | | 161 | | | | |
| 22.3 | SANDY SILT trace to some gravel, trace clay, very dense, brown, moist to wet (GLACIAL TILL) | | 20 | SS | 100/13cm | | 160 | | | | Jan.20 / Apr.29 |
| | | | 21 | SS | 192 | | 159 | | | | |
| 155.2 | | | | | | | 158 | | | | |
| 27.5 | 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 | | 157 | | | | RUN#1 TCR=19% SCR=11% RQD=0% |
| | | | 2 | RUN | NQ | | 156 | | | | RUN#2 TCR=62% SCR=34% RQD=18% |
| | | | | | | | 155 | | | | |
| | | | | | | | 154 | | | | |
| | | | | | | | 153 | | | | |

Continued Next Page

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

# RECORD OF BOREHOLE No WS1 3 OF 3 METRIC

W.P. 280-99-00 LOCATION Coords: N:4764163.6 E:327303.9 ORIGINATED BY MP

DIST HWY 406 BOREHOLE TYPE Solid Stem Augers / Casing and Washboring / NQ Rock Coring COMPILED BY DB

DATUM Geodetic DATE 01.19.10 - 04.29.10 CHECKED BY RA

| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | SAMPLES NUMBER | SAMPLES TYPE | SAMPLES "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100 | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ WATER CONTENT (%) 10 20 30 | UNIT WEIGHT $\gamma$ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 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. *(continued)* | | 3 | RUN | NQ | | 152 | | | | RUN#3 TCR=91% SCR=69% RQD=43% |
| 150.5 | | | 4 | RUN | NQ | | 151 | | | | RUN#4 TCR=94% SCR=80% RQD=30% |
| 32.2 | End of Borehole | | | | | | | | | | |

Water level at 6.1m (not stabilized) and hole open to full depth on completion.

Unable to push vane beyond 12.0m.

Resistance to augering below 23.6m.

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) |
|---|---|---|
| Jan.27.10 | 6.8 | 175.9 |
| Feb.08.10 | 6.8 | 175.9 |

April 29, 2010 borehole drilled 1m south of original borehole location.

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

# CORE LOG

Terraprobe

| | | | | | |
|---|---|---|---|---|---|
| Project: Highway 406 Twinning | Orientation: Vertical | Ground Elevation: 182.7m | Datum: Geodetic | Borehole No.: WS1 | |
| Location: Welland, Ontario | Date Started: April 29, 2010 | Completed: April 29, 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: No. OF SETS | JOINT TYPE | ORIENTATION | SPACING | ROUGHNESS | FILLING | APERTURE | WEATHERING | STRENGTH | FRACTURE FREQUENCY | RUN NO. CORE RECOVERY % | R Q D % | CORE SIZE/CASING | UNCONFINED COMPRESSIVE STRENGTH MPa | UNIT WEIGHT (kN/m³) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
| 155.7 | 27.0 | | Overburden, refer to Borehole Log WS1 | | | | | | | | | | | | | | | |
| 155.2 | 27.5 | | SALINA FORMATION BEDROCK | 1 | B | F | VC | RP | T | 0 to 1 | | | | #1 TCR 19 SCR 11 | 0 | NQ | | |
| 154.7 | 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. | | | | | | | | | | | | | | | |
| 154.2 | 28.5 | | | 1 | B | F | VC | RP | T | | | | | #2 TCR 62 SCR 34 | 18 | NQ | | |
| 153.7 | 29.0 | | | 1 | B | F | C | SP | T | 0 to 1 | | | | | | | | |
| 153.2 | 29.5 | | | 2 | BC | FV | VC | SP | T | | | | | | | | | |
| 152.7 | 30.0 | | | 1 | B | F | C | SP | T | 0 to 5 | | | | #3 TCR 91 SCR 69 | 43 | NQ | | |
| 152.2 | 30.5 | | | 1 | B | F | VC | SP | T | 0 to 1 | | | | | | | | |
| 151.7 | 31.0 | | | 1 | B | F | C | SP | T | 0 to 1 | | | | | | | | |
| | | | | 1 | B | F | VC | SP | T | 0 to 1 | | | | | | | | |
| 151.2 | 31.5 | | | 2 | BC | FV | C | SP | T | 0 to 1 | | | | #4 TCR 94 SCR 80 | 30 | NQ | | |
| 150.7 | 32.0 | | | 2 | BC | FV | VC | SP | T | 0 to 1 | | | | | | | | |
| | | | | 1 | B | F | C | SP | T | 0 to 2 | | | | | | | | |
| 150.5 | 32.5 | | End of Core Log<br>Rubbilized zones at:<br>27.50~29.00m; 29.50~29.70m; 30.70~30.80m; 31.00~31.30m.<br>Rubble indicated by 'q'.<br>Highly fractured zone at:<br>31.80~32.00m. | | | | | | | | | | | | | | | |
| 150.0 | 33.0 | | | | | | | | | | | | | | | | | |

Remarks:

LEGEND:
- Interbedded Dolostone and Shale
- Rubble

# RECORD OF BOREHOLE No WS2 1 OF 3 METRIC

W.P. 280-99-00 LOCATION Coords: N:4764174.7 E:327313.4 ORIGINATED BY AW

DIST HWY 406 BOREHOLE TYPE Hollow Stem Augers / NQ Rock Coring COMPILED BY DB

DATUM Geodetic DATE 01.26.10 - 02.01.10 CHECKED BY RA

| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | GROUND WATER CONDITIONS | GR | SA | SI | CL |
|---|---|---|---|---|---|---|---|---|---|---|
| 183.1 | Ground Surface | | | | | | | | | |
| 0.0 | firm | | 1 | SS | 7 | | | | | |
| | ---- | | | | | | | | | |
| | SILTY CLAY<br>trace sand, trace gravel,<br>hard, brown, damp | | 2 | SS | 38 | | 2 | 3 | 37 | 58 |
| | | | 3 | SS | 43 | | | | | |
| | | | 4 | SS | 36 | | 0 | 1 | 51 | 48 |
| | | | 5 | SS | 29 | | | | | |
| 178.7 | | | 6 | SS | 24 | | | | | |
| 4.4 | SILT<br>trace sand, frequent silty clay seams<br>and partings,<br>dense, brown, damp | | 7 | SS | 37 | | 0 | 1 | 79 | 20 |
| 177.2 | | | 8 | SS | 36 | | | | | |
| 5.9 | SILTY CLAY<br>trace sand, trace gravel,<br>stiff to very stiff,<br>brown, damp to moist | | 9 | SS | 21 | | 0 | 5 | 68 | 27 |
| | | | 10 | SS | 22 | | | | | |
| | | | 11 | TW | PH | | | | | |
| | | | 12 | SS | 10 | | 0 | 3 | 70 | 27 |
| | | | 13 | SS | 15 | | 0 | 2 | 72 | 26 |
| | | | 14 | SS | 28 | | | | | |
| 168.4 | | | | | | | | | | |
| 14.7 | | | | | | | | | | |

DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100)

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

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

UNIT WEIGHT $\gamma$ kN/m³

ELEVATION SCALE: 183, 182, 181, 180, 179, 178, 177, 176, 175, 174, 173, 172, 171, 170, 169

45 47 >> 1.6 1.2 1.1 1.3 >> 2.5

REMARKS & GRAIN SIZE DISTRIBUTION (%)

Continued Next Page

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

# RECORD OF BOREHOLE No WS2 2 OF 3 METRIC

W.P. 280-99-00 LOCATION Coords. N:4764174.7 E:327313.4 ORIGINATED BY AW

DIST HWY 406 BOREHOLE TYPE Hollow Stem Augers / NQ Rock Coring COMPILED BY DB

DATUM Geodetic DATE 01.28.10 - 02.01.10 CHECKED BY RA

| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | SAMPLES NUMBER | SAMPLES TYPE | SAMPLES "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (20 40 60 80 100) | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ WATER CONTENT (%) (10 20 30) | UNIT WEIGHT $\gamma$ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | SILTY CLAY<br>trace sand, trace gravel,<br>hard, brown, damp<br><br>(GLACIAL TILL) | | 15 | SS | 40 | | 168 | ○ | ○ | | |
| | | | | | | | 167 | | | | |
| | | | 16 | SS | 52 | | 166 | | ○ | | Jan.28<br>Jan.29 |
| 165.1 | | | | | | | 165 | | | | |
| 18.0 | SANDY SILT<br>trace to some clay,<br>trace gravel to gravelly,<br>very dense, brown, damp to moist<br><br>(GLACIAL TILL) | | 17 | SS | 111 | | | | ○ | | 26 17 45 12 |
| | | | 18 | SS | 100/<br>13cm | | 164 | | | | |
| 162.4 | | | | | | | 163 | | ○ | | |
| 20.7 | CLAYEY SILT<br>and sand, some gravel,<br>hard, brown, damp<br><br>(GLACIAL TILL) | | 19 | SS | 87 | | 162 | | ○ ⊢ | | 15 35 35 15 |
| 160.8 | | | | | | | 161 | | | | |
| 22.3 | SANDY SILT<br>and gravel, trace clay,<br>very dense, brown, moist<br><br>(GLACIAL TILL) | | 20 | SS | 100/<br>10cm | | 160 | | ○ | | |
| | | | 21 | SS | 100/<br>10cm | | 159 | | ○ | | |
| | | | | | | | 158 | | | | |
| | | | 22 | SS | 100/<br>5cm | | 157 | | ⊖ | | Jan 29<br>Feb.01 |
| 155.8 | ----<br>frequent cobbles | | | | | | 156 | | | | RUN#1<br>TCR=71%<br>SCR=57%<br>RQD=18% |
| 27.3 | BEDROCK - INTERBEDDED<br>DOLOSTONE AND SHALE<br>Unweathered, thinly laminated, grey,<br>medium strength, argillaceous with<br>unweathered, laminated, white, very<br>low strength gypsum and calcite<br>layers / veins and frequent<br>unweathered, white, low strength,<br>coarse grained calcitic vugs. | | 1 | RUN | NQ | | 155 | | | | |
| | | | 2 | RUN | NQ | | 154 | | | | RUN#2<br>TCR=89%<br>SCR=85%<br>RQD=30% |
| 153.2 | | | | | | | | | | | |

Continued Next Page

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

# RECORD OF BOREHOLE No WS2 3 OF 3 METRIC

W.P. 280-99-00 LOCATION Coords: N:4764174.7 E:327313.4 ORIGINATED BY AW

DIST HWY 406 BOREHOLE TYPE Hollow Stem Augers / NQ Rock Coring COMPILED BY DB

DATUM Geodetic DATE 01.28.10 - 02.01.10 CHECKED BY RA

| SOIL PROFILE | | | SAMPLES | | | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100 | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ WATER CONTENT (%) 10 20 30 | UNIT WEIGHT $\gamma$ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | | | | | | |
| 29.9 | End of Borehole<br><br>No sample recovery at SS12. Sampler redriven and disturbed sample collected.<br><br>Unable to push vane beyond 12m.<br><br>Borehole open to full depth and filled with drill water upon completion of drilling.<br><br>Borehole sealed with bentonite slurry to ground surface. | | | | | | | | | | |

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

# CORE LOG

Terraprobe

| | | | | |
|---|---|---|---|---|
| Project: Highway 406 Twinning | Orientation: Vertical | Ground Elevation: 183.1m | Datum: Geodetic | Borehole No.: WS2 |
| Location: Welland, Ontario | Date Started: February 1, 2010 | Completed: February 1, 2010 | Logged By: AW | Sheet: 1 of 1 |
| W.P.: 280-99-00 | Drilling Agency: GW | Drill Type: Track-Mount | Core Barrel & Bit Design: NQ | Project No.: 1-09-4135 |

| ELEVATION (m) | DEPTH (m) | SYMBOL | GENERAL DESCRIPTION | Joint Characteristics: No. OF SETS | JOINT TYPE | ORIENTATION | SPACING | ROUGHNESS | FILLING | APERTURE | WEATHERING | STRENGTH | FRACTURE FREQUENCY | RUN NO. CORE RECOVERY % | R Q D % | CORE SIZE/CASING | UNCONFINED COMPRESSIVE STRENGTH MPa | UNIT WEIGHT (KN/m³) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
| 156.6 | 26.5 | | Overburden, refer to Borehole Log WS2 | | | | | | | | | | | | | | | |
| 156.1 | 27.0 | | Sandy Silt TILL, refer to Borehole Log WS2 | | | | | | | | | | | | | | | |
| 155.6 | 27.5 | | SALINA FORMATION BEDROCK<br><br>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 3 | | | | #1 TCR 71 SCR 57 | 18 | NQ | | |
| 155.1 | 28.0 | | | 1 | B | F | VC | SP | T | 0 to 1 | | | | | | | | |
| | | | | 1 | B | F | C | SP | T | 0 to 1 | | | | | | | | |
| 154.6 | 28.5 | | | 1 | B | F | VC | SP | T | 0 to 1 | | | | #2 TCR 89 SCR 85 | 30 | NQ | | |
| 154.1 | 29.0 | | | | | | | | | | | | | | | | | |
| 153.6 | 29.5 | | | 1 | B | F | C | SP | T | 0 to 1 | | | | | | | | |
| 153.1 | 30.0 | | End of Core Log<br><br>Rubbilized zones at:<br>27.80-27.90m; 28.80-28.90m.<br><br>Rubble indicated by '◁'.<br><br>Highly fractured zone at:<br>28.30-28.80m. | | | | | | | | | | | | | | | |
| 152.6 | 30.5 | | | | | | | | | | | | | | | | | |
| 152.1 | 31.0 | | | | | | | | | | | | | | | | | |
| 151.6 | 31.5 | | | | | | | | | | | | | | | | | |
| 151.1 | 32.0 | | | | | | | | | | | | | | | | | |
| 150.6 | 32.5 | | | | | | | | | | | | | | | | | |

Remarks:

LEGEND:

- Interbedded Dolostone and Shale
- Rubble
- Sandy Silt TILL

# RECORD OF BOREHOLE No WS3 1 OF 2 METRIC

W.P. 280-99-00 LOCATION Coords: N:4764192.6 E:327292.7 ORIGINATED BY MP

DIST HWY 406 BOREHOLE TYPE Solid Stem Augers / NQ Rock Coring COMPILED BY DB

DATUM Geodetic DATE 01.20.10 - 01.22.10 CHECKED BY RA

| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | NUMBER | TYPE | "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ (WATER CONTENT (%)) | UNIT WEIGHT $\gamma$ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 183.0 | Ground Surface | | | | | | | | | | |
| 182.9 | 50mm TOPSOIL | | | | | | | | | | |
| | FILL - Silty Clay, trace sand, very stiff to hard, brown, damp | | 1 | SS | 17 | | | | | | |
| | | | 2 | SS | 23 | | | | | | |
| | | | 3 | SS | 36 | | | | | | 0 3 36 61 |
| | | | 4 | SS | 43 | | | | | | |
| 180.1 | | | | | | | | | | | |
| 2.9 | SILTY CLAY trace sand, trace gravel, stiff to hard, brown, damp | | 5 | SS | 39 | | | | | | 0 1 53 46 |
| | | | 6 | SS | 30 | | | | | | |
| | | | 7 | SS | 24 | | | | | | 0 1 65 34 |
| | | | 8 | SS | 20 | | | | | | |
| | | | 9 | TW | PH | | | | | | Jan.20 / Jan.21 |
| | | | 10 | SS | 9 | | | | | | 1 5 63 31 |
| | | | 11 | SS | 13 | | | | | | |
| | | | 12 | SS | 17 | | | | | | 8 5 65 22 |
| | | | 13 | SS | 23 | | | | | | |
| | | | 14 | SS | 23 | | | | | | 0 4 67 29 |
| 168.3 | | | | | | | | | | | |
| 14.7 | | | | | | | | | | | |

Continued Next Page

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

# RECORD OF BOREHOLE No WS3 2 OF 2 METRIC

W.P. 280-99-00 LOCATION Coords: N:4764192.6 E:327292.7 ORIGINATED BY MP

DIST HWY 406 BOREHOLE TYPE Solid Stem Augers / NQ Rock Coring COMPILED BY DB

DATUM Geodetic DATE 01.20.10 - 01.22.10 CHECKED BY RA

| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | SAMPLES: NUMBER | SAMPLES: TYPE | SAMPLES: "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE) | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ — WATER CONTENT (%) | UNIT WEIGHT $\gamma$ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | SILTY CLAY<br>trace sand to sandy, trace gravel, hard, brown, damp<br>(GLACIAL TILL) | | 15 | SS | 46 | | 167 | | | | |
| | | | 16 | SS | 79 | | 166 | | | | |
| 164.8 | | | | | | | 165 | | | | |
| 18.2 | SANDY SILT<br>some clay, trace gravel, dense to very dense, brown, damp to moist<br>(GLACIAL TILL) | | 17 | SS | 65 | | 164 | | | | 2 10 72 16 |
| 163.2 | | | | | | | | | | | |
| 19.8 | CLAYEY SILT<br>sandy, trace to some gravel, hard, brown, damp<br>(GLACIAL TILL) | | 18 | SS | 44 | | 163 | | | | |
| | | | 19 | SS | 68 | | 162 | | | | |
| 160.7 | | | | | | | 161 | | | | |
| 22.3 | SANDY SILT<br>trace to some gravel, trace clay, very dense, brown, damp to moist<br>(GLACIAL TILL) | | 20 | SS | 100/ 5cm | | 160 | | | | |
| | | | 21 | SS | 100/ 2.5cm | | 159 | | | | Jan.21<br>Jan.22 |
| | ---- boulder | | | | | | 158 | | | | |
| 157.1 | | | 1 | RUN | NQ | | 157 | | | | RUN#1<br>TCR=81%<br>SCR=70%<br>RQD=49% |
| 25.9 | BEDROCK - INTERBEDDED DOLOSTONE AND SHALE<br>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. | | 2 | RUN | NQ | | 156 | | | | RUN#2<br>TCR=99%<br>SCR=96%<br>RQD=49% |
| 154.8 | | | | | | | 155 | | | | |
| 28.2 | End of Borehole<br>Unable to push vane beyond 12m. Resistance to augering at 24.3m. Borehole open to full depth and filled with drill water upon completion of drilling. Borehole sealed with bentonite slurry to ground surface. | | | | | | | | | | |

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

# CORE LOG

Terraprobe

| | | | | |
|---|---|---|---|---|
| Project: Highway 406 Twinning | Orientation: Vertical | Ground Elevation: 183.0m | Datum: Geodetic | Borehole No.: WS3 |
| Location: Welland, Ontario | Date Started: January 22, 2010 | Completed: January 22, 2010 | Logged By: AW | Sheet 1 of 1 |
| W.P.: 280-99-00 | Drilling Agency: DBW | Drill Type: Track-Mount | Core Barrel & Bit Design: NQ | Project No.: 1-09-4135 |

| ELEVATION (m) | DEPTH (m) | SYMBOL | GENERAL DESCRIPTION | Joint Characteristics: No. OF SETS | JOINT TYPE | ORIENTATION | SPACING | ROUGHNESS | FILLING | APERTURE | WEATHERING | STRENGTH | FRACTURE FREQUENCY | RUN NO. CORE RECOVERY % | R Q D % | CORE SIZE/CASING | UNCONFINED COMPRESSIVE STRENGTH MPa | UNIT WEIGHT (KN/m³) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
| 158.5 | 24.5 | | | | | | | | | | | | | | | | | |
| 158.0 | 25.0 | | Overburden, refer to Borehole Log WS3 | | | | | | | | | | | | | | | |
| 157.5 | 25.5 | | Sandy Silt TILL, (Boulder 25.07 to 25.90m), refer to Borehole Log WS3 | | | | | | | | | | | #1 TCR 81 SCR 70 | 53 | NQ | | |
| 157.0 | 26.0 | | SALINA FORMATION BEDROCK | 1 | B | F | M | SP | T | | | | | | | | | |
| | | | 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 | SP | T | 0 to 1 | | | | | | | | |
| 156.5 | 26.5 | | | 1 | B | F | M | SP | T | | | | | | | | | |
| 156.0 | 27.0 | | | | | | | | | | | | | | | | | |
| 155.5 | 27.5 | | | 1 | B | F | M | SP | T | 0 to 1 | | | | #2 TCR 99 SCR 96 | 58 | NQ | | |
| 155.0 | 28.0 | | | | | | | | | | | | | | | | | |
| | | | End of Core Log | | | | | | | | | | | | | | | |
| 154.5 | 28.5 | | Rubbilized zones at: 26.10-26.20m. Rubble indicated by 'a'. | | | | | | | | | | | | | | | |
| 154.0 | 29.0 | | | | | | | | | | | | | | | | | |
| 153.5 | 29.5 | | | | | | | | | | | | | | | | | |
| 153.0 | 30.0 | | | | | | | | | | | | | | | | | |
| 152.5 | 30.5 | | | | | | | | | | | | | | | | | |

Remarks: 0.5m boulder present in recovered rock core at top of Run No.1

LEGEND:
- Interbedded Dolostone and Shale
- Rubble
- Sandy Silt TILL

# RECORD OF BOREHOLE No WS4 1 OF 3 METRIC

W.P. 280-99-00 LOCATION Coords: N:4764202.3 E:327305.2 ORIGINATED BY MP

DIST HWY 406 BOREHOLE TYPE Solid Stem Augers / NQ Rock Coring COMPILED BY DB

DATUM Geodetic DATE 01.28.10 - 02.01.10 CHECKED BY RA

| 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 ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (20 40 60 80 100) | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ WATER CONTENT (%) (10 20 30) | UNIT WEIGHT $\gamma$ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 182.7 | Ground Surface | | | | | | | | | | |
| | 25mm TOPSOIL | | 1 | SS | 13 | | | | | | |
| | FILL - Silty Clay, trace sand, trace gravel, stiff to very stiff, brown, damp to moist | | 2 | SS | 17 | | 182 | | | | |
| | | | 3 | SS | 13 | | 181 | | | | |
| 180.6 | | | | | | | | | | | |
| 2.1 | SILTY CLAY trace sand, trace gravel, hard, brown, damp | | 4 | SS | 45 | | 180 | | 45 | | 1 1 48 50 |
| | | | 5 | SS | 45 | | 179 | | | | |
| | | | 6 | SS | 43 | | | | | | |
| 177.7 | | | 7 | SS | 61 | | 178 | | | | |
| 5.0 | SILT trace clay, trace sand, frequent silty clay seams and partings, very dense, brown, damp | | 8 | SS | 64 | | 177 | | | | |
| 176.8 | | | | | | ▼ | | | | | |
| 5.9 | SILTY CLAY trace sand, trace gravel, stiff to hard, brown, damp | | 9 | SS | 37 | | 176 | | | | |
| | | | 10 | SS | 37 | | 175 | | | | |
| | | | 11 | SS | 20 | ▽ | 174 | | | | 0 3 67 30 |
| | | | 12 | TW | PH | | 173 | + | | | |
| | | | | | | | 172 | >> | | | |
| | | | | | | | 171 | +1.3 | | | |
| | | | 13 | SS | 25 | | | >> | | | 1 6 71 22 |
| | | | | | | | 170 | +1.0 | | | |
| | | | 14 | SS | 23 | | 169 | >> | | | |
| 168.0 | | | | | | | 168 | >> | | | |
| 14.7 | | | | | | | | | | | |

Continued Next Page

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

# RECORD OF BOREHOLE No WS4 2 OF 3 METRIC

W.P. 280-99-00 LOCATION Coords: N:4764202.3 E:327305.2 ORIGINATED BY MP

DIST HWY 406 BOREHOLE TYPE Solid Stem Augers / NQ Rock Coring COMPILED BY DB

DATUM Geodetic DATE 01.28.10 - 02.01.10 CHECKED BY RA

| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | SAMPLES NUMBER | SAMPLES TYPE | SAMPLES "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (20 40 60 80 100) | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ — WATER CONTENT (%) (10 20 30) | UNIT WEIGHT $\gamma$ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | SILTY CLAY some sand, some gravel, hard, brown, damp to moist (GLACIAL TILL) | | 15 | SS | 120 | | 167 | | ○ | | 17 17 48 18 |
| | | | 16 | SS | 73 | | 166 | | ○ | | Jan.28 / Jan.29 |
| 164.0 | | | 17 | SS | 102 | | 165 | | ○ | | |
| 18.7 | SAND AND SILT some gravel, trace clay, occasional cobbles, cemented, very dense, brown, damp to moist (GLACIAL TILL) | | 18 | SS | 67 | | 164 | | ○ | | |
| | | | 19 | SS | 100/13cm | | 163 | | ○ | | |
| | | | 20 | SS | 190 | | 162 | | ○ | | 18 38 36 8 |
| | | | 21 | SS | 177 | | 161 | | ○ | | |
| 156.4 | frequent cobbles | | 22 | SS | 100/0cm | | 160 | | | | Jan.29 / Feb.01 |
| 26.3 | 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 | | | | RUN#1 TCR=59% SCR=27% RQD=12% |
| | | | 2 | RUN | NQ | | 158 | | | | RUN#2 TCR=100% SCR=92% RQD=26% |
| 153.5 | | | 3 | RUN | NQ | | 157 | | | | RUN#3 TCR=58% SCR=47% RQD=22% |
| 29.2 | End of Borehole | | | | | | 156 | | | | |
| | | | | | | | 155 | | | | |
| | | | | | | | 154 | | | | |

Continued Next Page

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

# RECORD OF BOREHOLE No WS4 3 OF 3 METRIC

W.P. 280-99-00 LOCATION Coords: N:4764202.3 E:327305.2 ORIGINATED BY MP

DIST HWY 406 BOREHOLE TYPE Solid Stem Augers / NQ Rock Coring COMPILED BY DB

DATUM Geodetic DATE 01.28.10 - 02.01.10 CHECKED BY RA

| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | SAMPLES: NUMBER | SAMPLES: TYPE | SAMPLES: "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE) 20 40 60 80 100 | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ — WATER CONTENT (%) 10 20 30 | UNIT WEIGHT $\gamma$ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Water level at approx. 9.1m (not stabilized) and hole open to full depth on completion.<br><br>Unable to push vane beyond 14.7m.<br><br>Resistance to augering from 25.0m to 25.8m.<br><br>Piezometer installation consists of a 19mm diameter, Schedule 40 PVC pipe with a 1.52m slotted screen.<br><br>Water Level Readings:<br>Date — Depth(m) — Elevation(m)<br>Feb.08.10 — 4.7 — 178.0<br>Apr.16.10 — 2.1 — 180.6<br>Apr.29.10 — 5.1 — 177.6<br>May.04.10 — 5.7 — 177.0<br>May.06.10 — 4.1 — 178.6<br>May.18.10 — 5.9 — 176.8 | | | | | | | | | | |

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

# CORE LOG

Terraprobe

| | | | |
|---|---|---|---|
| Project: Highway 406 Twinning | Orientation: Vertical | Ground Elevation: 182.7m | Datum: Geodetic | Borehole No.: WS4 |
| Location: Welland, Ontario | Date Started: February 1, 2010 | Completed: February 1, 2010 | Logged By: AW | Sheet 1 of 1 |
| W.P.: 280-99-00 | Drilling Agency: DBW | Drill Type: Track-Mount | Core Barrel & Bit Design: NQ | Project No.: 1-09-4135 |

| ELEVATION (m) | DEPTH (m) | SYMBOL | GENERAL DESCRIPTION | Joint Characteristics: No. OF SETS | JOINT TYPE | ORIENTATION | SPACING | ROUGHNESS | FILLING | APERTURE | WEATHERING | STRENGTH | FRACTURE FREQUENCY | RUN NO. CORE RECOVERY % | R Q D % | CORE SIZE/CASING | UNCONFINED COMPRESSIVE STRENGTH (MPa) | UNIT WEIGHT (KN/m³) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
| 158.0 | 25.0 | | | | | | | | | | | | | | | | | |
| 157.5 | 25.5 | | Overburden, refer to Borehole Log WS4 | | | | | | | | | | | | | | | |
| 157.0 | 26.0 | | Sand and Silt TILL, refer to Borehole Log WS4 | | | | | | | | | | | #1 TCR 59 SCR 27 | 12 | NQ | | |
| 156.5 | 26.5 | | SALINA FORMATION BEDROCK<br>INTERBEDDED DOLOSTONE AND SHALE<br>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<br>1 | B<br>B | F<br>F | C<br>VC | SP<br>SP | T<br>T | 0 to 1 | | | | | | | | | |
| 156.0 | 27.0 | | | | | | | | | | | | | | | | | |
| 155.5 | 27.5 | | | 1 | B | F | C | SP | T | 0 to 1 | | | | #2 TCR 100 SCR 92 | 26 | NQ | | |
| 155.0 | 28.0 | | | | | | | | | | | | | | | | | |
| 154.5 | 28.5 | | | 1 | B | F | C | SP | T | 0 to 1 | | | | #3 TCR 58 SCR 47 | 22 | NQ | | |
| 154.0 | 29.0 | | End of Core Log<br>Rubbilized zones at:<br>26.50-26.80m.<br>Rubble indicated by '○'. | | | | | | | | | | | | | | | |
| 153.5 | 29.5 | | | | | | | | | | | | | | | | | |
| 153.0 | 30.0 | | | | | | | | | | | | | | | | | |
| 152.5 | 30.5 | | | | | | | | | | | | | | | | | |
| 152.0 | 31.0 | | | | | | | | | | | | | | | | | |

Remarks:

LEGEND:
- Interbedded Dolostone and Shale
- Rubble
- Sand and Silt TILL

# RECORD OF BOREHOLE No SBL 12+750CL 1 OF 1 METRIC

W.P. 280-99-00 LOCATION Coords: N:4764219.9 E:327296.2 ORIGINATED BY PK

DIST HWY 406 BOREHOLE TYPE Hollow Stem Augers COMPILED BY DB

DATUM Geodetic DATE 11.10.09 CHECKED BY RA

| ELEV / DEPTH | DESCRIPTION | STRAT PLOT | SAMPLES NUMBER | SAMPLES TYPE | SAMPLES "N" VALUES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) | PLASTIC LIMIT $w_P$ / NATURAL MOISTURE CONTENT $w$ / LIQUID LIMIT $w_L$ / WATER CONTENT (%) | UNIT WEIGHT $\gamma$ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 182.9 | Ground Surface | | | | | | | | | | |
| 182.7 | 200mm TOPSOIL | | | | | | | | | | |
| 0.2 / 182.2 | FILL - Silty Clay, trace sand, trace organics, stiff, dark brown, moist | | 1 | SS | 8 | | | | | | |
| 0.7 | SILTY CLAY trace sand, very stiff to hard, brown, moist | | 2 | SS | 24 | | 182 | | | | |
| | | | 3 | SS | 37 | | 181 | | | | |
| | | | 4 | SS | 46 | ▼ | 180 | | | | |
| | | | 5 | SS | 33 | | | | | | 0 0 60 40 |
| | | | 6 | SS | 20 | | 179 | | | | |
| | | | | | | | 178 | >> | | | |
| | | | 7 | SS | 27 | | 177 | | | | |
| | trace gravel | | 8 | SS | 34 | | 176 | | | | 0 4 68 28 |
| | | | 9 | SS | 21 | | 175 | | | | |
| | | | 10 | TW | PH | | 174 | | | | |
| | | | | | | | 173 | ○ >>× | | 21.1 | 6 3 65 26 |
| | | | | | | | 172 | >> 1.3 | | | |
| 171.6 | | | | | | | | >> 1.1 | | | |
| 11.3 | End of Borehole | | | | | | | | | | |

Water level at 10.4m (not stabilized) and hole open to full depth on completion.

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.19.09 | 4.6 | 178.3 |
| Nov.30.09 | 7.8 | 175.1 |
| Dec.08.09 | 4.1 | 178.8 |
| Dec.15.09 | 3.2 | 179.7 |
| Jan.04.10 | 2.7 | 180.2 |
| Jan.11.10 | 2.7 | 180.2 |
| Jan.19.10 | 2.6 | 180.3 |

Consolidation test performed on TW 10.

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

ONTARIO MOT 1-09-4135 WS BRIDGE.GPJ ONTARIO MOT.GDT 05/26/10


**Bedrock Core Sample**
Borehole: WS1
Runs: 1, 2, 3 & 4
Depth: 27.5m – 32.2m


**Bedrock Core Sample**
Borehole: WS2
Runs: 1 & 2
Depth: 26.8m – 29.9m

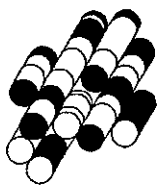

**Bedrock Core Sample**
Borehole: WS3
Runs 1 & 2
Depth: 25.1m – 28.2m


**Bedrock Core Sample**
Borehole: WS4
Runs: 1, 2 & 3
Depth: 25.8m – 29.2m

# APPENDIX B

## Laboratory Test Results

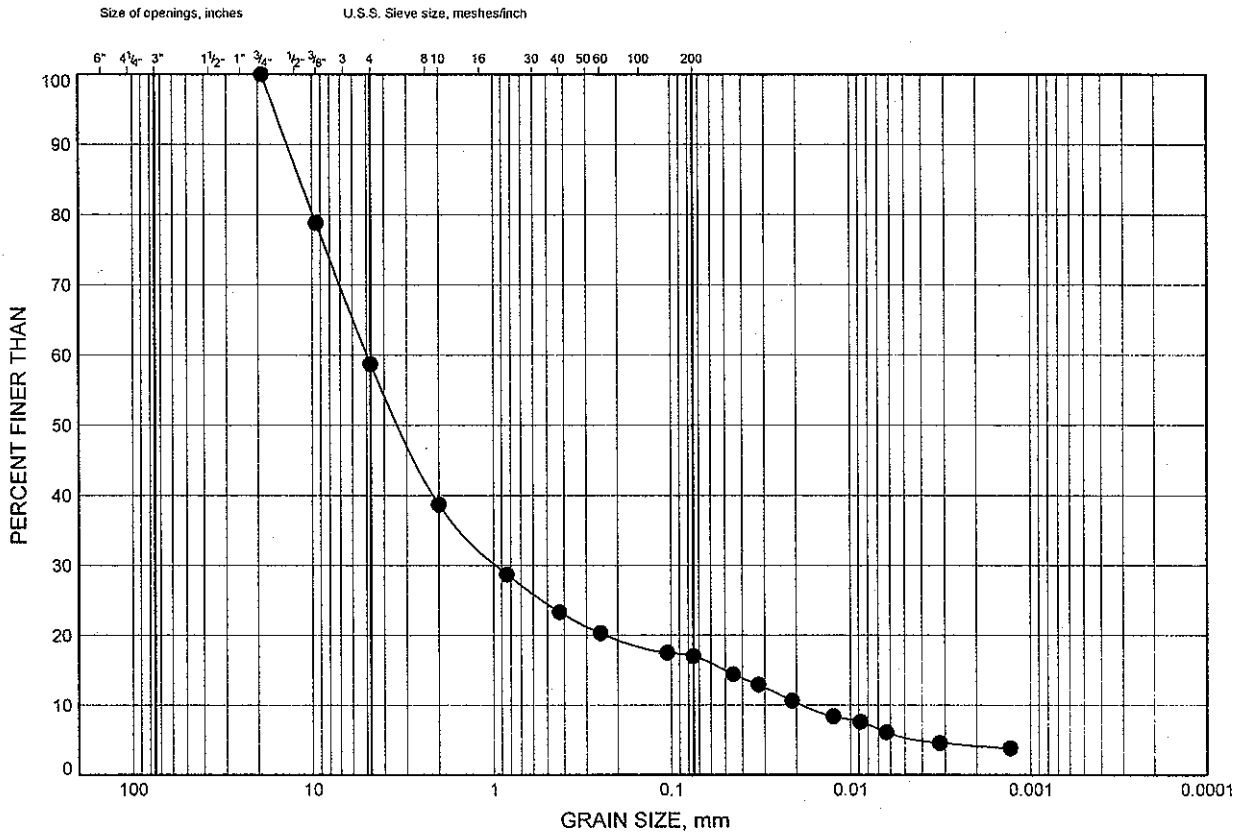
Terraprobe Inc.



# GRAIN SIZE DISTRIBUTION

FIGURE B1

## FILL - Sand and Gravel




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

| SYMBOL | BOREHOLE | DEPTH (m) | ELEVATION (m) |
|---|---|---|---|
| ● | SBL 12+685CL | 0.3 | 182.4 |

Date May 2010

Project 1-09-4135

Prep'd DB

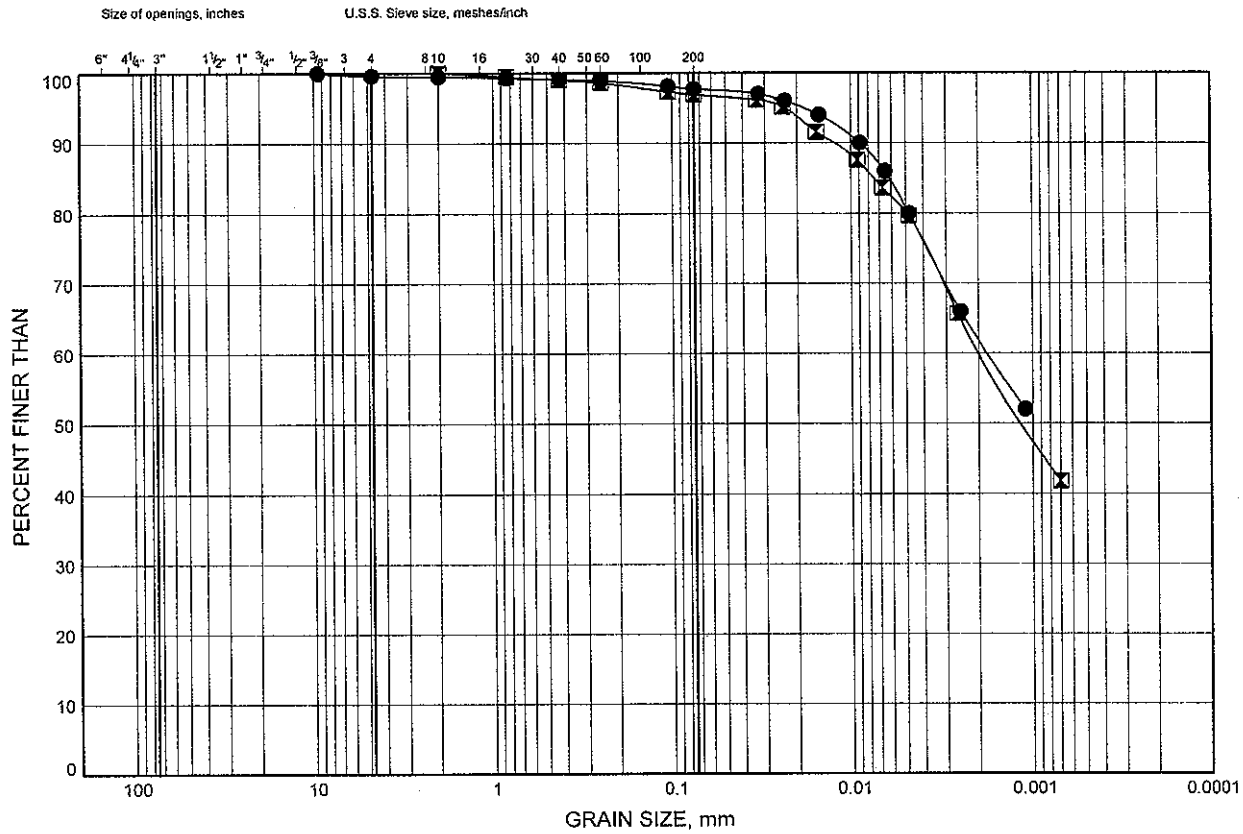
Chkd. MP

GSD 1-09-4135 WS BRIDGE.GPJ 05/27/10

# 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) |
|---|---|---|---|
| ● | WS1 | 1.0 | 181.7 |
| ⊠ | WS3 | 1.7 | 181.3 |

Date May 2010

Project 1-09-4135

Prep'd DB

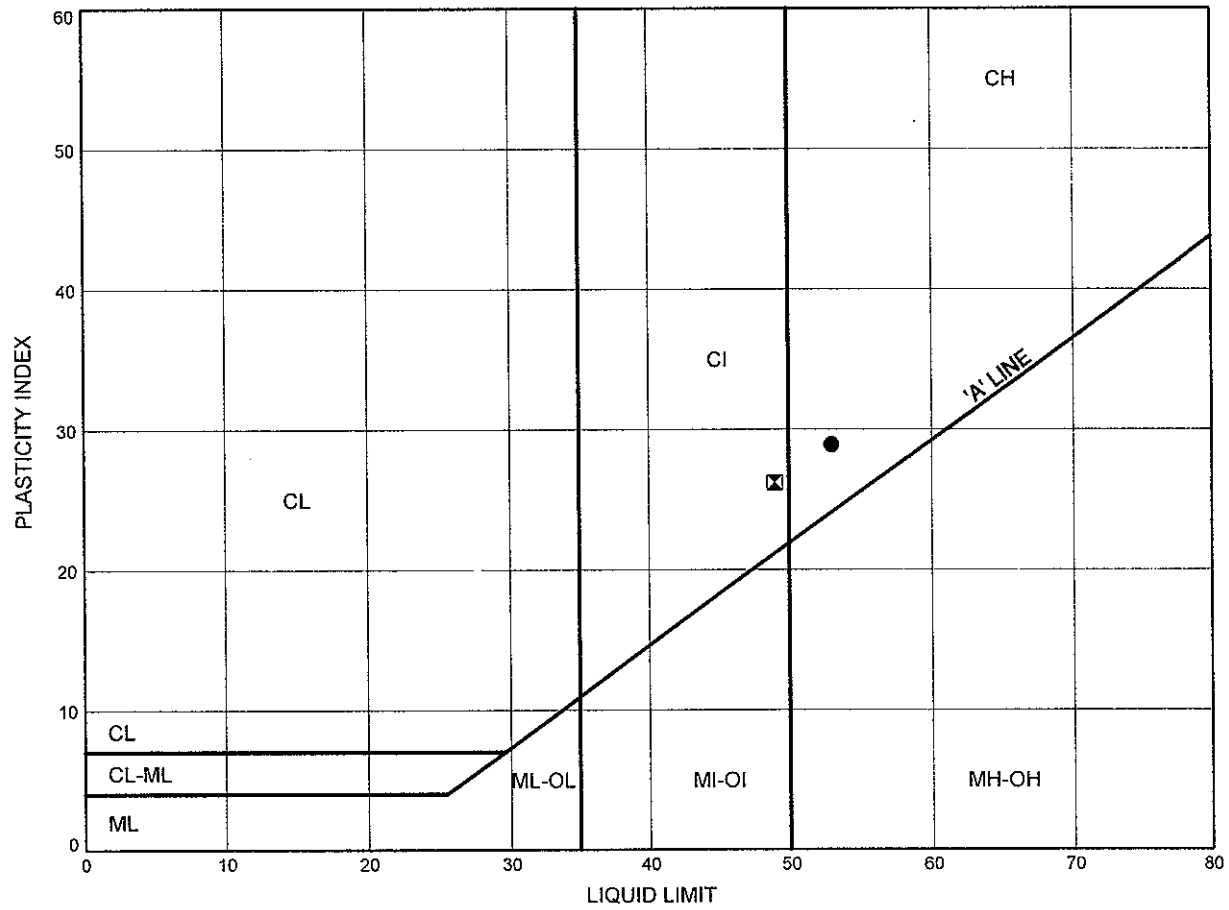
Chkd. MP

GSD 1-09-4135 WS BRIDGE.GPJ 05/27/10

# ATTERBERG LIMITS TEST RESULTS

FIGURE B3

## FILL - Silty Clay




| SYMBOL | BOREHOLE | DEPTH (m) | ELEVATION (m) |
|---|---|---|---|
| ● | WS1 | 1.0 | 181.7 |
| ⊠ | WS3 | 1.7 | 181.3 |

Date May 2010

Project 1-09-4135

Prep'd DB

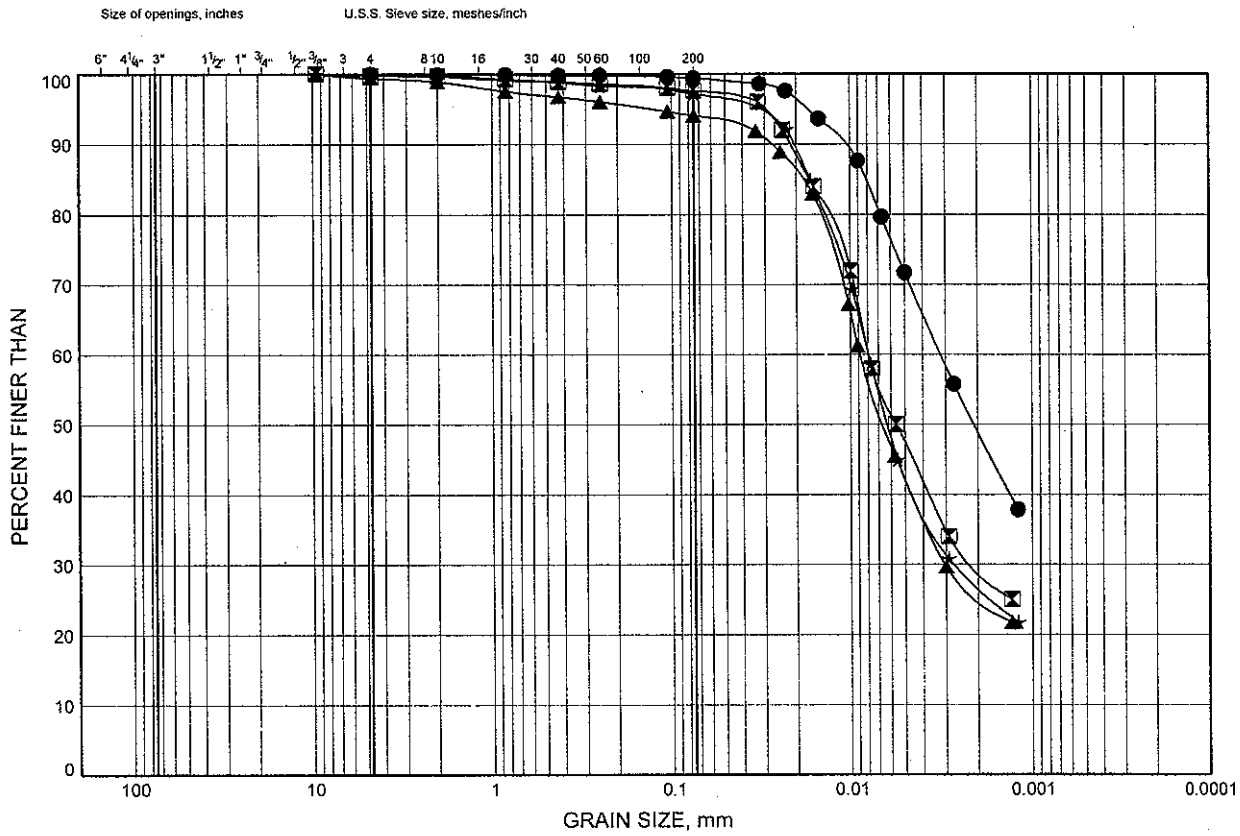
Chkd. MP

ALTR 1-09-4135 WS BRIDGE.GPJ 05/27/10

# 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) |
|---|---|---|---|
| ● | SBL 12+685CL | 2.5 | 180.2 |
| ⊠ | SBL 12+685CL | 6.3 | 176.4 |
| ▲ | SBL 12+685CL | 9.3 | 173.4 |
| ★ | SBL 12+685CL | 10.9 | 171.8 |

Date May 2010

Project 1-09-4135

Prep'd DB

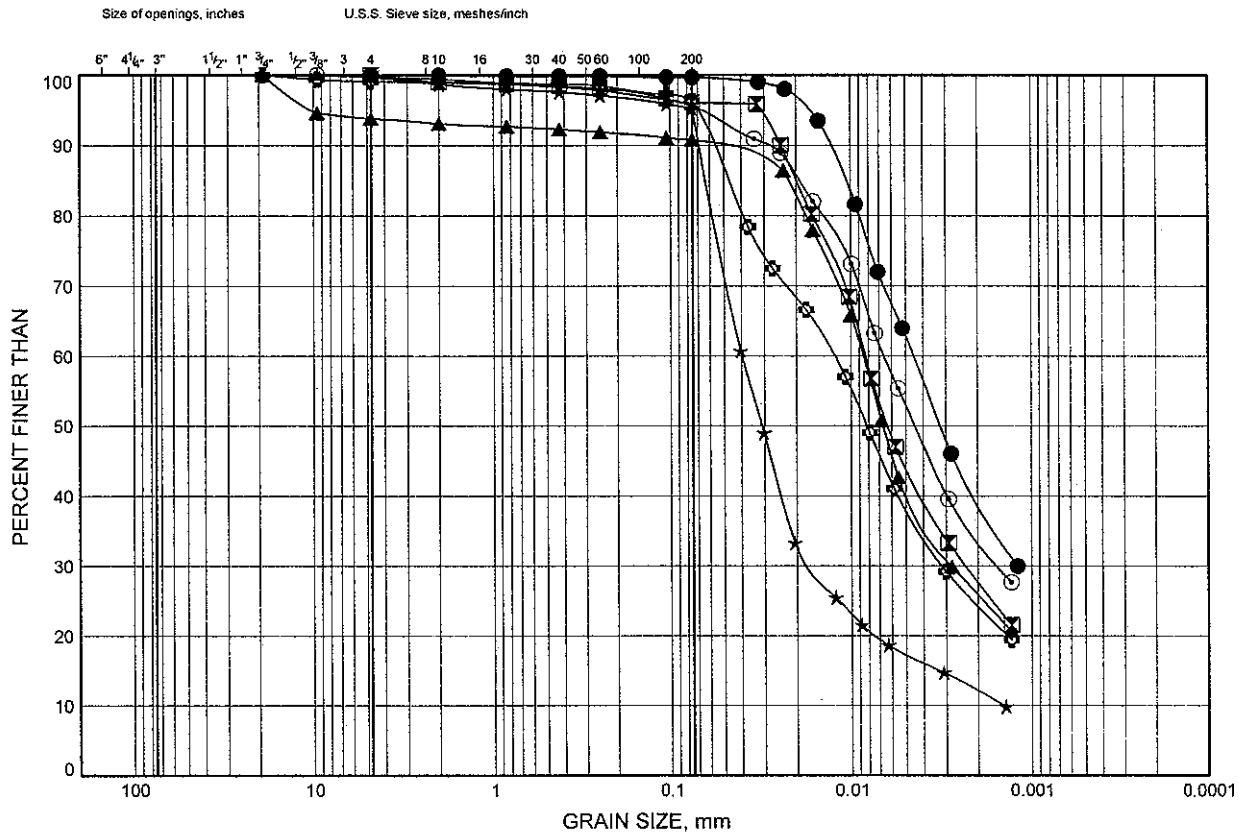
Chkd. MP

GSD 1-09-4135 WS BRIDGE.GPJ 05/27/10

# 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) |
|---|---|---|---|
| ● | SBL 12+750CL | 3.2 | 179.7 |
| ⊠ | SBL 12+750CL | 7.8 | 175.1 |
| ▲ | SBL 12+750CL | 10.1 | 172.8 |
| ★ | WS1 | 7.8 | 174.9 |
| ⊙ | WS1 | 9.3 | 173.4 |
| ✿ | WS1 | 13.9 | 168.8 |

Date May 2010

Project 1-09-4135

Prep'd DB

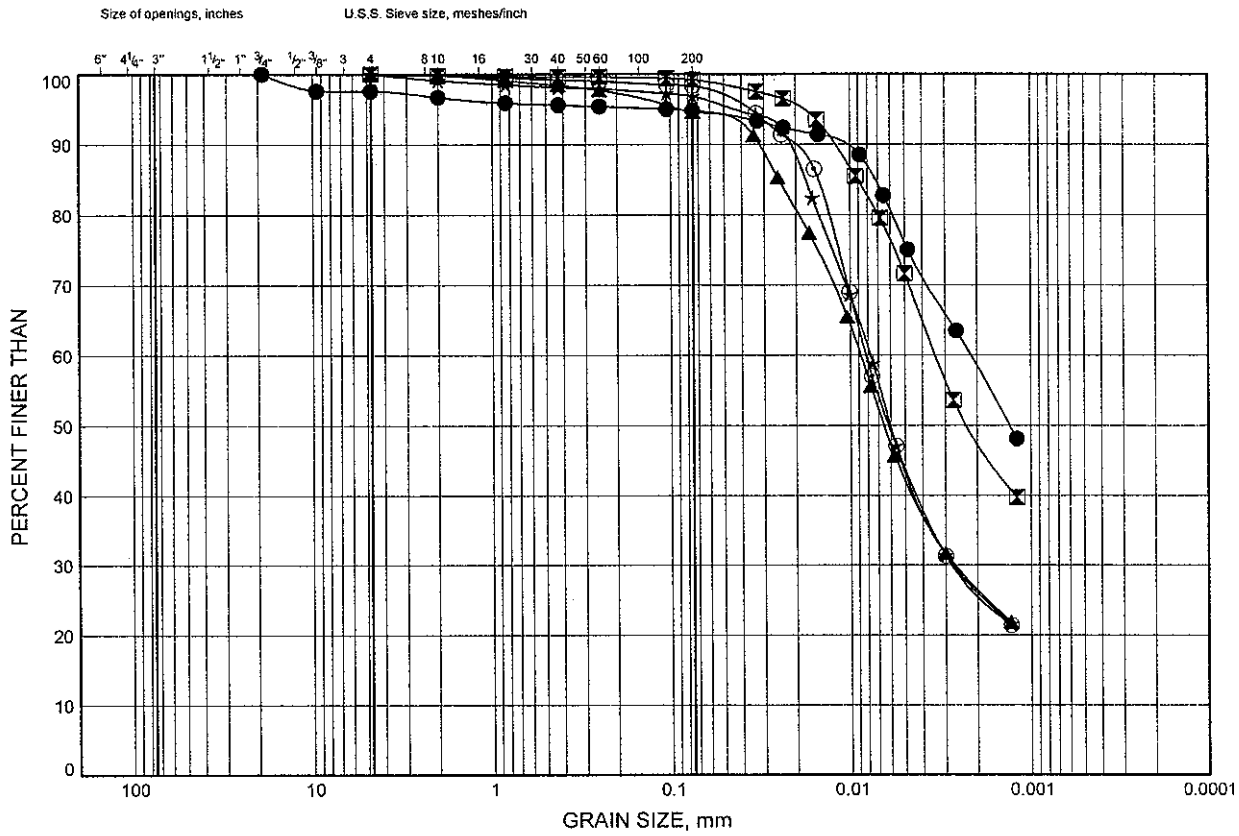
Chkd. MP

GSD 1-09-4135 WS BRIDGE.GPJ 05/27/10

# 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) |
|---|---|---|---|
| ● | WS2 | 1.0 | 182.1 |
| ⊠ | WS2 | 2.5 | 180.6 |
| ▲ | WS2 | 6.3 | 176.8 |
| ★ | WS2 | 10.9 | 172.2 |
| ⊙ | WS2 | 12.4 | 170.7 |

Date May 2010

Project 1-09-4135

Prep'd DB

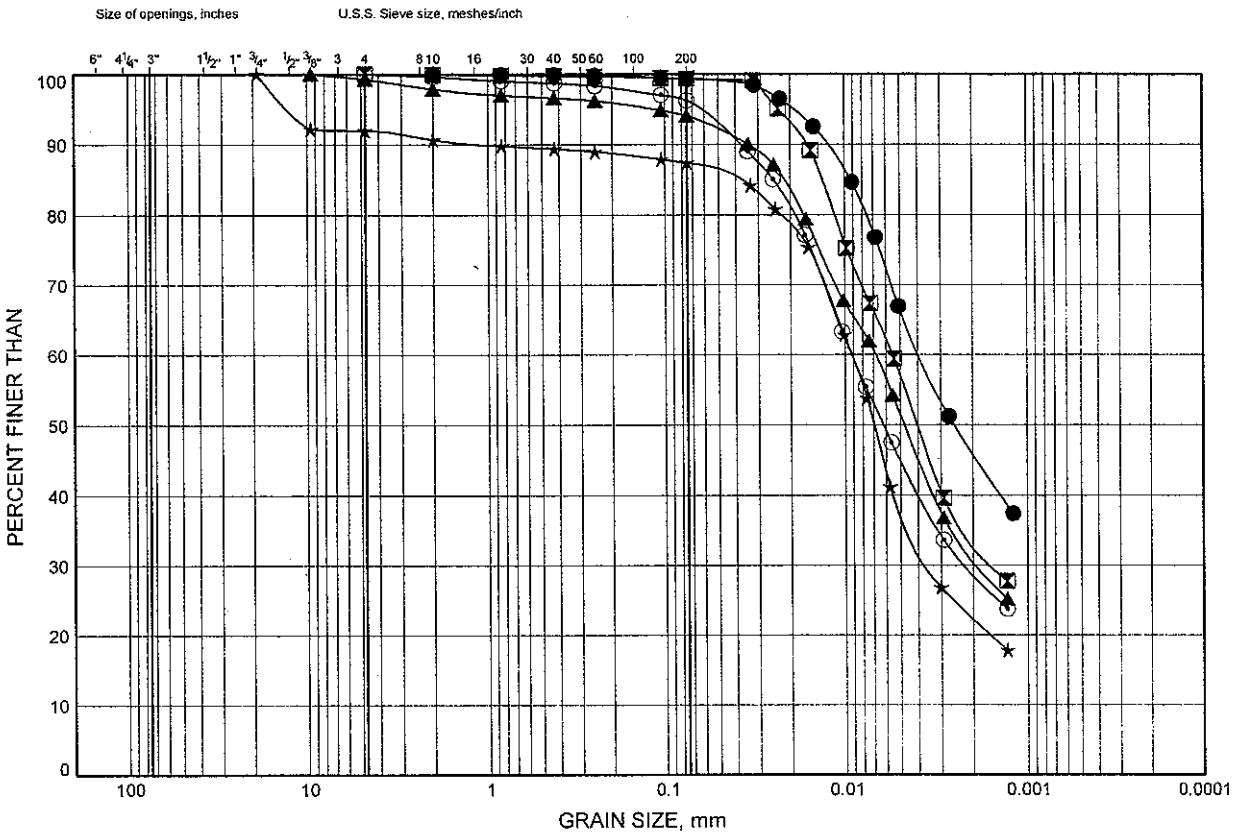
Chkd. MP

GSD 1-09-4135 WS BRIDGE.GPJ 05/27/10

# 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) |
|---|---|---|---|
| ● | WS3 | 3.2 | 179.8 |
| ⊠ | WS3 | 4.7 | 178.3 |
| ▲ | WS3 | 7.8 | 175.2 |
| ★ | WS3 | 10.9 | 172.1 |
| ⊙ | WS3 | 13.9 | 169.1 |

Date May 2010

Project 1-09-4135

Prep'd DB

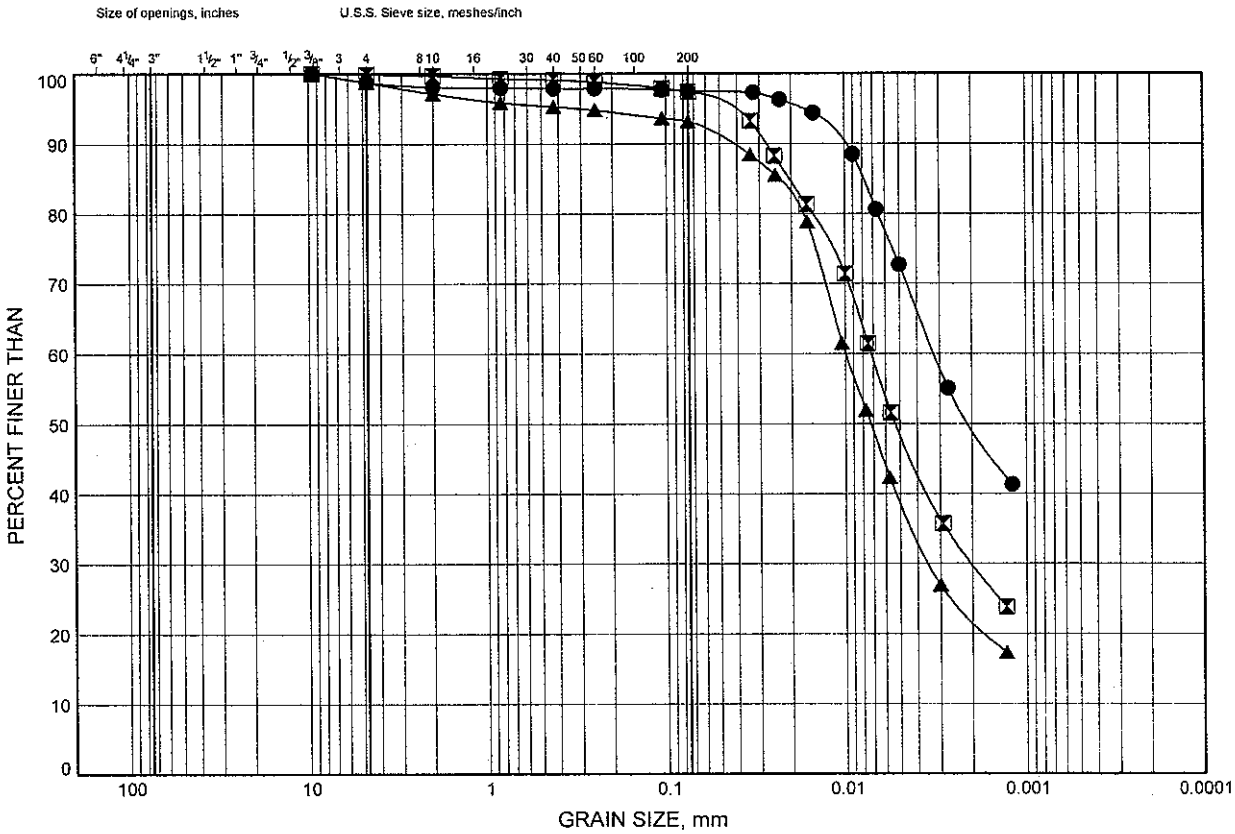
Chkd. MP

GSD 1-09-4135 WS BRIDGE.GPJ 05/27/10

# GRAIN SIZE DISTRIBUTION

FIGURE B8

## SILTY CLAY




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

| SYMBOL | BOREHOLE | DEPTH (m) | ELEVATION (m) |
|---|---|---|---|
| ● | WS4 | 2.5 | 180.2 |
| ⊠ | WS4 | 9.3 | 173.4 |
| ▲ | WS4 | 12.4 | 170.3 |

Date May 2010

Project 1-09-4135

Prep'd DB

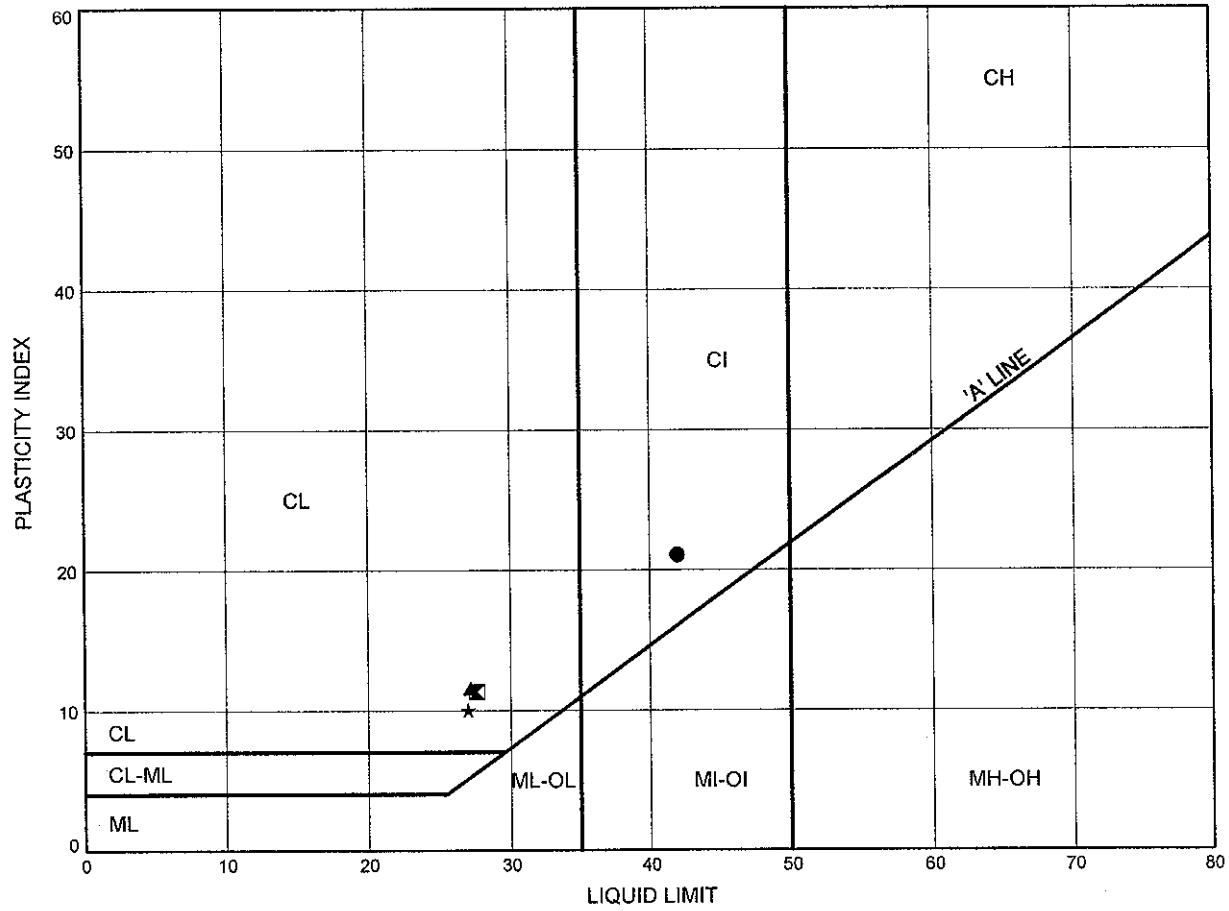
Chkd. MP

GSD 1-09-4135 WS BRIDGE.GPJ 05/27/10

# ATTERBERG LIMITS TEST RESULTS

FIGURE B9

## SILTY CLAY




| SYMBOL | BOREHOLE | DEPTH (m) | ELEVATION (m) |
|---|---|---|---|
| ● | SBL 12+685CL | 2.5 | 180.2 |
| ⊠ | SBL 12+685CL | 6.3 | 176.4 |
| ▲ | SBL 12+685CL | 9.3 | 173.4 |
| ★ | SBL 12+685CL | 10.9 | 171.8 |

Date May 2010

Project 1-09-4135

Prep'd DB

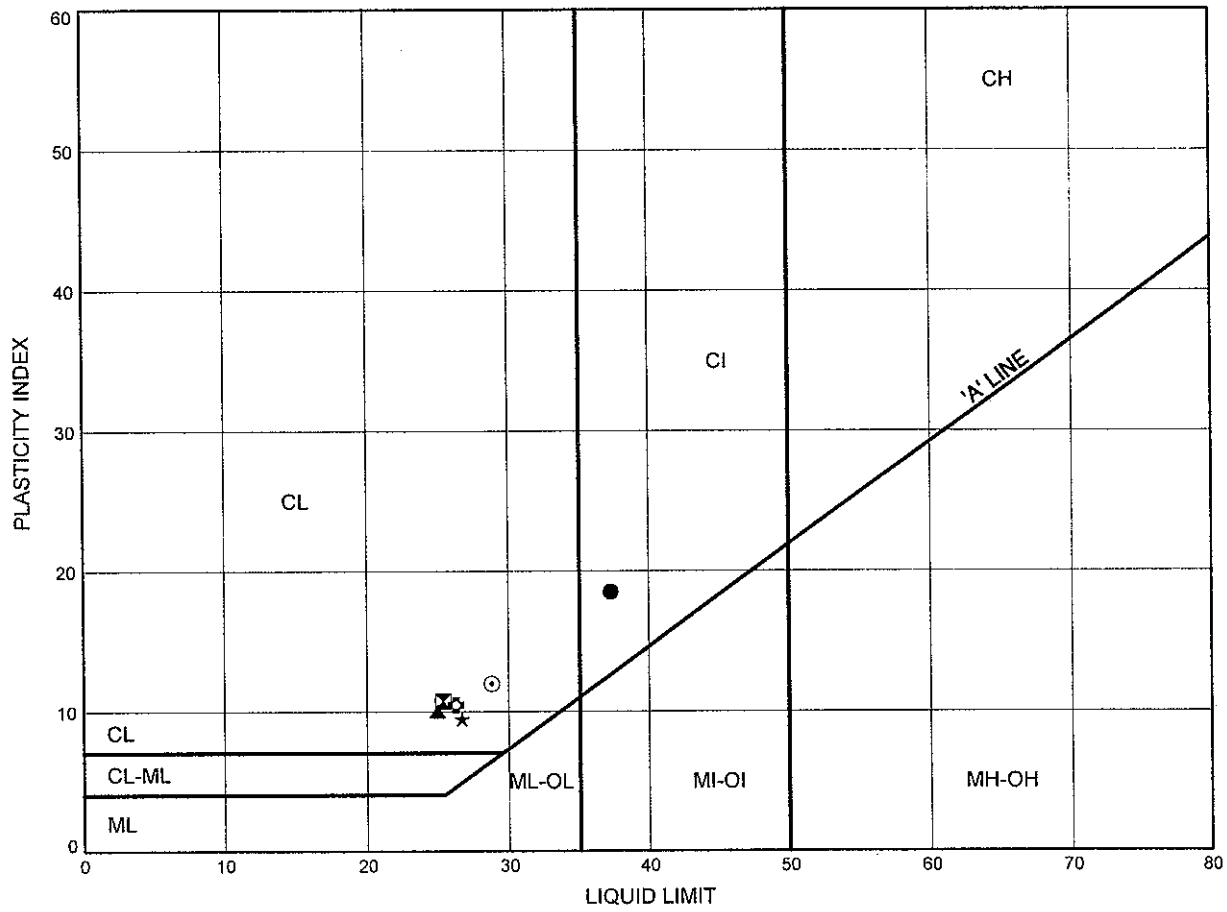
Chkd. MP

ALTR 1-09-4135 WS BRIDGE.GPJ 05/27/10

# ATTERBERG LIMITS TEST RESULTS

FIGURE B10

## SILTY CLAY




| SYMBOL | BOREHOLE | DEPTH (m) | ELEVATION (m) |
|---|---|---|---|
| ● | SBL 12+750CL | 3.2 | 179.7 |
| ⊠ | SBL 12+750CL | 7.8 | 175.1 |
| ▲ | SBL 12+750CL | 10.1 | 172.8 |
| ★ | WS1 | 7.8 | 174.9 |
| ⊙ | WS1 | 9.3 | 173.4 |
| ✿ | WS1 | 13.9 | 168.8 |

Date May 2010

Project 1-09-4135

Prep'd DB

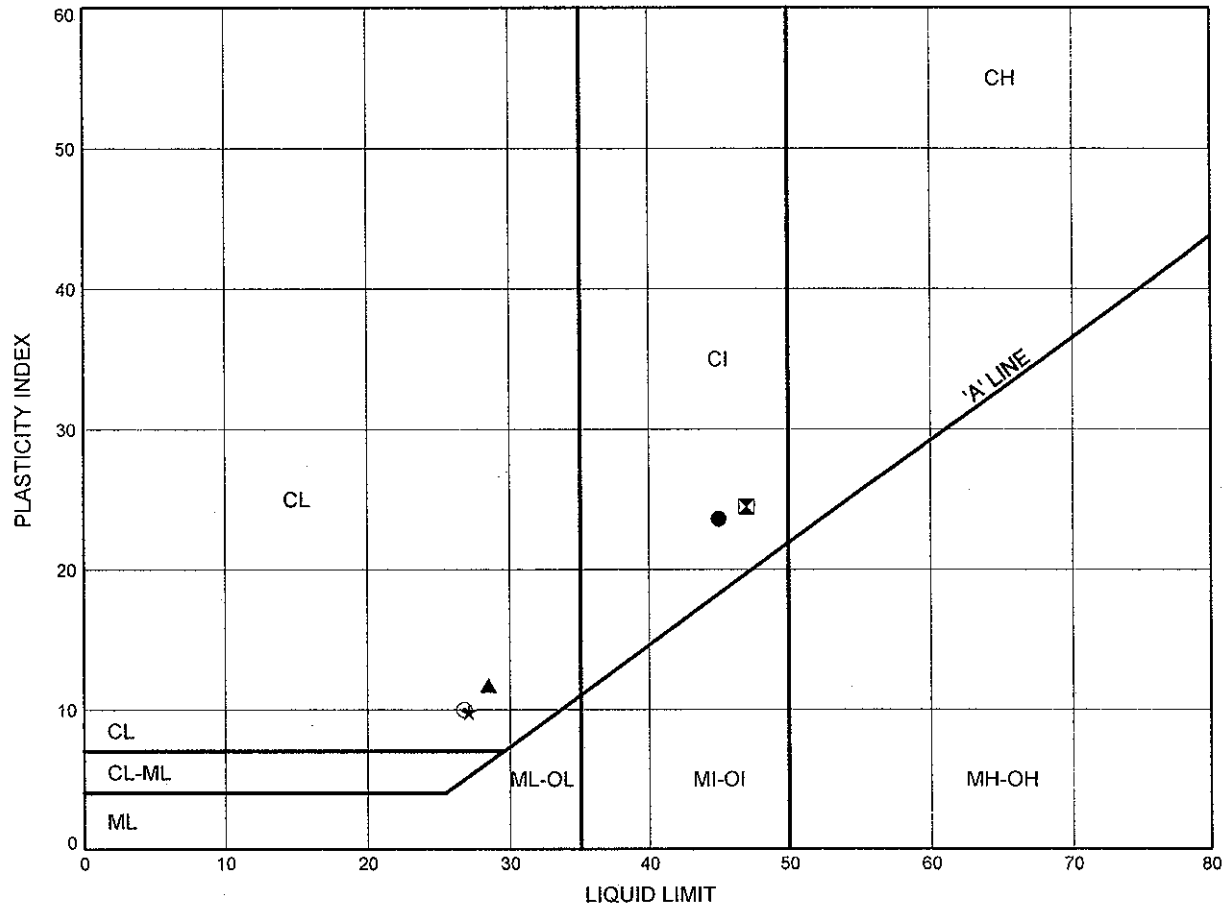
Chkd. MP

ALTR 1-09-4135 WS BRIDGE.GPJ 05/27/10

# ATTERBERG LIMITS TEST RESULTS

FIGURE B11

## SILTY CLAY




| SYMBOL | BOREHOLE | DEPTH (m) | ELEVATION (m) |
|---|---|---|---|
| ● | WS2 | 1.0 | 182.1 |
| ⊠ | WS2 | 2.5 | 180.6 |
| ▲ | WS2 | 6.3 | 176.8 |
| ★ | WS2 | 10.9 | 172.2 |
| ⊙ | WS2 | 12.4 | 170.7 |

Date May 2010

Project 1-09-4135

Prep'd DB

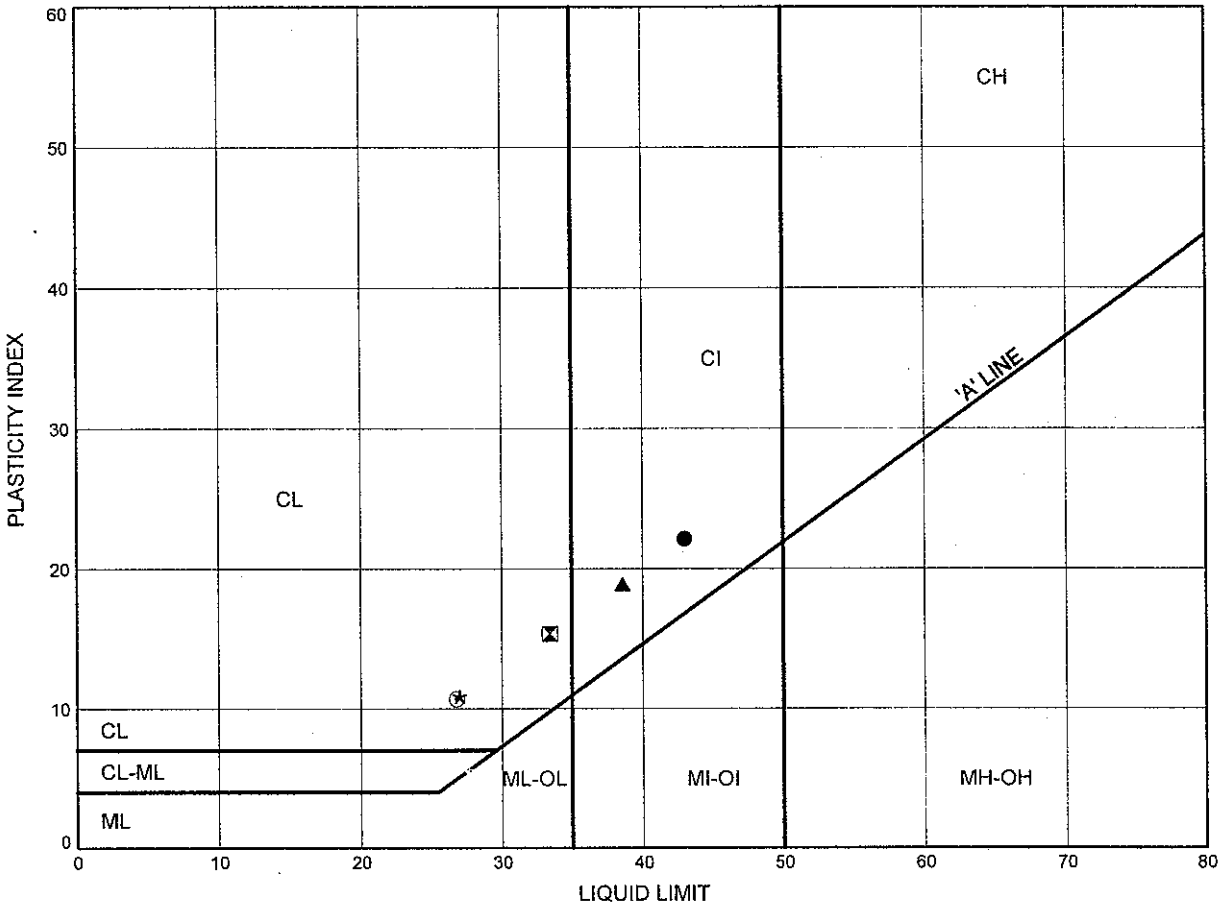
Chkd. MP

ALTR 1-09-4135 WS BRIDGE.GPJ 05/27/10

# ATTERBERG LIMITS TEST RESULTS

FIGURE B12

## SILTY CLAY




| SYMBOL | BOREHOLE | DEPTH (m) | ELEVATION (m) |
|---|---|---|---|
| ● | WS3 | 3.2 | 179.8 |
| ⊠ | WS3 | 4.7 | 178.3 |
| ▲ | WS3 | 7.8 | 175.2 |
| ★ | WS3 | 10.9 | 172.1 |
| ⊙ | WS3 | 13.9 | 169.1 |

Date May 2010

Project 1-09-4135

Prep'd DB

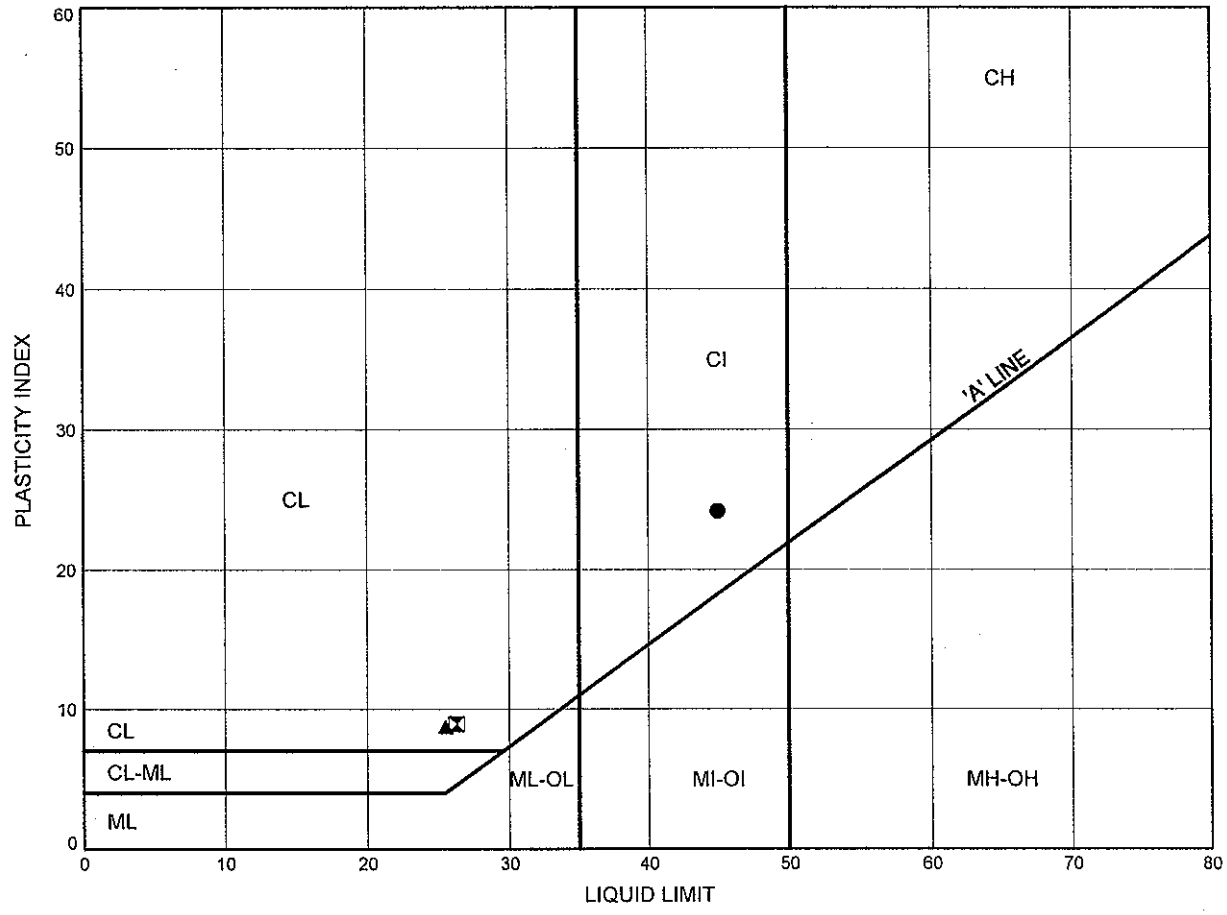
Chkd. MP

ALTR 1-09-4135 WS BRIDGE.GPJ 05/27/10

# ATTERBERG LIMITS TEST RESULTS

FIGURE B13

## SILTY CLAY




| SYMBOL | BOREHOLE | DEPTH (m) | ELEVATION (m) |
|---|---|---|---|
| ● | WS4 | 2.5 | 180.2 |
| ⊠ | WS4 | 9.3 | 173.4 |
| ▲ | WS4 | 12.4 | 170.3 |

Date May 2010

Project 1-09-4135

Prep'd DB

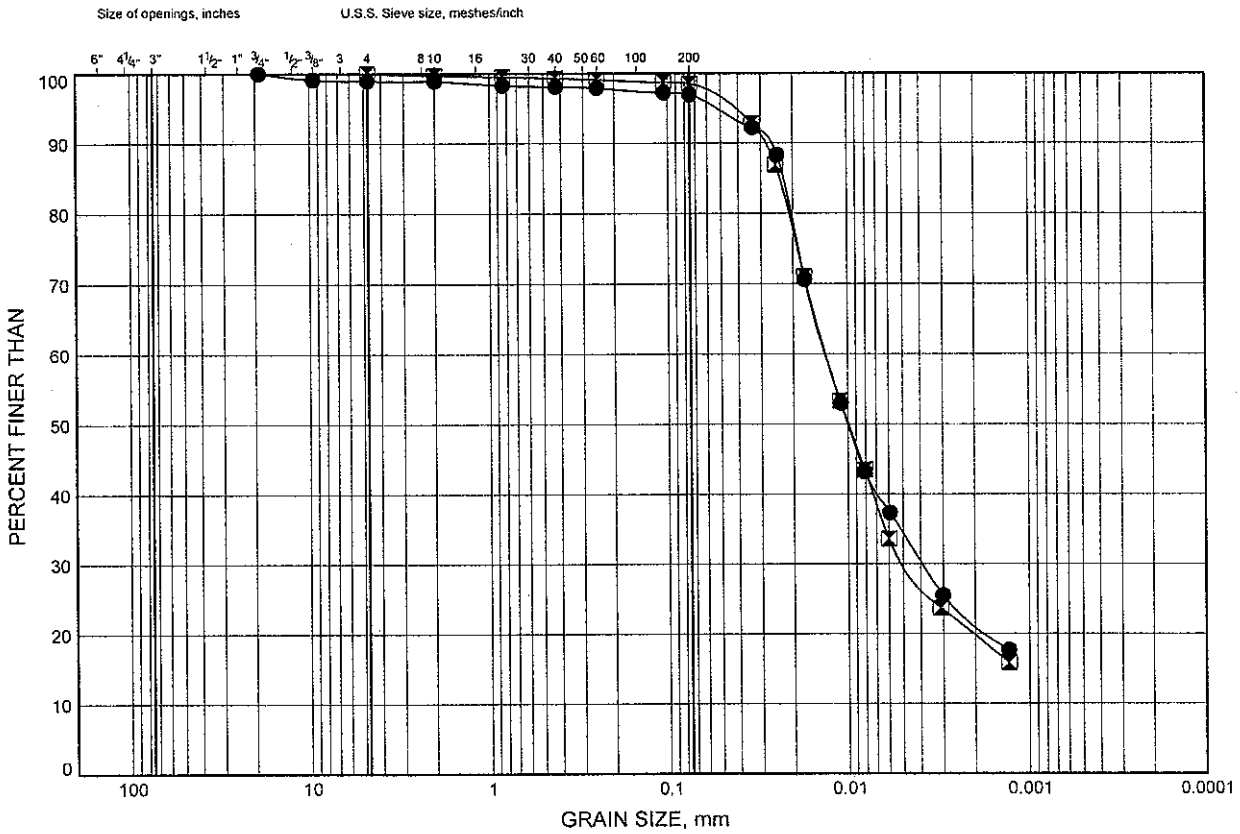
Chkd. MP

ALTR 1-09-4135 WS BRIDGE.GPJ 05/27/10

# 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) |
|---|---|---|---|
| ● | WS1 | 4.7 | 178.0 |
| ⊠ | WS2 | 4.7 | 178.4 |

Date May 2010

Project 1-09-4135

Prep'd DB

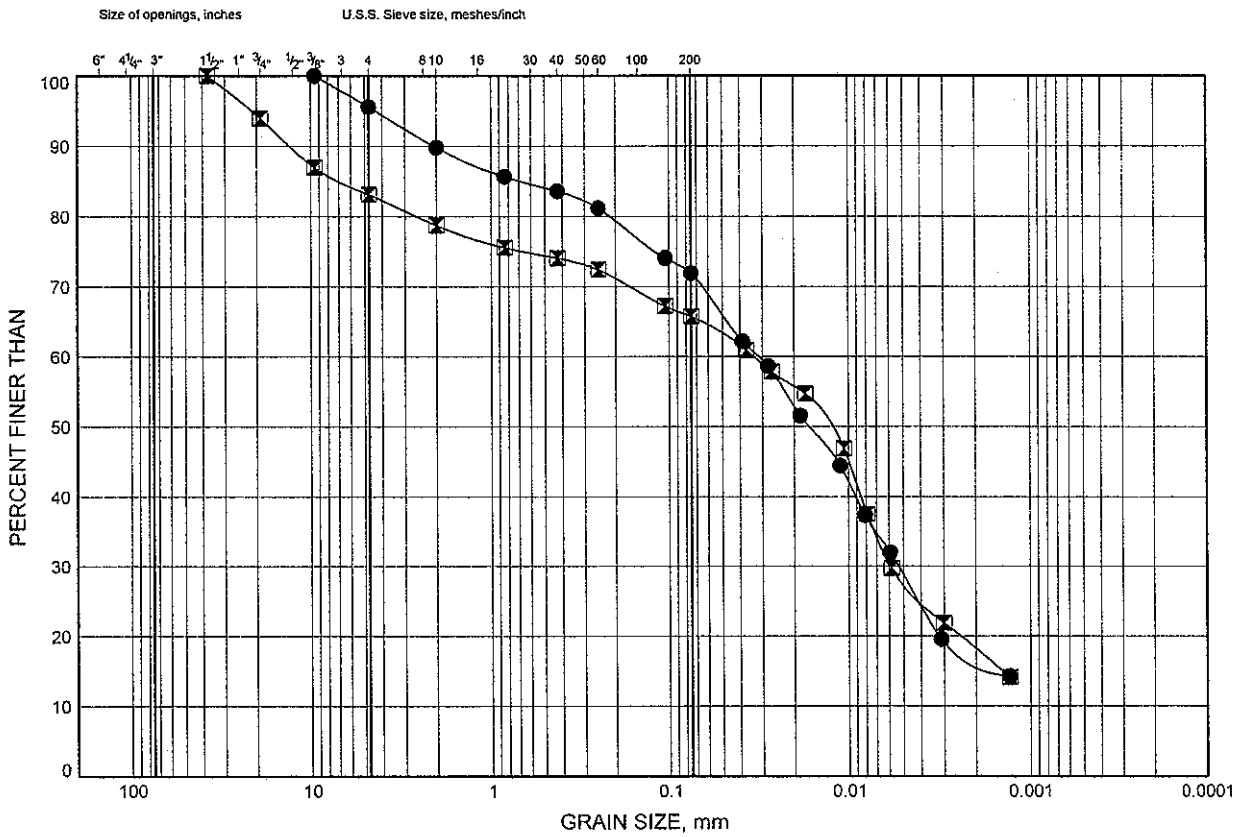
Chkd. MP

GSD 1-09-4135 WS BRIDGE.GPJ 05/27/10

# GRAIN SIZE DISTRIBUTION

FIGURE B15

## SILTY CLAY TILL




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

| SYMBOL | BOREHOLE | DEPTH (m) | ELEVATION (m) |
|---|---|---|---|
| ● | WS1 | 15.4 | 167.3 |
| ⊠ | WS4 | 15.4 | 167.3 |

Date May 2010

Project 1-09-4135

Prep'd DB

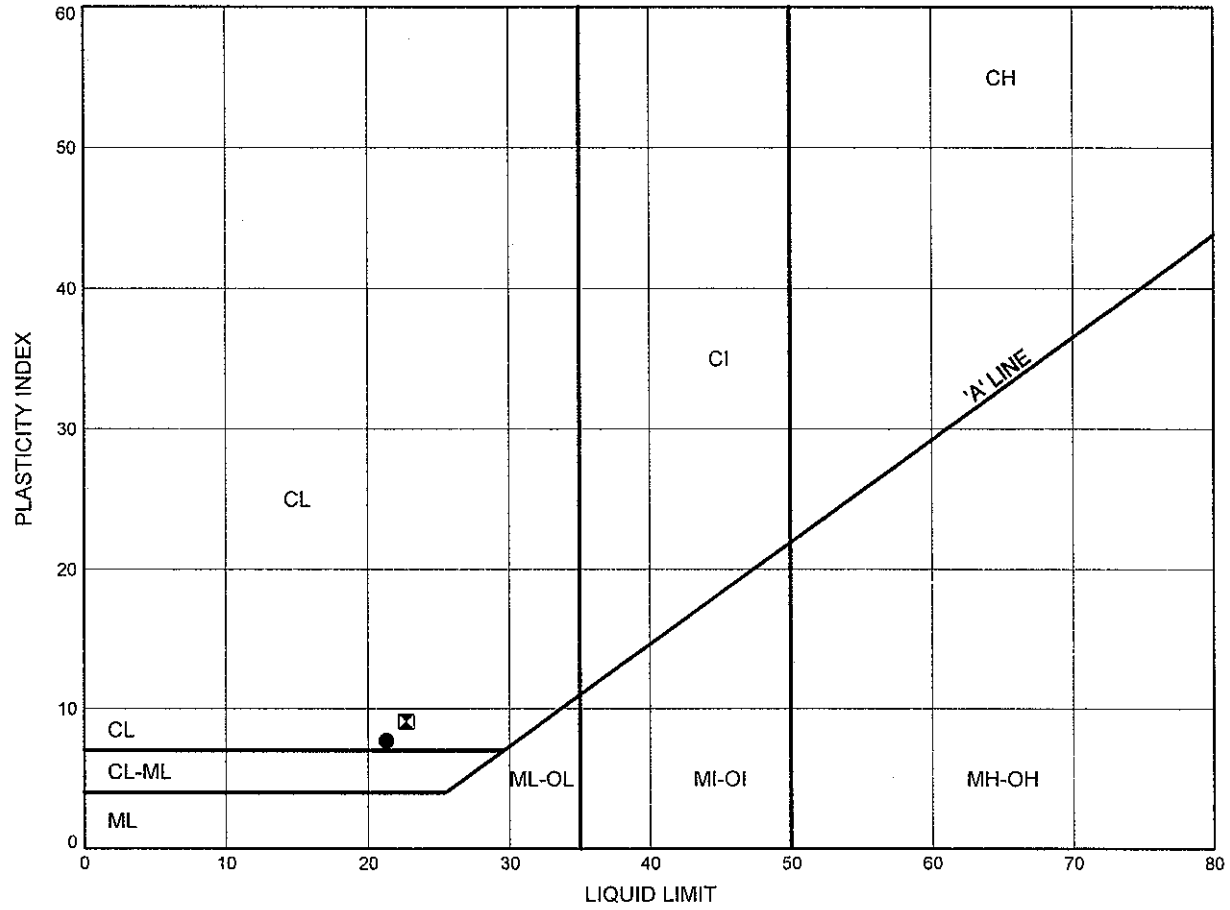
Chkd. MP

GSD 1-09-4135 WS BRIDGE.GPJ 05/27/10

# ATTERBERG LIMITS TEST RESULTS

FIGURE B16

## SILTY CLAY TILL




| SYMBOL | BOREHOLE | DEPTH (m) | ELEVATION (m) |
|---|---|---|---|
| ● | WS1 | 15.4 | 167.3 |
| ⊠ | WS4 | 15.4 | 167.3 |

Date May 2010

Project 1-09-4135

Prep'd DB

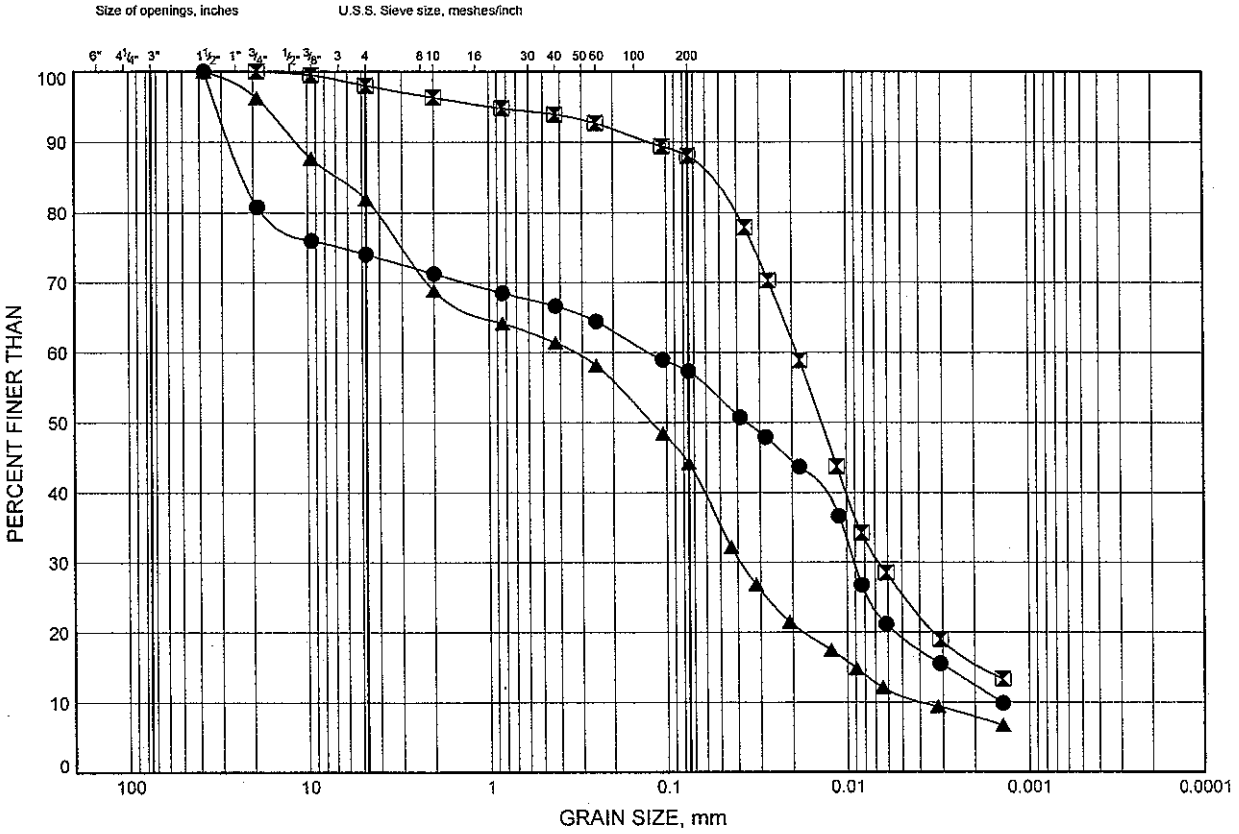
Chkd. MP

ALTR 1-09-4135 WS BRIDGE.GPJ 05/27/10

# GRAIN SIZE DISTRIBUTION

FIGURE B17

## SANDY SILT TO SAND AND SILT TILL




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

| SYMBOL | BOREHOLE | DEPTH (m) | ELEVATION (m) |
|---|---|---|---|
| ● | WS2 | 18.5 | 164.6 |
| ⊠ | WS3 | 18.5 | 164.5 |
| ▲ | WS4 | 23.1 | 159.6 |

Date May 2010

Project 1-09-4135

Prep'd DB

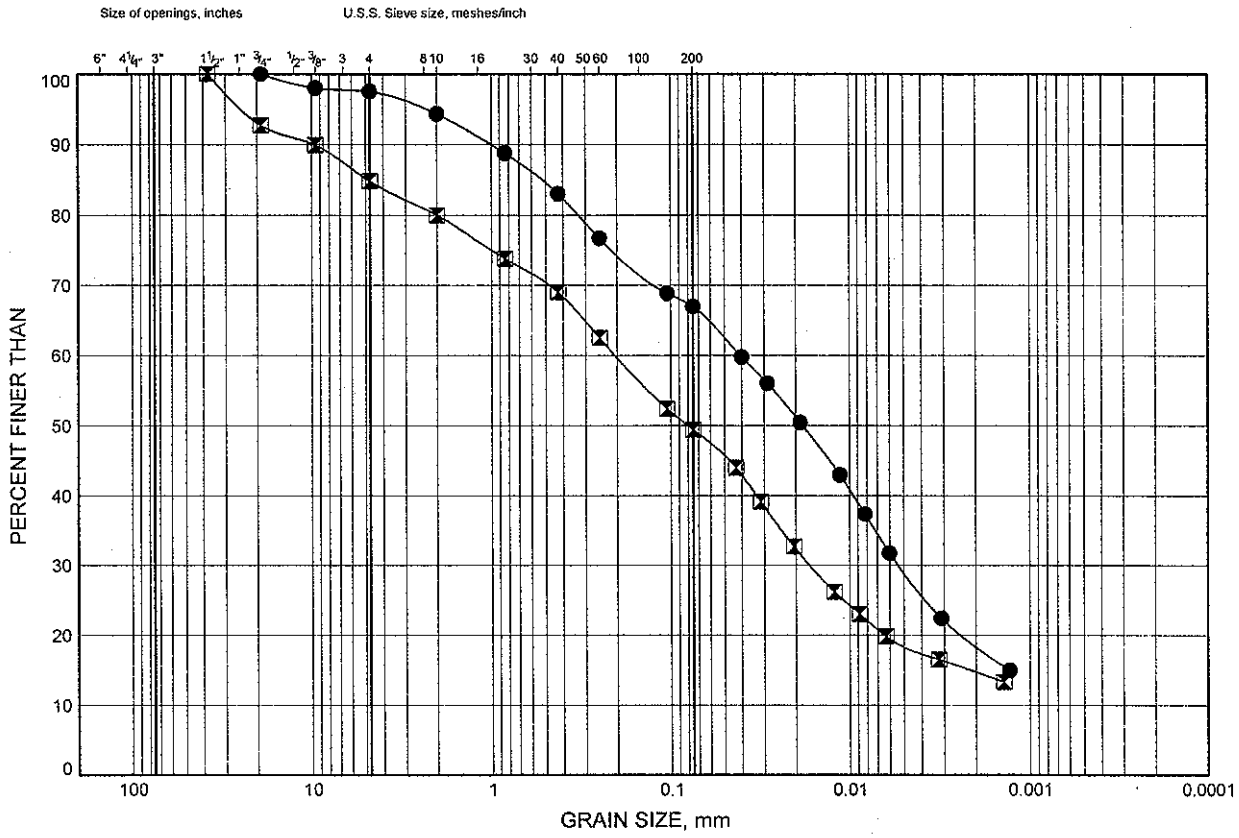
Chkd. MP

GSD 1-09-4135 WS BRIDGE.GPJ 05/27/10

# GRAIN SIZE DISTRIBUTION

FIGURE B18

## CLAYEY SILT TILL




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

| SYMBOL | BOREHOLE | DEPTH (m) | ELEVATION (m) |
|---|---|---|---|
| ● | WS1 | 21.5 | 161.2 |
| ⊠ | WS2 | 21.5 | 161.6 |

Date May 2010

Project 1-09-4135

Prep'd DB

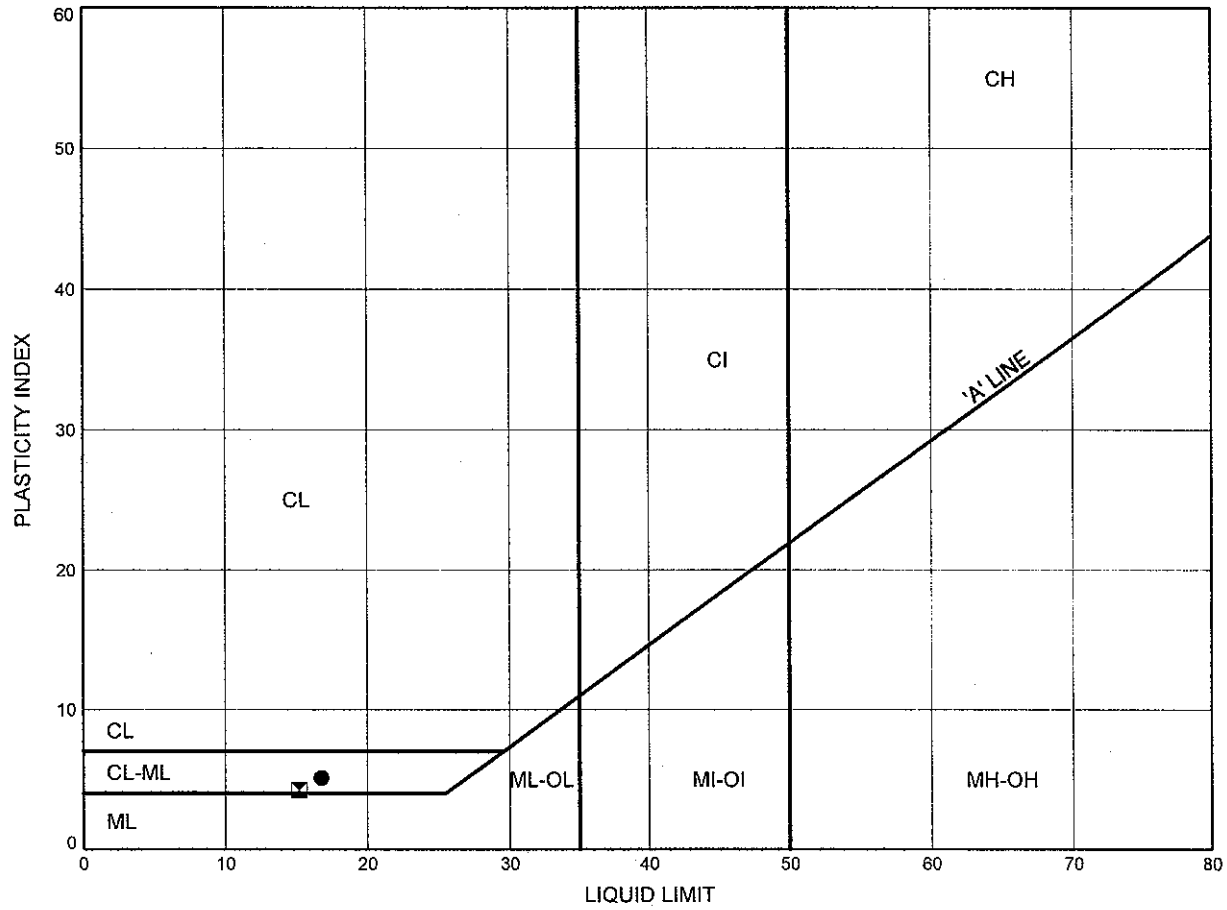
Chkd. MP

GSD 1-09-4135 WS BRIDGE.GPJ 05/27/10

# ATTERBERG LIMITS TEST RESULTS

FIGURE B19

## CLAYEY SILT TILL




| SYMBOL | BOREHOLE | DEPTH (m) | ELEVATION (m) |
|---|---|---|---|
| ● | WS1 | 21.5 | 161.2 |
| ⊠ | WS2 | 21.5 | 161.6 |

Date May 2010

Project 1-09-4135

Prep'd DB

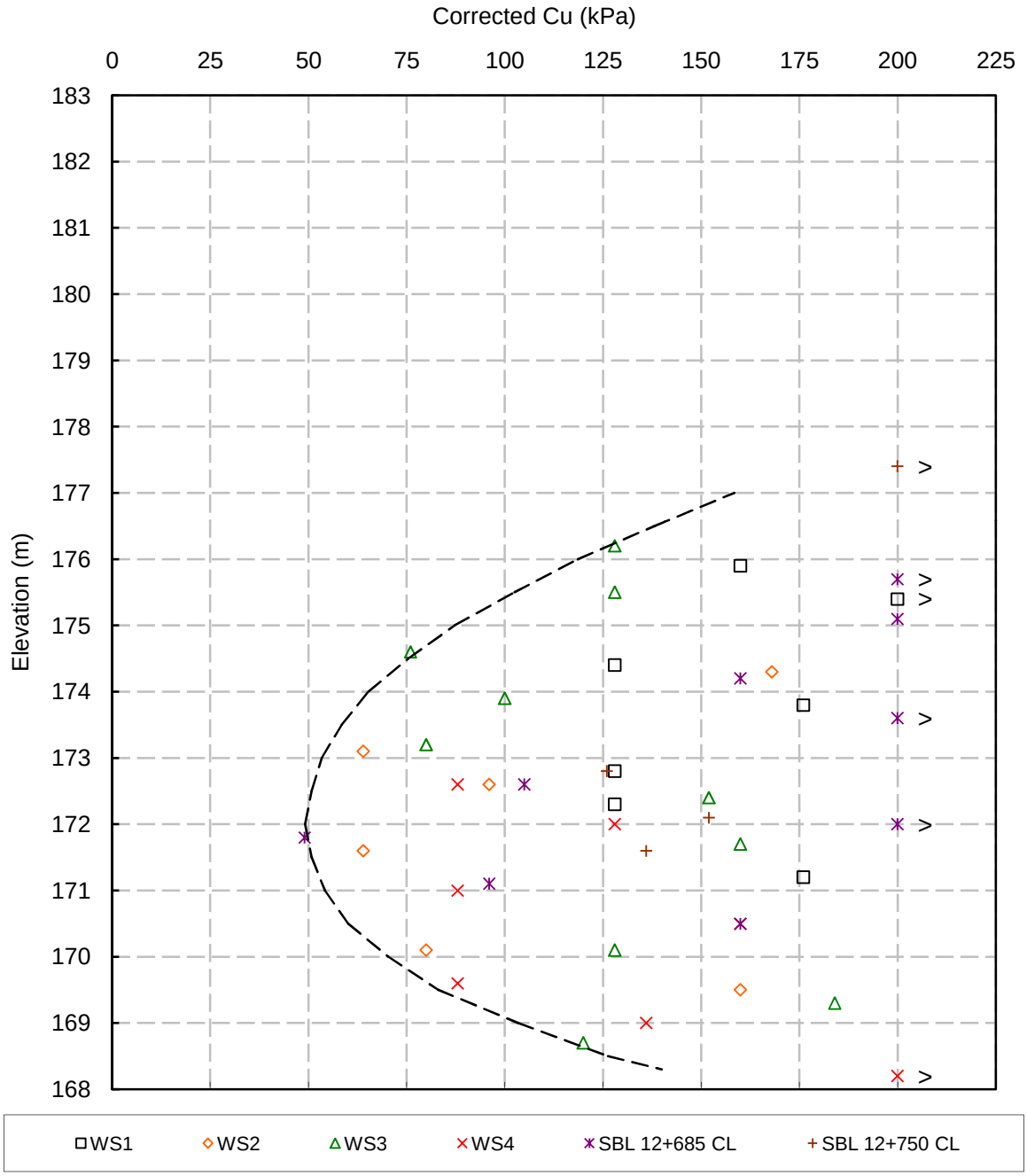
Chkd. MP

ALTR 1-09-4135 WS BRIDGE.GPJ 05/27/10

| CORRECTED UNDRAINED SHEAR STRENGTH | FIGURE B20 |
|---|---|

HWY 406 TWINNING - WOODLAWN OVERPASS (SBL)

Silty Clay




**Field Shear Vane Correction**

Morris & Williams (1994)

($\mu$ = 1.18 EXP(-0.08 Ip) + 0.57)

Applied Correction Factors

0.79 (Elev.>177m)

1.00 (Elev.<177m)

Project No. : 1-09-4135

Date : September, 2010

Terraprobe Inc.

Prepared By : HW

Checked By : RA

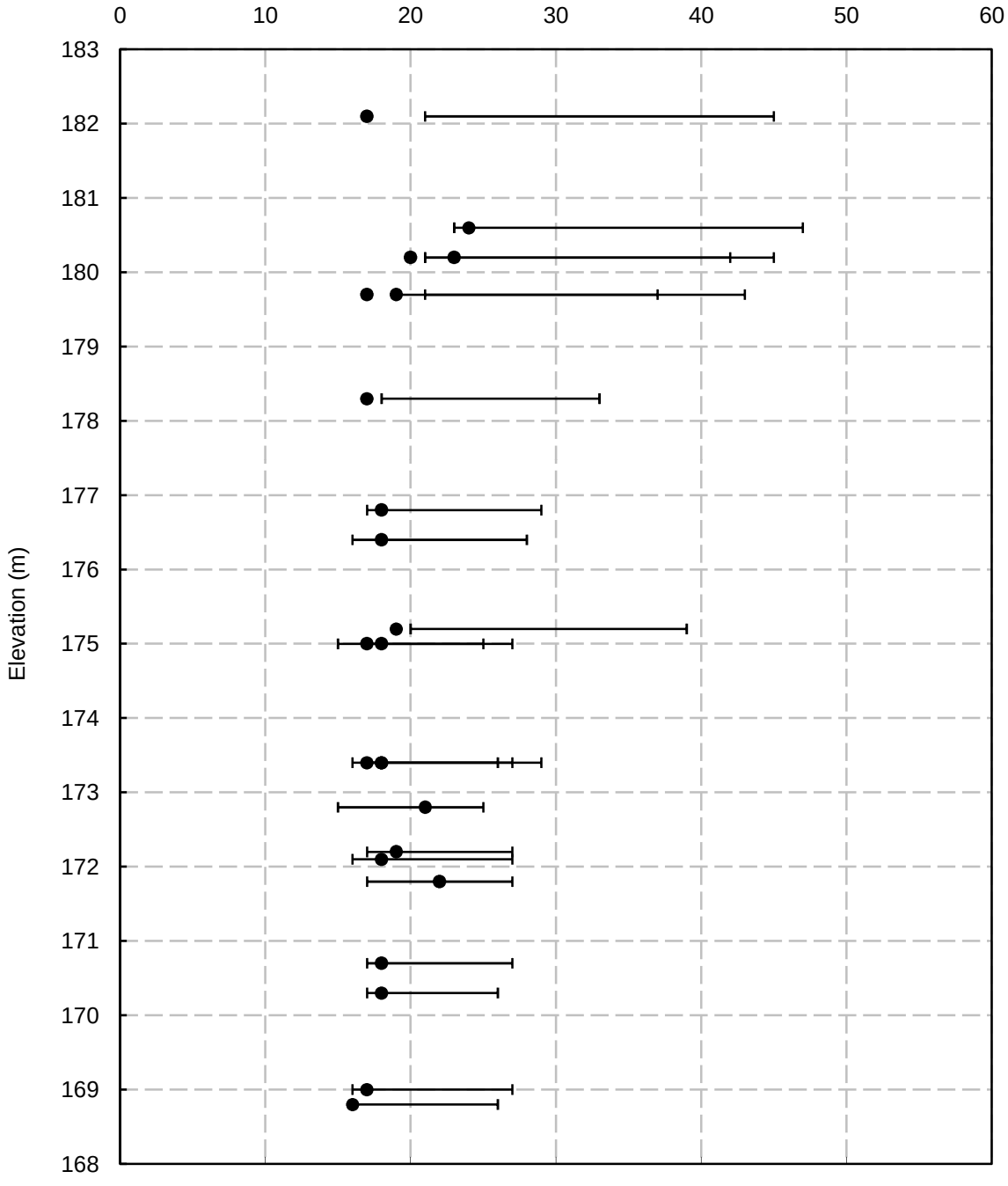
C:\Documents and Settings\HongliuMy Documents\Project 2009\1-09-4135 - HWY 406 Foundations\Bridges\1-09-4135 Soil Parameter Estimation-WS1.xls

| ATTERBERG LIMITS AND WATER CONTENTS | FIGURE B21 |
|---|---|

HWY 406 TWINNING - WOODLAWN OVERPASS (SBL)

Silty Clay

Atterberg Limits & Water Contents (%)




Project No. : 1-09-4135

Date : September, 2010

Terraprobe Inc.

Prepared By : HW

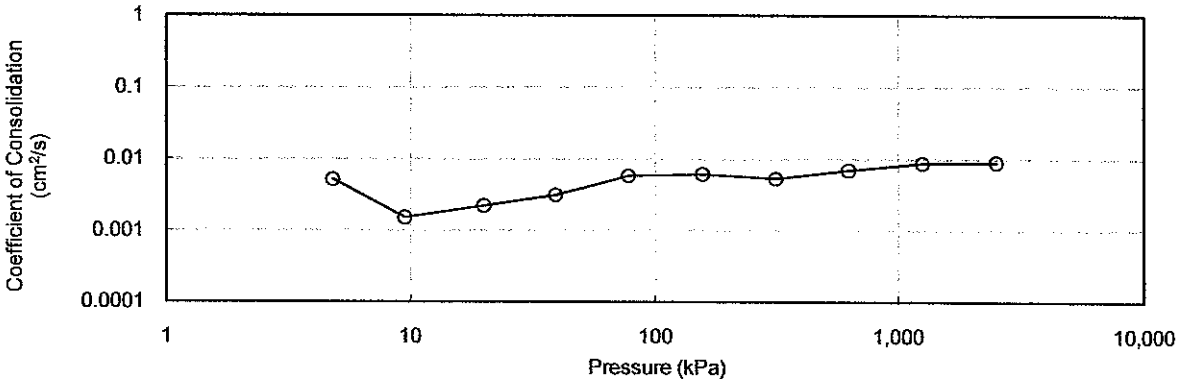
Checked By : RA

C:\Documents and Settings\HongliuMy Documents\Project 2009\1-09-4135 - HWY 406 Foundations\Bridges\1-09-4135 Soil Parameter Estimation-WS1.xls

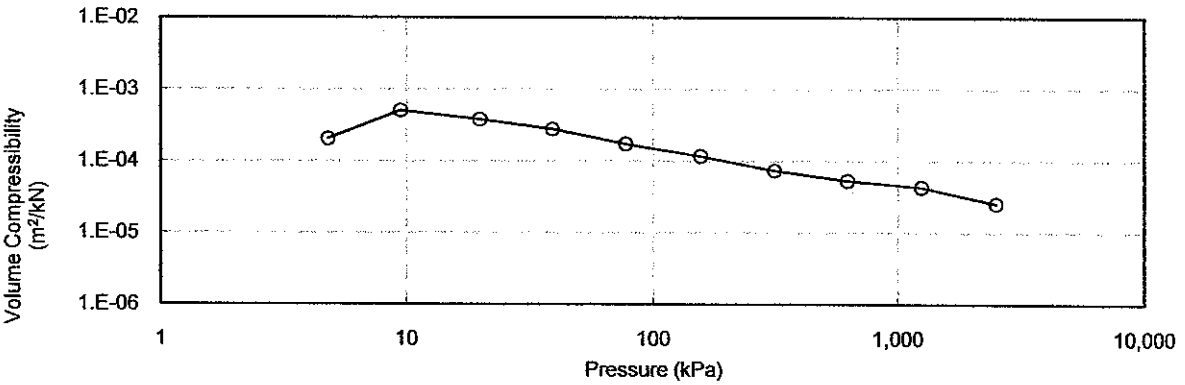
## HWY 406 TWINNING - WOODLAWN OVERPASS (SBL)

**FIGURE B22**

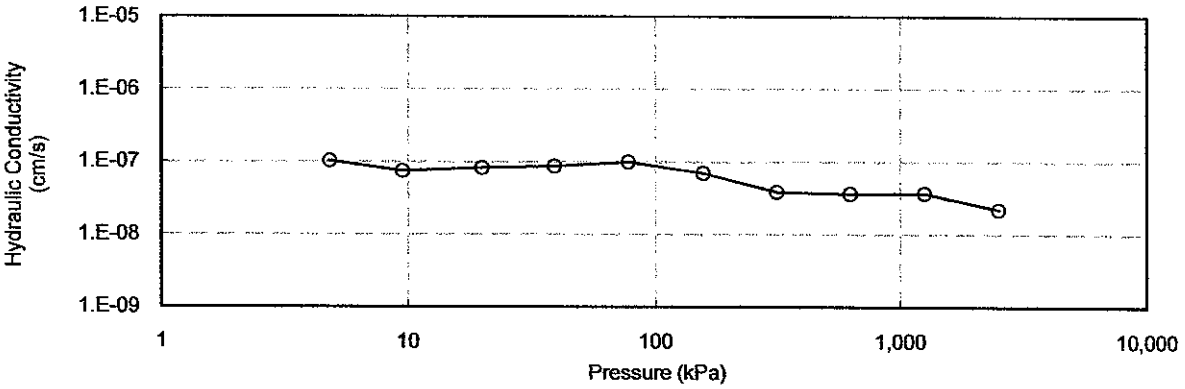
CONSOLIDATION TEST
Cv vs Pressure
SBL 12+685 CL, TW10




CONSOLIDATION TEST
mv vs Pressure
SBL 12+685 CL, TW10




CONSOLIDATION TEST
k vs Pressure
SBL 12+685 CL, TW10




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

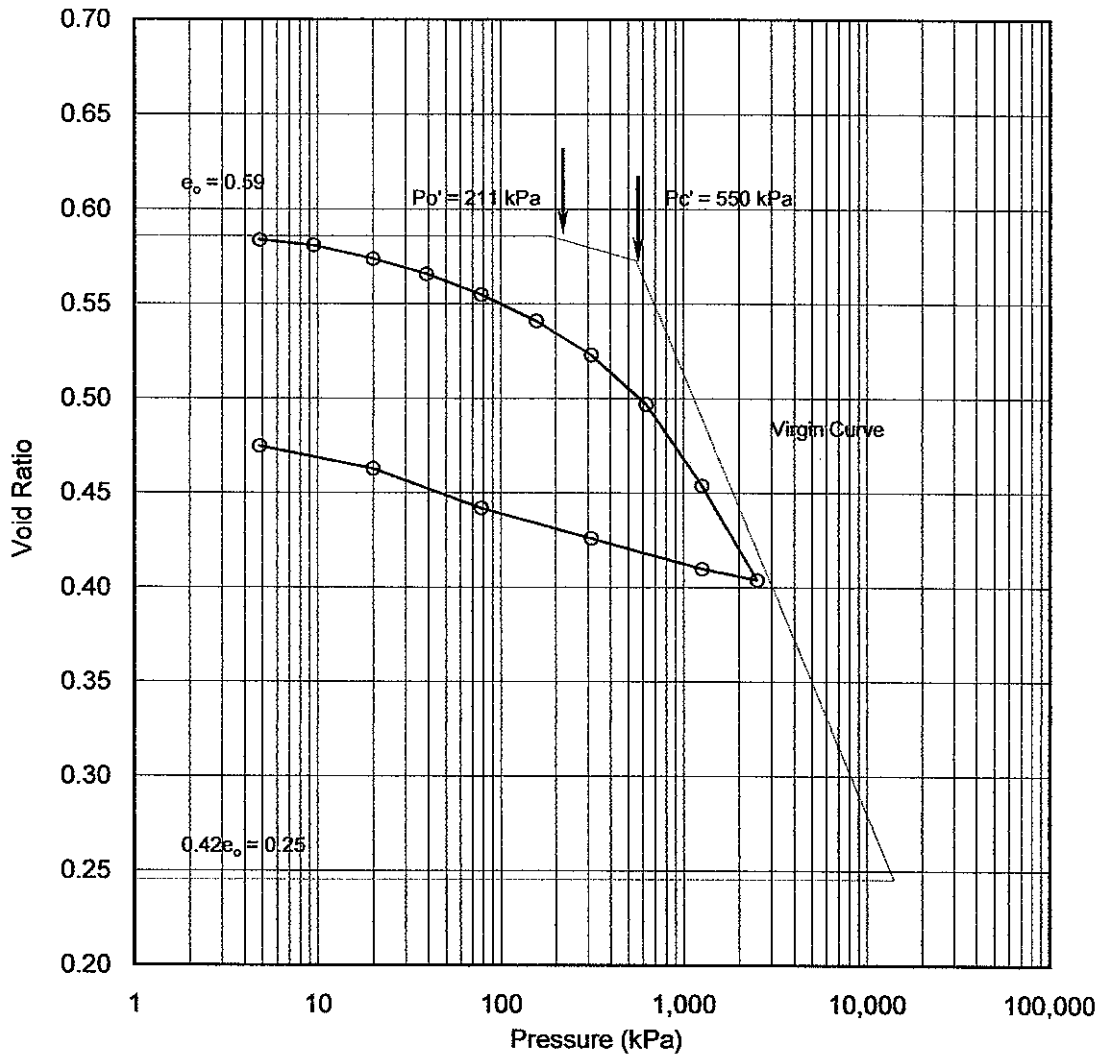
Terraprobe Inc.

Prepared By : HW
Checked By : RA

C:\Documents and Settings\Hongliu\My Documents\Project 2009\1-09-4135 - HWY 406 Foundations\Bridges\1-09-4135 Consolidation Results-WS.xls

| HWY 406 TWINNING - WOODLAWN OVERPASS (SBL) | FIGURE B23 |
|---|---|

CONSOLIDATION TEST
e vs Pressure
SBL 12+685 CL, TW10




| Soil Type : | Silty Clay | | | | |
|---|---|---|---|---|---|
| $e_o$ = | 0.59 | $\omega_L$ = | 27% | Po' = | 211 kPa |
| $\omega$ = | 22% | $\omega_P$ = | 17% | Pc' = | 550 kPa |
| $\gamma$ = | 20.7 kN/m$^3$ | PI = | 10% | Cc = | 0.233 |
| Gs = | 2.75 | | | Cr = | 0.027 |

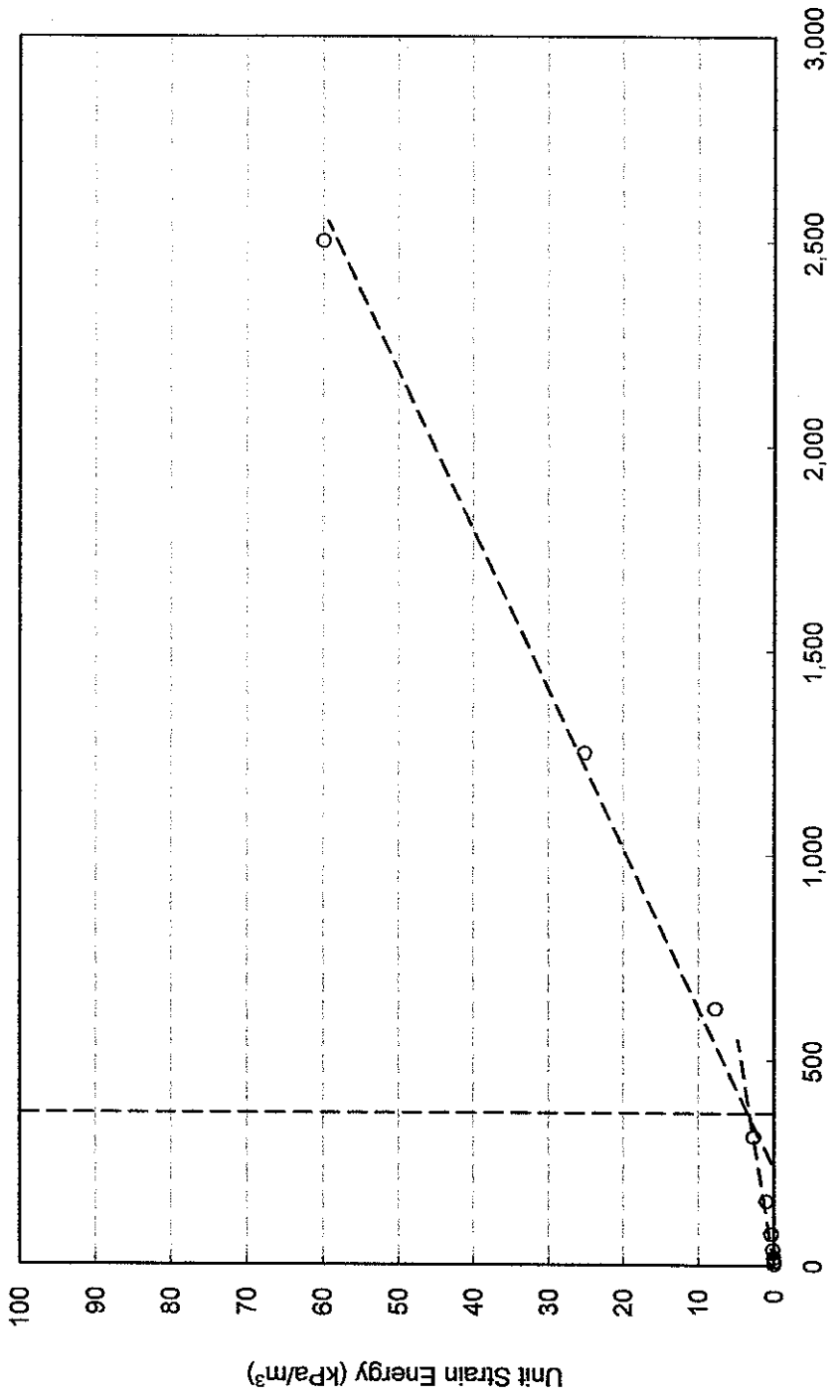
Project No. : 1-09-4135
Date : September 2010

Terraprobe Inc.

Prepared By : HW
Checked By : RA

C:\Documents and Settings\Hongliu\My Documents\Project 2009\1-09-4135 - HWY 406 Foundations\Bridges\1-09-4135 Consolidation Results-WS.xls

| HWY 406 TWINNING - WOODLAWN OVERPASS (SBL) | FIGURE B24 |
|---|---|




Project No. : 1-09-4135

Date : September 2010

Terraprobe Inc.

Prepared By : HW

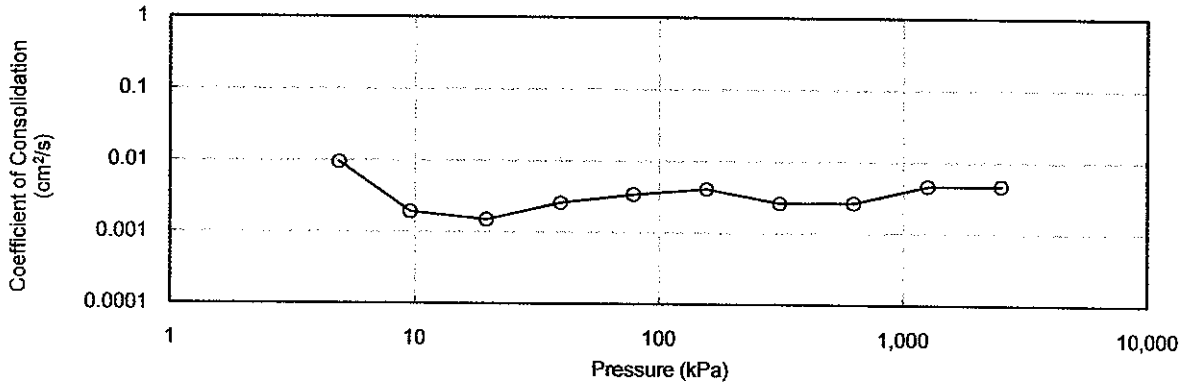
Checked By : RA

C:\Documents and Settings\Hongliu\My Documents\Project 2009\1-09-4135 - HWY 405 Foundations\Bridges\1-09-4135 Consolidation Results-WS.xls

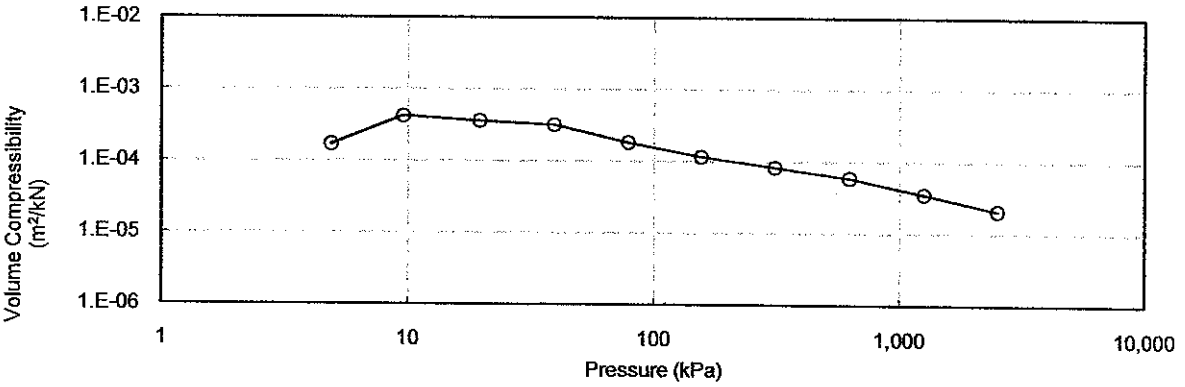
## HWY 406 TWINNING - WOODLAWN OVERPASS (SBL)

**FIGURE B25**

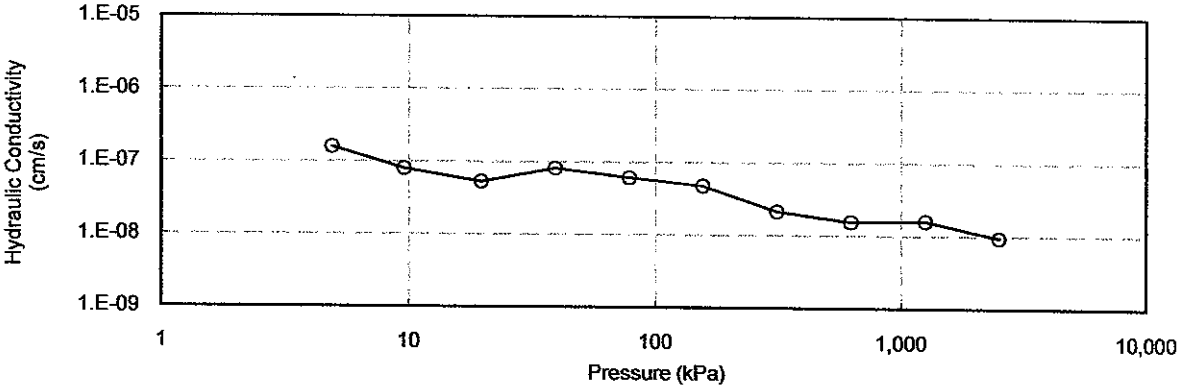
CONSOLIDATION TEST
Cv vs Pressure
SBL 12+750 CL, TW10




CONSOLIDATION TEST
mv vs Pressure
SBL 12+750 CL, TW10




CONSOLIDATION TEST
k vs Pressure
SBL 12+750 CL, TW10




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

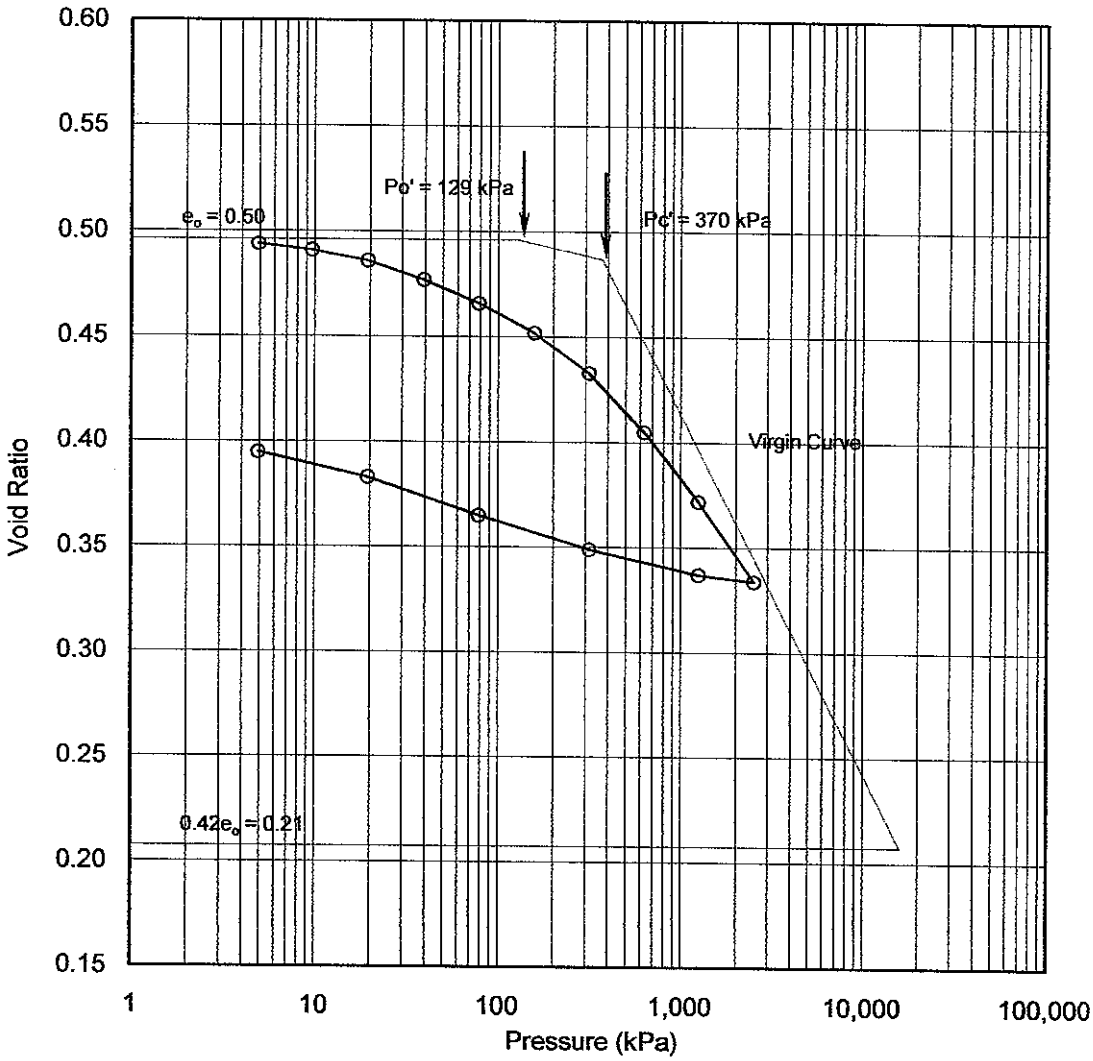
Terraprobe Inc.

Prepared By : HW
Checked By : RA

C:\Documents and Settings\Hongliu\My Documents\Project 2009\1-09-4135 - HWY 406 Foundations\Bridges\1-09-4135 Consolidation Results-WS.xls

| HWY 406 TWINNING - WOODLAWN OVERPASS (SBL) | FIGURE B26 |
|---|---|

CONSOLIDATION TEST
e vs Pressure
SBL 12+750 CL, TW10




| Soil Type : | Silty Clay | | | | |
|---|---|---|---|---|---|
| $e_o$ = | 0.50 | $\omega_L$ = | 25% | Po' = | 129 kPa |
| $\omega$ = | 19% | $\omega_P$ = | 15% | Pc' = | 370 kPa |
| $\gamma$ = | 21.1 kN/m$^3$ | PI = | 10% | Cc = | 0.171 |
| Gs = | 2.70 | | | Cr = | 0.020 |

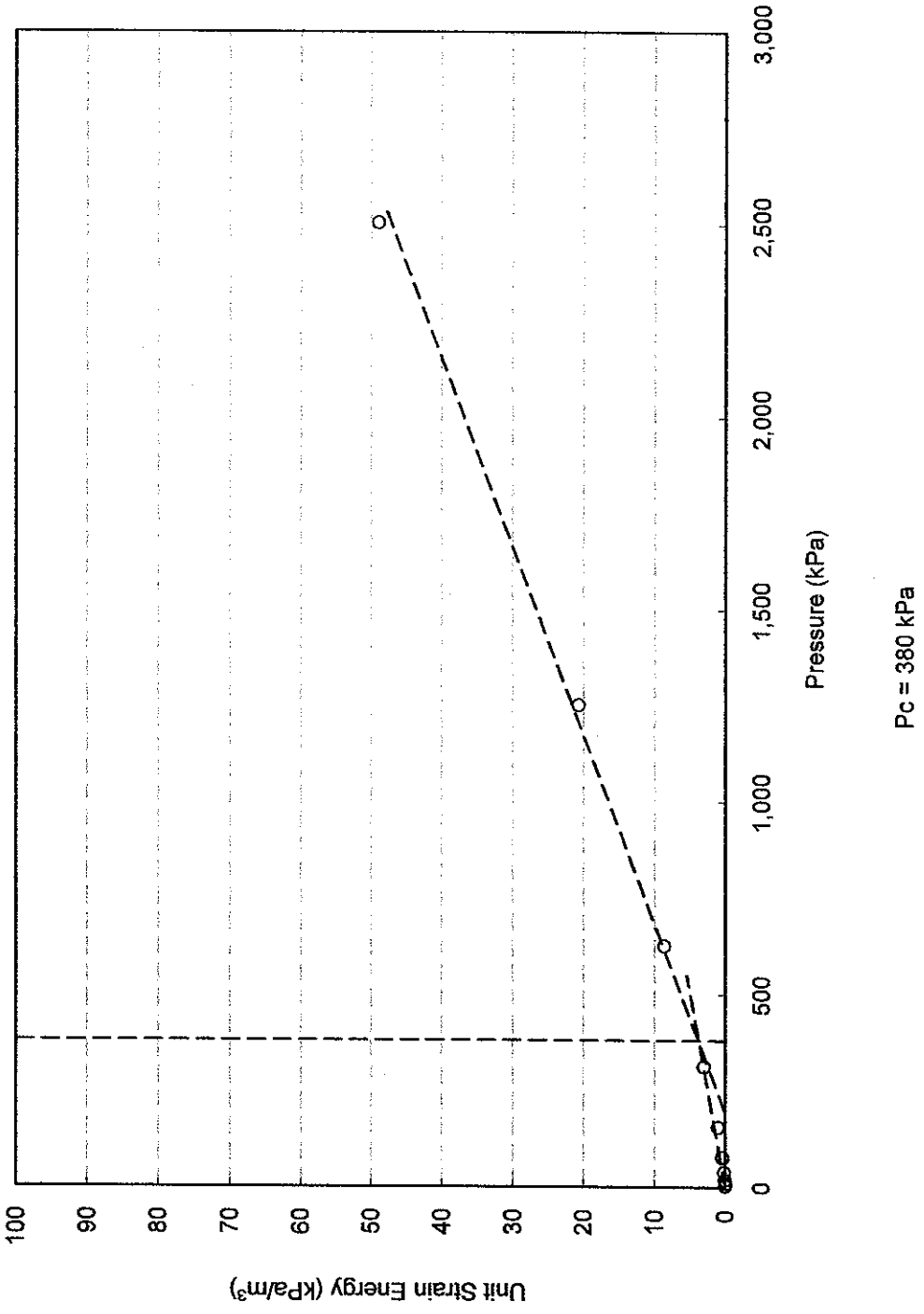
Project No. : 1-09-4135
Date : September 2010

Terraprobe Inc.

Prepared By : HW
Checked By : RA

C:\Documents and Settings\Hongliu\My Documents\Project 2008\1-09-4135 - HWY 406 Foundations\Bridges\1-09-4135 Consolidation Results-WS.xls

**HWY 406 TWINNING - WOODLAWN OVERPASS (SBL)** | **FIGURE B27**




Project No. : 1-09-4135

Date : September 2010

Terraprobe Inc.

Prepared By : HW

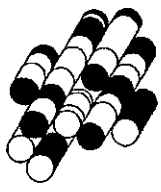
Checked By : RA

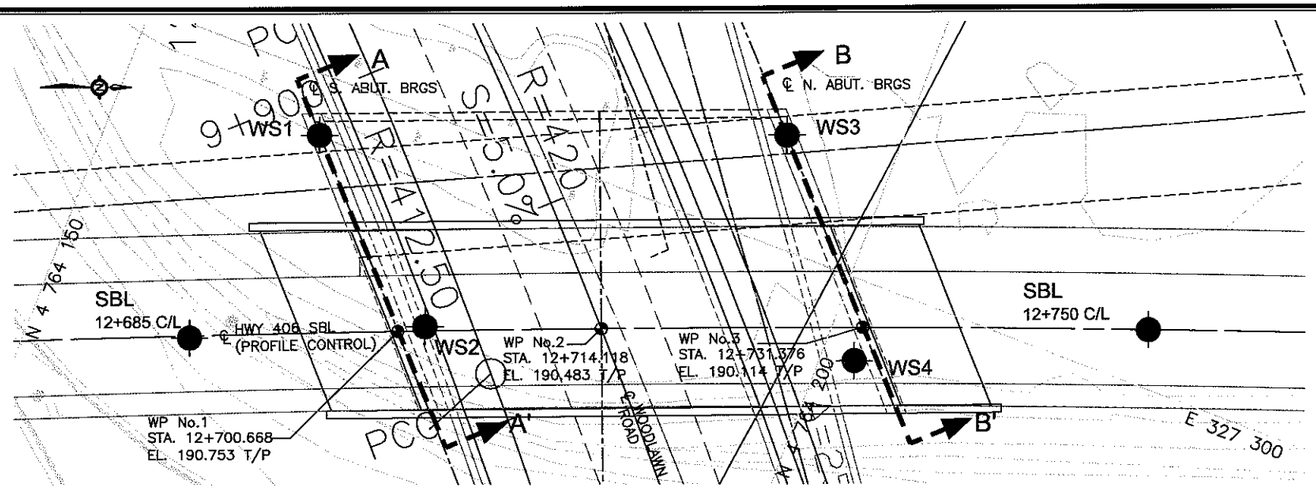
C:\Documents and Settings\Hongliu\My Documents\Project 2009\1-09-4135 - HWY 406 Foundations\Bridges\1-09-4135 Consolidation Results-WS.xls

# APPENDIX C

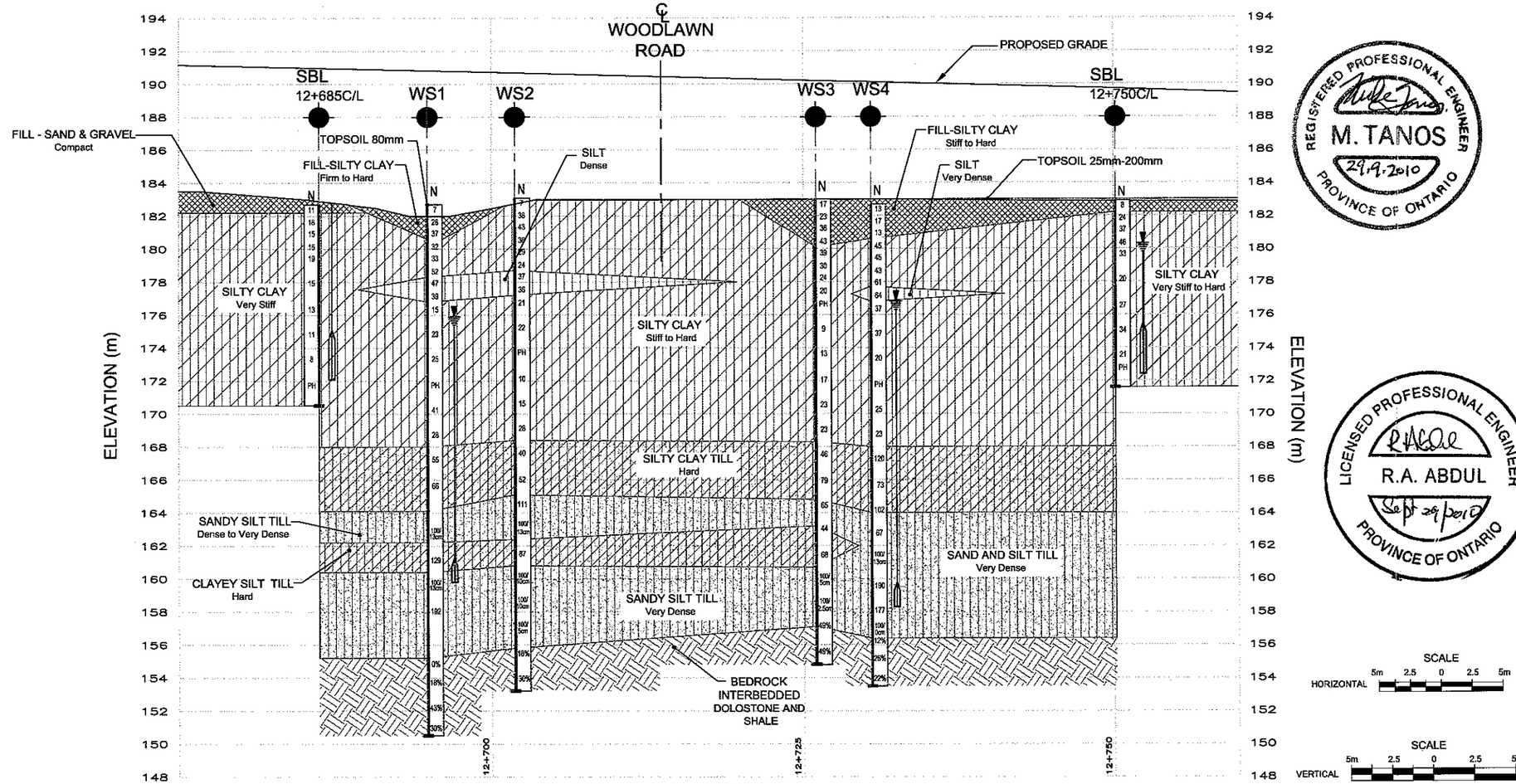
## Drawings titled "Borehole Locations and Soil Strata"

Terraprobe Inc.






PLAN SCALE 5m 2.5 0 2.5 5m




SCALE
HORIZONTAL 5m 2.5 0 2.5 5m

SCALE
VERTICAL 5m 2.5 0 2.5 5m

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

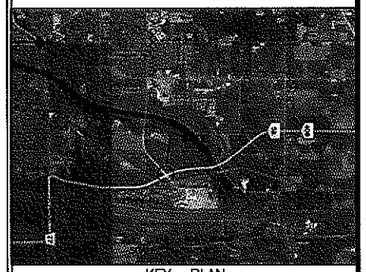
CONT No
WP No 280-99-00

HIGHWAY 406
HIGHWAY 406 SBL
WOODLAWN ROAD OVERPASS
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET 1 OF

Giffels Associates Limited
Consulting Engineers and Architects
An IBI Group Company

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



KEY PLAN

LEGEND

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

| No | ELEV. | COORDINATES | |
|---|---|---|---|
| | | NORTHING | EASTING |
| WS1 | 182.7 | 4 764 163.6 | 327 303.9 |
| WS2 | 183.1 | 4 764 174.7 | 327 313.4 |
| WS3 | 183.0 | 4 764 192.6 | 327 292.7 |
| WS4 | 182.7 | 4 764 202.3 | 327 305.2 |
| SBL 12+685C/L | 182.7 | 4 764 160.4 | 327 319.7 |
| SBL 12+750C/L | 182.9 | 4 764 219.9 | 327 296.2 |

REGISTERED PROFESSIONAL ENGINEER M. TANOS 29.9.2010 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER R.A. ABDUL Sept 29/2010 PROVINCE OF ONTARIO

NOTE

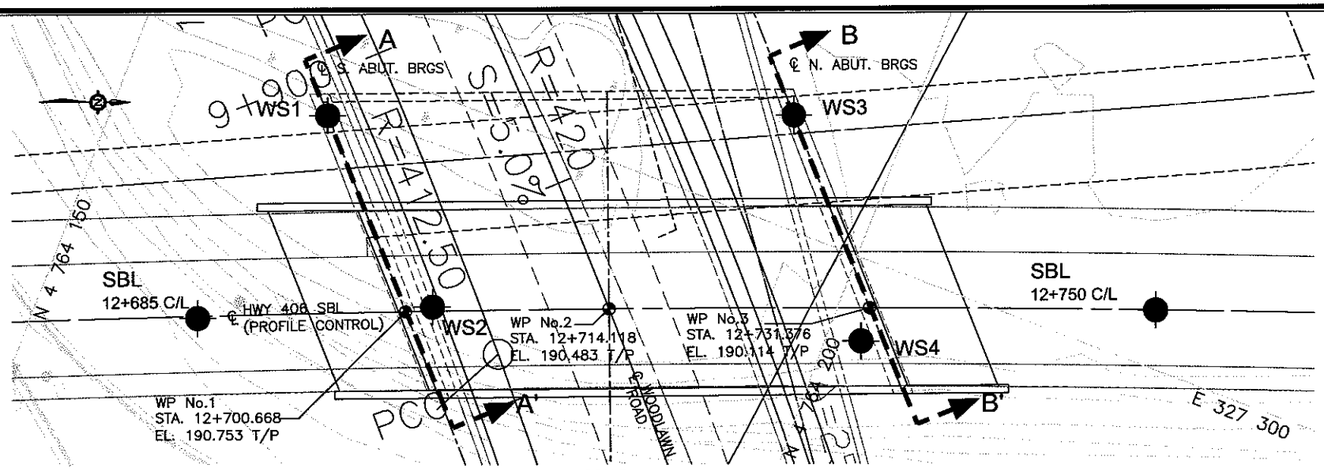
The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.

This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

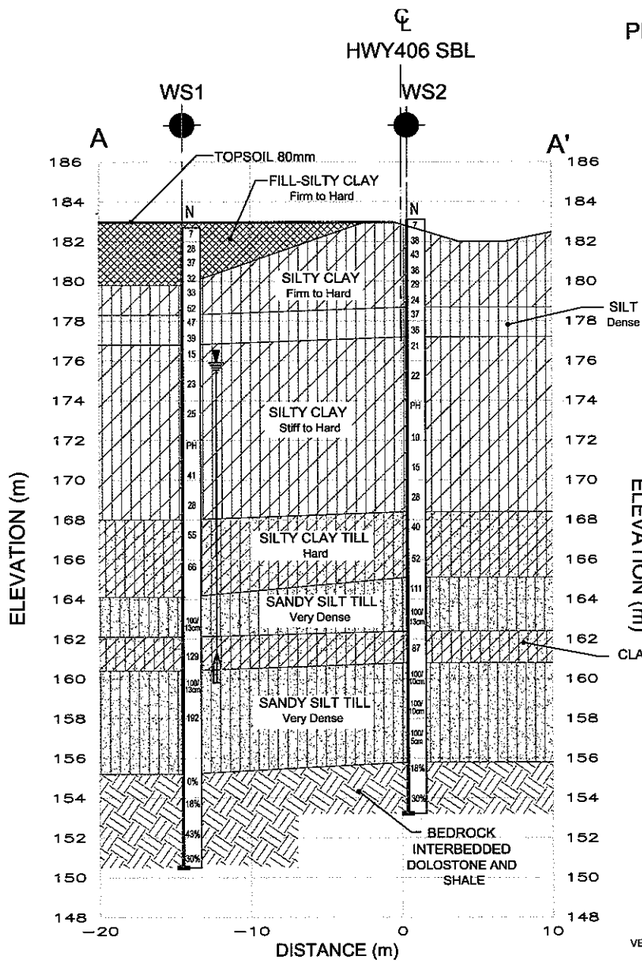
| REVISIONS | DATE | BY | DESCRIPTION |
|---|---|---|---|
| | | | |

| | | | | |
|---|---|---|---|---|
| DESIGN R.A | CODE CHBDC2006 | | LOAD | DATE SEPT. 2010 |
| DRAWN K.C | CHK R.A | STRUCT 34-463/2 | | GEOCRES 30M3-260 |

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

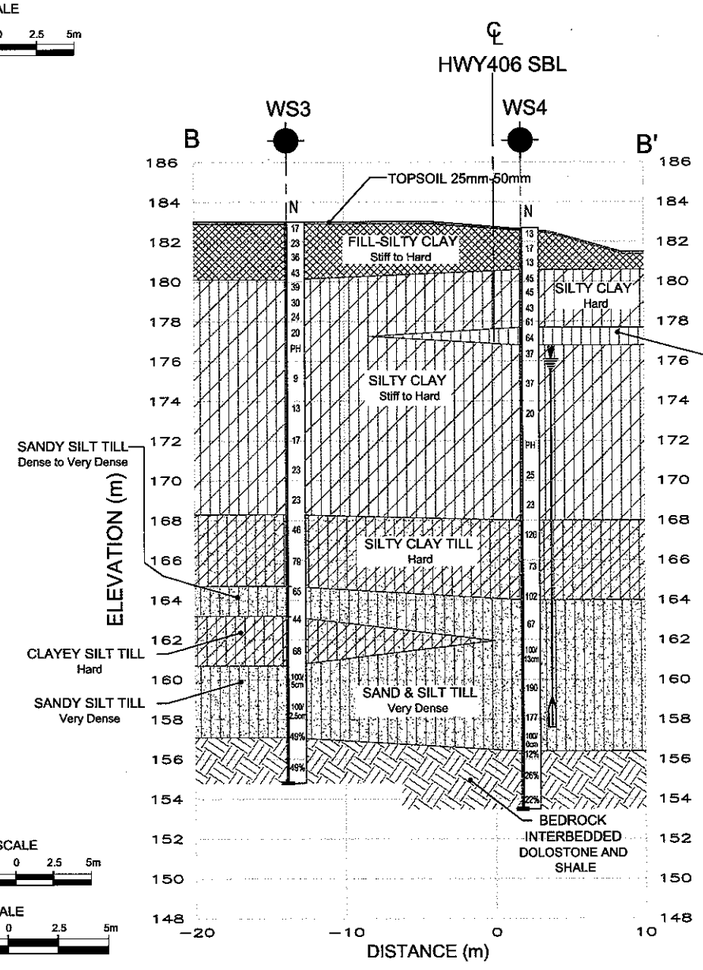



PLAN
SCALE 5m 2.5 0 2.5 5m




SECTION A-A'

SCALE
HORIZONTAL 5m 2.5 0 2.5 5m
SCALE
VERTICAL 5m 2.5 0 2.5 5m




SECTION B-B'

REGISTERED PROFESSIONAL ENGINEER
M. TANOS
24.9.2010
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
R.A. ABDUL
Sept 29/2010
PROVINCE OF ONTARIO

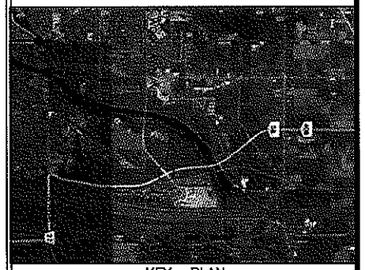
CONT No
WP No 280-99-00

HIGHWAY 406
HIGHWAY 406 SBL
WOODLAWN ROAD OVERPASS
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET 1 OF

Giffels Associates Limited
Consulting Engineers and Architects
An IBI Group Company

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



KEY PLAN

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

| No | ELEV. | COORDINATES | |
|---|---|---|---|
| | | NORTHING | EASTING |
| WS1 | 182.7 | 4 764 163.6 | 327 303.9 |
| WS2 | 183.1 | 4 764 174.7 | 327 313.4 |
| WS3 | 183.0 | 4 764 192.6 | 327 292.7 |
| WS4 | 182.7 | 4 764 202.3 | 327 305.2 |
| SBL 12+685C/L | 182.7 | 4 764 160.4 | 327 319.7 |
| SBL 12+750C/L | 182.9 | 4 764 219.9 | 327 296.2 |

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

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 34-483/2 | GEOCRES 30M3-260 |