



# Terraprobe

Consulting Geotechnical & Environmental Engineering  
Construction Materials Inspection & Testing

**FOUNDATION INVESTIGATION REPORT  
OLD WELLAND CANAL/WELLAND RIVER BRIDGE  
HIGHWAY 406 TWINNING  
PORT ROBINSION ROAD TO EAST MAIN STREET  
AGREEMENT No. 2008-E-0016, W.P. 280-99-00, SITE: 34-304/1  
GEOCRES No. 30M3-253**

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File No. 1-09-4135  
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**FOUNDATION INVESTIGATION REPORT**  
**OLD WELLAND CANAL/WELLAND RIVER BRIDGE**  
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**PART 1: FACTUAL INFORMATION**

**1 INTRODUCTION**

This report presents the factual findings obtained from a foundation investigation conducted at the Old Welland Canal/Welland River bridge site on the proposed two-lane Highway 406 NBL in the City of Thorold, Ontario. The Ministry of Transportation (MTO) conducted investigations at this site for the existing eleven span bridge to the west of this alignment, and the factual data from these investigations have been used as general reference for the preparation of this report.

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.

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

- Ministry of Transportation, “Highway 406 Old Welland Canal Overpass and Causeway”, W.P. 11-68-16, MTO District 4, GEOCRES 30M3-188, dated February 04, 1988.
- Ministry of Transportation, “Highway 406 Welland River and Welland Canal Bridge, Highway 406”, W.P. 171-90-01, MTO District 4, GEOCRES 30M3-192, dated May, 1991.

**2 SITE DESCRIPTION & PHYSIOGRAPHY**

The site is located about 1.2 km south of Merritt Road and about 900 m north of Woodlawn Road in the City of Thorold, Regional Municipality of Niagara. The centre line of the proposed alignment is approximately 30 m east of the centre line of the present eleven span concrete bridge that currently carries both north and south bound traffic on Highway 406.

The alignment crosses the Welland River and the Old Welland Canal. The Welland River is located south of the Old Welland Canal and is separated from the canal by a narrow strip of parkland (Merritt Island). Merritt Island is man made and was created when the Welland Canal was constructed adjacent to the Welland River.



The topography is generally flat to undulating with scattered man-made high ground areas. Vegetation at this site consists primarily of deciduous trees and wild bush. Minor areas of groomed grass can be found on Merritt Island and the north shore of the Old Welland Canal. There is an asphalt paved roadway on Merritt Island and on the north shore of the Old Welland Canal both of which are oriented parallel to the existing bodies of water.

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<sup>1</sup>.

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 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<sup>2</sup>. This unit consists essentially of easily weathered, grey, very finely crystalline, laminated argillaceous dolostone with grey, calcareous shale partings and gypsum veins and lenses of varying thicknesses.

### **3 SITE INVESTIGATION AND FIELD TESTING**

The site investigation and field testing for this project were carried out between November 18 and December 08, 2009 and consisted of drilling and sampling sixteen boreholes to depths ranging from 12.0 m to 30.9 m. The boreholes were numbered W1 to W16 inclusive and their approximate locations are shown on the attached Borehole Locations and Soil Strata Drawing in Appendix D.

The borehole locations were marked in the field by surveyors from Callon Dietz Inc. who also provided Terraprobe with their coordinates and geodetic elevations. Callon Dietz Inc. also completed topographic surveys of the Welland River and the Old Welland Canal beds. Utility clearances and permits were obtained by Terraprobe 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 and pier locations 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

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

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



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. This procedure was also used to seal Borehole W5 where artesian conditions were encountered.

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
W1	12.2/166.1	Piezometer with 1.5 m slotted screen installed with filter sand to 10.4 m, bentonite seal from 10.4 m to 9.8 m, drill cuttings from 9.8 m to 0.6 m and bentonite seal from 0.6 m to ground surface.
W2	10.7/167.7	Piezometer with 1.5 m slotted screen installed with filter sand to 8.8 m, bentonite seal from 8.8 m to 8.2 m, drill cuttings from 8.2 m to 0.6 m and bentonite seal from 0.6 m to ground surface.
W3	24.7/152.1	Hole sealed to 24.7 m with bentonite, piezometer with 1.5 m slotted screen installed with filter sand to 22.3 m and bentonite seal from 22.3 m to ground surface.
W6	21.3/154.3	Hole sealed to 21.3 m with bentonite, piezometer with 1.5 m slotted screen installed with filter sand to 19.2 m and bentonite seal from 19.2 m to ground surface.
W9	25.0/150.6	Piezometer with 1.5 m slotted screen installed with filter sand to 22.9 m and bentonite seal from 22.9 m to ground surface.
W14	22.7/152.2	Piezometer with 1.5 m slotted screen installed with filter sand to 19.3 m, bentonite seal from 19.3 m to ground surface.
W15	15.2/164.0	Piezometer with 1.5 m slotted screen installed with filter sand to 13.4 m, bentonite seal from 13.4 m to 13.1 m, drill cuttings from 13.1 m to 2.1 m and bentonite seal from 2.1 m to ground surface.
W16	12.2/170.7	Piezometer with 1.5 m slotted screen installed with filter sand to 10.4 m, bentonite seal from 10.4 m to 9.8 m, drill cuttings from 9.8 m to 0.6 m and bentonite seal from 0.6 m to ground surface.

The drilling, sampling and coring operations were observed on a full time basis by members of Terraprobe's technical staff. The supervisors 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 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 and the boreholes drilled by MTO in 1987 for the existing bridge (Appendix C). Details of the encountered soil and rock stratigraphy are presented in these appendices and on the “Borehole Locations and Soil Strata” drawings in Appendix D. An overall description of the stratigraphy is given in the following paragraphs. However, the factual data presented in the Record of Borehole Sheets governs any interpretation of the site conditions.

In general, the site is underlain by water, topsoil and about 21.3 m to 27.5 m of overburden soils consisting of fill material (sand and gravel, silty clay, cobbles and gravel) and native deposits of silty clay, silt, silty clay till, sandy silt to silt and sand till, sand and gravel and cobbles. These soils are underlain by bedrock of the Salina formation.

### **5.1 Topsoil**

Topsoil ranging from 50 mm to 200 mm thick was encountered across the site. Topsoil thickness may vary between and beyond the boreholes.

### **5.2 Fill – Sand and Gravel**

Sand and gravel fill containing trace to some silt and trace clay was encountered in Boreholes W3 and W13. The thickness of the fill is approximately 200 mm and this layer extends to Elev. 176.6 m and Elev. 174.4 m below ground surface. The moisture content (by weight) of a sample of this fill was 8%.

### **5.3 Fill – Silty Clay**

Fill material consisting of silty clay, trace sand to sandy, trace to some gravel and occasional cobbles were encountered across this site at variable depths. On the south side of the Welland River the fill extends to depths ranging from 0.7 m to 0.9 m below ground surface or to elevations ranging from 177.7 m to 176.1 m. On Merritt Island the fill extends to depths ranging from 8.6 m (Elev. 167.3 m) to 10.8 m (Elev. 164.8 m) below ground surface. North of the Old Welland Canal this silty clay fill extends to depths ranging from 0.7 m to 7.0 m below ground surface i.e. elevations ranging from 175.9 m to 174.1 m.

The grain size distribution plots of tested samples of this fill are presented in Figures B1 and B2. These results show a grain size distribution consisting of 0-13% gravel, 0-17% sand, 43-73% silt and 25-54% clay size particles.

Samples were also subjected to Atterberg Limits tests and the results are presented in Figures B3 and B4. The index values from these tests are summarized below:

Liquid Limit:	29-50%
Plastic Limit:	17-25%
Plasticity Index:	12-25%
Natural Moisture Content:	9-27%



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

Standard Penetration tests in the silty clay fill gave 'N' values that ranged from 5 to 73 blows for 0.3 m penetration but generally 'N' values ranged from 5 to 28 blows for 0.3 m penetration. Based on these results the fill is considered to have a generally firm to very stiff consistency with occasional hard zones. The moisture content of samples of this fill ranged from 4% to 27% by weight.

#### **5.4 Fill – Cobbles and Gravel**

A 1.1 m thick layer of fill consisting of cobbles and gravel was encountered in Borehole W1 extending to a depth of 1.8 m (Elev. 176.5 m) below ground surface. SPT 'N' values ranged from 48 to 100 blows for less than 0.3 m penetration indicating a very dense relative density. The moisture content of samples of this fill varies from 18% to 20% by weight.

#### **5.5 Silty Clay**

A native silty clay deposit was encountered at this site. South of the Welland River the deposit extends to depths ranging from 2.9 m to 4.9 m below ground surface or to elevations ranging from 174.6 m to 173.5 m. In the Welland River this stratum extends to a depth of 7.3 m (Elev. 163.5 m) in Borehole W5. North of the Old Welland Canal the silty clay deposit extends to depths ranging from 0.7 m to 8.6 m below ground surface i.e. elevations ranging from 174.3 m to 172.7 m.

The grain size distribution plots of tested samples of the silty clay are presented in Figures B5 and B6. These results show a grain size distribution consisting of 0% gravel, 0-2% sand, 62-77% silt and 21-38% clay size particles.

Samples were also subjected to Atterberg Limits tests and the results are illustrated on the plasticity charts, Figures B7 and B8. The index values from these tests are summarized below:

Liquid Limit:	26-45%
Plastic Limit:	14-21%
Plasticity Index:	10-24%
Natural Moisture Content:	18-22%

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

Standard Penetration tests in this stratum gave 'N' values that ranged from 0 to 83 blows for 0.3 m penetration but generally 'N' values ranged from 6 to 26 blows for 0.3 m penetration. Based on these results the silty clay deposit is considered to have a generally firm to very stiff consistency with occasional hard zones. The moisture content of samples from this stratum ranged from 18% to 25% by weight.



## **5.6 Silt**

A silt deposit was encountered at this site south of the Welland River and north of the Old Welland Canal. The deposit extends below ground surface to depths ranging from 4.4 m to 5.9 m (elevations ranging from 172.5 m to 172.4 m) south of the Welland River. North of the Old Welland Canal this deposit extends to depths ranging from 2.1 m to 10.3 m below ground surface i.e. elevations ranging from 172.6 m to 171.9 m.

The grain size distribution plots of tested samples of the silt are presented in Figure B9. These results show a grain size distribution consisting of 0% gravel, 0-2% sand, 89-96% silt and 4-10% clay size particles.

The deposit is considered to have a loose to very dense relative density based on SPT 'N' values that ranged from 8 to 52 blows for 0.3 m penetration. The moisture content of samples from this deposit ranged from 19% to 30% by weight.

## **5.7 Silty Clay Till**

Discontinuous upper and lower layers of silty clay till were encountered across the site. Boreholes W1, W2, W15 and W16 were terminated in the upper silty clay deposit at depths ranging from 12.0 m to 19.7 m below ground surface i.e. elevations ranging from 166.4 m to 163.2 m. In the remaining boreholes the upper silty clay till stratum was fully explored and was found to extend to depths ranging from 12.2 m to 19.5 m below ground surface or to elevations ranging from 159.0 m to 156.1 m.

The grain size distribution plots of samples retrieved from the upper till deposit are presented in Figures B10 to B16 inclusive. These results show a grain size distribution consisting of 0-14% gravel, 0-26% sand, 42-83% silt and 12-57% clay size particles. Till soils will also contain random cobble and boulder inclusions.

Samples of the upper silty clay till were also subjected to Atterberg Limits tests and the results are presented in Figures B17 to B23 inclusive. The index values from these tests are summarized below:

Liquid Limit:	19-38%
Plastic Limit:	12-18%
Plasticity Index:	4-19%
Natural Moisture Content:	9-32%

These values indicate that the silty clay has a generally low to intermediate plasticity with occasional clayey silt zones.





Standard Penetration tests in this upper silty clay till yielded 'N' values ranging from 2 to more than 100 blows for 0.3 m penetration. Field vane tests gave in-situ undrained shear strengths ranging from 32 kPa to in excess of 100 kPa and laboratory vane tests on relatively undisturbed Shelby tube samples gave undrained shear strengths ranging from 25 kPa to in excess of 100 kPa. These values indicate that the consistency of the silty clay is generally firm to very stiff with occasional hard zones. Moisture content of samples of the upper silty clay till range from 9% to 35% by weight and the unit weight of selected samples ranged from 19.6 to 22.5 kN/m<sup>3</sup>

The variation of undrained shear strength with elevation is depicted in Figure B28. No apparent relationship is evident between these two variables. The Atterberg Limits tests results are also plotted against elevation, Figure B29. These results illustrate that the natural moisture content is generally between the plastic and liquid limits except for a zone from about Elev. 163 m to Elev. 160 m where the natural moisture content is at or close to the plastic limit.

Consolidation tests of the upper silty clay till were also performed on Shelby tube samples retrieved from Boreholes W2 and W15 and the results are presented in Figures B30 to B35. These results indicate an estimated preconsolidation pressure that ranges between 250 kPa and 375 kPa.

The lower silty clay till extends to depths ranging from 18.4 m to 25.3 m below ground surface or to elevations ranging from 153.5 m to 150.5 m.

Grain size distribution plots of tested samples of the lower silty clay till are illustrated in Figure B24. These results show a grain size distribution consisting of 0-3% gravel, 4-30% sand, 36-50% silt and 23-58% clay size particles. Random cobble and boulder inclusions can also be expected in till soils.

Samples of the lower silty clay till were also subjected to Atterberg Limits tests and the results are presented in Figures B25. The index values from these tests are summarized below:

Liquid Limit:	16-35%
Plastic Limit:	12-18%
Plasticity Index:	4-17%
Natural Moisture Content:	9-26%

These values indicate that the till is generally a low plasticity silty clay with occasional clayey silt zones.

Standard Penetration tests in the lower silty clay till yielded 'N' values ranging from 8 to more than 100 blows per 0.3 m penetration and field vane tests attempted in this deposit gave undrained shear strengths more than 100 kPa. Based on these results the lower silty clay till is considered to have a stiff to hard consistency. The moisture content of samples obtained this lower till deposit ranged from 9% to 34% by weight.



## **5.8 Sandy Silt to Silt and Sand Till**

The site is underlain by upper and lower granular till deposits with a soil matrix that ranges from sandy silt to silt and sand. These deposits extend to depths ranging from 18.4 m to 26.5 m or to elevations ranging from 155.0 m to 150.0 m.

The results of grain size distribution tests conducted on samples obtained from the upper and lower deposits are illustrated in Figures B26 and B27. These results show grain size distributions consisting of 1-13% gravel, 28-46% sand, 37-62% silt and 5-11% clay size particles.

Standard Penetration tests in these deposits gave 'N' values that generally ranged from 11 to more than 100 blows per 0.3 m penetration indicating a compact to very dense relative density. Recorded 'N' values of 3 blows per 0.3 m penetration were obtained in boreholes W6, W7 and W8 in the upper portion of the stratum indicating a very loose relative density. The moisture content of samples from these strata ranged from 7% to 21% by weight.

## **5.9 Sand and Gravel**

Layers of sand and gravel containing occasional cobble inclusions were encountered in Borehole W5 and W14. The deposits are approximately 1.1 m to 1.4 m thick and extend to depths ranging from 21.9 m (Elev. 152.9 m) to 21.3 m (Elev. 149.5 m) below ground surface.

Standard Penetration tests in these deposits gave 'N' values that ranged from 71 to more than 100 blows for 0.3 m penetration. Based on these results the deposits are considered to have a very dense relative density. The moisture content of samples from these strata ranged from 7% to 15% by weight.

## **5.10 Cobbles**

A deposit of cobbles containing some gravel overlies the bedrock in some of the boreholes. Diamond drilling techniques had to be implemented in order to penetrate this deposit at some locations. The deposit ranges in thickness from 0.4 m to 1.5 m and extends to depths ranging from 21.4 m to 27.5 m below ground surface or to elevations ranging from 152.0 m to 150.0 m.

Based on recorded 'N' values of more than 100 blows for 0.3 m penetration, the deposit is considered to have a very dense relative density.



### 5.11 Bedrock (Salina Formation)

The overburden soils described above are underlain by the Salina Formation. Bedrock was proved by coring at the abutments and pier 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	W3	26.8	150.0
	W4	27.5	150.1
Pier 2	W5	21.3	149.5
Pier 4	W6	25.1	150.5
	W7	25.2	150.0
Pier 5	W8	25.3	150.6
	W9	25.2	150.4
Pier 7	W10	22.0	151.3
Pier 8	W11	21.4	152.0
Pier 9	W12	21.4	152.0
North Abutment	W13	21.4	153.2
	W14	21.9	152.9

The bedrock is described as slightly weathered and its colour is light grey to dark grey. It is thin to medium bedded with light grey to dark grey moderately weathered shale interbeds. Total core recovery in the bedrock generally ranged from 42% to 100% and a recorded TCR of 0% was obtained in the first run of Borehole W7.

The RQD values ranged widely from 0% to 79% but generally, most of the RQD values were below 50%. The core data also reveals that there is no trend of improving rock quality with depth. Based on these results the rock quality is considered to be very poor to poor with occasional zones of fair to good quality rock.



## 5.12 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)
W1	November 30, 2009	3.0	175.3
	December 08, 2009	2.7	175.6
	December 16, 2009	2.6	175.7
	January 04, 2010	2.5	175.8
	January 11, 2010	2.5	175.8
W2	November 30, 2009	6.3	172.1
	December 08, 2009	4.4	174.0
	December 16, 2009	4.7	173.7
	January 14, 2010	4.2	174.2
W3	December 08, 2009	4.3	172.5
	December 16, 2009	4.2	172.6
	January 04, 2010	4.2	172.6
W5*	December 08, 2009	0.9 (high)	Above 171.7
W6	November 30, 2009	2.4	173.2
	December 08, 2009	2.7	172.9
	December 16, 2009	2.4	173.2
	January 04, 2010	2.4	173.2
W9	December 08, 2009	2.5	173.1
	December 16, 2009	2.3	173.3
	January 11, 2010	2.4	173.2
	January 14, 2010	2.4	173.2
W14	December 08, 2009	1.5	173.3
	December 16, 2009	1.4	173.4
	January 11, 2010	1.5	173.3
	January 14, 2010	1.5	173.3
W15	November 30, 2009	4.1	175.1
	December 08, 2009	4.2	175.0
	December 16, 2009	4.2	175.0
	January 04, 2010	4.2	175.0
W16	November 30, 2009	7.8	175.1
	December 08, 2009	7.7	175.2
	January 04, 2010	7.5	175.4
	January 14, 2010	7.5	175.4

\* Artesian Condition

Based on these observations, the local ground water level generally follows the contours of the land existing at approximately Elev. 175.8 m south of the Welland River falling to about Elev. 172.6 m near the south bank of the river. North of the Old Welland Canal the water table exists at about Elev. 175.4 m falling gradually to about Elev. 173.3 at the north bank of the canal. On Merritt Island the water table is estimated to be at about Elev. 173.2 m.

In the Welland River artesian conditions were encountered in Borehole W5 in the lower granular deposits overlying bedrock. The head of water is estimated to be about 0.9 m (Elev. 171.7 m) above the free water level in the river. Below Merritt Island excess hydrostatic pressure was encountered in the underlying sandy silt to silty sand till confined between the less permeable upper and lower silty clay deposits.



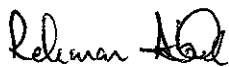
All ground water observations at this site are short term and the levels are expected to fluctuate seasonally and after severe weather events. The ground water level will also be controlled by the water levels in the Welland River and Old Welland Canal.

### 5.13 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 drilling techniques and casing and washboring methods were used to advance the boreholes. Coring also had to be resorted to in Boreholes W4 and W12 in order to penetrate frequent cobbles overlying the top of bedrock.

Messrs. Lucas Yu, E.I.T, Marc Paoliello, E.I.T, and Phil Khuu, B.A.T, observed and recorded the field work and the laboratory testing was performed at Terraprobe's Brampton laboratory. 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

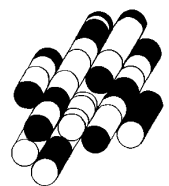


Report Reviewed by:  
Michael Tanos, P.Eng.,  
Review Principal



# APPENDICES

**TERRAPROBE INC.**



## 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
$\epsilon$	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	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 <sup>-1</sup>	COEFFICIENT OF VOLUME CHANGE
$C_c$	1	COMPRESSION INDEX
$C_s$	1	SWELLING INDEX
$C_\alpha$	1	RATE OF SECONDARY CONSOLIDATION
$C_v$	m <sup>2</sup> /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
$S_r$	1	SENSITIVITY = $c_u / \tau_r$

## PHYSICAL PROPERTIES OF SOIL

$\rho_s$	kg/m <sup>3</sup>	DENSITY OF SOLID PARTICLES	e	1%	VOID RATIO	$e_{min}$	1%	VOID RATIO IN DENSEST STATE
$\gamma_s$	kN/m <sup>3</sup>	UNIT WEIGHT OF SOLID PARTICLES	n	1%	POROSITY	$I_p$	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
$\rho_w$	kg/m <sup>3</sup>	DENSITY OF WATER	w	1%	WATER CONTENT	D	mm	GRAIN DIAMETER
$\gamma_w$	kN/m <sup>3</sup>	UNIT WEIGHT OF WATER	$S_r$	%	DEGREE OF SATURATION	$D_n$	mm	n PERCENT - DIAMETER
$\rho$	kg/m <sup>3</sup>	DENSITY OF SOIL	$w_L$	%	LIQUID LIMIT	$C_u$	1	UNIFORMITY COEFFICIENT
$\gamma$	kN/m <sup>3</sup>	UNIT WEIGHT OF SOIL	$w_p$	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
$\rho_d$	kg/m <sup>3</sup>	DENSITY OF DRY SOIL	$w_s$	%	SHRINKAGE LIMIT	q	m <sup>2</sup> /s	RATE OF DISCHARGE
$\gamma_d$	kN/m <sup>3</sup>	UNIT WEIGHT OF DRY SOIL	$I_p$	%	PLASTICITY INDEX = $(w_L - w_p)$	v	m/s	DISCHARGE VELOCITY
$\rho_{sat}$	kg/m <sup>3</sup>	DENSITY OF SATURATED SOIL	$I_L$	1	LIQUIDITY INDEX = $(w - w_p)/I_p$	i	1	HYDRAULIC GRADIENT
$\gamma_{sat}$	kN/m <sup>3</sup>	UNIT WEIGHT OF SATURATED SOIL	$I_c$	1	CONSISTENCY INDEX = $(w_L - w)/I_p$	k	m/s	HYDRAULIC CONDUCTIVITY
$\rho'$	kg/m <sup>3</sup>	DENSITY OF SUBMERGED SOIL	$e_{max}$	1%	VOID RATIO IN LOOSEST STATE	j	kN/m <sup>2</sup>	SEEPAGE FORCE
$\gamma'$	kN/m <sup>3</sup>	UNIT WEIGHT OF SUBMERGED SOIL						

## EXPLANATORY SHEET FOR CORE LOG

### Column Number

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

### Joint (discontinuity) Characteristics

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

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

9. Roughness:

RU = Rough Undulating  
SU = Smooth Undulating  
LU = Slickensided Undulating

RP = Rough Planar  
SP = Smooth Planar  
LP = Slickensided Planar

10. Filling:

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

#### Approximate $\phi$

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

11. Aperture: estimated size of joint opening.

12. Degree of weathered rock material:

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

13. Strength of rock material:

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



## **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.

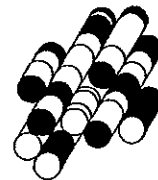
The design advice is based on the factual data obtained from this investigation made at the site by Terraprobe and are intended for use by the owner and its retained designers in the design phase of the project. If there are changes to the project scope and development features, or there is any additional 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

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# **APPENDIX A**

## **Record of Borehole Sheets**

**Terraprobe Inc.**



# RECORD OF BOREHOLE No W1

1 OF 2

METRIC

W.P. 280-99-00 LOCATION Coords: N:4764997.1 E:327226.3 ORIGINATED BY PK  
DIST HWY 406 BOREHOLE TYPE Hollow Stem Augers COMPILED BY DB  
DATUM Geodetic DATE 11.20.09 CHECKED BY RA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × LAB VANE						
178.3	Ground Surface							20 40 60 80 100	10 20 30						
178.1	200mm TOPSOIL														
0.2	FILL - Silty Clay, some gravel, trace sand, firm, brown, dry to damp		1	SS	7									13 4 44 39	
177.6															
0.7	FILL - Cobbles and Gravel, very dense, grey, moist to wet		2	SS	100/ 8cm										
176.5															
1.8	SILTY CLAY very stiff to hard, brown, damp to moist		3	SS	48										
			4	SS	30									0 0 62 38	
			5	SS	19										
174.6															
3.7	SILT trace clay, compact to dense, brown, wet		6	SS	48										
			7	SS	46									0 0 96 4	
			8	SS	21										
172.4															
5.9	SILTY CLAY trace sand, trace gravel, stiff to very stiff, grey, damp to moist  (GLACIAL TILL)		9	SS	23										
			10	SS	20									2 3 69 26	
			11	SS	15									0 2 71 27	
			12	TW	PH								21.0	0 3 69 28	
			13	SS	17										
164.7															
13.6	End of Borehole														
	Borehole was dry (not stabilized) and hole open to full depth on completion.														
	Sampler bouncing on probable obstruction at 0.7m														

Continued Next Page

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

ONTARIO MOT 1-09-4135 WELLAND CANAL GPJ ONTARIO MOT GDT 03/22/10

## METRIC

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

Date	Depth(m)	Elevation(m)
Nov.30.09	3.0	175.3
Dec.08.09	2.7	175.6
Dec.16.09	2.6	175.7
Jan.04.10	2.5	175.8
Jan.11.10	2.5	175.8

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

# RECORD OF BOREHOLE No W2

1 OF 1

METRIC

W.P. 280-99-00 LOCATION Coords: N:4765017.0 E:327225.3 ORIGINATED BY PK  
DIST HWY 406 BOREHOLE TYPE Hollow Stem Augers COMPILED BY DB  
DATUM Geodetic DATE 11.20.09 CHECKED BY RA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
178.4	Ground Surface							20 40 60 80 100						
178.2	180mm TOPSOIL							20 40 60 80 100						
0.2	FILL - Silty Clay, trace sand, trace gravel, trace rootlets, very stiff, brown, moist		1	SS	17		178				○			
177.7														
0.7	SILTY CLAY very stiff to hard, brown, damp to moist		2	SS	83		177				○			
			3	SS	26		176				○			0 0 64 35
			4	SS	58		175				○			
			5	SS	41		174				○			0 0 77 23
			6	SS	52		173				○			
			7	SS	53		172				○			
173.5			8	SS	18		171				○			
4.9	SILT trace clay, compact, brown, wet		9	SS	12		170				○			
172.5			10	SS	15		169				○			
5.9	SILTY CLAY trace sand, trace gravel, firm to very stiff, grey, damp to moist  (GLACIAL TILL)		11	TW	PH		168				○			
			12	SS	18		167				○			
166.4														
12.0	End of Borehole Borehole was dry (not stabilized) and hole open to full depth on completion. No sample recovery at SS9 and SS10. Sampler redriven and disturbed sample collected.  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) Nov.30.09 6.3 172.1 Dec.08.09 4.4 174.0 Dec.16.09 4.7 173.7 Jan.14.10 4.2 174.2													

ONTARIO MOT 1-09-4135 WELLAND CANAL\_GPJ ONTARIO MOT GDT 03/22/10

# RECORD OF BOREHOLE No W3

1 OF 3

METRIC

W.P. 280-99-00 LOCATION Coords: N:4765031.1 E:327217.8 ORIGINATED BY MP  
DIST HWY 406 BOREHOLE TYPE Hollow Stem Augers / Casing and Washboring / NQ Rock Coring COMPILED BY DB  
DATUM Geodetic DATE 11.23.09 - 11.24.09 CHECKED BY RA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
								20 40 60 80 100							
								○ UNCONFINED + FIELD VANE							
								● QUICK TRIAXIAL × LAB VANE							
								20 40 60 80 100							
176.8	Ground Surface														
176.6	FILL - Sand and Gravel, trace silt, grey / brown, damp to moist		1	SS	6										
0.2	FILL - Silty Clay, trace sand, trace gravel, firm, brown, damp														
176.1															
0.7	SILTY CLAY trace sand, very stiff, brown, damp to moist		2	SS	17		176								
			3	SS	25		175							0 1 63 36	
			4	SS	21		174								
173.9			5	SS	52		173							0 2 92 6	
2.9	SILT trace sand, trace clay, dense to very dense, brown, wet		6	SS	32		172								
			7	SS	14		171								
172.4	SILTY CLAY trace sand, trace gravel, stiff to very stiff, grey, damp to moist  (GLACIAL TILL)		8	SS	19		170							5 3 68 24	
4.4			9	SS	9		169								
			10	SS	10		168							1 2 72 25	
			11	TW	PH		166						21.0	0 2 71 27	
			12	SS	14		165								
			13	SS	38		163							6 8 63 23	
							162								
161.8															

Continued Next Page

+<sup>3</sup>, x<sup>3</sup>: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE



RECORD OF BOREHOLE No W3

3 OF 3

METRIC

W.P. 280-99-00 LOCATION Coords: N:4765031.1 E:327217.8 ORIGINATED BY MP  
DIST HWY 406 BOREHOLE TYPE Hollow Stem Augers / Casing and Washboring / NQ Rock Coring COMPILED BY DB  
DATUM Geodetic DATE 11.23.09 - 11.24.09 CHECKED BY RA

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa					WATER CONTENT (%)			
						20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					10 20 30 W <sub>p</sub> W W <sub>L</sub>					
145.9			3	RUN	NQ											RUN#3 TCR=98% SCR=68% RQD=21%
30.9	End of Borehole  No sample recovery at SS10. Sampler redriven and disturbed sample collected.  Vane sinking under weight of rods at 11.6m.  Resistance to augering at 13.7m and 14.3m.  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) Dec.08.09 4.3 172.5 Dec.16.09 4.2 172.6 Jan.04.10 4.2 172.6															



# CORE LOG



**Terraprobe**

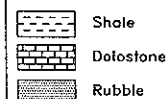
Project	Highway 406 Twinning	Orientation	Vertical	Ground Elevation	176.8m	Datum	Geodetic	Borehole No.	W3
Location	Welland, Ontario	Date Started	November 24, 2009	Completed	November 24, 2009	Logged By	B. Ripley	Sheet	1 of 1
W.P.:	280-99-00	Drilling Agency	Ground Works	Drill Type	Bombardier	Core Barrel & Bit Design	NQ	Project No.	1-09-4135

ELEVATION (m)	DEPTH (m)	SYMBOL	GENERAL DESCRIPTION	Joint Characteristics								WEATHERING	STRENGTH	FRACTURE FREQUENCY	RUN NO.	CORE RECOVERY %	R Q D %	CORE SIZE/CASING	MPa UNCONFINED COMPRESSIVE STRENGTH	UNIT WEIGHT (kN/m³)
				No. OF SETS	JOINT TYPE	ORIENTATION	SPACING	ROUGHNESS	FILLING	APERTURE										
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19		
150.8	26.0																			
150.3	26.5		Overburden, see Borehole Log W3																	
150.0	26.8																			
149.8	27.0		SALINA FORMATION BEDROCK																	
			Dolostone (93.9%) Frequent shale seams to shaly, light grey, highly fractured, thinly to medium bedded, medium strength, slightly weathered.																	
149.3	27.5		Shale (6.1%) Moderately weathered, dark grey, low to medium strength.	1	B	F V	C	RP SP	T	0 to 1										
148.8	28.0																			
148.3	28.5																			
147.8	29.0			1	B	V	C	RP SP	T	0 to 1										
147.3	29.5																			
146.8	30.0			1	B	F D V	C	RP SP	T	0 to 1										
146.3	30.5																			
145.9	30.9																			
145.8	31.0		End of Core Log																	
			Highly fractured zones at: 26.8-27.0m; 27.3-27.34m; 30.7-30.8m; 30.3-30.5m.																	
145.3	31.5		Rubble at 26.8-26.9m.																	
144.8	32.0																			

Remarks:

Rubble indicated by '4'.

## LEGEND:



# RECORD OF BOREHOLE No W4

1 OF 3

METRIC

W.P. 280-99-00 LOCATION Coords: N:4765036.5 E:327230.2 ORIGINATED BY MP  
 DIST HWY 406 BOREHOLE TYPE Hollow Stem Augers / Casing and Washboring / NQ Rock Coring COMPILED BY DB  
 DATUM Geodetic DATE 11.25.09 - 11.27.09 CHECKED BY RA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
								20 40 60 80 100							
								20 40 60 80 100							
177.6	Ground Surface														
177.5	100mm TOPSOIL														
0.1	FILL - Silty Clay, trace sand, trace gravel, stiff, brown, damp to moist		1	SS	14		177								
176.7			2	SS	52		176								
0.9	SILTY CLAY trace sand, very stiff to hard, brown, damp to moist		3	SS	37		175								
			4	SS	27		174								
			5	SS	19		173								
173.9			6	SS	37		172								
3.7	SILT trace clay, trace sand, compact to dense, brown, wet		7	SS	26		171								
172.4			8	SS	18		170								
5.2	SILTY CLAY trace sand, stiff to very stiff, grey, damp to moist  (GLACIAL TILL)		9	SS	17		169								
			10	TW	PH		168								
			11	SS	11		167								
			12	SS	15		166								
			13	SS	3		165								
			14	SS	17		164								
162.6	hard						163								

ONTARIO MOT 1-09-4135 WELLAND CANAL.GPJ ONTARIO MOT.GDT 03/22/10

Continued Next Page

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

# RECORD OF BOREHOLE No W4

2 OF 3

METRIC

W.P. 280-99-00 LOCATION Coords: N:4765036.5 E:327230.2 ORIGINATED BY MP  
 DIST HWY 406 BOREHOLE TYPE Hollow Stem Augers / Casing and Washboring / NQ Rock Coring COMPILED BY DB  
 DATUM Geodetic DATE 11.25.09 - 11.27.09 CHECKED BY RA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)			
							20	40	60	80	100							
							20	40	60	80	100							
15.0	SILTY CLAY trace sand, trace gravel, hard, grey, damp  (GLACIAL TILL)		15	SS	50		162									6 9 64 21		
							161											
				16	SS	120/ 15cm		160										
				17	SS	44		159										
158.3																		
19.3	SAND AND SILT trace to some clay, trace gravel, compact to very dense, grey, moist to wet  (GLACIAL TILL)		18	SS	27		158											
							157											
				19	SS	67		156								6 42 42 10		
155.3																		
22.3	SILTY CLAY trace sand to sandy, trace gravel, very stiff to hard, grey, damp to moist  (GLACIAL TILL)		20	SS	39		155											
							154											
				21	SS	28		153										
152.3																		
25.3	SILT AND SAND trace clay, trace to some gravel, very dense, grey, moist (GLACIAL TILL)		22	SS	70		152									Nov.26 Nov.27		
							151											
151.1																		
26.5	COBBLES some gravel, inferred very dense, grey, wet			1	RUN	NQ		150									RUN#1 TCR=89% SCR=53% RQD=22%	
150.1																		
27.5	DOLOSTONE BEDROCK Light grey, slightly weathered, thinly to medium bedded, medium strength, with interbeds of dark grey, moderately weathered, low to medium strength shale.			2	RUN	NQ		149									RUN#2 TCR=94% SCR=94% RQD=63%	
147.9																		
29.7	End of Borehole																	


Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity ○ 3% STRAIN AT FAILURE

ONTARIO MOT 1-09-4135 WELLAND CANAL GPJ ONTARIO MOT GDT 03/22/10

## 3 OF 3

**METRIC**

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

Unable to push vane to 15.2m.  
Resistance to augering at 13.7m and 14.3m.  
Borehole sealed with bentonite slurry to ground surface.

# CORE LOG



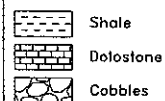
**Terraprobe**

Project	Highway 406 Twinning	Orientation	Vertical	Ground Elevation	177.6m	Datum	Geodetic	Borehole No.	W4
Location	Welland, Ontario	Date Started	November 27, 2009	Completed	November 27, 2009	Logged By	B. Ripley	Sheet	1 of 1
W.P.:	280-99-00	Drilling Agency	Ground Works	Drill Type	Bombardier	Core Barrel & Bit Design	NQ	Project No.	1-09-4135

ELEVATION (m)	DEPTH (m)	SYMBOL	GENERAL DESCRIPTION	Joint Characteristics								WEATHERING	STRENGTH	FRACTURE FREQUENCY	RUN NO. CORE RECOVERY %	R Q D %	CORE SIZE/CASING	MPa UNCONFINED COMPRESSIVE STRENGTH	UNIT WEIGHT (KN/m³)
				NO. OF SETS	JOINT TYPE	ORIENTATION	SPACING	ROUGHNESS	FILLING	APERTURE									
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	
151.6	26.0																		
151.1	26.5		Overburden, see Borehole Log W4																
150.9	26.7		Overburden,																
150.6	27.0		COBBLES some gravel, see Borehole Log W4																
150.1	27.5		SALINA FORMATION BEDROCK	1	B	F	C	RP	T	0 to 1				#1 TCR 69 SCR 53	22	NQ			
149.6	28.0		Dolostone (91%) Frequent shale seams to shaly, light to medium grey, highly fractured, thinly to medium bedded, medium strength, slightly weathered.																
149.1	28.5		Shale (9%) Moderately weathered, medium to dark grey, low to medium strength.	1	B	V	C	RP	T	0 to 1				#2 TCR 94 SCR 94	63	NQ			
148.6	29.0																		
148.1	29.5																		
147.9	29.7		End of Core Log																
147.6	30.0		Highly fractured zones at: 27.9-27.95m.																
147.1	30.5		Rubble at 27.5 and 27.8m.																
146.6	31.0																		
146.1	31.5																		
145.6	32.0																		

Remarks:

## LEGEND:



## 1 OF 2

METRIC

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

# RECORD OF BOREHOLE No W5

2 OF 2

METRIC

W.P. 280-99-00 LOCATION Coords: N:4765094.5 E:327222.4 ORIGINATED BY PK  
 DIST HWY 406 BOREHOLE TYPE Hollow Stem Augers / Casing and Washboring / NQ Rock Coring COMPILED BY DB  
 DATUM Geodetic DATE 12.08.09 CHECKED BY RA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
								20 40 60 80 100	20 40 60 80 100	10 20 30					
								○ UNCONFINED    + FIELD VANE ● QUICK TRIAXIAL    × LAB VANE	WATER CONTENT (%)						
155.5 15.3	SILTY CLAY some sand, trace gravel, very stiff to hard, reddish brown, moist to wet  (GLACIAL TILL)		10	SS	34		155								2 18 50 30
								154							
									153						
152.4 18.4	SILT AND SAND some gravel, trace clay, compact, grey, wet  (GLACIAL TILL)		11	SS	15			152							
								151							
150.9 19.9	SAND AND GRAVEL occasional cobbles, very dense, grey, wet		12	SS	16		150								
								149							
149.5 21.3	DOLOSTONE BEDROCK Light grey, slightly weathered, thinly to medium bedded, medium strength, with interbeds of light to dark grey, moderately weathered, low to medium strength shale.		13	SS	100/ 5cm		148								
								147							
								146							
145.5 25.3	End of Borehole														
	Artesian conditions encountered. Water flowing from augers. Top of auger stem is Elev. ~ 171.7m.  Resistance to augering at 9.1m.  Borehole sealed by pumping bentonite slurry into hole from 25.3m to 5.2m.														

ONTARIO MOT 1-09-4135 WELLAND CANAL GPJ ONTARIO MOT.GDT 03/22/10

# CORE LOG



**Terraprobe**

Project	Highway 406 Twinning	Orientation	Vertical	Ground Elevation	170.8m	Datum	Geodetic	Borehole No.	W5
Location	Welland, Ontario	Date Started	December 8, 2009	Completed	December 9, 2009	Logged By	B. Ripley	Sheet	1 of 1
W.P.:	280-99-00	Drilling Agency	DDSI	Drill Type	Bombardier	Core Barrel & Bit Design	NQ	Project No.	1-09-4135

ELEVATION (m)	DEPTH (m)	SYMBOL	GENERAL DESCRIPTION	Joint Characteristics								STRENGTH	FRACTURE FREQUENCY	RUN NO. CORE RECOVERY %	R Q D %	CORE SIZE/CASING	UNCONFINED COMPRESSIVE STRENGTH MPa	UNIT WEIGHT (kN/m <sup>3</sup> )
				No. OF SETS	JOINT TYPE	ORIENTATION	SPACING	ROUGHNESS	FILLING	APERTURE	WEATHERING							
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
150.3	20.5																	
149.8	21.0		Overburden, see Borehole Log W5															
149.5	21.3																	
149.3	21.5		SALINA FORMATION BEDROCK															
			Dolostone (97%)	1	B	V	C	RP	T	0 to 1				#1	13	NQ		
			Frequent shale seams to shaly, light to medium grey, highly fractured, thinly to medium bedded, medium strength, slightly weathered.											TCR 100				
148.8	22.0													SCR 62				
			Shale (3%)											#2	41	NQ		
			Moderately weathered, medium to dark grey, low to medium strength.											TCR 100				
148.3	22.5													SCR 81				
147.8	23.0			1	B	V	C	RP	T	0 to 1								
147.3	23.5																	
146.8	24.0													#3	34	NQ		
														TCR 100				
146.3	24.5			1	B	V	C	RP	T	0 to 1				SCR 92				
145.8	25.0																	
145.5	25.3																	
145.3	25.5		End of Core Log															
			Highly fractured zones at:															
			21.4-21.5m; 21.7-21.9m; 22.8-23.1m;															
144.8	26.0		23.6-23.7m; 24.8-24.9m.															
144.3	26.5																	

Remarks:

LEGEND:



Dolostone



RECORD OF BOREHOLE No W6

1 OF 3

METRIC

W.P. 280-99-00 LOCATION Coords: N:4765154.5 E:327213.4 ORIGINATED BY MP  
DIST HWY 406 BOREHOLE TYPE Hollow Stem Augers / Casing and Washboring / NQ Rock Coring COMPILED BY DB  
DATUM Geodetic DATE 11.19.09 - 11.20.09 CHECKED BY RA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × LAB VANE						
175.6	Ground Surface						20 40 60 80 100		10 20 30						
175.6 0.1	50mm TOPSOIL		1	SS	5										
	FILL - Silty Clay, trace sand, trace gravel, firm to very stiff, brown / greyish brown, damp to moist		2	SS	8										
			3	SS	5										
			4	SS	11										
			5	SS	7										
			6	SS	10										
		---		7	SS	12									
		frequent silt inclusions		8	SS	15									
		---		9	SS	17									
				10	SS	13									
		---		11	SS	8									
167.0	SILTY CLAY trace sand, trace gravel, firm to stiff, grey, moist  (GLACIAL TILL)		12	SS	3										
8.6			13	SS	6										
			14	TW	PH										
160.6															

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

ONTARIO MOT-1-09-4135 WELLAND CANAL.GPJ ONTARIO MOT.GDT 03/22/10

# RECORD OF BOREHOLE No W6

2 OF 3

METRIC

W.P. 280-99-00 LOCATION Coords: N:4765154.5 E:327213.4 ORIGINATED BY MP  
 DIST HWY 406 BOREHOLE TYPE Hollow Stem Augers / Casing and Washboring / NQ Rock Coring COMPILED BY DB  
 DATUM Geodetic DATE 11.19.09 - 11.20.09 CHECKED BY RA

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES		20	40	60	80	100					
15.0	SILTY CLAY trace sand, trace gravel, stiff to very stiff, grey, moist (GLACIAL TILL)		15	SS	26											1 8 69 22
			16	SS	3											
157.1	very loose		17	SS	3											
18.5	SANDY SILT trace gravel, trace clay, compact to very dense, grey, wet (GLACIAL TILL)		18	SS	16											2 28 62 8
			19	SS	37											
153.3	SILTY CLAY trace sand, trace gravel, stiff, grey, moist (GLACIAL TILL)		20	SS	8											Nov.19 Nov.20 Commence Washboring
22.3			21	SS	10											1 4 49 46
150.5	DOLOSTONE BEDROCK Light to dark grey, slightly weathered, thinly to medium bedded, medium strength, with interbeds of dark grey, moderately weathered, low to medium strength shale.		1	RUN	NQ											RUN#1 TCR=100% SCR=66% RQD=63%
25.1			2	RUN	NQ											RUN#2 TCR=99% SCR=99% RQD=32%
			3	RUN	NQ											RUN#3 TCR=100% SCR=91% RQD=52%
146.2	End of Borehole															
29.4																

Continued Next Page

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

ONTARIO MOT 1-09-4135 WELLAND CANAL.GPJ ONTARIO MOT GDT 03/22/10



# CORE LOG



**Terraprobe**

Project	Highway 406 Twinning	Orientation	Vertical	Ground Elevation	175.5m	Datum	Geodetic	Borehole No.	W6
Location	Welland, Ontario	Date Started	November 20, 2009	Completed	November 20, 2009	Logged By	B. Ripley	Sheet	1 of 1
W.P.:	280-99-00	Drilling Agency	DDSI	Drill Type	Bombardier	Core Barrel & Bit Design	NQ	Project No.	1-09-4135

ELEVATION (m)	DEPTH (m)	SYMBOL	GENERAL DESCRIPTION	Joint Characteristics								STRENGTH	FRACTURE FREQUENCY	RUN NO. CORE RECOVERY %	R Q D %	CORE SIZE/CASING	UNCONFINED COMPRESSIVE STRENGTH MPa	UNIT WEIGHT (KN/m³)
				No. OF SETS	JOINT TYPE	ORIENTATION	SPACING	ROUGHNESS	FILLING	APERTURE	WEATHERING							
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
151.1	24.5		Overburden, see Borehole Log W6															
150.6	25.0																	
150.5	25.1																	
150.1	25.5		SALINA FORMATION BEDROCK															
			Dolostone (99%)															
			Occasional to frequent shale seams, light to medium grey, moderately to highly fractured, thinly to medium bedded, medium strength, slightly weathered. Calcite filled joints (occasional in RUN#2 and RUN#3).	1	B	V	C	RP SP	T	0 to 1				#1	63	NQ		
149.6	26.0													TCR 100				
														SCR 66				
149.1	26.5		Shale (1%)															
			Moderately weathered, medium to dark grey, low to medium strength.															
148.6	27.0			1	B	V	C	RP SP	T	0 to 1				#2	32	NQ		
														TCR 99				
														SCR 99				
148.1	27.5																	
147.6	28.0																	
147.1	28.5			1	B	V	C	RP SP	T	0 to 1				#3	52	NQ		
														TCR 100				
														SCR 91				
146.6	29.0																	
146.2	29.4																	
146.1	29.5		End of Core Log															
145.6	30.0		Highly fractured zones at:															
			25.2m; 25.4-25.6m; 28.0-28.2m.															
145.1	30.5																	

Remarks:

LEGEND:



Dolostone

# RECORD OF BOREHOLE No W7

1 OF 2

METRIC

W.P. 280-99-00 LOCATION Coords: N:4765147.3 E:327203.1 ORIGINATED BY MP  
 DIST HWY 406 BOREHOLE TYPE Hollow Stem Augers / Casing and Washboring / NQ Rock Coring COMPILED BY DB  
 DATUM Geodetic DATE 11.23.09 - 11.24.09 CHECKED BY RA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× LAB VANE					
175.2	Ground Surface					20	40	60	80	100	10	20	30			
175.1 0.1	80mm TOPSOIL		1	SS	9											
	FILL - Silty Clay, trace sand, trace gravel, firm to hard, brown / greyish brown, damp to moist		2	SS	42											
			3	SS	10											
			4	SS	11											
			5	SS	25											
	----- frequent silt inclusions -----		6	SS	19											
			7	SS	15											
			8	SS	15											
	----- frequent silt inclusions -----		9	SS	8											
			10	SS	24											
166.6 8.6	SILTY CLAY trace sand, trace gravel, stiff to very stiff, grey, damp to moist  (GLACIAL TILL)		11	SS	5											
			12	SS	3											
			13	TW	PH											
			14	SS	21											
160.2																

ONTARIO MOT 1-09-4135 WELLAND CANAL GPJ ONTARIO MOT GDT 03/22/10

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+ 3, x 3: Numbers refer to  
Sensitivity

○ 3% STRAIN AT FAILURE



# CORE LOG



**Terraprobe**

Project	Highway 406 Twinning	Orientation	Vertical	Ground Elevation	175.2m	Datum	Geodetic	Borehole No.	W7
Location	Welland, Ontario	Date Started	November 23, 2009	Completed	November 24, 2009	Logged By	B. Ripley	Sheet	1 of 1
W.P.:	280-99-00	Drilling Agency	DDSI	Drill Type	Bombardier	Core Barrel & Bit Design	NQ	Project No.	1-09-4135

ELEVATION (m)	DEPTH (m)	SYMBOL	GENERAL DESCRIPTION	Joint Characteristics								STRENGTH	FRACTURE FREQUENCY	RUN NO. CORE RECOVERY %	R Q D %	CORE SIZE/CASING	MPa UNCONFINED COMPRESSIVE STRENGTH	UNIT WEIGHT (kN/m <sup>3</sup> )
				No. OF SETS	JOINT TYPE	ORIENTATION	SPACING	ROUGHNESS	FILLING	APERTURE	WEATHERING							
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
150.7	24.5																	
150.2	25.0		Overburden, see Borehole Log W7															
150.0	25.2																	
149.7	25.5		SALINA FORMATION BEDROCK	1	B	V	C	SP RP	T	0 to 1				#1 TCR 0	0	NQ		
149.2	26.0		Dolostone (99%) Occasional to frequent shale seams, light to medium grey, moderate to highly fractured, thinly to medium bedded, medium strength, slightly weathered.	1	B	V	C	SP RP	T	0 to 1				#2 TCR 97 SCR 91	57	NQ		
148.7	26.5		Shale (1%) Moderately weathered, medium to dark grey, low to medium strength.															
148.2	27.0													#3 TCR 95 SCR 88	48			
147.7	27.5			1	B	V	C	SP RP	T	0 to 1						NQ		
147.2	28.0																	
147.1	28.2		End of Core Log															
146.7	28.5		Highly fractured zones at: 25.2-25.5m; 27.9-28.1m.															
146.2	29.0																	
145.7	29.5																	
145.2	30.0																	
144.7	30.5																	

Remarks:

LEGEND:



Dolostone

# RECORD OF BOREHOLE No W8

1 OF 3

METRIC

W.P. 280-99-00 LOCATION Coords: N:4765168.4 E:327205.7 ORIGINATED BY MP  
 DIST HWY 406 BOREHOLE TYPE Hollow Stem Augers / Casing and Washboring / NQ Rock Coring COMPILED BY DB  
 DATUM Geodetic DATE 11.30.09 - 12.01.09 CHECKED BY RA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)			
								○ UNCONFINED	+ FIELD VANE							● QUICK TRIAXIAL	× LAB VANE	
175.9	Ground Surface						20	40	60	80	100	10	20	30	kN/m <sup>3</sup>	GR SA SI CL		
175.9 0.1	50mm TOPSOIL		1	SS	17													
	FILL - Silty Clay, trace sand, trace gravel, stiff to hard, brown / greyish brown, damp to moist		2	SS	12													
			3	SS	15													
			4	SS	26													
			5	SS	14													
			6	SS	28													
			7	SS	25													
			8	SS	22													
			9	SS	27													
		----- frequent silt inclusions -----		10	SS	73												
167.3 8.6		SILTY CLAY trace sand, trace gravel, occasional cobbles between 15.2m and 16.8m, stiff to very stiff, hard between 13.2m and 17.7m, grey, damp to moist  (GLACIAL TILL)		11	SS	18												
			12	TW	PH													
			13	SS	10													
			14	SS	41													
160.9																		

ONTARIO MOT 1-09-4135 WELLAND CANAL GPJ ONTARIO MOT GDT 03/22/10

Continued Next Page

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



RECORD OF BOREHOLE No W8

2 OF 3

METRIC

W.P. 280-99-00 LOCATION Coords: N:4765166.4 E:327205.7 ORIGINATED BY MP  
DIST HWY 406 BOREHOLE TYPE Hollow Stem-Augers / Casing and Washboring / NQ Rock Coring COMPILED BY DB  
DATUM Geodetic DATE 11.30.09 - 12.01.09 CHECKED BY RA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																											
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ONTARIO MOT 1-09-4135 WELLAND CANAL GPJ ONTARIO MOT GDT 03/22/10

Continued Next Page

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

## METRIC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT  W <sub>p</sub>	NATURAL MOISTURE CONTENT  W	LIQUID LIMIT  W <sub>L</sub>	UNIT WEIGHT  γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	"N" VALUES			20	40						60	80	100

Resistance to augering from 15.2m to 16.8m, and from 21.9m to 22.3m.

Borehole filled with drill water to 7.6m on completion of drilling.

Borehole sealed with bentonite slurry to ground surface.

+3, X3: Numbers refer to Sensitivity      ○ 3% STRAIN AT FAILURE

# CORE LOG



**Terraprobe**

Project	Highway 406 Twinning	Orientation	Vertical	Ground Elevation	175.9m	Datum	Geodetic	Borehole No.	W8
Location	Welland, Ontario	Date Started	December 1, 2009	Completed	December 1, 2009	Logged By	B. Ripley	Sheet	1 of 1
W.P.:	280-99-00	Drilling Agency	Ground Works	Drill Type	Bombardier	Core Barrel & Bit Design	NQ	Project No.	1-09-4135

ELEVATION (m)	DEPTH (m)	SYMBOL	GENERAL DESCRIPTION	Joint Characteristics							WEATHERING	STRENGTH	FRACTURE FREQUENCY	RUN NO.	CORE RECOVERY %	R Q D %	CORE SIZE/CASING	UNCONFINED COMPRESSIVE STRENGTH MPa	UNIT WEIGHT (kN/m <sup>3</sup> )
				No. OF SETS	JOINT TYPE	ORIENTATION	SPACING	ROUGHNESS	FILLING	APERTURE									
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	
151.4	24.5																		
150.9	25.0		Overburden, see Borehole Log W8																
150.6	25.3		SALINA FORMATION BEDROCK																
150.4	25.5		Dolostone (99%) Occasional to frequent shale seams, light to medium grey, moderately to highly fractured, thinly to medium bedded, medium strength, slightly weathered.												#1				
149.9	26.0		Occasional calcite filled joints.	1	B	V	C	RP SP	T	0 to 1					TCR 100 SCR 78	37	NQ		
149.4	26.5		Shale (1%) Moderately weathered, medium to dark grey, low to medium strength.																
148.9	27.0			1	B	V	C	RP SP	T	0 to 1					#2				
148.4	27.5														TCR 97 SCR 90	26	NQ		
147.9	28.0																		
147.4	28.5				1	B	V	C	RP SP	T	0 to 1				#3				
146.9	29.0														TCR 99 SCR 89	43	NQ		
146.4	29.5			End of Core Log															
			Highly fractured zones at:																
145.9	30.0		25.3m; 25.6-25.7m; 25.8m;																
			27.4m; 28.1m.																
145.4	30.5																		

Remarks:

LEGEND:



Dolostone

RECORD OF BOREHOLE No W9

1 OF 3

METRIC

W.P. 280-99-00 LOCATION Coords: N:4765163.6 E:327199.4 ORIGINATED BY MP  
DIST HWY 406 BOREHOLE TYPE Hollow Stem Augers / Casing and Washboring / NQ Rock Coring COMPILED BY DB  
DATUM Geodetic DATE 12.02.09 - 12.04.09 CHECKED BY RA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
175.6	Ground Surface							20 40 60 80 100						
175.5	80mm TOPSOIL							○ UNCONFINED + FIELD VANE						
0.1								● QUICK TRIAXIAL × LAB VANE						
	FILL - Silty Clay, trace sand, trace gravel, firm to very stiff, brown / greyish brown, damp to moist		1	SS	7		175							
			2	SS	13		174							
			3	SS	20		173							0 3 43 54
			4	SS	14		172							
			5	SS	14		171							
			6	SS	23		170							
	----- frequent silt inclusions -----		7	SS	19		169							
			8	SS	19		168							
			9	SS	17		167							
			10	SS	28		166							
			11	SS	15		165							
164.8			12	SS	13		164							
10.8	SILTY CLAY trace to some sand, trace gravel, stiff to hard, grey, damp to moist  (GLACIAL TILL)		13	SS	12		163							1 15 62 22
			14	SS	33		162							
							161							2 9 65 24
160.6														

Continued Next Page

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

ONTARIO MOT 1-09-4135 WELLAND CANAL.GPJ ONTARIO MOT.GDT 03/22/10

2 OF 3

METRIC

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

## 3 OF 3

METRIC

ONTARIO MOT 1-09-4135 WELLAND CANAL.GPJ ONTARIO MOT.GDT 03/22/10

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

# CORE LOG



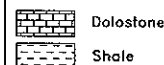
**Terraprobe**

Project	Highway 406 Twinning	Orientation	Vertical	Ground Elevation	175.6m	Datum	Geodetic	Borehole No.	W9
Location	Welland, Ontario	Date Started	December 4, 2009	Completed	December 4, 2009	Logged By	B. Ripley	Sheet	1 of 1
W.P.:	280-99-00	Drilling Agency	Ground Works	Drill Type	Bombardier	Core Barrel & Bit Design	NQ	Project No.	1-09-4135

ELEVATION (m)	DEPTH (m)	SYMBOL	GENERAL DESCRIPTION	Joint Characteristics								STRENGTH	FRACTURE FREQUENCY	RUN NO. CORE RECOVERY %	R Q D %	CORE SIZE/CASING	UNCONFINED COMPRESSIVE STRENGTH MPa	UNIT WEIGHT (kN/m³)
				No. OF SETS	JOINT TYPE	ORIENTATION	SPACING	ROUGHNESS	FILLING	APERTURE	WEATHERING							
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
151.1	24.5																	
150.6	25.0		Overburden, see Borehole Log W9															
150.4	25.2																	
150.1	25.5		SALINA FORMATION BEDROCK															
			Dolostone (98%)															
			Occasional to frequent sand seams, light to medium grey, moderately to highly fractured, thinly to medium bedded, medium strength, slightly weathered.	1	B	V	C	RP SP	T	0 to 1				#1	24	NQ		
149.6	26.0		Occasional calcite filled joints / partings / bedding planes.															
149.1	26.5		Shale (2%)															
			Moderately weathered, medium to dark grey, low to medium strength, thinly laminated to fissile.															
148.6	27.0																	
148.1	27.5			1	B	V	C	RP SP	T	0 to 1				#2	22	NQ		
147.6	28.0																	
147.5	28.2		End of Core Log															
147.1	28.5																	
			Highly fractured zones at:															
			25.2-25.9m; 26.1-26.4m;															
146.6	29.0		Shale at 26.3-26.4m.															
146.1	29.5																	
145.6	30.0																	
145.1	30.5																	

Remarks:

## LEGEND:



## METRIC

ONTARIO MOT 1-09-4135 WELLAND CANAL.GPJ ONTARIO MOT.GDT 03/22/10

Continued Next Page

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



RECORD OF BOREHOLE No W10

2 OF 2

METRIC

W.P. 280-99-00 LOCATION Coords: N:4765222.6 E:327185.7 ORIGINATED BY PK  
DIST HWY 406 BOREHOLE TYPE Hollow Stem Augers / Casing and Washboring / NQ Rock Coring COMPILED BY DB  
DATUM Geodetic DATE 11.30.09 CHECKED BY RA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT   NATURAL MOISTURE CONTENT   LIQUID LIMIT			UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)							
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)						
								○ UNCONFINED   + FIELD VANE ● QUICK TRIAXIAL   × LAB VANE							w <sub>p</sub> w   w <sub>L</sub>						
							20	40	60	80	100	10	20	30	GR	SA	SI	CL			
15.0	SILTY CLAY trace sand, trace gravel, soft, grey, damp to moist  (GLACIAL TILL)						158														
			6	SS	3		157														0   2   68   30
156.5																					
16.8	SILT AND SAND trace clay, trace gravel, compact to dense, grey, wet  (GLACIAL TILL)						156														
			7	SS	33		155														1   37   57   5
			8	SS	17		154														
153.6	SILTY CLAY trace sand, very stiff, grey, damp to moist  (GLACIAL TILL)						153														
19.7																					0   6   36   58
			9	SS	16		152														
151.7	COBBLES - some gravel, very dense, grey, wet						151														
21.6																					
151.3																					
22.0	DOLOSTONE BEDROCK Light grey, slightly weathered, thinly to medium bedded, medium strength, with interbeds of dark grey, moderately weathered, low to medium strength shale.		10	SS	100/ 8cm		151														
																					RUN#1 TCR=95% SCR=63% RQD=16%
			1	RUN	NQ		150														
			2	RUN	NQ		149														
148.2	End of Borehole  Borehole filled with drill water upon completion of coring.  Borehole sealed with bentonite slurry from 25.1m to 11.1m.																				
25.1																					

ONTARIO MOT 1-09-4135 WELLAND CANAL GPJ ONTARIO MOT GDT 03/22/10

# CORE LOG



**Terraprobe**

Project	Highway 406 Twinning	Orientation	Vertical	Ground Elevation	173.3m	Datum	Geodetic	Borehole No.	W10
Location	Welland, Ontario	Date Started	November 30, 2009	Completed	November 30, 2009	Logged By	B. Ripley	Sheet	1 of 1
W.P.:	280-99-00	Drilling Agency	DDSI	Drill Type	Bombardier	Core Barrel & Bit Design	NQ	Project No.	1-09-4135

ELEVATION (m)	DEPTH (m)	SYMBOL	GENERAL DESCRIPTION	Joint Characteristics								STRENGTH	FRACTURE FREQUENCY	RUN NO. CORE RECOVERY %	R Q D %	CORE SIZE/CASING	MPa UNCONFINED COMPRESSIVE STRENGTH	UNIT WEIGHT (kN/m <sup>3</sup> )
				NO. OF SETS	JOINT TYPE	ORIENTATION	SPACING	ROUGHNESS	FILLING	APERTURE	WEATHERING							
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
151.8	21.5		Overburden, see Borehole Log W10															
151.3	22.0		SALINA FORMATION BEDROCK															
150.8	22.5		Dolostone (>99%) Occasional shale seams, light to medium grey, moderately to highly fractured, medium bedded, medium strength, slightly weathered.	1	B	V	C	RP	T	0 to 1				#1 TCR 95 SCR 63	16	NQ		
150.3	23.0		Occasional calcite filled joints poorly fossiliferous.															
149.8	23.5		Shale (<1%) Moderately weathered, medium to dark grey, low to medium strength.															
149.3	24.0			1	B	V	C	RP	T	0 to 1				#2 TCR 100 SCR 91	43	NQ		
148.8	24.5																	
148.3	25.0																	
148.2	25.1		End of Core Log															
147.8	25.5		Highly fractured zones at: 23.2-23.6m; 24.1-24.2m.															
147.3	26.0																	
146.8	26.5																	
146.3	27.0																	
145.8	27.5																	

Remarks:

LEGEND:



Dolostone

## 1 OF 2

## METRIC

ONTARIO MOT 1-09-4135 WELLAND CANAL.GPJ ONTARIO MOT.GDT 03/22/10

Continued Next Page

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE

RECORD OF BOREHOLE No W11										2 OF 2		METRIC			
W.P. 280-99-00		LOCATION		Coords: N:4765254.3 E:327185.9				ORIGINATED BY PK							
DIST _____ HWY 406		BOREHOLE TYPE		Hollow Stem Augers				COMPILED BY DB							
DATUM Geodetic		DATE		11.25.09 - 11.26.09				CHECKED BY RA							
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)
15.0	SILTY CLAY trace to some sand, trace to some gravel, sandy below 15.8m, firm, grey, damp to moist  (GLACIAL TILL)						20	40	60	80	100				
156.6															
16.8															
155.0	SILT AND SAND trace clay, trace gravel, very dense, grey, moist to wet.  (GLACIAL TILL)		7	SS	51										
18.4															
152.4															
21.0	SILTY CLAY trace to some sand, trace gravel, very stiff to hard, grey, damp  (GLACIAL TILL)		8	SS	58										
152.0															
21.4															
148.9	COBBLES - some gravel, inferred very dense, grey, wet		9	SS	20										
24.5															
149	DOLOSTONE BEDROCK Light to dark grey, slightly weathered, medium bedded, medium strength, with occasional dark grey, moderately weathered, low to medium strength shale seams.		1	RUN	NQ										
	End of Borehole  Borehole sealed with bentonite slurry from 24.5m to 11.3m.  No sample recovery at SS8.		2	RUN	NQ										
			3	RUN	NQ										

ONTARIO MOT 1-09-4135 WELLAND CANAL GPJ ONTARIO MOT GDT 03/22/10

# CORE LOG



**Terraprobe**

Project	Highway 406 Twinning	Orientation	Vertical	Ground Elevation	173.4m	Datum	Geodetic	Borehole No.	W11
Location	Welland, Ontario	Date Started	November 26, 2009	Completed	November 26, 2009	Logged By	B. Ripley	Sheet	1 of 1
W.P.:	280-99-00	Drilling Agency	DDSI	Drill Type	Bombardier	Core Barrel & Bit Design	NQ	Project No.	1-09-4135

ELEVATION (m)	DEPTH (m)	SYMBOL	GENERAL DESCRIPTION	Joint Characteristics								STRENGTH	FRACTURE FREQUENCY	RUN NO. CORE RECOVERY %	R Q D %	CORE SIZE/CASING	MPa UNCONFINED COMPRESSIVE STRENGTH	UNIT WEIGHT (kN/m <sup>3</sup> )
				No. OF SETS	JOINT TYPE	ORIENTATION	SPACING	ROUGHNESS	FILLING	APERTURE	WEATHERING							
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
152.9	20.5																	
152.4	21.0		Overburden, see Borehole Log W11															
152.2	21.2		Overburden, COBBLES - some gravel, see Borehole Log W11															
152.0	21.4		SALINA FORMATION BEDROCK															
151.9	21.5																	
			Dolostone (99%) Occasional shale seams and partings, light to medium grey, moderately to highly fractured, medium bedded, medium strength, slightly weathered.	1	B	V	C	RP SP	T	0 to 1				#1 TCR 88 SCR 33	0	NQ		
151.4	22.0																	
150.9	22.5		Shale (1%) Moderately weathered, medium to dark grey, low to medium strength.											#2 TCR 100 SCR 16	79	NQ		
150.4	23.0			1	B	V	C	RP SP	T	0 to 1								
149.9	23.5																	
149.4	24.0			1	B	V	C	RP SP	T	0 to 1				#2 TCR 100 SCR 100	16	NQ		
148.9	24.5		End of Core Log															
148.4	25.0		Highly fractured zones at: 21.4-21.7m; 22.4-22.7m; 23.0-23.3m.															
147.9	25.5																	
147.4	26.0																	
146.9	26.5																	

Remarks:

## LEGEND:



Dolostone  
Cobbles

# RECORD OF BOREHOLE No W12

1 OF 2

METRIC

W.P. 280-99-00 LOCATION Coords: N:4765274.6 E:327168.7 ORIGINATED BY PK  
 DIST HWY 406 BOREHOLE TYPE Hollow Stem Augers / Casing and Washboring / NQ Rock Coring COMPILED BY DB  
 DATUM Geodetic DATE 11.24.09 - 11.25.09 CHECKED BY RA

SOIL PROFILE				SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	SHEAR STRENGTH kPa			WATER CONTENT (%)							
						○ UNCONFINED				+ FIELD VANE	● QUICK TRIAXIAL					
173.4 0.0	Water Surface						20	40	60	80	100	10	20	30		
	WATER (Old Welland Canal)															
							173									
							172									
							171									
							170									
							169									
							168									
							167									
							166									
							165									
							164									
163.6 9.8	CANAL BED						163									
	Augered to 12.6m without sampling to stabilize augers.  Inferred Silty Clay Till						162									
							161									
160.8 12.6	SILTY CLAY trace sand, trace gravel, firm to very stiff, grey, damp to moist  (GLACIAL TILL)		1	SS	24		160									
			2	SS	12		159									
			3	SS	7											
158.4																

Continued Next Page

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

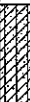




ONTARIO MOT 1-09-4135 WELLAND CANAL GPJ ONTARIO MOT.GDT 03/22/10

RECORD OF BOREHOLE No W12

2 OF 2

METRIC

W.P. 280-99-00 LOCATION Coords: N:4765274.6 E:327168.7 ORIGINATED BY PK  
DIST HWY 406 BOREHOLE TYPE Hollow Stem Augers / Casing and Washboring / NQ Rock Coring COMPILED BY DB  
DATUM Geodetic DATE 11.24.09 - 11.25.09 CHECKED BY RA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		W <sub>p</sub>	W	W <sub>L</sub>			
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	WATER CONTENT (%)						
						20 40 60 80 100	20 40 60 80 100	10 20 30							
15.0	SILTY CLAY trace sand, trace gravel, soft to firm, grey, damp to moist  (GLACIAL TILL)		4	SS	3		158							Nov.24	
			5	SS	7			157							Nov.25 0 1 83 16
156.7 16.7	SILT AND SAND trace clay, trace gravel, compact to dense, grey, wet  (GLACIAL TILL)		6	SS	18		156							7 42 44 7	
			7	SS	39			155							
			8	SS	100/ 10cm			154							
153.9 19.5 153.5 19.9	SILTY CLAY - trace to some sand, trace gravel, hard, grey, damp (GLACIAL TILL)		1	RUN	NQ		153							RUN#1 TCR=26% SCR=26%	
	COBBLES some gravel, inferred very dense, grey, wet														
152.0 21.4	DOLOSTONE BEDROCK Light to dark grey, slightly weathered, medium bedded, medium strength, with occasional dark grey, moderately weathered, low to medium strength shale seams.		2	RUN	NQ		152							RUN#2 TCR=99% SCR=75% RQD=0%	
			3	RUN	NQ			151							RUN#3 TCR=100% SCR=89% RQD=32%
			4	RUN	NQ			150							RUN#4 TCR=71% SCR=63% RQD=24%
149.0 24.4	End of Borehole  Borehole sealed with bentonite slurry from 24.4m to 12.6m.						149								

# CORE LOG



**Terraprobe**

Project Highway 406 Twinning				Orientation Vertical		Ground Elevation 173.4m		Datum Geodetic		Borehole No. W12	
Location Welland, Ontario				Date Started November 25, 2009		Completed November 25, 2009		Logged By B. Ripley		Sheet 1 of 1	
W.P.: 280-99-00				Drilling Agency DDSI		Drill Type Bombardier		Core Barrel & Bit Design NQ		Project No. 1-09-4135	

ELEVATION (m)	DEPTH (m)	SYMBOL	GENERAL DESCRIPTION	Joint Characteristics								WEATHERING	STRENGTH	FRACTURE FREQUENCY	RUN NO. CORE RECOVERY %	R Q D %	CORE SIZE/CASING	MPa UNCONFINED COMPRESSIVE STRENGTH	UNIT WEIGHT (KN/m³)
				No. OF SETS	JOINT TYPE	ORIENTATION	SPACING	ROUGHNESS	FILLING	APERTURE									
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	
153.9	19.5		Overburden, see Borehole Log W12																
153.6	19.8		Overburden, SILTY CLAY TILL																
153.5	19.9		see Borehole Log W12																
153.4	20.0		Overburden,																
			COBBLES																
			some gravel,																
152.9	20.5		see Borehole Log W12																
152.4	21.0																		
152.0	21.4																		
151.9	21.5		SALINA FORMATION BEDROCK																
			Dolostone (>99%)	1	B	V	C	RP	T	0 to 1									
			Occasional to frequent shale seams and partings, light to medium grey to buff, moderately to highly fractured, medium bedded, medium strength, slightly weathered.																
151.4	22.0			1	B	V	C	RP	T	0 to 1									
150.9	22.5																		
			Shale (<1%)																
			Moderately weathered, medium to dark grey, low to medium strength, fissile locally.																
150.4	23.0																		
149.9	23.5			1	B	V	C	RP	T	0 to 1									
149.4	24.0																		
149.0	24.4																		
148.9	24.5		End of Core Log																
			Highly fractured zones of:																
			22.8-23.6m;																
148.4	25.0																		
147.9	25.5																		

Remarks:

**LEGEND:**

Dolostone

Silty Clay Till

Cobbles



# RECORD OF BOREHOLE No W13

1 OF 2

METRIC

W.P. 280-99-00 LOCATION Coords: N:4765319.2 E:327146.7 ORIGINATED BY PK  
DIST HWY 406 BOREHOLE TYPE Hollow Stem Augers / Casing and Washboring / NQ Rock Coring COMPILED BY DB  
DATUM Geodetic DATE 11.25.09 - 11.26.09 CHECKED BY RA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100					
174.6	Ground Surface													
174.4	200mm FILL - Sand and Gravel, trace to some silt, trace clay, grey, damp		1	SS	11		174							
0.2														
173.9	SILTY CLAY - trace sand, stiff, brown, damp		2	SS	33		173							0 1 92 7
0.7														
	SILT trace clay, trace sand, compact to dense, brown, wet		3	SS	24		172							
172.5														
2.1	SILTY CLAY trace sand, trace gravel, firm to stiff, grey, damp to moist  (GLACIAL TILL)		4	SS	7		171							
			5	SS	10		170							0 3 72 25
			6	SS	5		169							
			7	TW	PH		168						21.3	1 3 71 25
			8	SS	8		167							1 2 68 29
			9	SS	10		166							
							165							
			10	SS	5		164							0 5 71 24
							163							
			11	SS	29		162							
			12	SS	30		161							5 7 66 22
159.6							160							

very stiff to hard

Continued Next Page

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

ONTARIO MOT 1-09-4135 WELLAND CANAL.GPJ ONTARIO MOT.GDT 03/22/10

# RECORD OF BOREHOLE No W13

2 OF 2

METRIC

W.P. 280-99-00 LOCATION Coords: N:4765319.2 E:327146.7 ORIGINATED BY PK  
 DIST HWY 406 BOREHOLE TYPE Hollow Stem Augers / Casing and Washboring / NQ Rock Coring COMPILED BY OB  
 DATUM Geodetic DATE 11.25.09 - 11.26.09 CHECKED BY RA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ KN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)			
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE										
							20	40	60	80	100							
15.0	SILTY CLAY trace sand, trace gravel, hard, grey, damp to moist  (GLACIAL TILL)		13	SS	33													
158.4																		
16.2	SAND AND SILT trace to some gravel, trace clay, compact to very dense, grey, moist to wet  (GLACIAL TILL)		14	SS	22													
				15	SS	54												
				16	SS	56												
153.2			17	SS	35/ 10cm													
21.4	DOLOSTONE BEDROCK Light to dark grey, slightly weathered, medium bedded, medium strength, with occasional dark grey, moderately weathered, low to medium strength shale seams.		1	RUN	NQ													
			2	RUN	NQ													
			3	RUN	NQ													
149.9	End of Borehole																	
24.7	Borehole filled with drill water on completion of coring.  Unable to push vane to 10.5m.  Resistance to augering at 14.6m.  Borehole sealed with bentonite slurry to ground surface.																	

+ 3 . x 3: Numbers refer to  
Sensitivity

○ 3% STRAIN AT FAILURE

ONTARIO MOT 1-09-4135 WELLAND CANAL.GPJ ONTARIO MOT.GDT 04/28/10

# CORE LOG



**Terraprobe**

Project	Highway 406 Twinning	Orientation	Vertical	Ground Elevation	174.6m	Datum	Geodetic	Borehole No.	W13
Location	Welland, Ontario	Date Started	November 26, 2009	Completed	November 26, 2009	Logged By	B. Ripley	Sheet	1 of 1
W.P.:	280-99-00	Drilling Agency	DBW Drilling	Drill Type	Bombardier	Core Barrel & Bit Design	NQ	Project No.	1-09-4135

ELEVATION (m)	DEPTH (m)	SYMBOL	GENERAL DESCRIPTION	Joint Characteristics								STRENGTH	FRACTURE FREQUENCY	RUN NO. CORE RECOVERY %	R Q D %	CORE SIZE/CASING	MPa UNCONFINED COMPRESSIVE STRENGTH	UNIT WEIGHT (KN/m <sup>3</sup> )
				No. OF SETS	JOINT TYPE	ORIENTATION	SPACING	ROUGHNESS	FILLING	APERTURE	WEATHERING							
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
154.1	20.5																	
153.6	21.0		Overburden, see Borehole Log W13															
153.3	21.3		Overburden, SAND AND SILT TILL															
153.2	21.4		see Borehole Log W13															
153.1	21.5																	
			SALINA FORMATION BEDROCK															
152.6	22.0		Dolostone (99%)															
			Occasional to frequent shale seams and partings, light to medium grey, moderately to highly fractured, medium bedded, medium strength, slightly weathered, poorly fossiliferous.															
152.1	22.5			1	B	V	C	RP	T	0 to 1								
151.6	23.0		Shale (1%)															
			Moderately weathered, medium to dark grey, low to medium strength.															
151.1	23.5																	
150.6	24.0			1	B	V	C	RP	T	0 to 1								
150.1	24.5																	
149.9	24.7		End of Core Log															
149.6	25.0																	
			Highly fractured zones at:															
149.1	25.5		22.3-22.4m; 22.5-22.6m; 23.0-23.1m.															
148.6	26.0																	
148.1	26.5																	

Remarks:

## LEGEND:

	Dolostone
	SAND AND SILT TILL

RECORD OF BOREHOLE No W14

1 OF 2

METRIC

W.P. 280-99-00 LOCATION Coords: N:4765327.6 E:327158.2 ORIGINATED BY LY  
DIST HWY 406 BOREHOLE TYPE Hollow Stem Augers / Casing and Washboring / NQ Rock Coring COMPILED BY DB  
DATUM Geodetic DATE 11.23.09 - 11.24.09 CHECKED BY RA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
174.8	Ground Surface													
0.0	FILL - Silty Clay, sandy, some gravel, stiff, brown, dry to damp		1	SS	13									
174.1														
0.7	SILTY CLAY trace sand, firm to stiff, brown, damp to moist		2	SS	8									0 1 71 28
			3	SS	8									
172.7														
2.1	SILT trace clay, trace sand, loose, brown, wet		4	SS	8									
171.9														
2.9	SILTY CLAY trace sand, trace gravel, firm to stiff, brown, damp to moist  (GLACIAL TILL)		5	SS	8									
			6	SS	8									
			7	SS	7									
			8	SS	8									
			9	TW	PH								21.2	7 3 65 25
			10	SS	11									
			11	SS	30									3 6 66 25
			12	SS	32									
					</									

Continued Next Page

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

# RECORD OF BOREHOLE No W14

2 OF 2

METRIC

W.P. 280-99-00 LOCATION Coords: N:4765327.6 E:327158.2 ORIGINATED BY LY  
DIST HWY 406 BOREHOLE TYPE Hollow Stem Augers / Casing and Washboring / NQ Rock Coring COMPILED BY DB  
DATUM Geodetic DATE 11.23.09 - 11.24.09 CHECKED BY RA

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

15.0	SILTY CLAY trace sand, trace gravel, very stiff, grey, damp to moist  (GLACIAL TILL)		13	SS	16															
159.6																				
16.2	SAND AND SILT trace gravel, trace clay, compact to dense, grey, moist to wet  (GLACIAL TILL)		14	SS	22															
			15	SS	37															
			16	SS	49															
154.0	SAND AND GRAVEL occasional cobbles, very dense, grey, wet		17	SS	71															
			18	SS	100/ 8cm															
152.9	DOLOSTONE BEDROCK Light to dark grey, slightly weathered, medium bedded, medium strength, with occasional dark grey, moderately weathered, low to medium strength shale seams.		1	RUN	NQ															
21.9			2	RUN	NQ															
150.0	End of Borehole																			
24.9	Unable to push vane to 12.1m.  No sample recovery at SS17.  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) Dec.08.09      1.5      173.3 Dec.16.09      1.4      173.4 Jan.11.10      1.5      173.3 Jan.14.10      1.5      173.3																			

5 42 47 6

Nov.23

Nov.24

RUN#1  
TCR=67%  
SCR=82%  
RQD=35%

RUN#2  
TCR=87%  
SCR=97%  
RQD=66%

ONTARIO MOT 1-09-4135 WELLAND CANAL.GPJ ONTARIO MOT.GDT 03/22/10

# CORE LOG



**Terraprobe**

Project Highway 406 Twinning				Orientation Vertical		Ground Elevation 174.8m		Datum Geodetic		Borehole No. W14	
Location Welland, Ontario				Date Started November 24, 2009		Completed November 24, 2009		Logged By B. Ripley		Sheet 1 of 1	
W.P.: 280-99-00				Drilling Agency DBW Drilling		Drill Type Bombardier		Core Barrel & Bit Design NQ		Project No. 1-09-4135	

ELEVATION (m)	DEPTH (m)	SYMBOL	GENERAL DESCRIPTION	Joint Characteristics							WEATHERING	STRENGTH	FRACTURE FREQUENCY	RUN NO. CORE RECOVERY %	R Q D %	CORE SIZE/CASING	MPa UNCONFINED COMPRESSIVE STRENGTH	UNIT WEIGHT (kN/m³)
				No. OF SETS	JOINT TYPE	ORIENTATION	SPACING	ROUGHNESS	FILLING	APERTURE								
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
153.3	21.5		Overburden, see Borehole Log W14															
153.0	21.8		Overburden, SAND AND GRAVEL see Borehole Log W14															
152.9	21.9																	
152.8	22.0		SALINA FORMATION BEDROCK															
			Dolostone (>99%) Occasional shale seams and partings, light to medium grey, moderately to highly fractured, medium bedded, medium strength, slightly weathered, poorly fossiliferous.	1	B	V	C	RP SP	T	0 to 1							NQ	
152.3	22.5																	
151.8	23.0																	
			Shale (<1%) Moderately weathered, medium to dark grey, low to medium strength.															
151.3	23.5																	
150.8	24.0			1	B	V	C	RP SP	T	0 to 1							NQ	
150.3	24.5																	
150.0	24.9																	
149.8	25.0		End of Core Log															
			Highly fractured zones at: 21.9-21.95m; 22.6-22.7m.															
149.3	25.5																	
148.8	26.0																	
148.3	26.5																	
147.8	27.0																	
147.3	27.5																	

Remarks:

**LEGEND:**

Dolostone

Sand and Gravel

# RECORD OF BOREHOLE No W15

1 OF 2

METRIC

W.P. 280-99-00 LOCATION Coords: N:4765346.7 E:327144.9 ORIGINATED BY LY  
DIST HWY 406 BOREHOLE TYPE Hollow Stem Augers COMPILED BY DB  
DATUM Geodetic DATE 11.26.09 - 11.27.09 CHECKED BY RA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100					
179.2 0.0	Ground Surface													
	firm		1	SS	5		179							
	----													
	FILL - Silty Clay, trace sand, trace gravel, stiff to very stiff, brown, moist		2	SS	10		178							
			3	SS	9									1 8 49 42
			4	SS	25		177							
			5	SS	26		176							
175.5 3.7	SILTY CLAY trace sand, very stiff, brown, damp to moist		6	SS	19		175							
			7	SS	17									
174.0 5.2	SILT trace clay, trace sand, compact, grey, wet		8	SS	29		174							
			9	SS	19		173							0 1 89 10 Nov.26 Nov.27
172.2 7.0	SILTY CLAY trace sand, trace gravel, firm to stiff, hard below 14.8m, grey, damp to moist (GLACIAL TILL)		10	SS	6		172							1 3 64 32
			11	TW	PH		171							
							170						21.1	
			12	SS	8		169							
							168							
			13	SS	10		167							0 2 73 25
							166							
			14	SS	8		165							
164.2														

Continued Next Page

+ 3. X 3. Numbers refer to  
Sensitivity



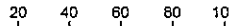
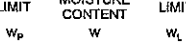
○ 3% STRAIN AT FAILURE

# RECORD OF BOREHOLE No W15

2 OF 2

METRIC

W.P. 280-99-00 LOCATION Coords: N:4765346.7 E:327144.9 ORIGINATED BY LY  
 DIST HWY 406 BOREHOLE TYPE Hollow Stem Augers COMPILED BY DB  
 DATUM Geodetic DATE 11.26.09 - 11.27.09 CHECKED BY RA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
15.0	SILTY CLAY - sandy, some gravel, hard, grey, damp (GLACIAL TILL)		15	SS	31		164								14 26 42 18
163.5								20 40 60 80 100			10 20 30				
15.7	End of Borehole														
	Unable to push vane to 15.0m.														
	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)														
	Nov.30.09      4.1      175.1														
	Dec.08.09      4.2      175.0														
	Dec.16.09      4.2      175.0														
	Jan.04.10      4.2      175.0														

ONTARIO MOT 1-09-4135 WELLAND CANAL.GPJ ONTARIO MOT.GDT 03/22/10



# RECORD OF BOREHOLE No W16

1 OF 2

METRIC

W.P. 280-99-00 LOCATION Coords: N:4765364.8 E:327139.5 ORIGINATED BY PK  
 DIST HWY 406 BOREHOLE TYPE Hollow Stem Augers COMPILED BY DB  
 DATUM Geodetic DATE 11.18.09 - 11.19.09 CHECKED BY RA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
182.9 0.0	Ground Surface							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE						GR SA SI CL
	FILL - Silty Clay, some sand, trace gravel, frequent cobbles to 4.5m, firm to hard, damp to moist		1	SS	6						○			
			2	SS	17		182				○			
			3	SS	22		181			○			9	16 47 28
			4	SS	31		180				○			
			5	SS	26		179						4	17 50 29
	----- frequent gravel inclusions -----		6	SS	15		178			○				
	----- trace wood pieces -----		7	SS	13		177				○			
	----- topsoil stained -----		9	SS	9		176					○		
175.9 7.0	SILTY CLAY trace sand, very stiff, brown, moist		10	SS	20		175						0	1 65 34
174.3 8.6	SILT trace clay, trace sand, dense, brown, wet		11	SS	36		174				○			sampler wet
172.6 10.3	SILTY CLAY trace sand, trace gravel, firm to very stiff, grey, moist  (GLACIAL TILL)		12	SS	7		173							
			13	SS	5		172				○			Nov. 18
							171		1.6					Nov. 19
							170						2	4 65 29
							169		1.1					
			14	SS	11		168			1.7			22.5	
									2.0					
167.9														

Continued Next Page

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



ONTARIO MOT 1-09-4135 WELLAND CANAL.GPJ ONTARIO MOT.GDT 03/22/10

# RECORD OF BOREHOLE No W16

2 OF 2

METRIC

W.P. 280-99-00 LOCATION Coords: N:4765364.8 E:327139.5 ORIGINATED BY PK  
 DIST HWY 406 BOREHOLE TYPE Hollow Stem Augers COMPILED BY DB  
 DATUM Geodetic DATE 11.18.09 - 11.19.09 CHECKED BY RA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								
								20 40 60 80 100								
								○ UNCONFINED + FIELD VANE								
								● QUICK TRIAXIAL × LAB VANE								
								20 40 60 80 100								
15.0	SILTY CLAY trace sand, trace gravel, stiff to very stiff, grey, moist  (GLACIAL TILL)		15	SS	17											
				16	SS		17									
			17	TW	PH				×					20.9	1 3 71 25	
163.2																
19.7	End of Borehole															
	Resistance to augering at 14.9m.  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) Nov.30.09      7.8      175.1 Dec.08.09      7.7      175.2 Jan.04.10      7.5      175.4 Jan.14.10      7.5      175.4															

ONTARIO MOT 1-09-4135 WELLAND CANAL.GPJ ONTARIO MOT.GDT 03/22/10

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

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**Bedrock Core Sample**  
Borehole: W3  
Runs: 1, 2 & 3  
Depth: 26.8 m – 30.9 m



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

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**Bedrock Core Sample**

Borehole: W4

Runs: 1 & 2

Depth: 26.6 m – 29.7 m





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

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**Bedrock Core Sample**  
Borehole: W5  
Runs: 1, 2 & 3  
Depth: 21.3 m – 25.3 m



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

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**Bedrock Core Sample**  
Borehole: W6  
Runs: 1, 2 & 3  
Depth: 25.1 m – 29.4 m





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

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**Bedrock Core Sample**

Borehole: W7

Runs: 1, 2 & 3

Depth: 25.2 m – 28.2 m



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

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**Bedrock Core Sample**  
Borehole: W8  
Runs: 1, 2 & 3  
Depth: 25.3 m – 29.5 m





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

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**Bedrock Core Sample**

Borehole: W9

Runs: 1 & 2

Depth: 25.2 m – 28.1 m



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

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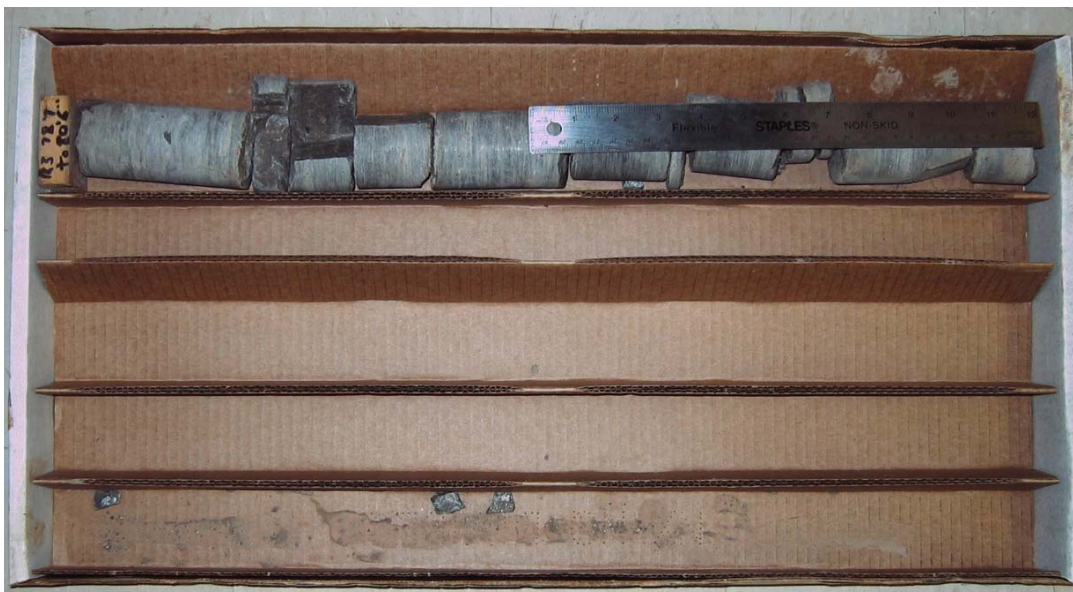


**Bedrock Core Sample**  
Borehole: W10  
Runs: 1 & 2  
Depth: 22.1 m – 25.1 m



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

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**Bedrock Core Sample**  
Borehole: W11  
Runs: 1, 2 & 3  
Depth: 21.2 m – 24.5 m





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

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**Bedrock Core Sample**

Borehole: W12

Runs: 1, 2, 3 & 4

Depth: 19.8 m – 24.4 m



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

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**Bedrock Core Sample**

Borehole: W13

Runs: 1, 2 & 3

Depth: 21.3 m – 24.9 m



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

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**Bedrock Core Sample**

Borehole: W14

Runs: 1 & 2

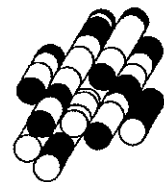
Depth: 21.8 m – 24.8 m



# **APPENDIX B**

## **Laboratory Test Results**

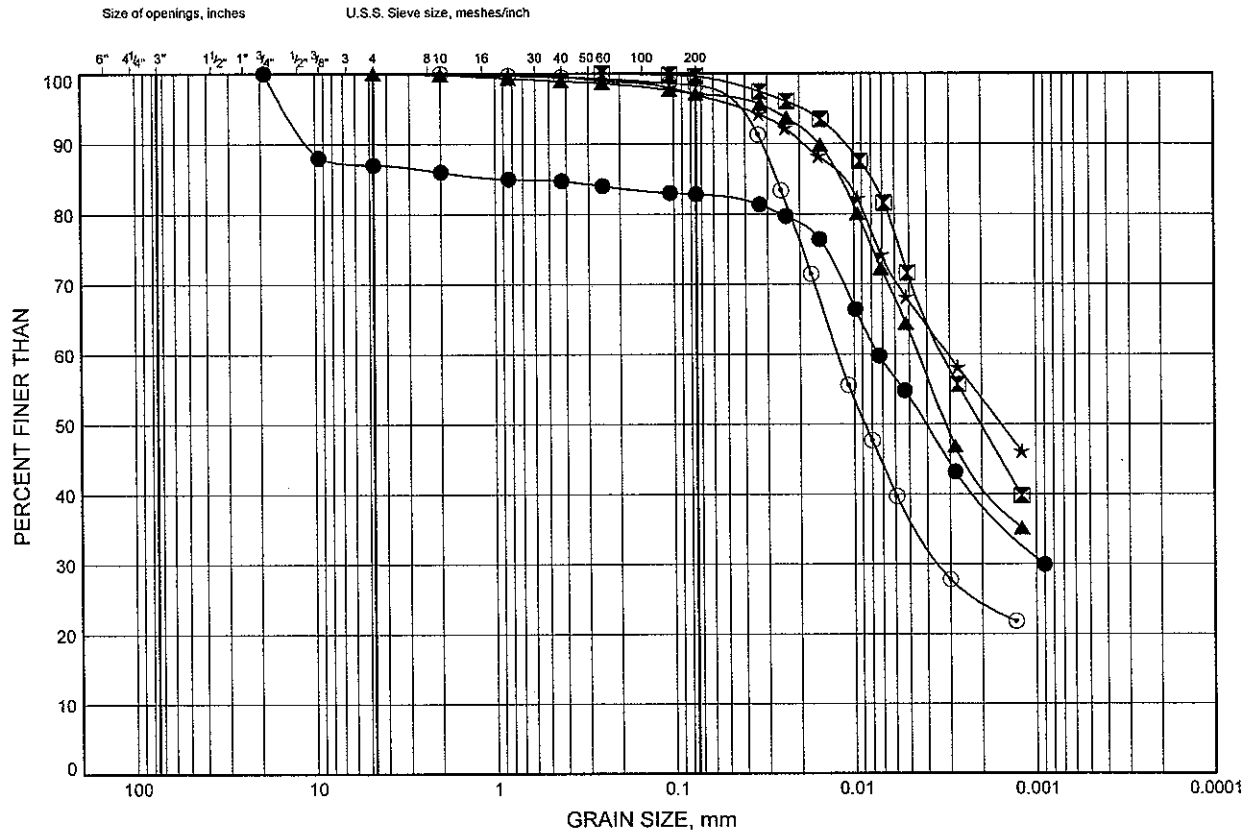
**Terraprobe Inc.**



# GRAIN SIZE DISTRIBUTION

FIGURE B1

## FILL - Silty Clay

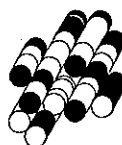


COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT and CLAY
	GRAVEL		SAND			FINE GRAINED

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	W1	0.3	178.0
☒	W6	1.7	173.9
▲	W6	5.5	170.1
★	W9	1.7	173.9
⊙	W9	7.8	167.8

Date March 2010

Project 1-09-4135



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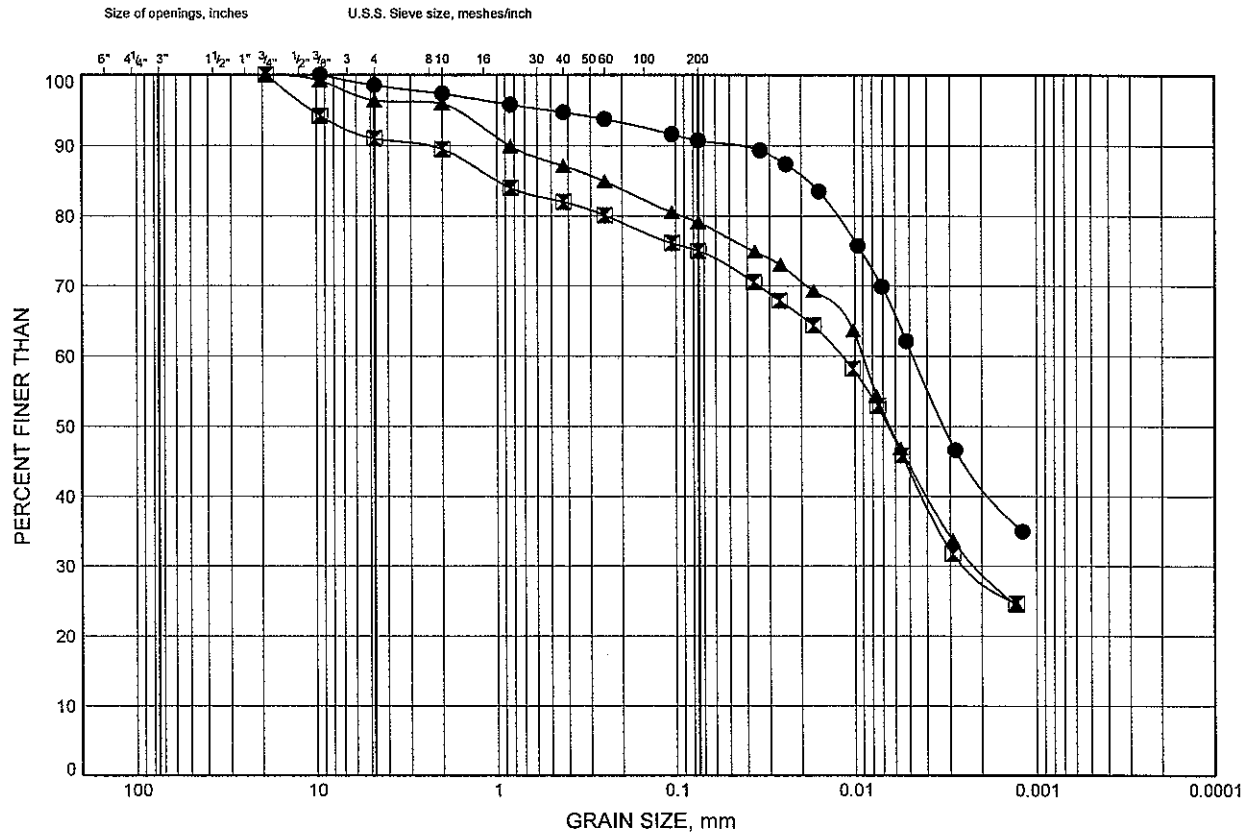
Chkd. RA



# GRAIN SIZE DISTRIBUTION

FIGURE B2

## FILL - Silty Clay



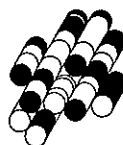
COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT and CLAY
	GRAVEL		SAND			FINE GRAINED

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
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●	W15	1.7	177.5
⊠	W16	1.7	181.2
▲	W16	3.2	179.7

Date March 2010

Project 1-09-4135



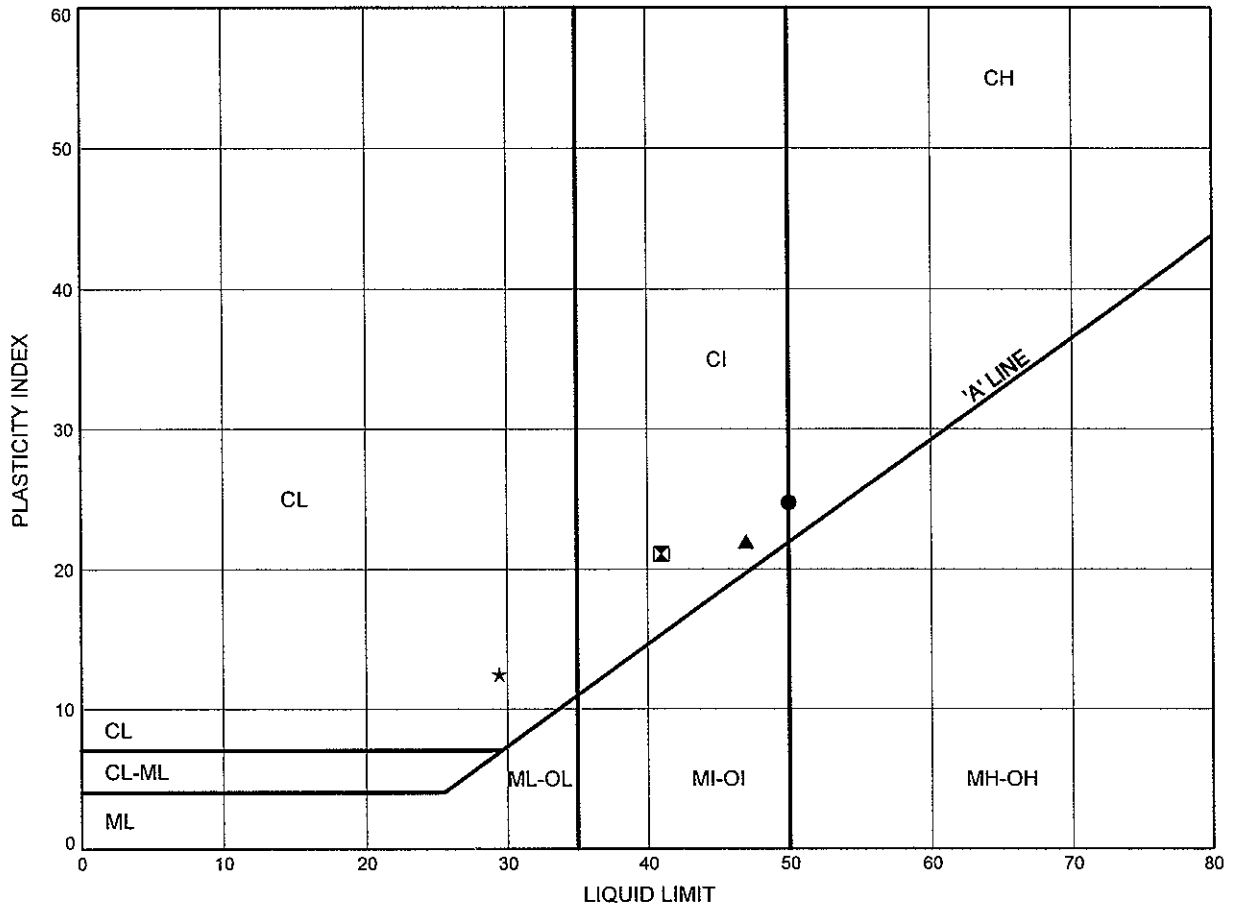
Prep'd DB

Chkd. RA

# ATTERBERG LIMITS TEST RESULTS

FIGURE B3

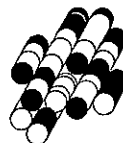
## FILL - Silty Clay



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	W1	0.3	178.0
⊠	W6	1.7	173.9
▲	W9	1.7	173.9
★	W9	7.8	167.8

Date March 2010

Project 1-09-4135



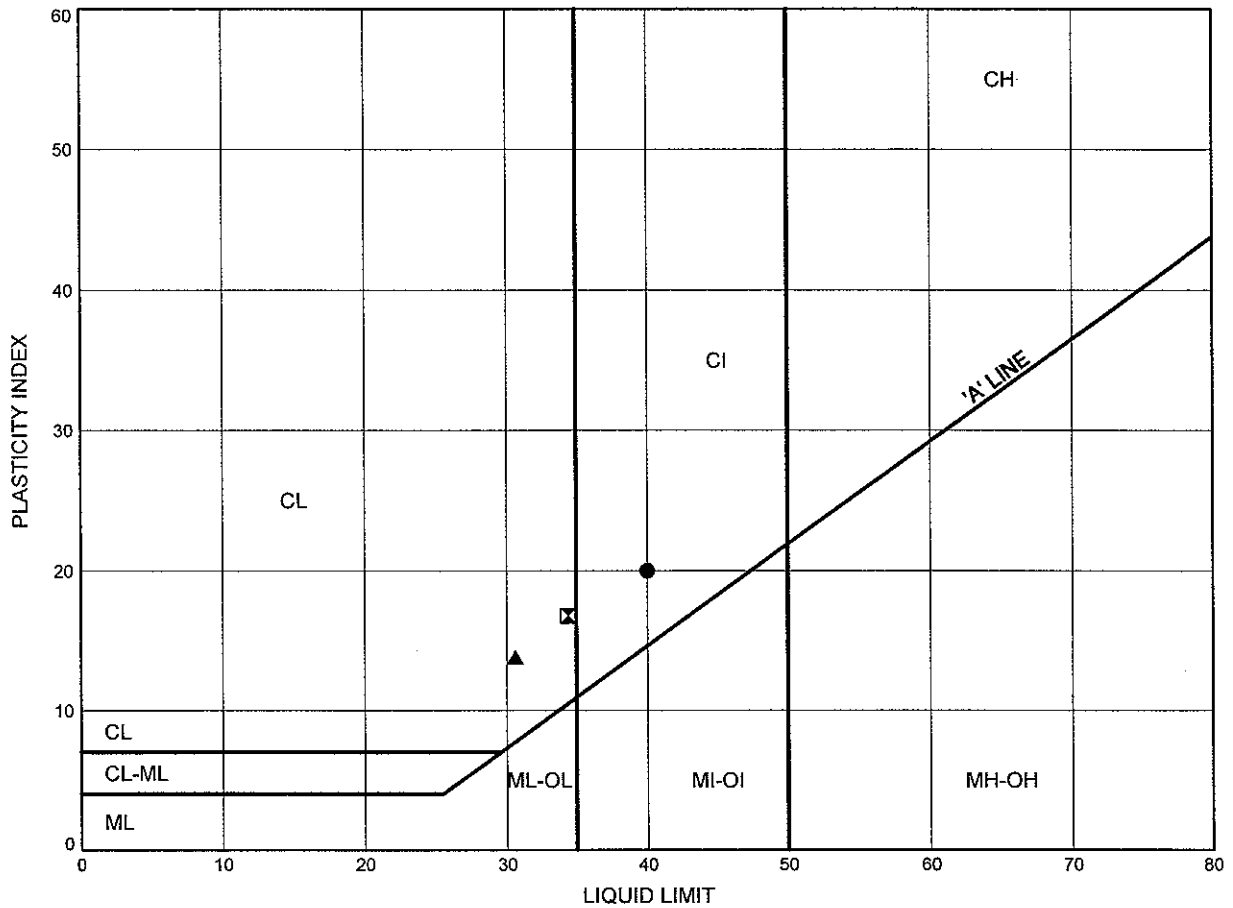
Prep'd DB

Chkd. RA

# ATTERBERG LIMITS TEST RESULTS

FIGURE B4

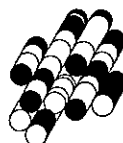
## FILL - Silty Clay



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	W15	1.7	177.5
⊠	W16	1.7	181.2
▲	W16	3.2	179.7

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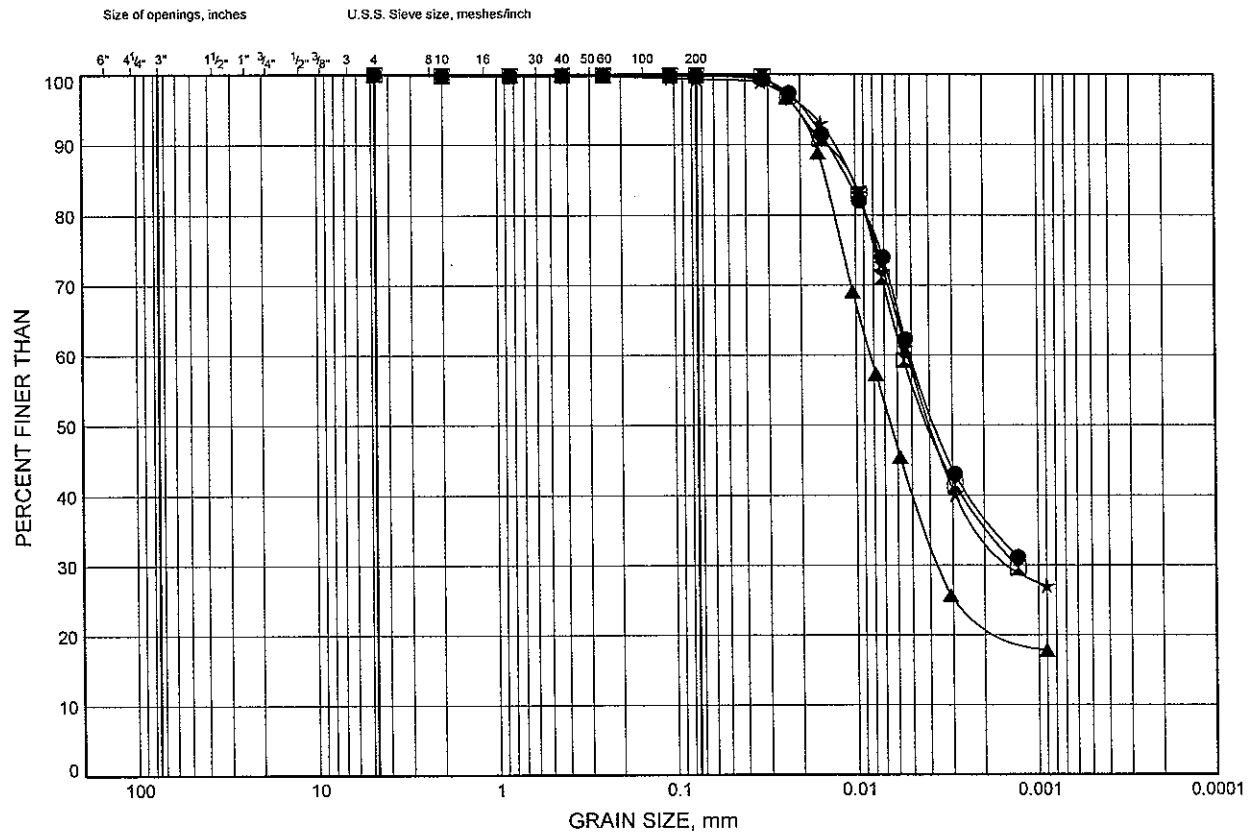
Prep'd DB

Chkd. RA

# GRAIN SIZE DISTRIBUTION

FIGURE B5

## SILTY CLAY



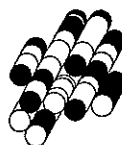
COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT and CLAY
	GRAVEL		SAND			FINE GRAINED

SYMBOL    BOREHOLE    DEPTH (m)    ELEVATION (m)

●	W1	2.5	175.8
⊠	W2	1.7	176.7
▲	W2	3.2	175.2
★	W3	1.7	175.1

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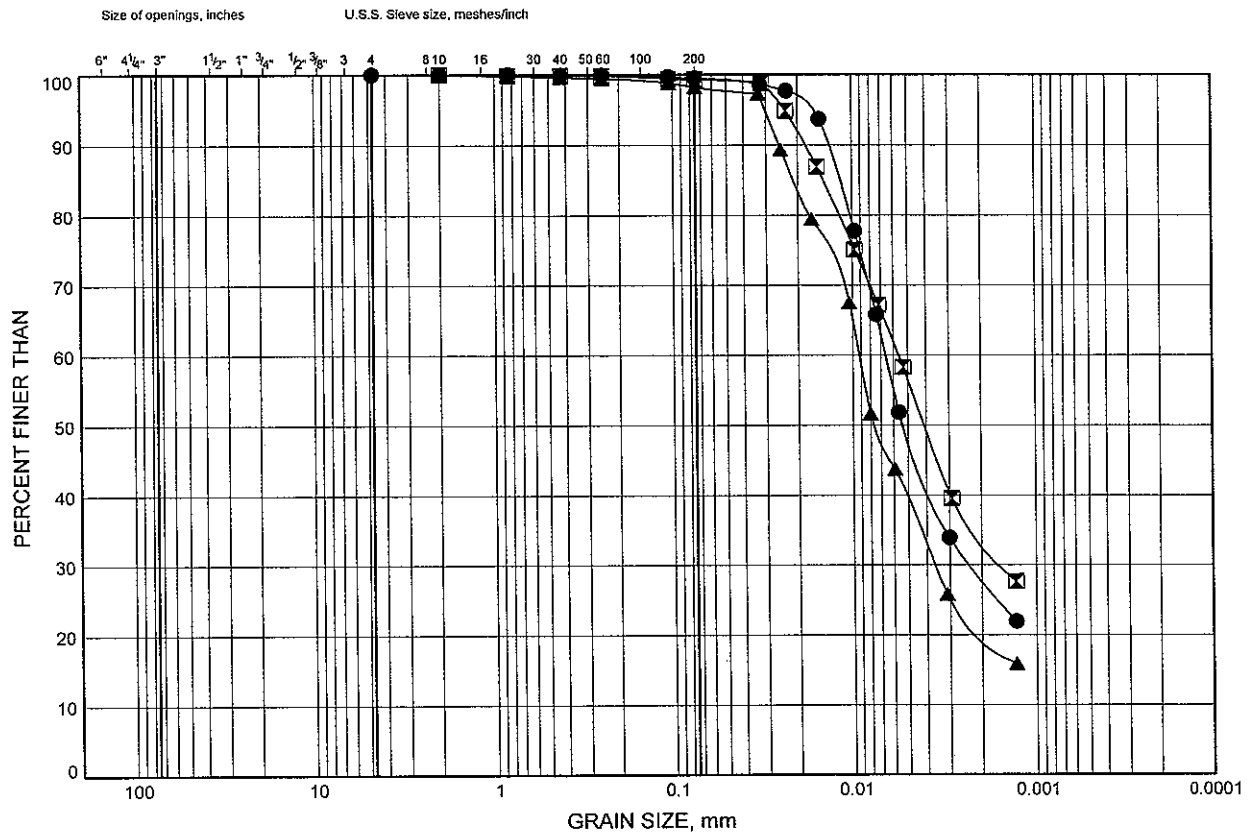
Prep'd DB

Chkd. RA

# GRAIN SIZE DISTRIBUTION

FIGURE B6

## SILTY CLAY



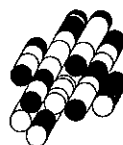
COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT and CLAY
	GRAVEL		SAND			FINE GRAINED

SYMBOL    BOREHOLE    DEPTH (m)    ELEVATION (m)

▲	W5	6.3	164.5
●	W14	1.0	173.8
⊠	W16	7.8	175.1

Date March 2010

Project 1-09-4135



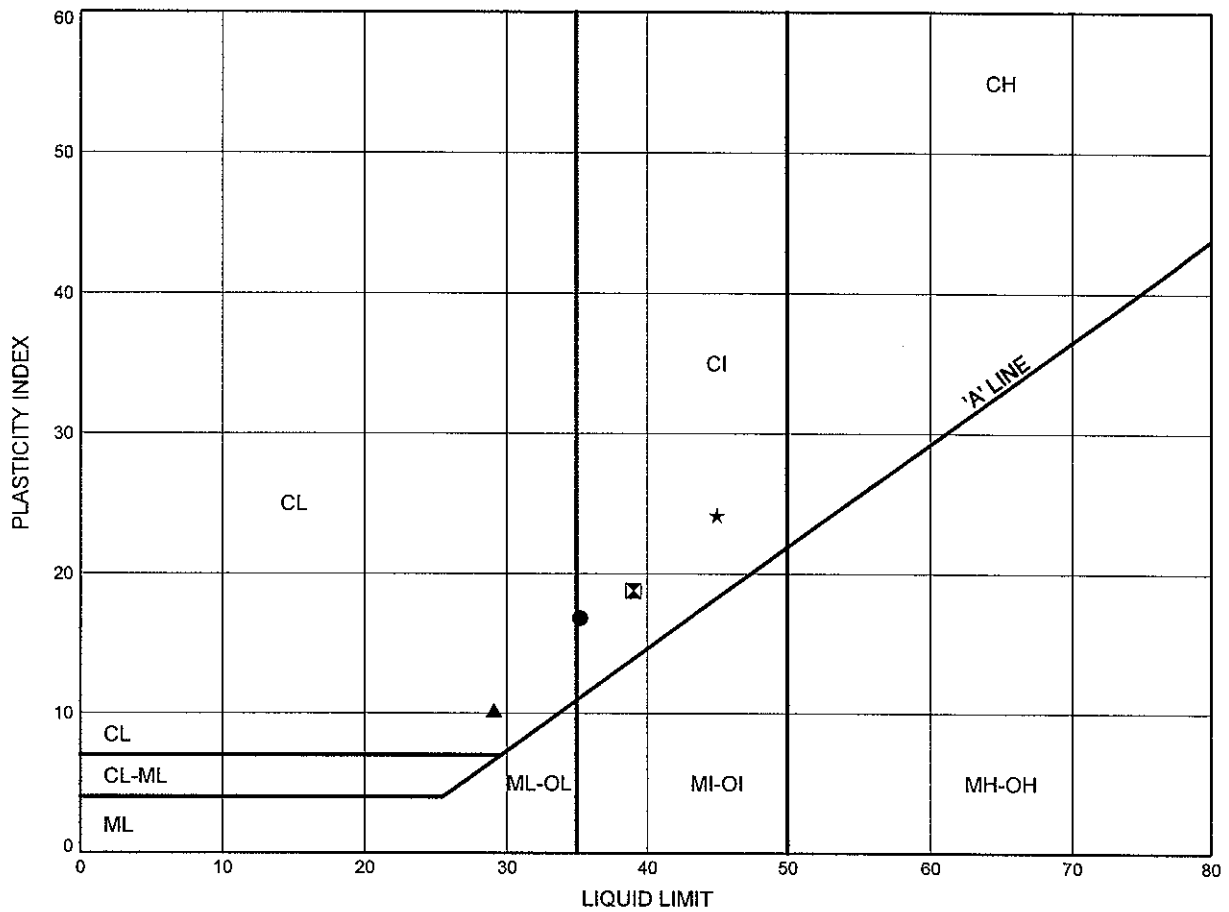
Prep'd DB

Chkd. RA

# ATTERBERG LIMITS TEST RESULTS

FIGURE B7

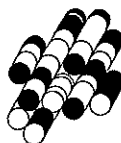
## SILTY CLAY



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	W1	2.5	175.8
⊠	W2	1.7	176.7
▲	W2	3.2	175.2
★	W3	1.7	175.1

Date March 2010

Project 1-09-4135



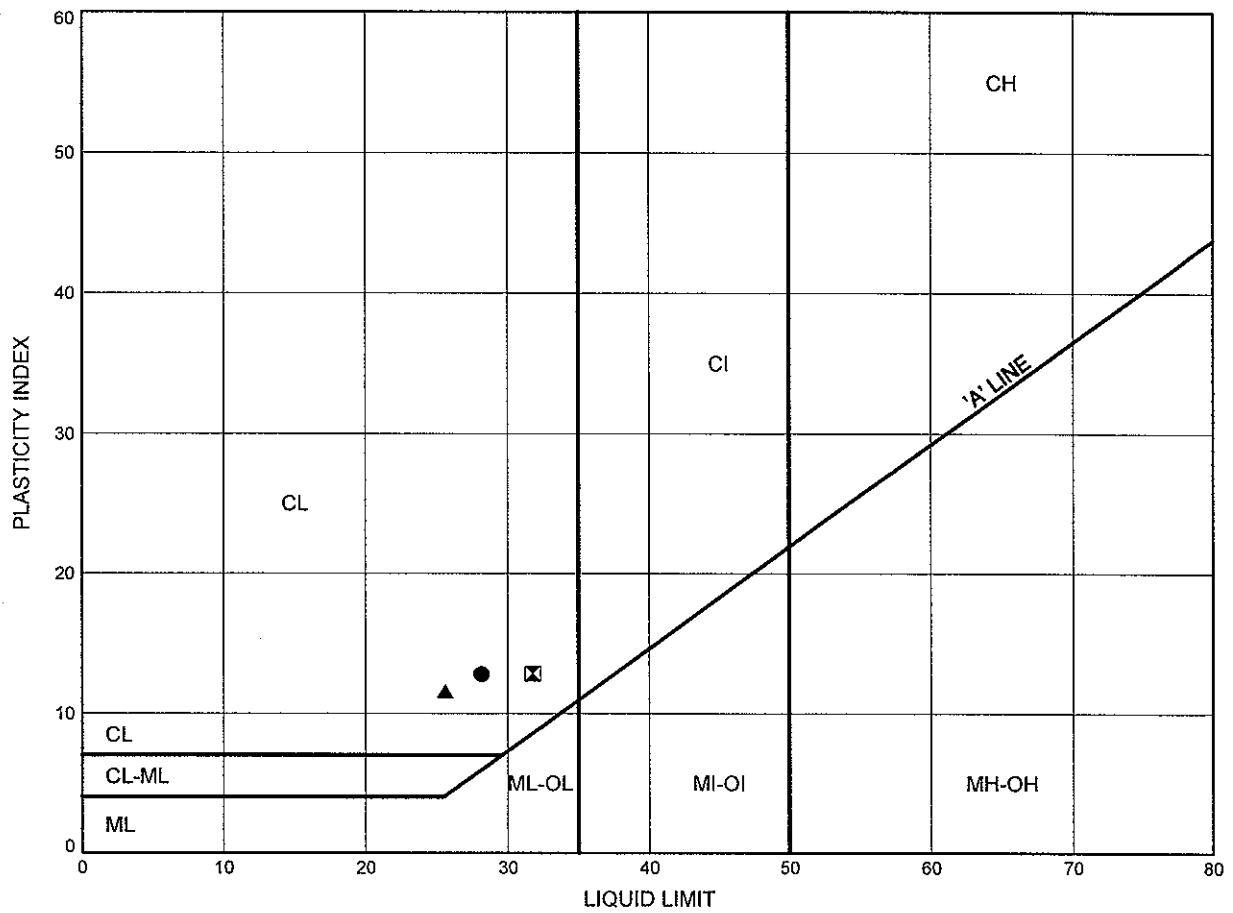
Prep'd DB

Chkd. RA

# ATTERBERG LIMITS TEST RESULTS

FIGURE B8

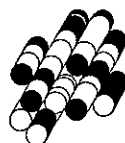
## SILTY CLAY



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
▲	W5	6.3	164.5
●	W14	1.0	173.8
⊠	W16	7.8	175.1

Date March 2010

Project 1-09-4135



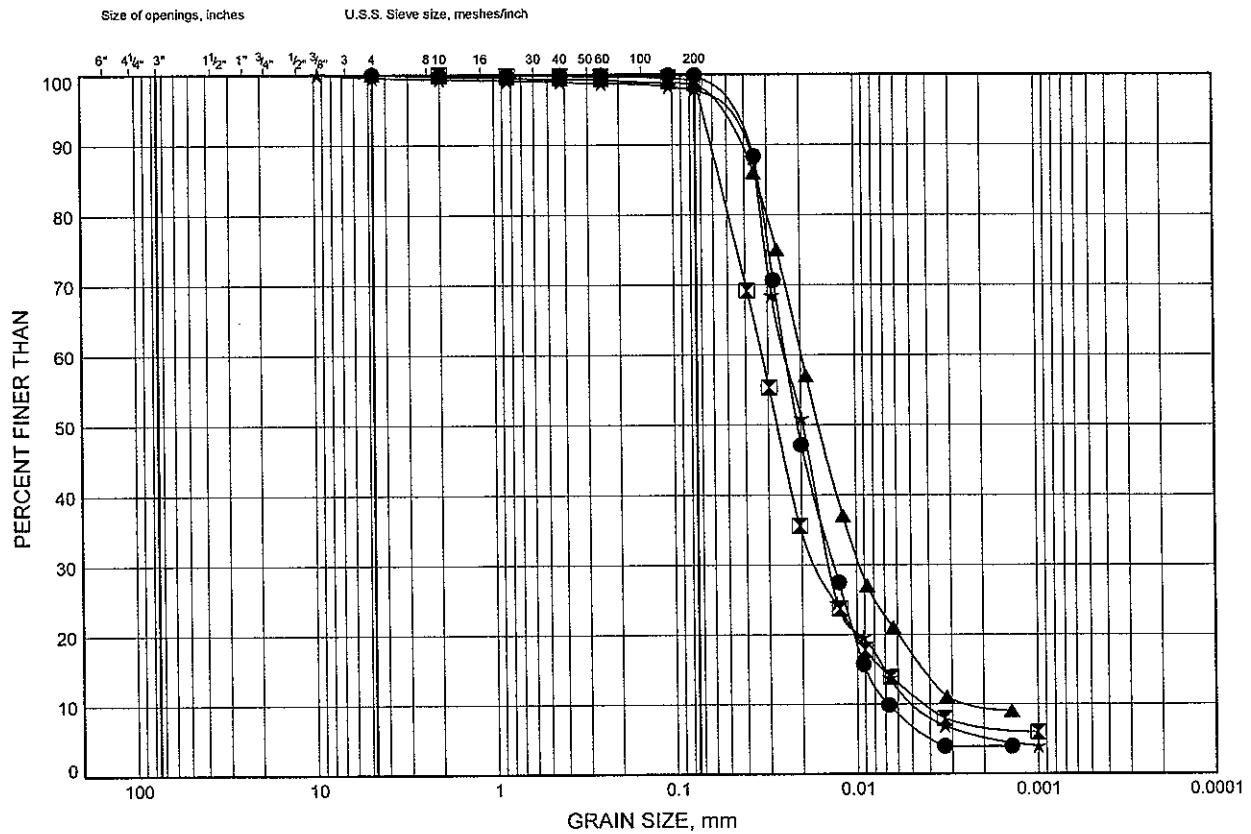
Prep'd DB

Chkd. RA

# GRAIN SIZE DISTRIBUTION

FIGURE B9

## SILT



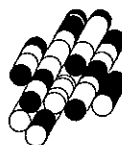
COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT and CLAY
	GRAVEL		SAND			FINE GRAINED

SYMBOL    BOREHOLE    DEPTH (m)    ELEVATION (m)

●	W1	4.7	173.6
★	W3	3.2	173.6
⊠	W13	1.7	172.9
▲	W15	6.3	172.9

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Prep'd DB

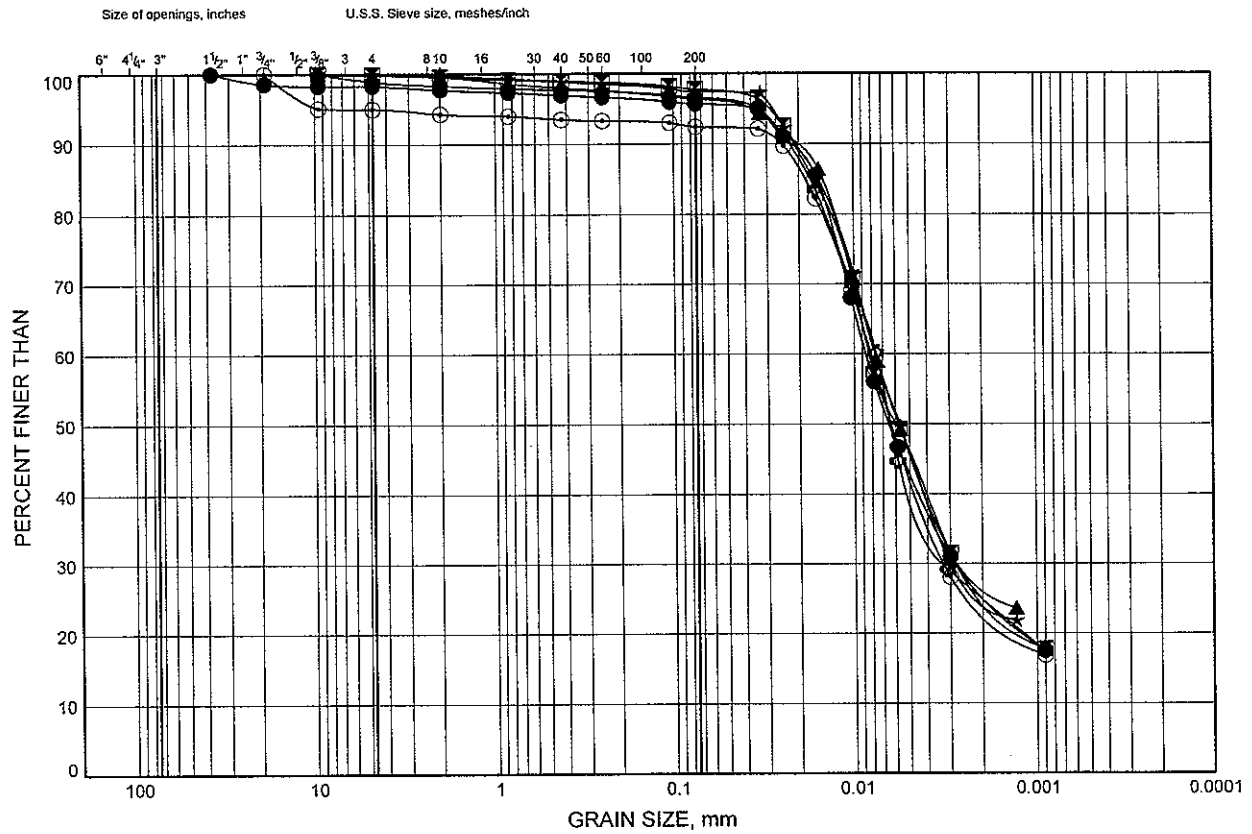
Chkd. RA



# GRAIN SIZE DISTRIBUTION

FIGURE B10

## UPPER SILTY CLAY TILL



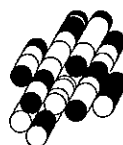
COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT and CLAY
	GRAVEL		SAND			FINE GRAINED

SYMBOL    BOREHOLE    DEPTH (m)    ELEVATION (m)

●	W1	7.8	170.5
⊠	W1	9.3	169.0
▲	W1	10.9	167.4
★	W2	9.3	169.1
⊙	W3	6.3	170.5
⊛	W3	9.3	167.5

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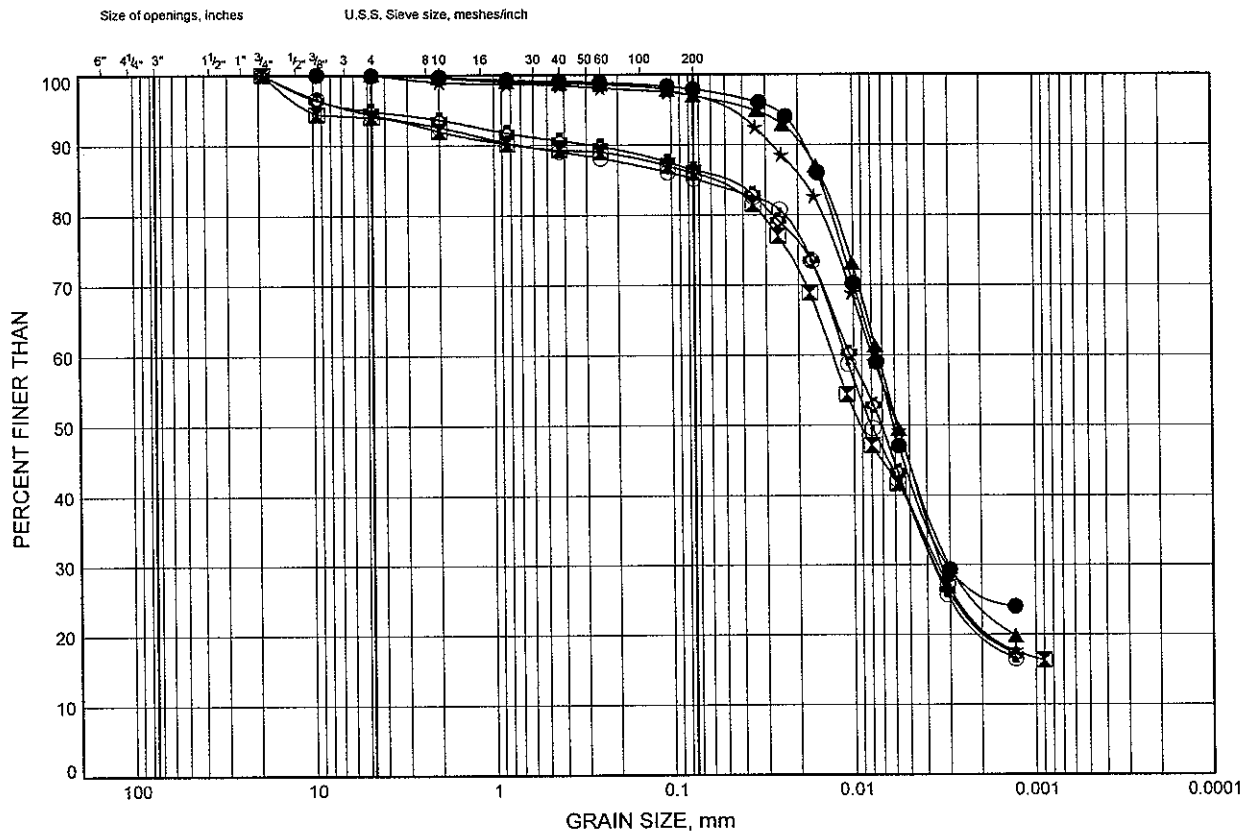
Prep'd DB

Chkd. RA

# GRAIN SIZE DISTRIBUTION

FIGURE B11

## UPPER SILTY CLAY TILL



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

SYMBOL    BOREHOLE    DEPTH (m)    ELEVATION (m)

●	W3	10.9	165.9
⊠	W3	13.9	162.9
▲	W4	9.3	168.3
★	W4	12.4	165.2
⊙	W4	15.4	162.2
⊗	W5	8.4	162.4

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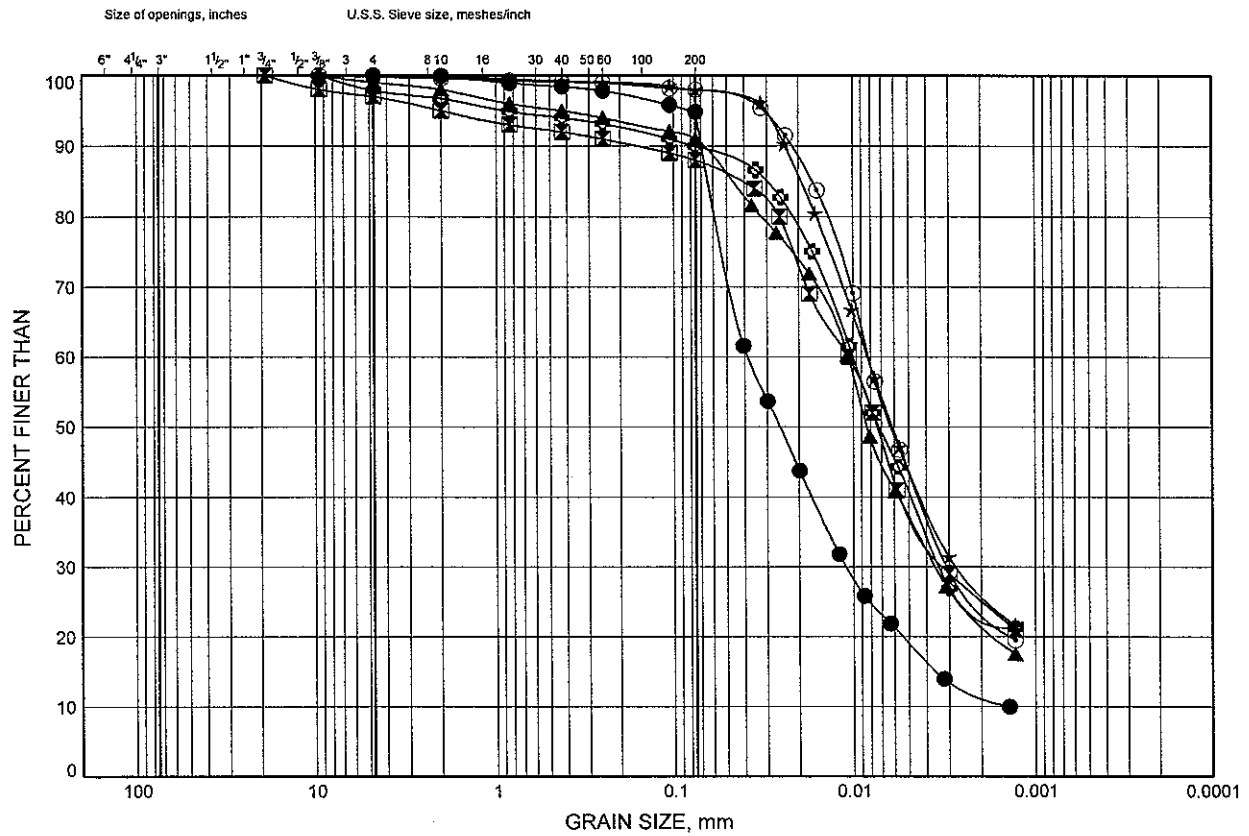


Prep'd DB  
Chkd. RA

# GRAIN SIZE DISTRIBUTION

FIGURE B12

## UPPER SILTY CLAY TILL



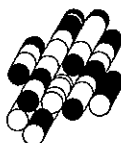
COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT and CLAY
	GRAVEL		SAND			FINE GRAINED

SYMBOL    BOREHOLE    DEPTH (m)    ELEVATION (m)

●	W6	12.4	163.2
⊠	W6	13.9	161.7
▲	W6	15.4	160.2
★	W7	12.4	162.8
⊙	W8	10.9	165.0
⊕	W8	13.9	162.0

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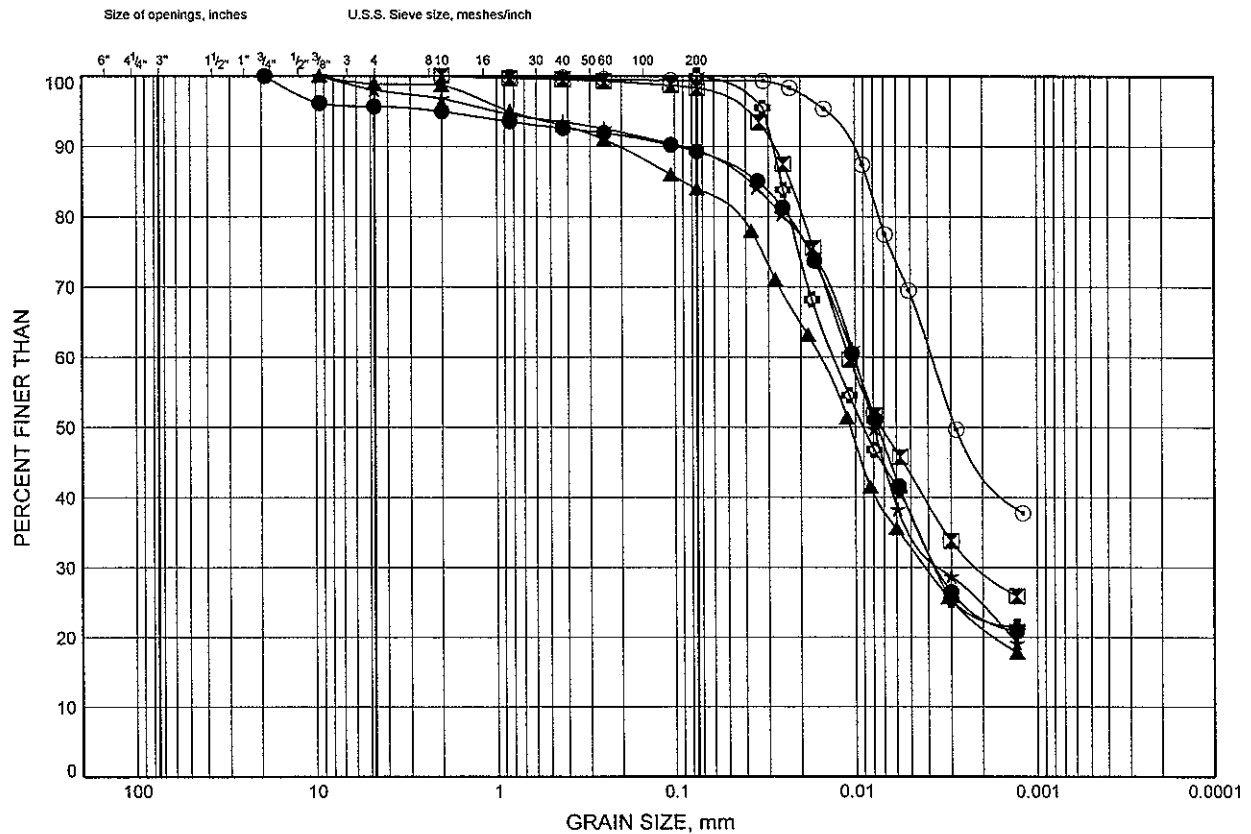
Prep'd DB

Chkd. RA

# GRAIN SIZE DISTRIBUTION

FIGURE B13

## UPPER SILTY CLAY TILL

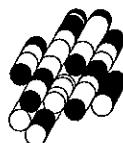


COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT and CLAY
	GRAVEL		SAND			FINE GRAINED

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
▲	W9	12.4	163.2
★	W9	13.9	161.7
⊙	W9	17.0	158.6
⊕	W9	18.5	157.1
●	W10	12.8	160.5
⊠	W10	15.9	157.4

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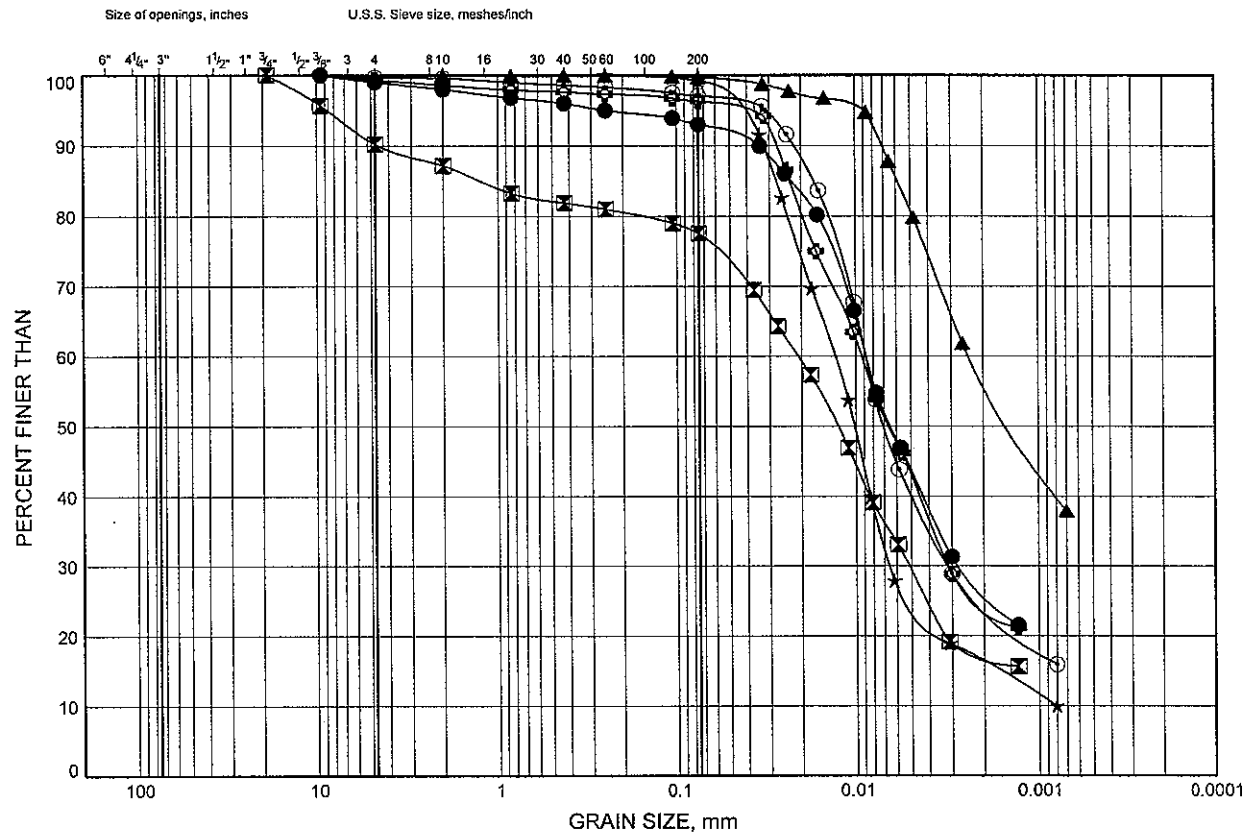
Prep'd DB

Chkd. RA

# GRAIN SIZE DISTRIBUTION

FIGURE B14

## UPPER SILTY CLAY TILL

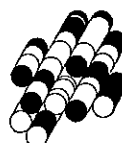


COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT and CLAY
	GRAVEL		SAND			FINE GRAINED

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	W11	12.2	161.2
⊠	W11	16.0	157.4
▲	W12	14.4	159.0
★	W12	15.9	157.5
⊙	W13	4.0	170.6
⊕	W13	6.3	168.3

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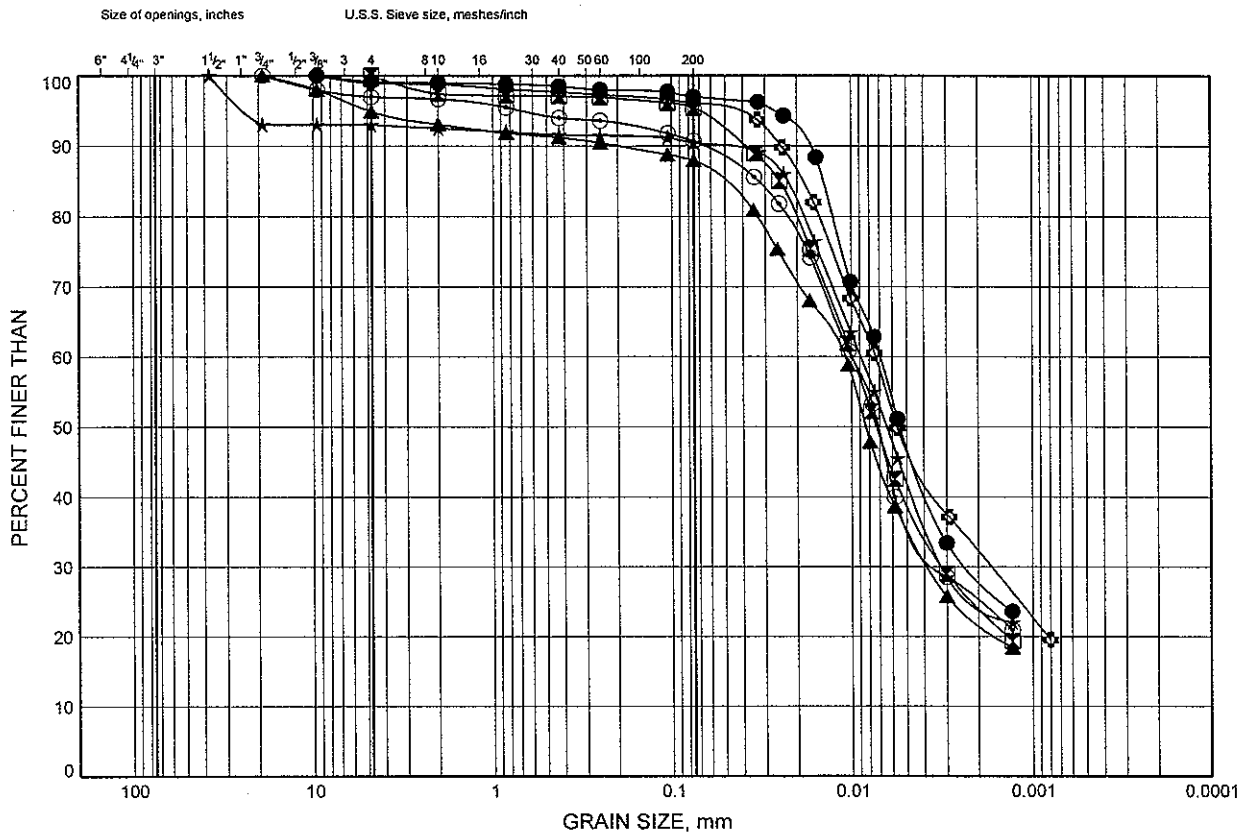
Prep'd DB

Chkd. RA

# GRAIN SIZE DISTRIBUTION

FIGURE B15

## UPPER SILTY CLAY TILL



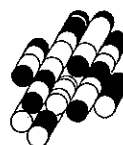
COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT and CLAY
	GRAVEL		SAND			FINE GRAINED

SYMBOL    BOREHOLE    DEPTH (m)    ELEVATION (m)

●	W13	7.8	166.8
⊠	W13	10.9	163.7
▲	W13	13.9	160.7
★	W14	9.3	165.5
⊙	W14	12.4	162.4
⊛	W15	7.8	171.4

Date    March 2010

Project    1-09-4135



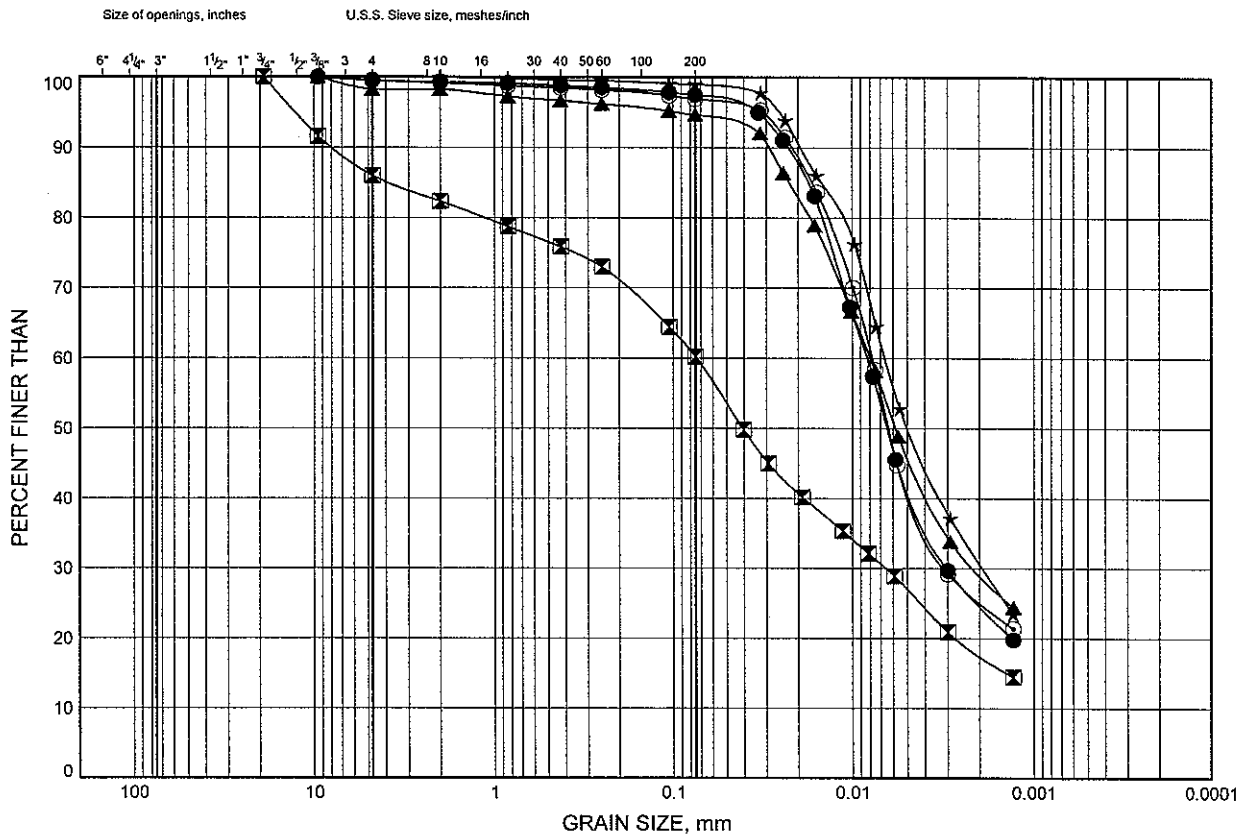
Prep'd    DB

Chkd.    RA

# GRAIN SIZE DISTRIBUTION

FIGURE B16

## UPPER SILTY CLAY TILL

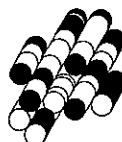


COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT and CLAY
	GRAVEL		SAND			FINE GRAINED

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	W15	12.4	166.8
⊠	W15	15.4	163.8
▲	W16	12.4	170.5
★	W16	17.0	165.9
⊙	W16	18.5	164.4

Date March 2010

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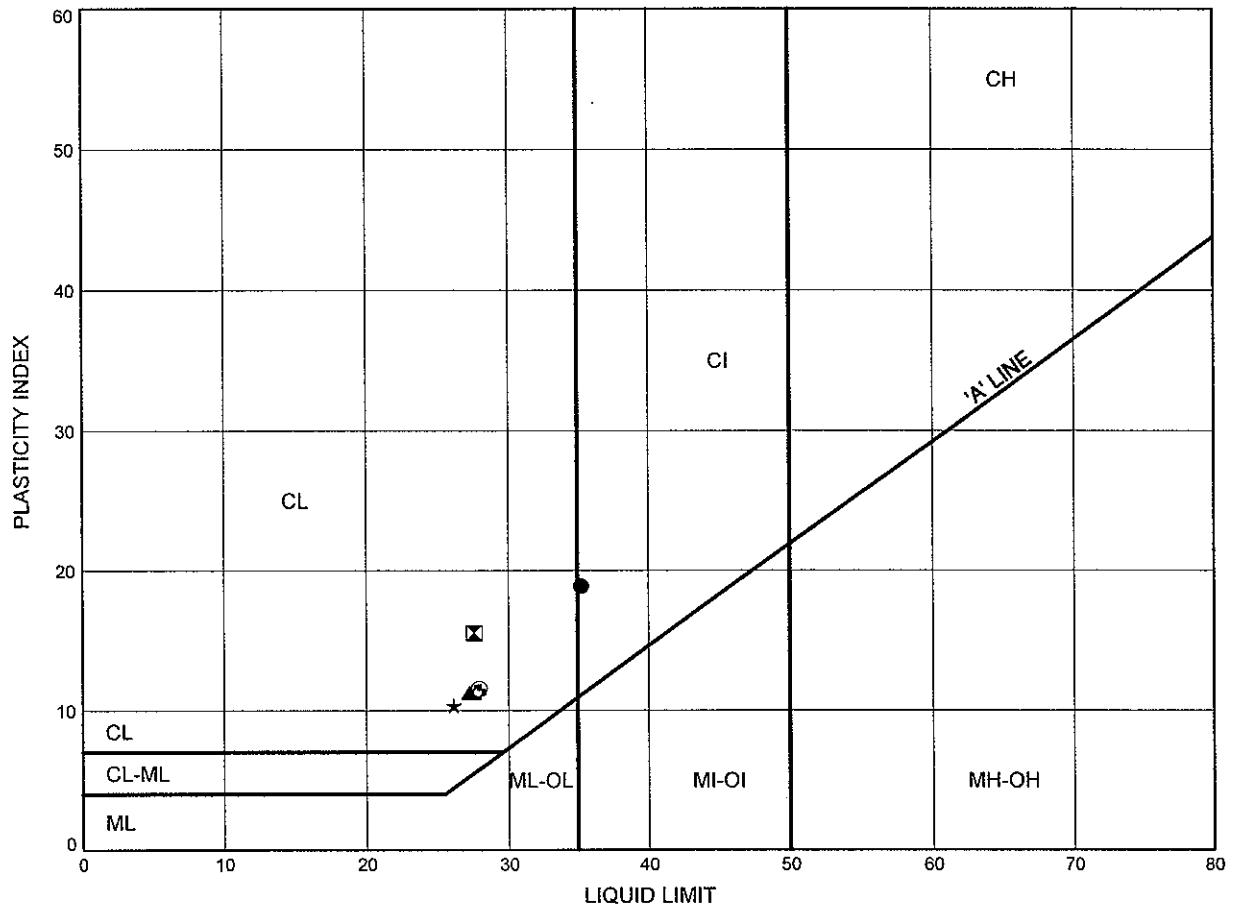
Prep'd DB

Chkd. RA

# ATTERBERG LIMITS TEST RESULTS

FIGURE B17

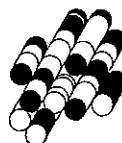
## UPPER SILTY CLAY TILL



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	W1	7.8	170.5
⊠	W1	9.3	169.0
▲	W1	10.9	167.4
★	W2	9.3	169.1
⊙	W3	6.3	170.5
⊗	W3	9.3	167.5

Date March 2010

Project 1-09-4135



Prep'd DB

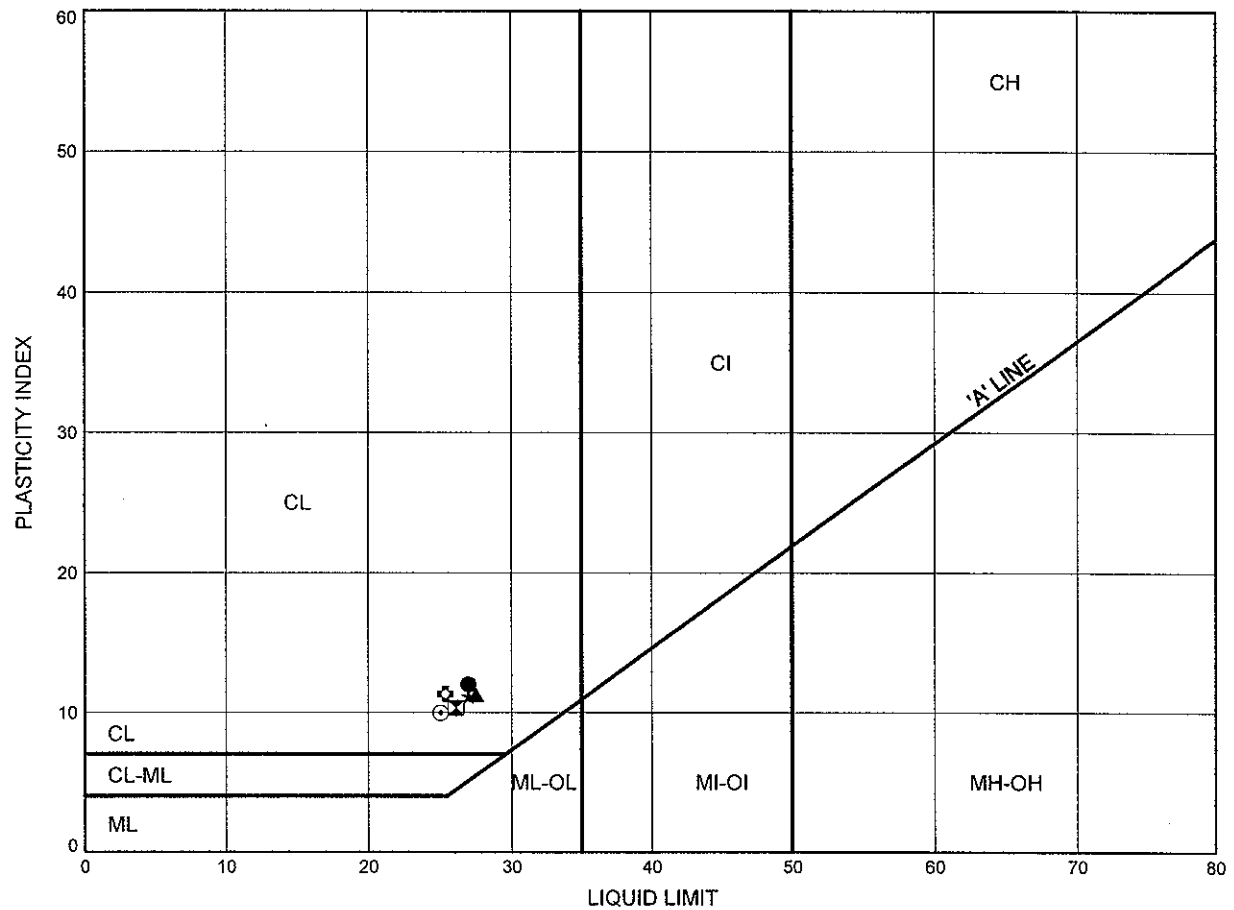
Chkd. RA



# ATTERBERG LIMITS TEST RESULTS

FIGURE B18

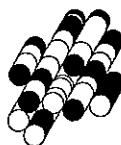
## UPPER SILTY CLAY TILL



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	W3	10.9	165.9
⊠	W3	13.9	162.9
▲	W4	9.3	168.3
★	W4	12.4	165.2
⊙	W4	15.4	162.2
⊛	W5	8.4	162.4

Date March 2010

Project 1-09-4135



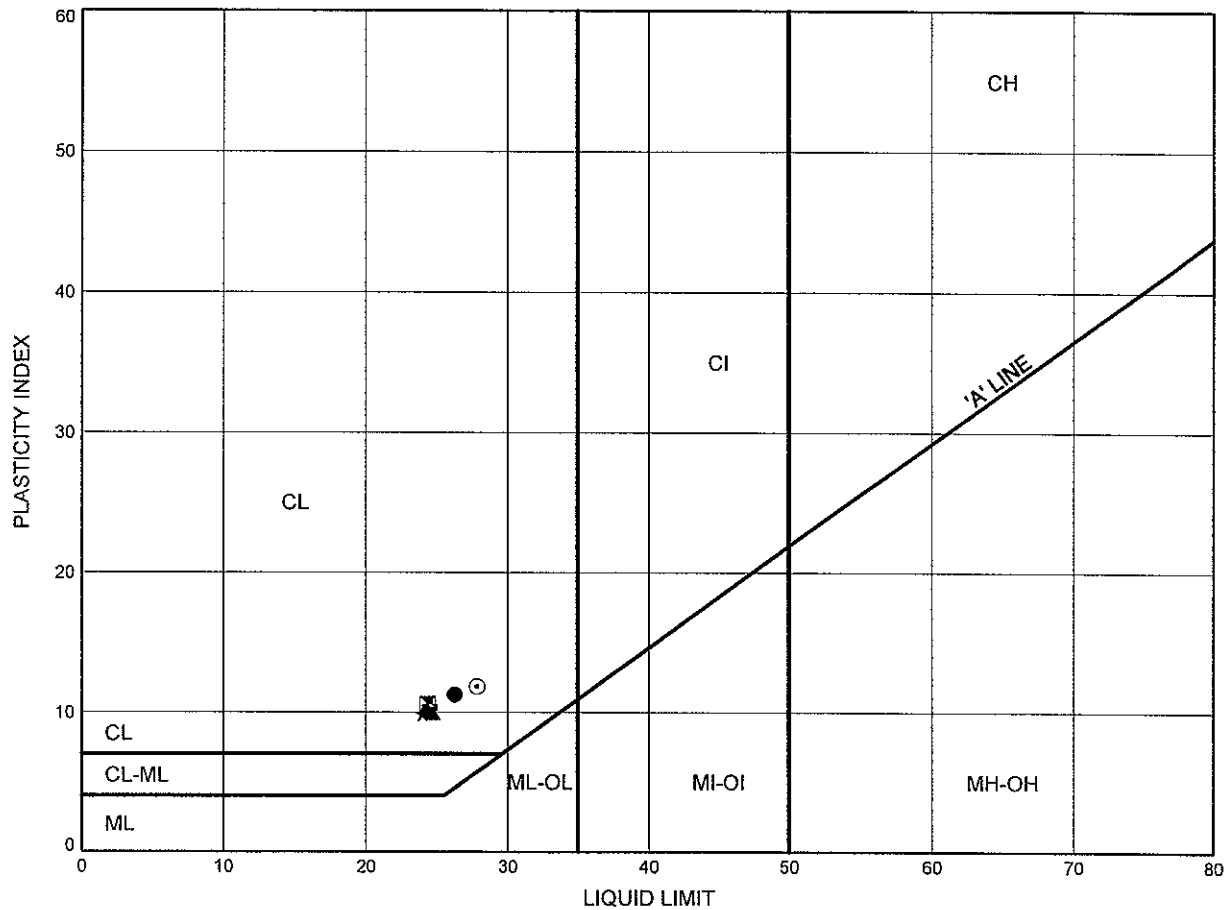
Prep'd DB

Chkd. RA

# ATTERBERG LIMITS TEST RESULTS

FIGURE B19

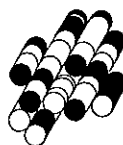
## UPPER SILTY CLAY TILL



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	W6	12.4	163.2
⊠	W6	13.9	161.7
▲	W6	15.4	160.2
★	W7	12.4	162.8
⊙	W8	10.9	165.0
⊛	W8	13.9	162.0

Date March 2010

Project 1-09-4135



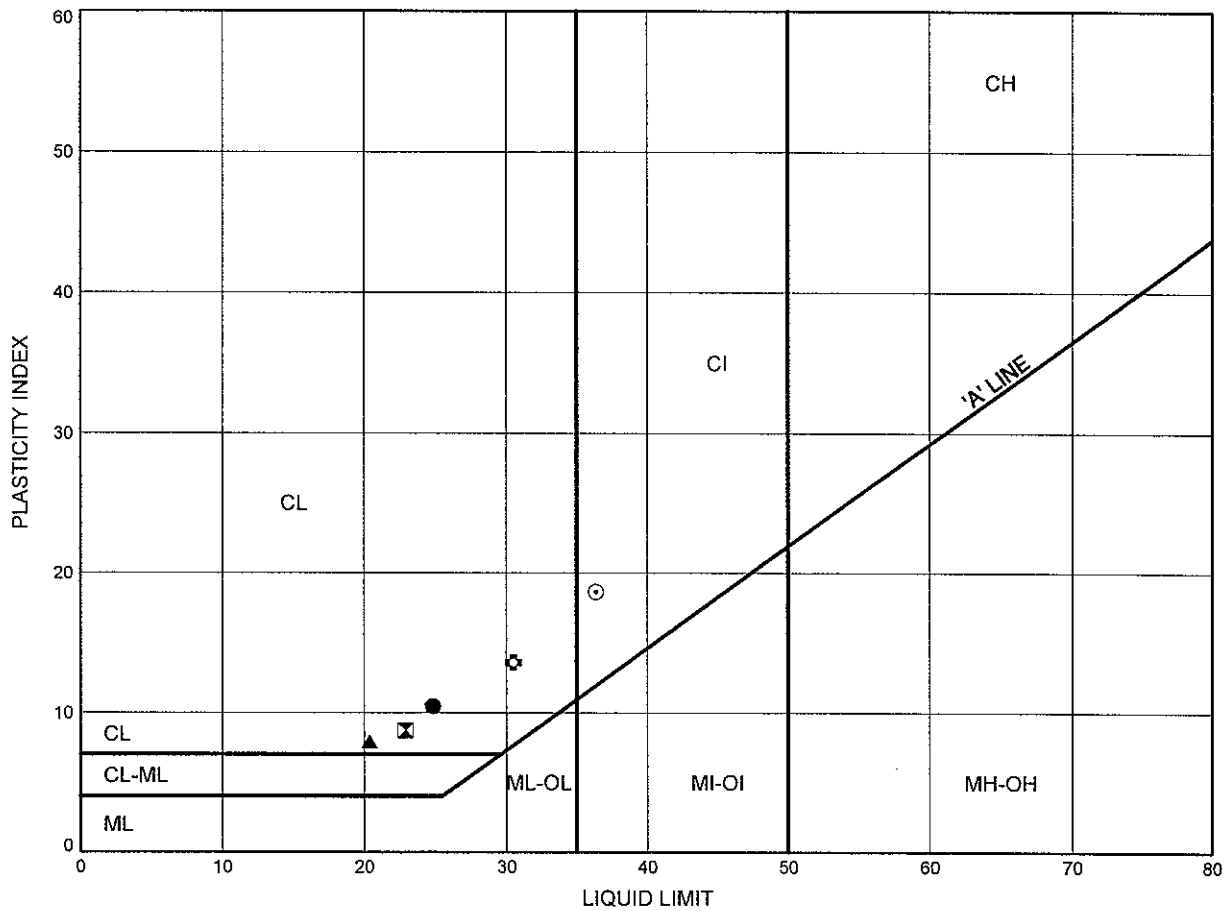
Prep'd DB

Chkd. RA

# ATTERBERG LIMITS TEST RESULTS

FIGURE B20

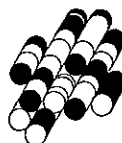
## UPPER SILTY CLAY TILL



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
▲	W9	12.4	163.2
★	W9	13.9	161.7
⊕	W9	17.0	158.6
⊗	W9	18.5	157.1
●	W10	12.8	160.5
⊠	W10	15.9	157.4

Date March 2010

Project



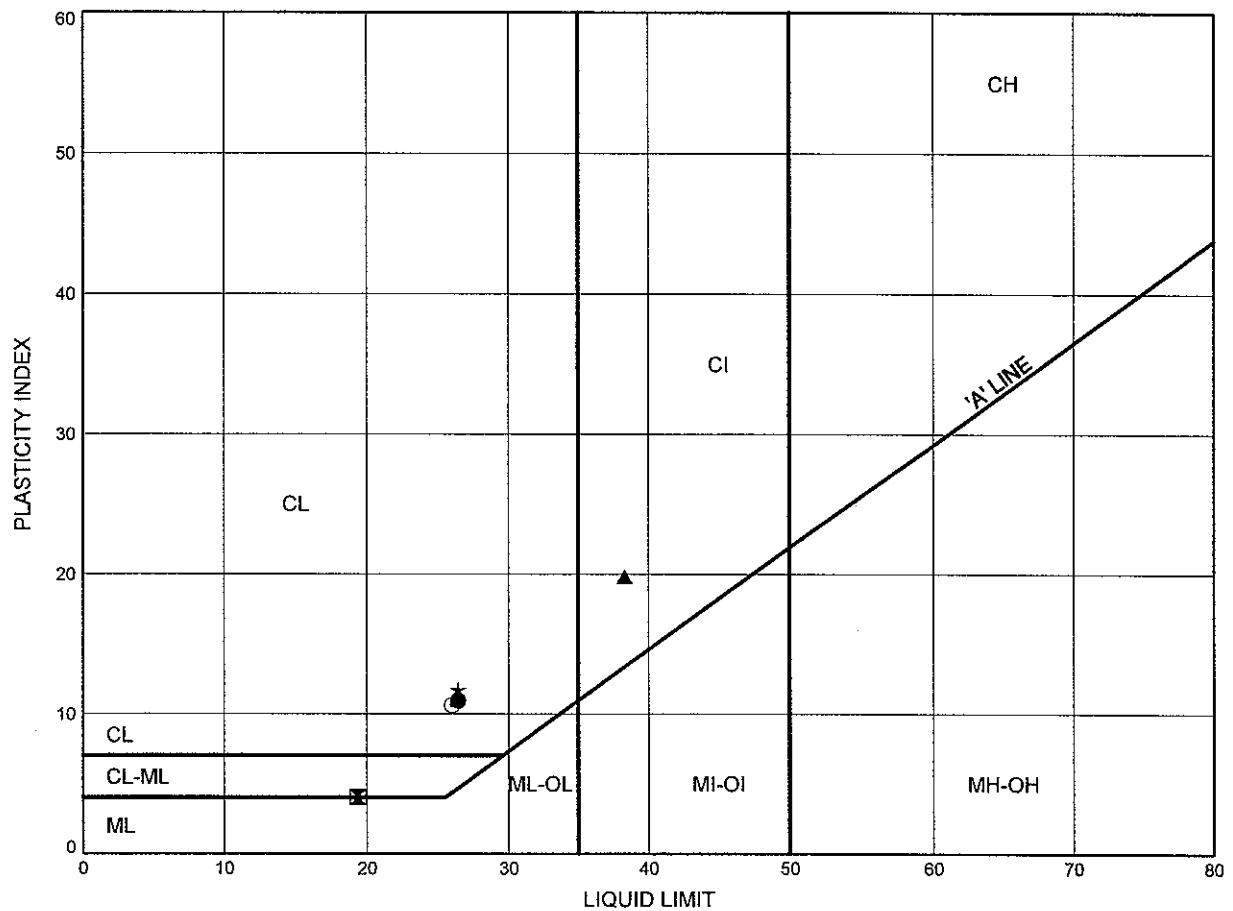
Prep'd DB

Chkd. RA

# ATTERBERG LIMITS TEST RESULTS

FIGURE B21

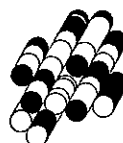
## UPPER SILTY CLAY TILL



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	W11	12.2	161.2
⊠	W11	16.0	157.4
▲	W12	14.4	159.0
★	W13	4.0	170.6
⊙	W13	6.3	168.3

Date March 2010

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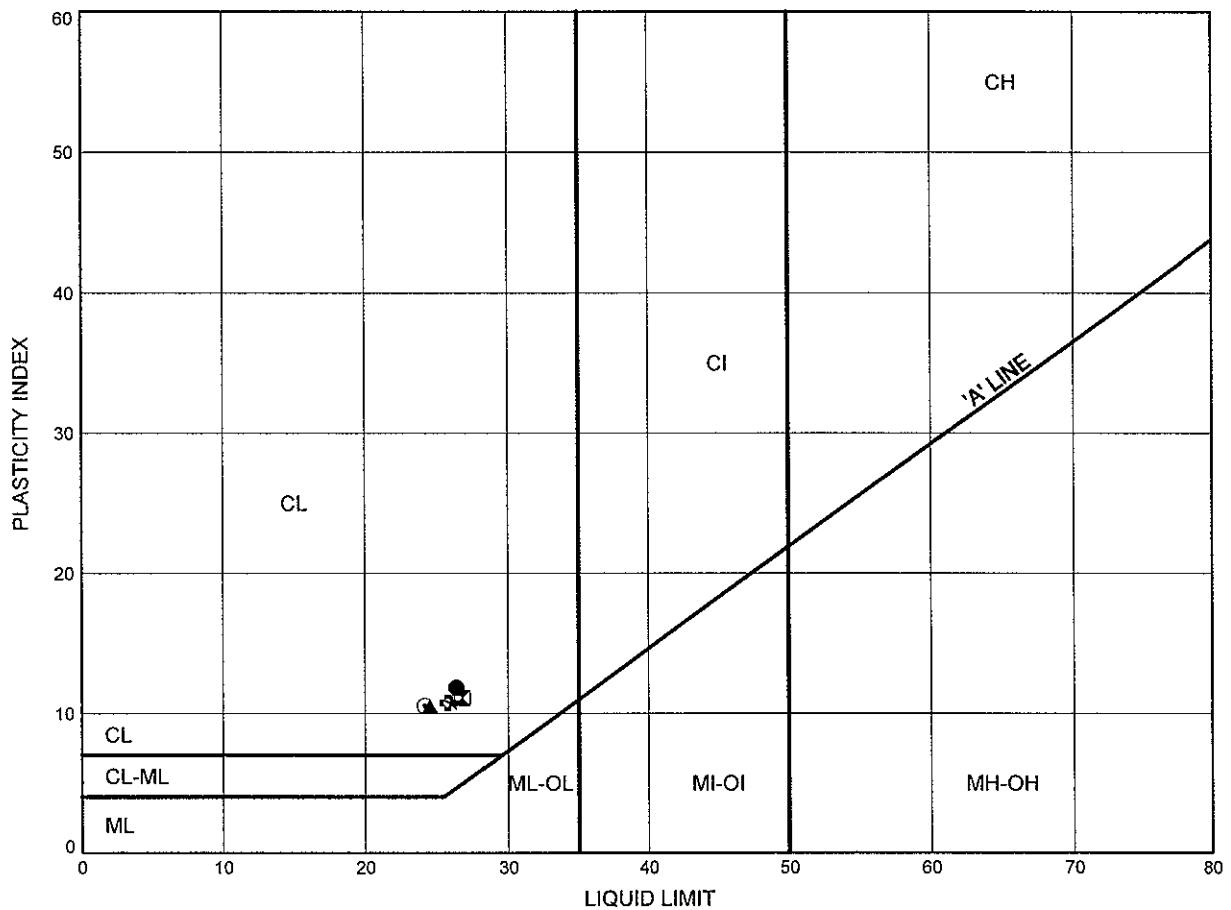
Prep'd DB

Chkd. RA

# ATTERBERG LIMITS TEST RESULTS

FIGURE B22

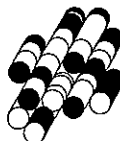
## UPPER SILTY CLAY TILL



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	W13	7.8	166.8
⊠	W13	10.9	163.7
▲	W13	13.9	160.7
★	W14	9.3	165.5
⊙	W14	12.4	162.4
⊛	W15	7.8	171.4

Date March 2010

Project 1-09-4135



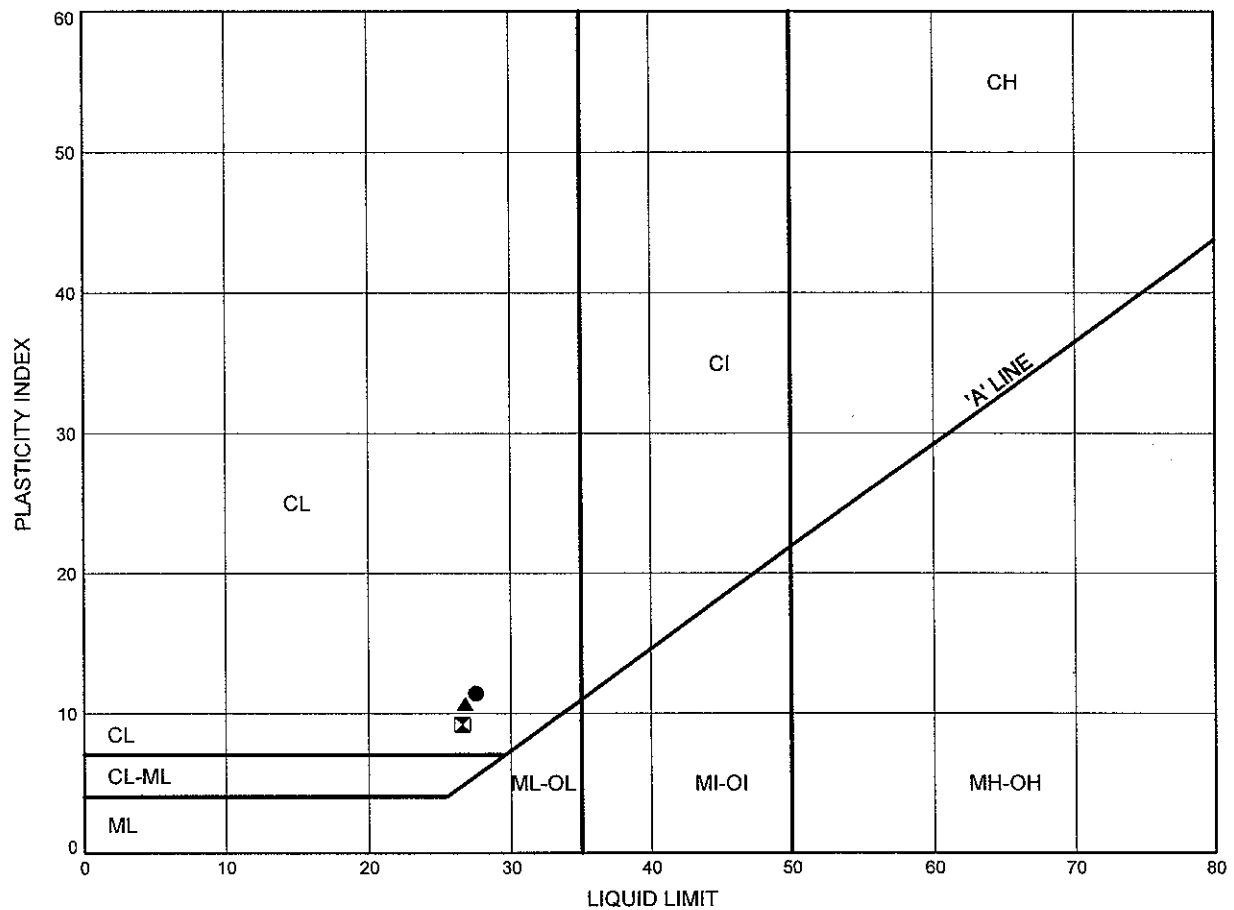
Prep'd DB

Chkd. RA

# ATTERBERG LIMITS TEST RESULTS

FIGURE B23

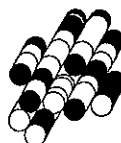
## UPPER SILTY CLAY TILL



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	W16	12.4	170.5
⊠	W16	17.0	165.9
▲	W16	18.5	164.4

Date March 2010

Project 1-09-4135



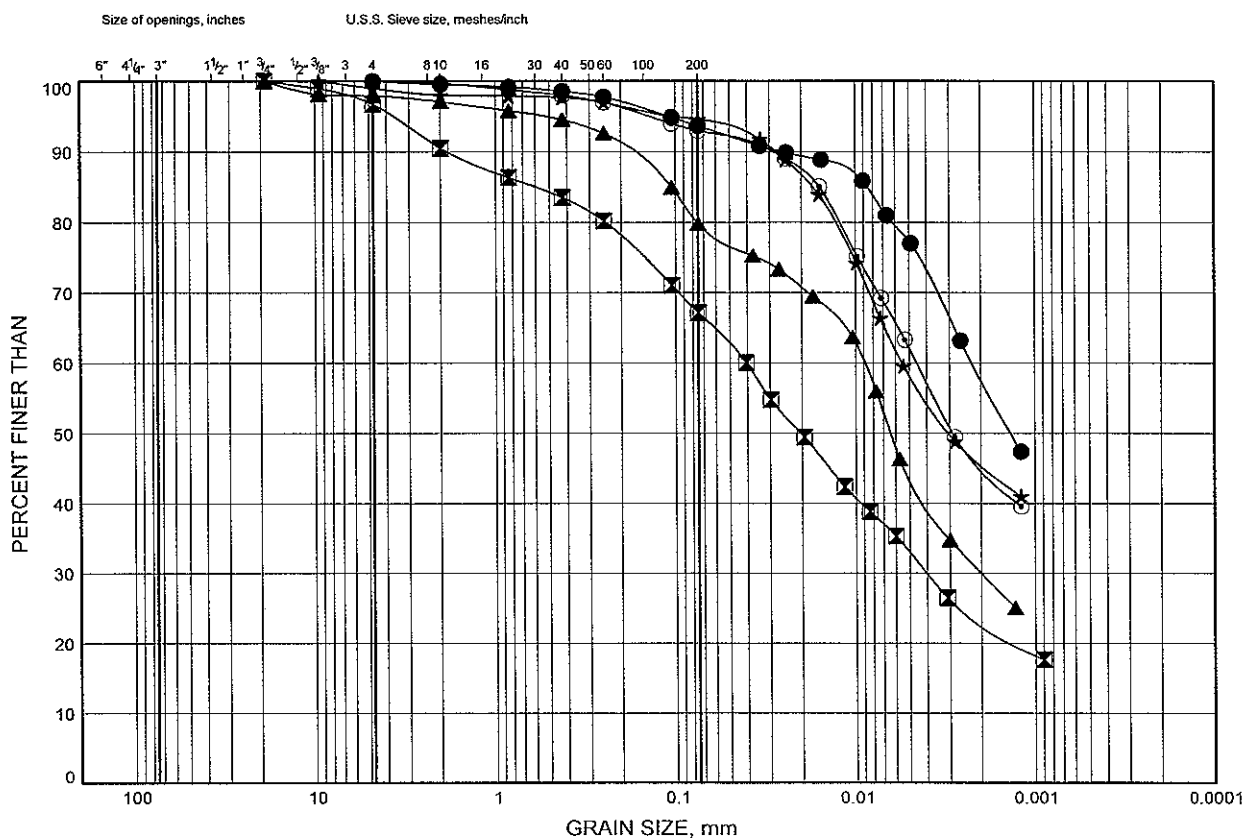
Prep'd DB

Chkd. RA

# GRAIN SIZE DISTRIBUTION

FIGURE B24

## LOWER SILTY CLAY TILL

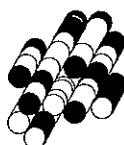


COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT and CLAY
	GRAVEL		SAND			FINE GRAINED

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
☒	W3	23.1	153.7
▲	W5	16.0	154.8
★	W6	23.1	152.5
⊙	W9	23.1	152.5
●	W10	20.5	152.8

Date March 2010

Project 1-09-4135



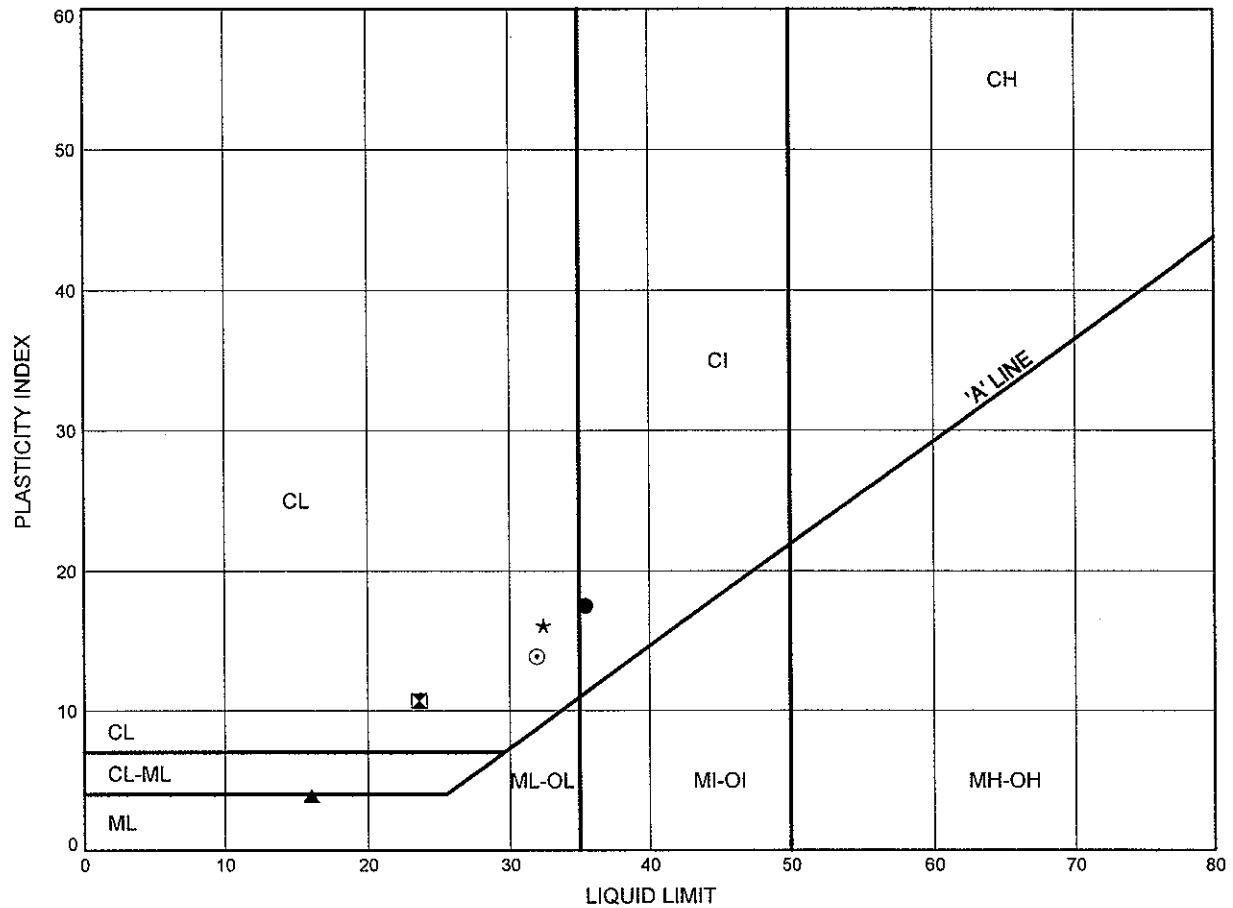
Prep'd DB

Chkd. RA

# ATTERBERG LIMITS TEST RESULTS

FIGURE B25

## LOWER SILTY CLAY TILL



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
⊠	W3	23.1	153.7
▲	W5	16.0	154.8
★	W6	23.1	152.5
⊙	W9	23.1	152.5
●	W10	20.5	152.8

Date March 2010

Project 1-09-4135



Prep'd DB

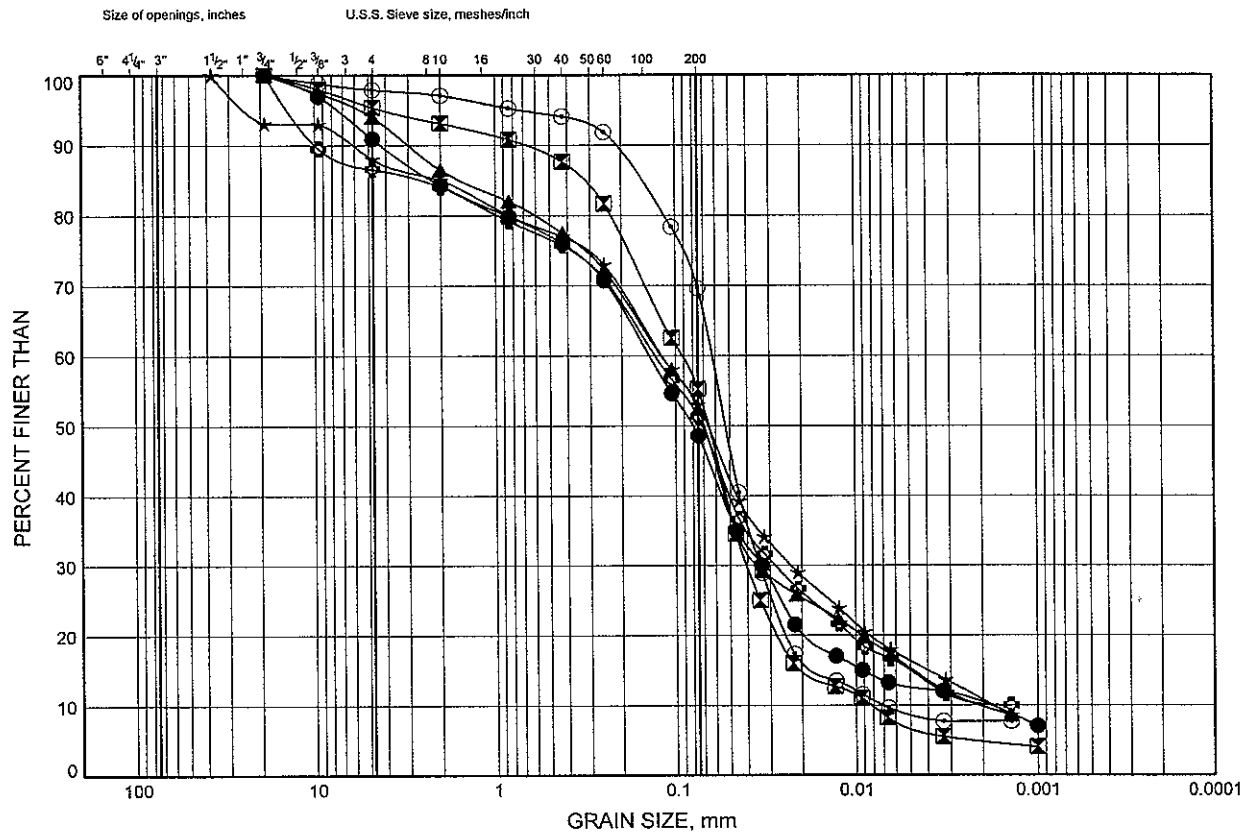
Chkd. RA



# GRAIN SIZE DISTRIBUTION

FIGURE B26

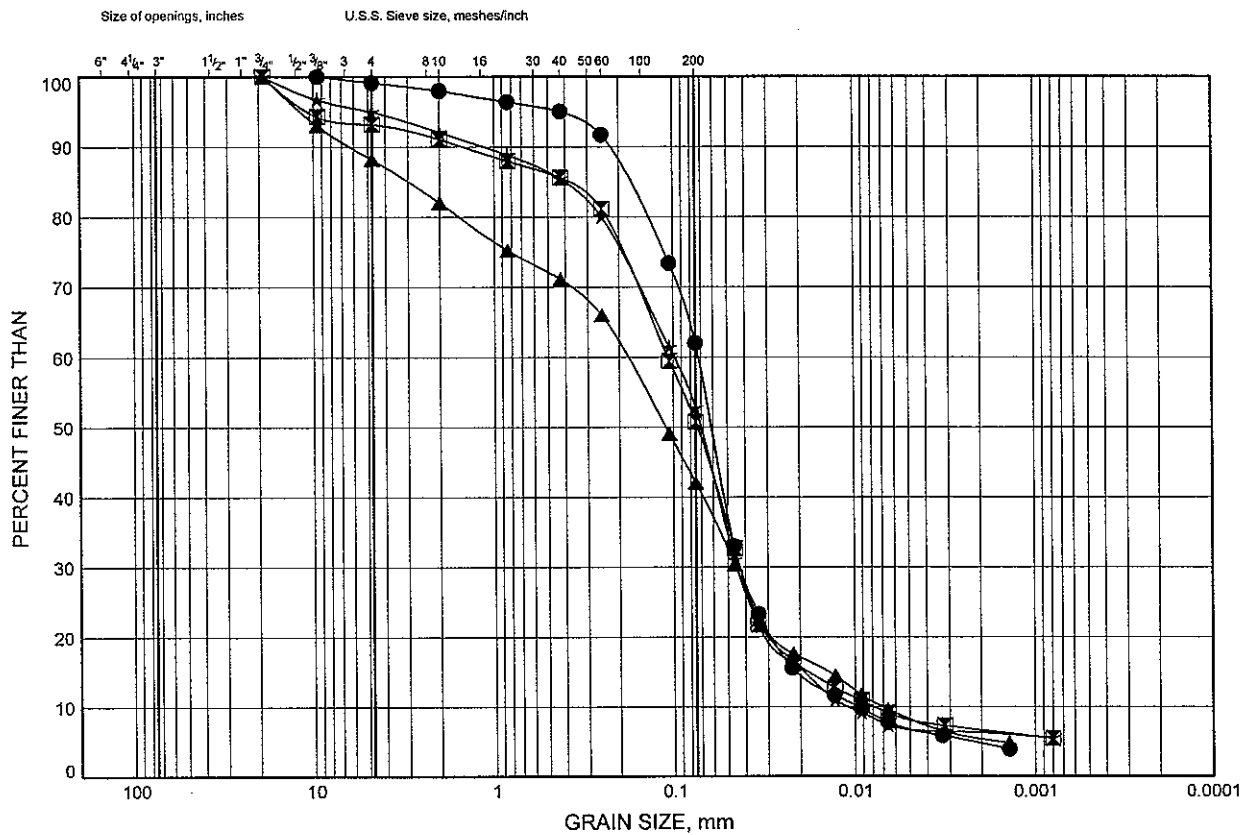
## SANDY SILT TO SILT AND SAND TILL



# GRAIN SIZE DISTRIBUTION

FIGURE B27

## SANDY SILT TO SILT AND SAND TILL



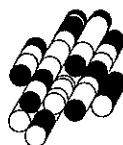
COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT and CLAY
	GRAVEL		SAND			FINE GRAINED

SYMBOL    BOREHOLE    DEPTH (m)    ELEVATION (m)

●	W10	17.4	155.9
⊠	W12	17.4	156.0
▲	W13	18.5	156.1
★	W14	18.5	156.3

Date    March 2010

Project    1-09-4135



Prep'd    DB

Chkd.    RA

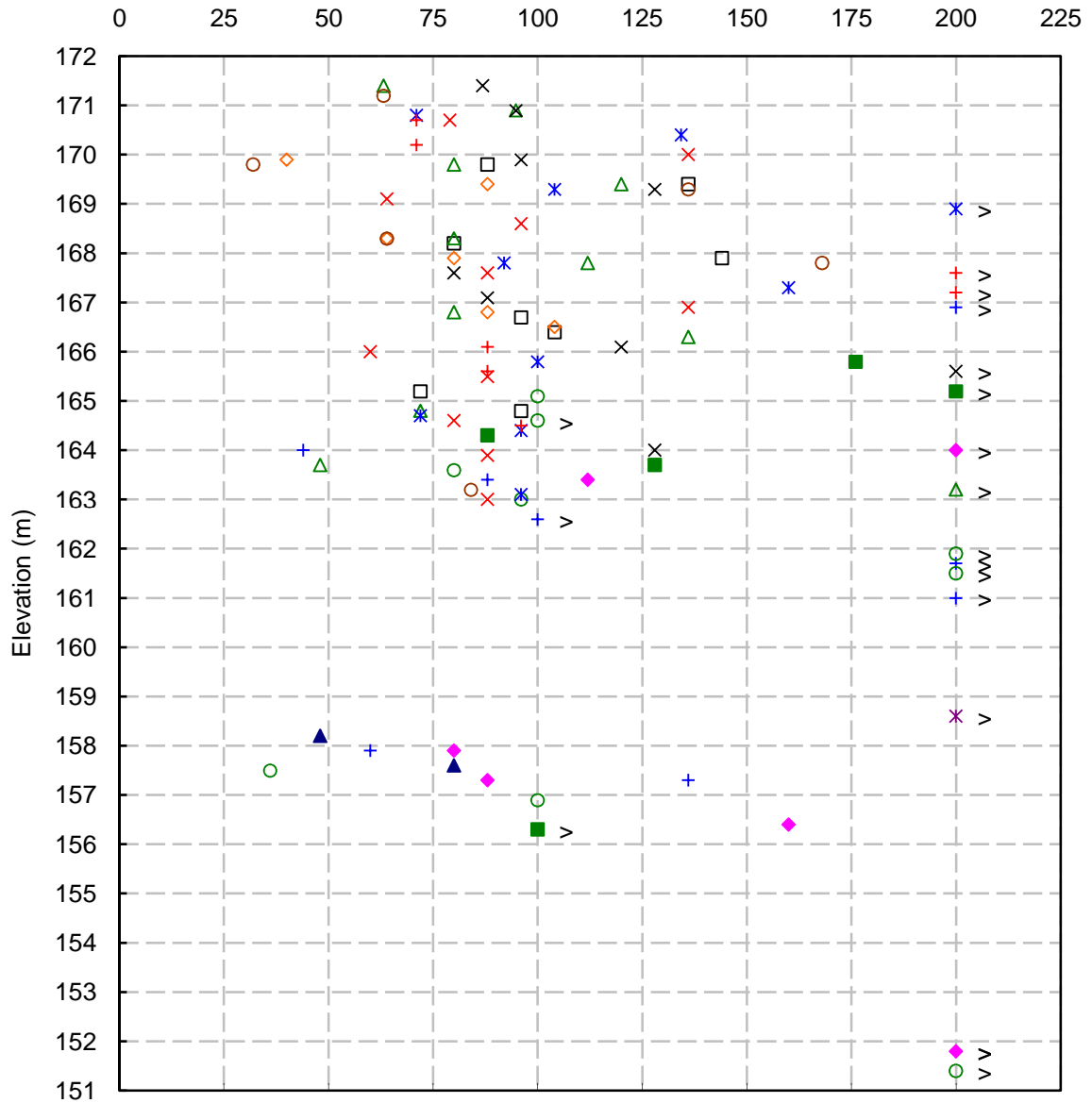
# CORRECTED UNDRAINED SHEAR STRENGTH

FIGURE B28

## OLD WELLAND CANAL / WELLAND RIVER BRIDGE

Silty Clay Till

Corrected Cu (kPa)



□ W1 ◇ W2 △ W3 × W4 \* W5 + W6 ○ W7 ■ W8 ◆ W9 ▲ W11 × W13 \* W14 + W15 ○ W16

### Field Shear Vane Correction

Morris & Williams (1994)

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

### Applied Correction Factors

0.99 (Elev.>170m)

1.00 (Elev.<170m)

Project No. : 1-09-4135

Date : September, 2010



**Terraprobe Inc.**

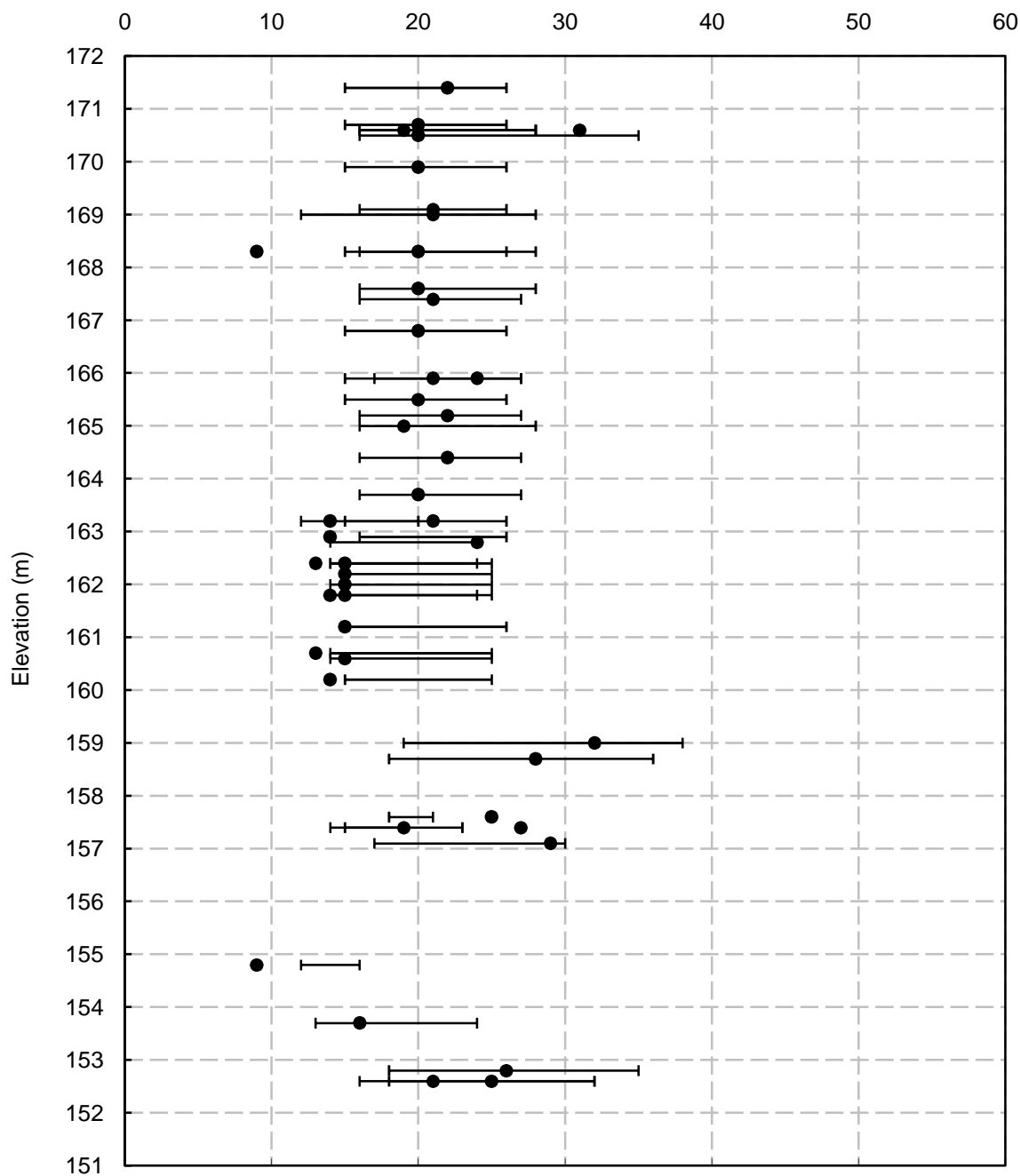
Prepared By : HW

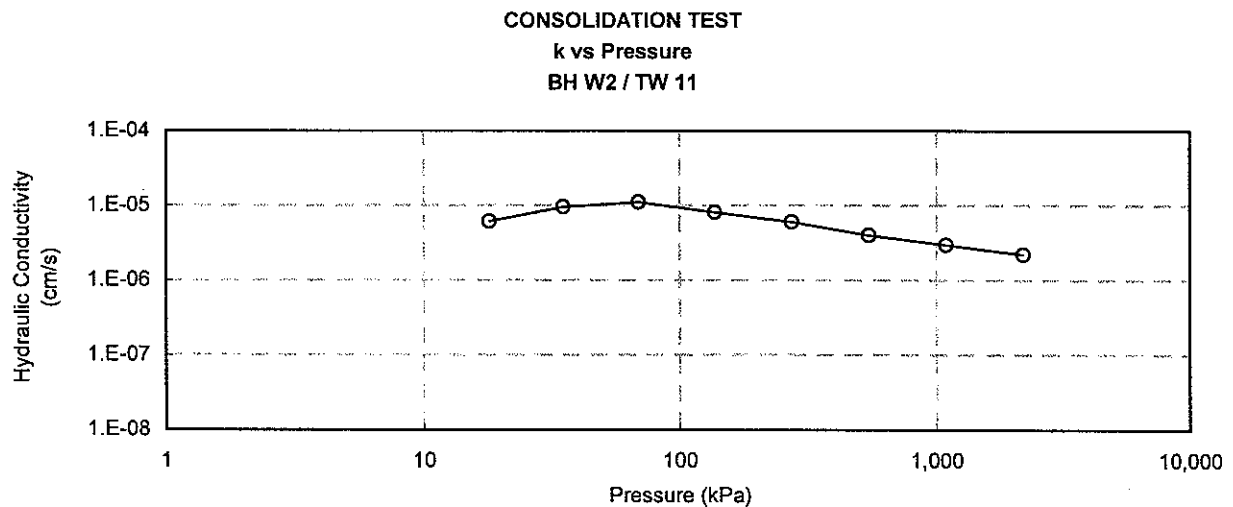
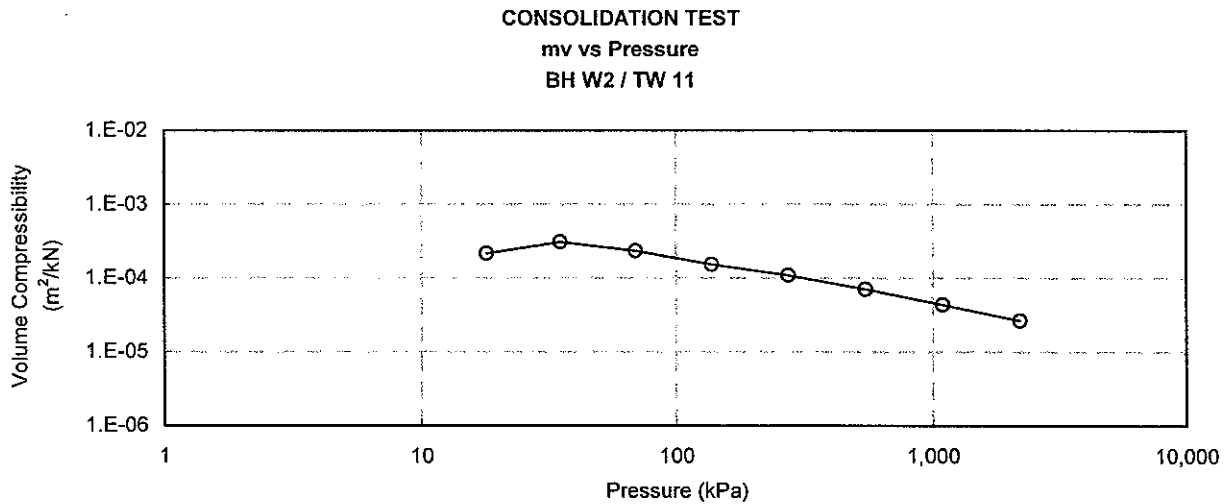
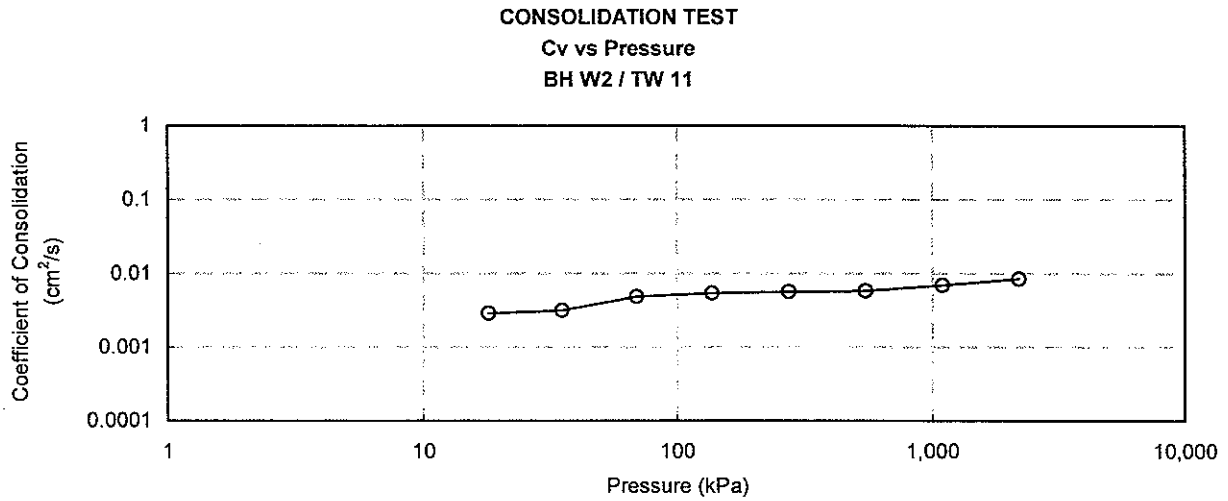
Checked By : RA

OLD WELLAND CANAL / WELLAND RIVER BRIDGE

Silty Clay Till

Atterberg Limits & Water Contents (%)

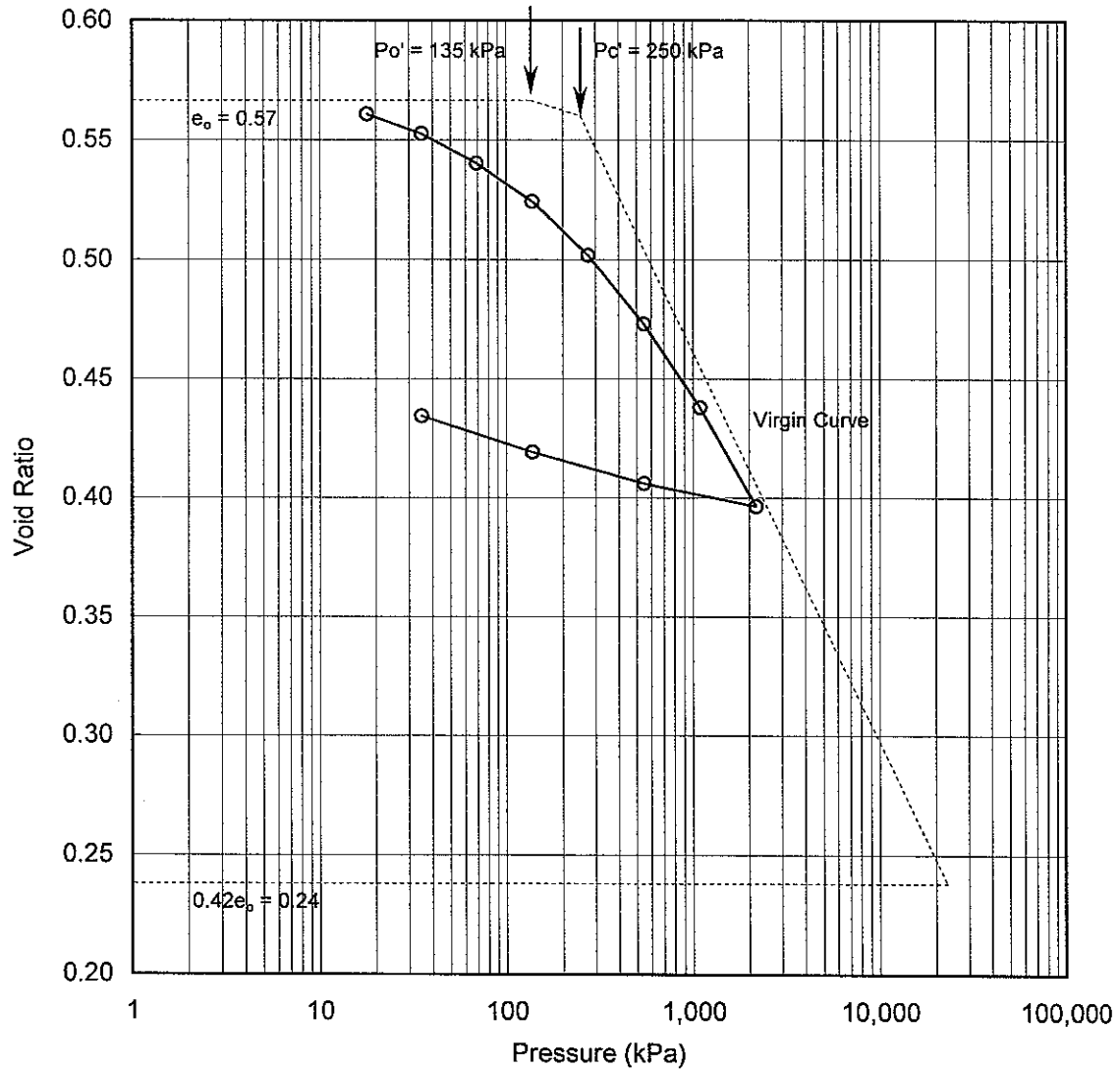




CONSOLIDATION TEST

e vs Pressure

BH W2 / TW 11



Soil Type : Silty Clay Till

$e_0 =$	0.57	$\omega_L =$	26%	$P_{o'} =$	135 kPa
$\omega =$	21%	$\omega_P =$	16%	$P_{c'} =$	250 kPa
$\gamma =$	20.6 kN/m <sup>3</sup>	PI =	10%	Cc =	0.164
Gs =	2.72			Cr =	0.024

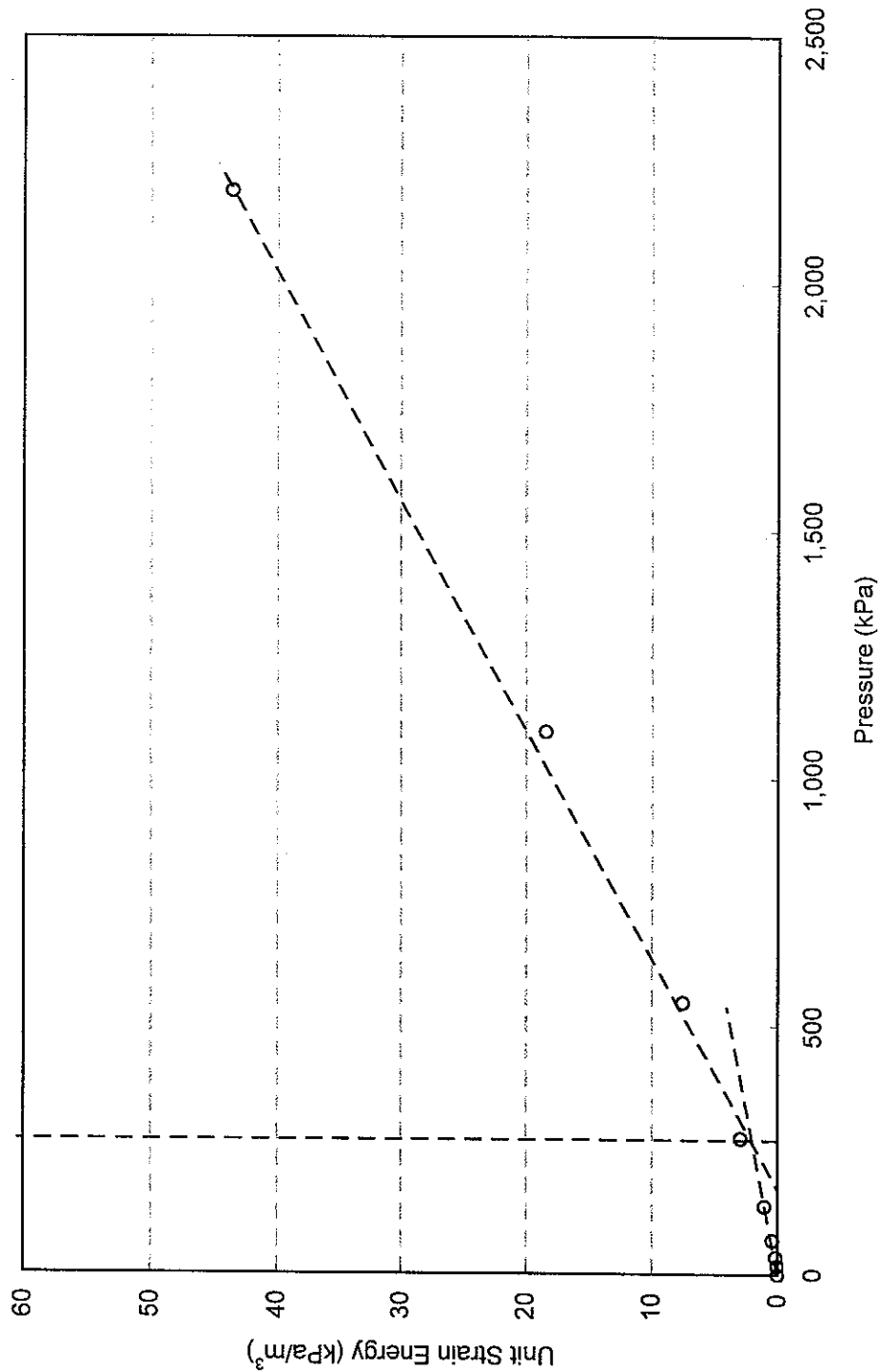
Project No. : 1-09-4135  
Date : April 2010



**Terraprobe Inc.**

Prepared By : HW  
Checked By : RA

**CONSOLIDATION TEST**  
**Unit Strain Energy vs Pressure**  
**BH W2 / TW 11**



$P_c = 270 \text{ kPa}$

Project No. : 1-09-4135

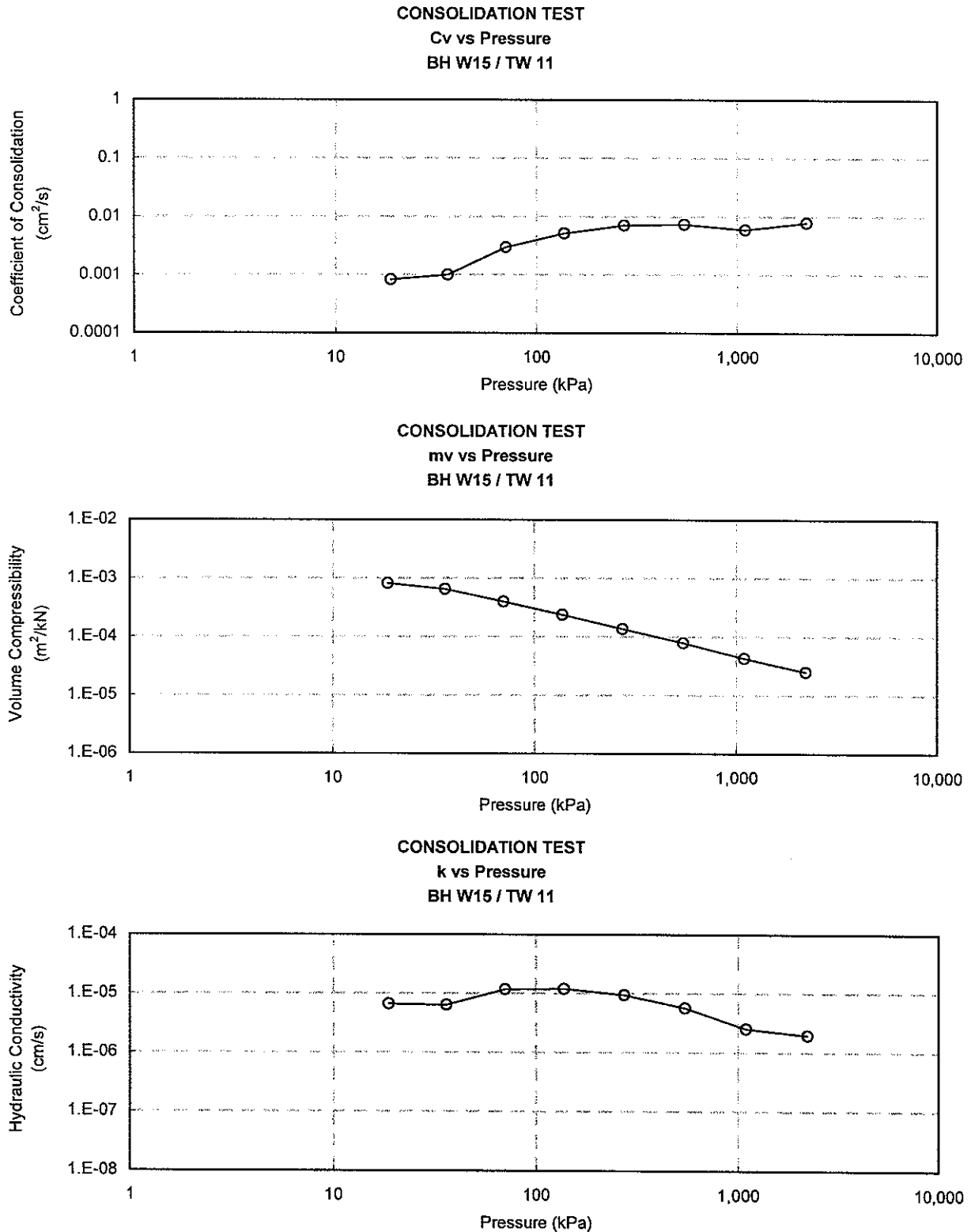
Date : April 2010



**Terraprobe Inc.**

Prepared By : HW

Checked By : RA



C:\Documents and Settings\Hongji\My Documents\Project 2009\1-09-4135 - HWY 406 Foundations\Welland Canal\Consolidation Tests\1-09-4135 Consolidation Results.xls

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



**Terraprobe Inc.**

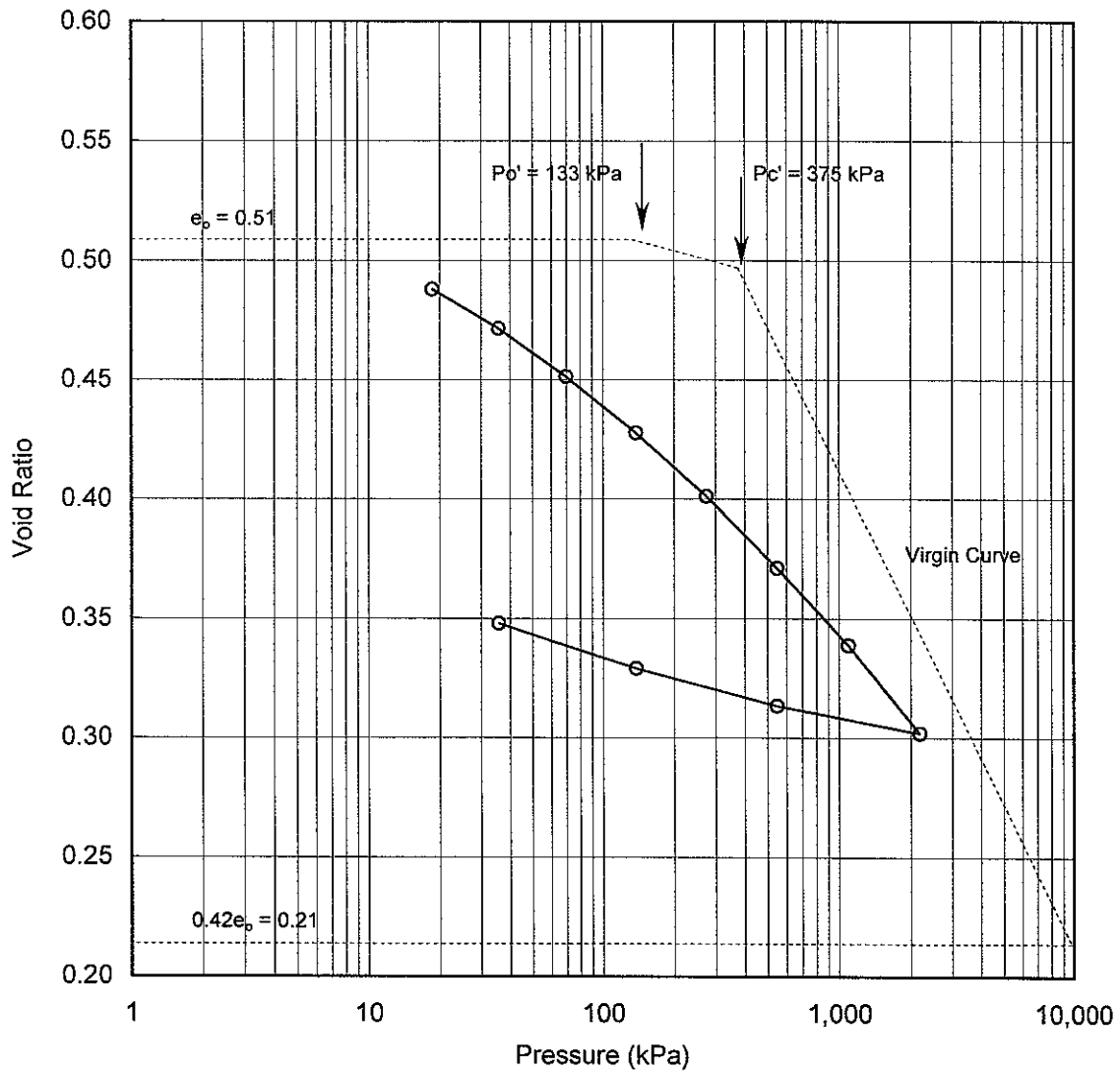
Prepared By : HW  
Checked By : RA



CONSOLIDATION TEST

e vs Pressure

BH W15 / TW 11



Soil Type : Silty Clay Till

$e_o =$	0.51	$\omega_L =$	26%	$P_o' =$	133 kPa
$\omega =$	22%	$\omega_p =$	15%	$P_c' =$	375 kPa
$\gamma =$	21.4 kN/m <sup>3</sup>	PI =	11%	Cc =	0.200
Gs =	2.75			Cr =	0.026

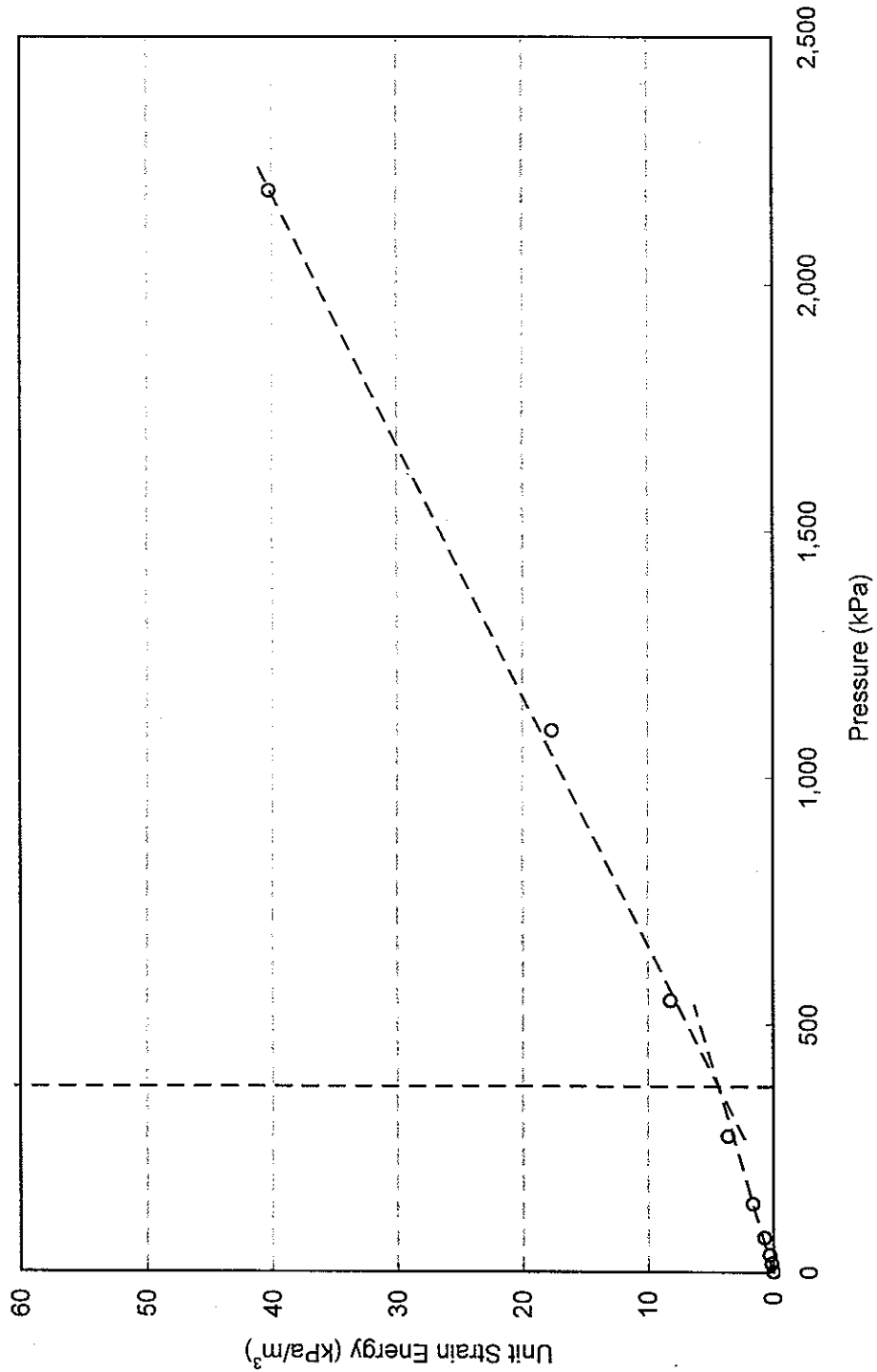
Project No. : 1-09-4135  
Date : April 2010



**Terraprobe Inc.**

Prepared By : HW  
Checked By : RA

**CONSOLIDATION TEST**  
**Unit Strain Energy vs Pressure**  
**BH W15 / TW 11**



$P_c = 375 \text{ kPa}$

Project No. : 1-09-4135

Date : April 2010



**Terraprobe Inc.**

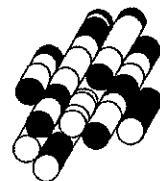
Prepared By : HW

Checked By : RA

# **APPENDIX C**

## **Record of Borehole Sheets (Previous Investigations)**

**Terraprobe Inc.**



# RECORD OF BOREHOLE No 101

1 OF 1

METRIC

W.P. 171 - 90 - 01 LOCATION CO - ORDS. N 4 784 905.4; E 327 177.5 ORIGINATED BY P.V.  
 DIST 4 HWY 406 BOREHOLE TYPE CONTINUOUS FLIGHT AUGER (H.S.) & CONE TEST COMPILED BY M.S.  
 DATUM GEODETTIC DATE 87 10 19 to 87 10 21 CHECKED BY M.S.

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			NATURAL MOISTURE CONTENT	UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100			
171.9	Ground Level												
0.0			1	SS	12								
			2	SS	17								
			3	SS	13								
			4	SS	15								
	CLAYEY SILT to SILTY CLAY. With Occasional Silt Seams, Trace of Sand, Stiff to Firm		5	SS	12								
			6	SS	14								
			7	SS	6								
			8	SS	5								
			9	TW	PH								
			10	SS	38								
			11	SS	37								
			12	SS	47								
155.8			13	SS	6								
16.1			14	SS	9								
	SANDY SILT, Trace of Gravel, Loose to Compact												
151.9			15	SS	29								
20.0	CLAYEY SILT to SILTY CLAY, Trace of Sand, Very Stiff												
150.3													
21.6			16	RC	REC								
	DOLOSTONE BEDROCK Sound		17	RC	REC								
147.9													
24.0	End of Borehole												
	• Note: Artesian Condition Water Level Rose to 0.5m Above Ground Level @: 172.4												

+3, x 3 Numbers refer to  
Sensitivity

20  
15-25 (%) STRAIN AT FAILURE  
10

RECORD OF BOREHOLE No 102

1 OF 1

METRIC

W.P. 171 - 90 - 01 LOCATION CO - ORDS. N 4 784 893.6; E 327 185.0 ORIGINATED BY P.M.  
DIST 4 HWY 408 BOREHOLE TYPE CONTINUOUS FLIGHT AUGER (H.S.) & CONE TEST COMPILED BY M.  
DATUM GEODETIC DATE 87 10 22 to 87 10 23 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		WATER CONTENT (%)		UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100	W <sub>p</sub> W W <sub>L</sub>			
171.7	Ground Level												
0.0	Boulders		1	SS	42								67 12 13 3
			2	SS	36								48 36 13 3
	SANDY GRAVEL Some Silt, Trace of Clay Compact to Very Dense ( Fill )		3	SS	14								
			4	SS	16								
			5	SS	59								
			6	SS	80								
166.5			7	SS	74								
5.2			8	SS	20								
	CLAYEY SILT to SILTY CLAY Trace of Sand, Stiff		9	SS	13								
			10	SW	PH							20.6	1 2 (97)
			11	SS	49								
	Hard		12	SS	60								
			13	SS	13								0 1 (99)
156.3			14	SS	10								9 30 (52)
15.4			15	SS	110								5 35 (80)
	SANDY SILT, Trace of Gravel, Compact to Very Dense												
152.2													
19.5	Presumed CLAYEY SILT to SILTY CLAY, Trace of Sand, Very Stiff												
150.4													
21.3	End of Borehole Presumed Bedrock												

+3, x3: Numbers refer to  
Sensitivity

20  
15-0-5 (X) STRAIN AT FAILURE  
10

RECORD OF BOREHOLE No 103

1 OF 1

METRIC

W.P. 171 - 90 - 01 LOCATION CO - ORDS, N 4. 784 804.1; E 327 188.6 ORIGINATED BY .  
DIST 4 HWY 405 BOREHOLE TYPE CONTINUOUS FLIGHT AUGER ( H 5 ) & CONE TEST COMPILED BY .  
DATUM GEODETIC DATE 87 10 24 to 87 10 27 CHECKED BY .

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT	PLASTIC LIMIT P	NATURAL MOISTURE CONTENT W	LIQUID LIMIT L	UNIT WEIGHT 7 kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) CF SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES								
177.4	Ground Level												
0.0			1	SS	39								
			2	SS	40								
			3	SS	21								
			4	SS	20								
			5	SS	53								
			6	SS	20								
			7	SS	10								
			8	TW	PH								
			9	TW	PH								
			10	SS	8								
			11	SS	10								
			12	TW	PH								
			13	SS	58								
			14	SS	22								
157.3			15	SS	73								
20.1			16	SS	12								
154.2			17	RC	28%								
23.2			18	RC BX	REC 78%								
150.5			19	RC BX	REC 100%								
28.9													
146.8													

30.5 End of Borehole

+3, x5, Numbers refer to  
Sensitivity

20  
15-25 (x) STRAIN AT FAILURE  
10

RECORD OF BOREHOLE No. 104										1 OF 1		METRIC					
W.P. 171 - 90 - 01			LOCATION CO - ORDS. N 4 754 830.8; E 327 186.4			ORIGINATED BY: M											
DIST 4 HWY 408			BOREHOLE TYPE CONTINUOUS FLIGHT AUGER (H.S.) & CONE TEST			COMPILED BY: M											
DATUM GEOIDETIC			DATE 87 10 30 to 87 11 05			CHECKED BY: J											
SOIL PROFILE		SAMPLES			GROUND WATER * CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT		NATURAL MOISTURE CONTENT		LIQUID LIMIT		UNIT WEIGHT	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20	40	60	80	100	W <sub>p</sub>	W			W <sub>L</sub>
170.9	Water Level																
0.0																	
168.5	Ground Level																
2.4	CLAYEY SILT to SILTY CLAY, Trace of Sand, Stiff to Very Stiff  Hard		1	SS	10												
			2	SS	10												
			3	SS	9												
			4	SS	34												
			5	SS	45												
			6	SS	56												
			7	SS	22												
157.8	SANDY SILT, Some Gravel, Very Dense		8	SS	53												
13.1			9	SS	74												
155.4																	
13.5	End of Borehole																
	• Note: Artesian Condition Water Level Rose to 1.4m Above Ground Level El: 172.3																

RECORD OF BOREHOLE No 105												1 OF 1		METRIC	
W.P. 171 - 90 - 01			LOCATION CO - ORDS. N 4 764 844.0; E 327 185.0			ORIGINATED BY									
DIST 4 HWY 406			BOREHOLE TYPE CONE TEST			COMPILED BY									
DATUM GEODETTIC			DATE 87 11 05			CHECKED BY									
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH kPa	WATER CONTENT (%)						
170.9	Water Level														
0.0							170								
167.1	Ground Level						168								
3.8							166								
	Presumed CLAYEY SILT to SILTY CLAY. Trace of Sand, Stiff						164								
161.3							162								
9.4	End of Cone Test														

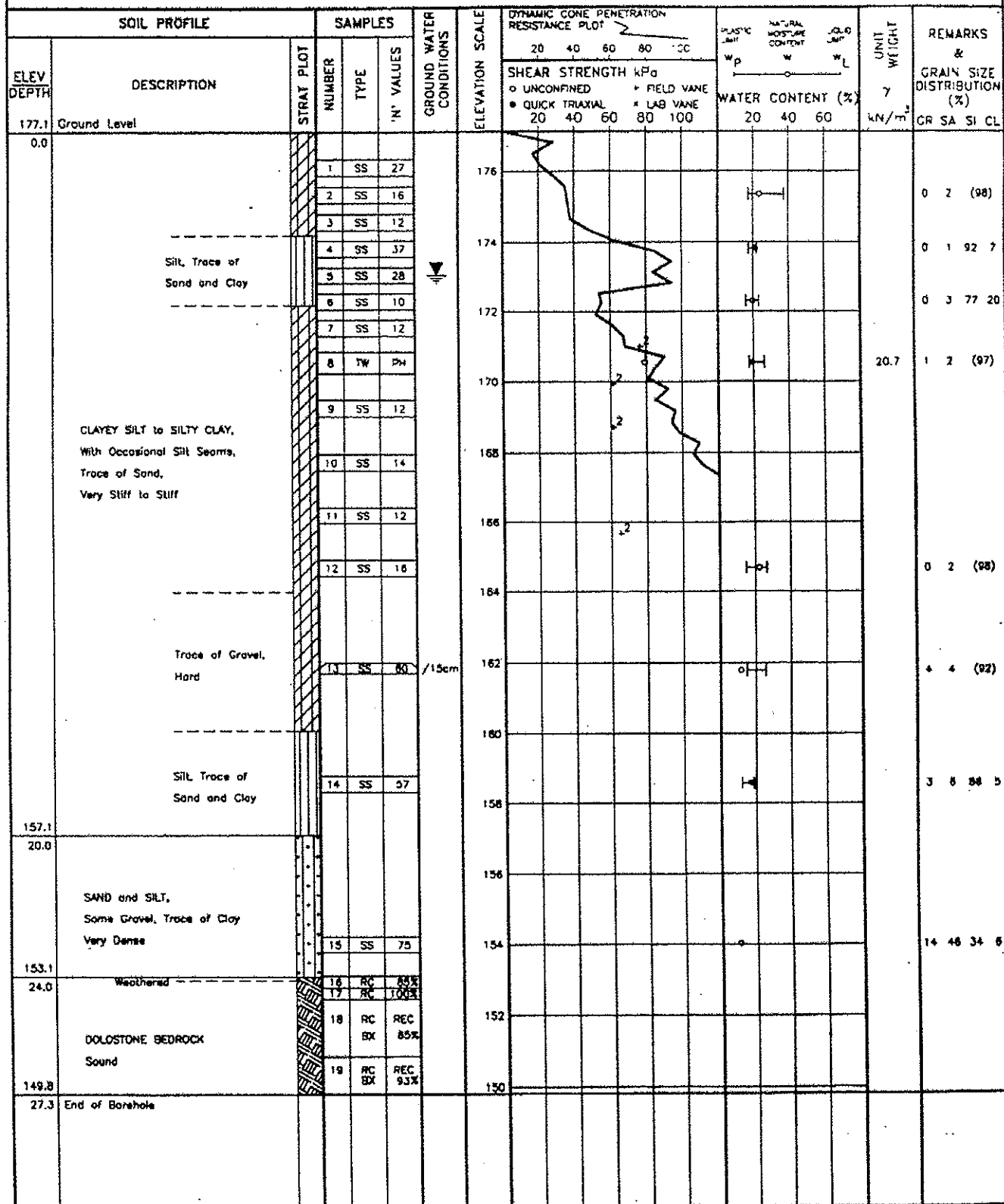


# RECORD OF BOREHOLE No 201

1 OF 1

METRIC

W.P. 171 - 90 - 01 LOCATION CO - ORDS. N 4 765 090.2; E 327 121.8 ORIGINATED BY P.W.  
 DIST 4 HWY 405 BOREHOLE TYPE CONTINUOUS FLIGHT AUGER (H.S.) & CONE TEST COMPILED BY W.V.  
 DATUM GEODETIC DATE 87 10 14 to 87 10 16 CHECKED BY J.D.



+3, x3: Numbers refer to  
Sensitivity

20  
15-25 (X) STRAIN AT FAILURE  
10

# RECORD OF BOREHOLE No 202

1 OF 1

METRIC

W.P. 171 - 90 - 01

LOCATION CO - QROS. N 4 785 073.8; E 327 128.3

ORIGINATED BY P

DIST 4 HWY 406

BOREHOLE TYPE SX CASING & CONE TEST

COMPILED BY M

DATUM GEODETIC

DATE 87 11 07 to 87 11 10

CHECKED BY P.P.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT		NATURAL MOISTURE CONTENT		LIQUID LIMIT		UNIT WEIGHT 7 kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES		20 40 60 80 100	120	W <sub>p</sub>	W	W <sub>L</sub>	WATER CONTENT (%)		20 40 60		
173.4	Water Level															
0.0																
171.4	Ground Level															
2.0																
			1	SS	10											
			2	SS	10											
			3	SS	10											
			4	SS	11											
			5	SS	11											
			6	SS	11											
			7	SS	11											
			8	SS	67											
			9	SS	94											
			10	SS	61											
			11	SS	63											
157.4																
16.0	SAND and SILT, Some Gravel, Trace of Clay, Dense		12	SS	33											
156.0			13	SS	48											
17.4	End of Borehole															
154.8																
18.6	End of Cone Test															
	• Note: Artesian Condition Water Level Rose to 0.3m Above Ground Level Et: 173.7															

+3, x3 Numbers refer to  
Sensitivity

20  
15-25 (%) STRAIN AT FAILING  
16

RECORD OF BOREHOLE No 203

1 OF 1

METRIC

W.P. 171 - 80 - 01 LOCATION CO - QROD, N 4.784, 944.0; E 327.188.0 ORIGINATED BY  
DIST 4 HWY 406 BOREHOLE TYPE CONE TEST COMPILED BY  
DATUM GEODETIC DATE 87.11.12 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		WATER CONTENT (%)	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20 40 60 80 100	20 40 60 80 100			
173.4	Water Level											
0.0												
170.7	Ground Level											
2.7												
	Presumed CLAYEY SILT to SILTY CLAY, Trace of Sand and Gravel, Stiff to Hard											
161.9												
11.5	End of Cone Test											

+3, x3: Numbers refer to  
Sensitivity

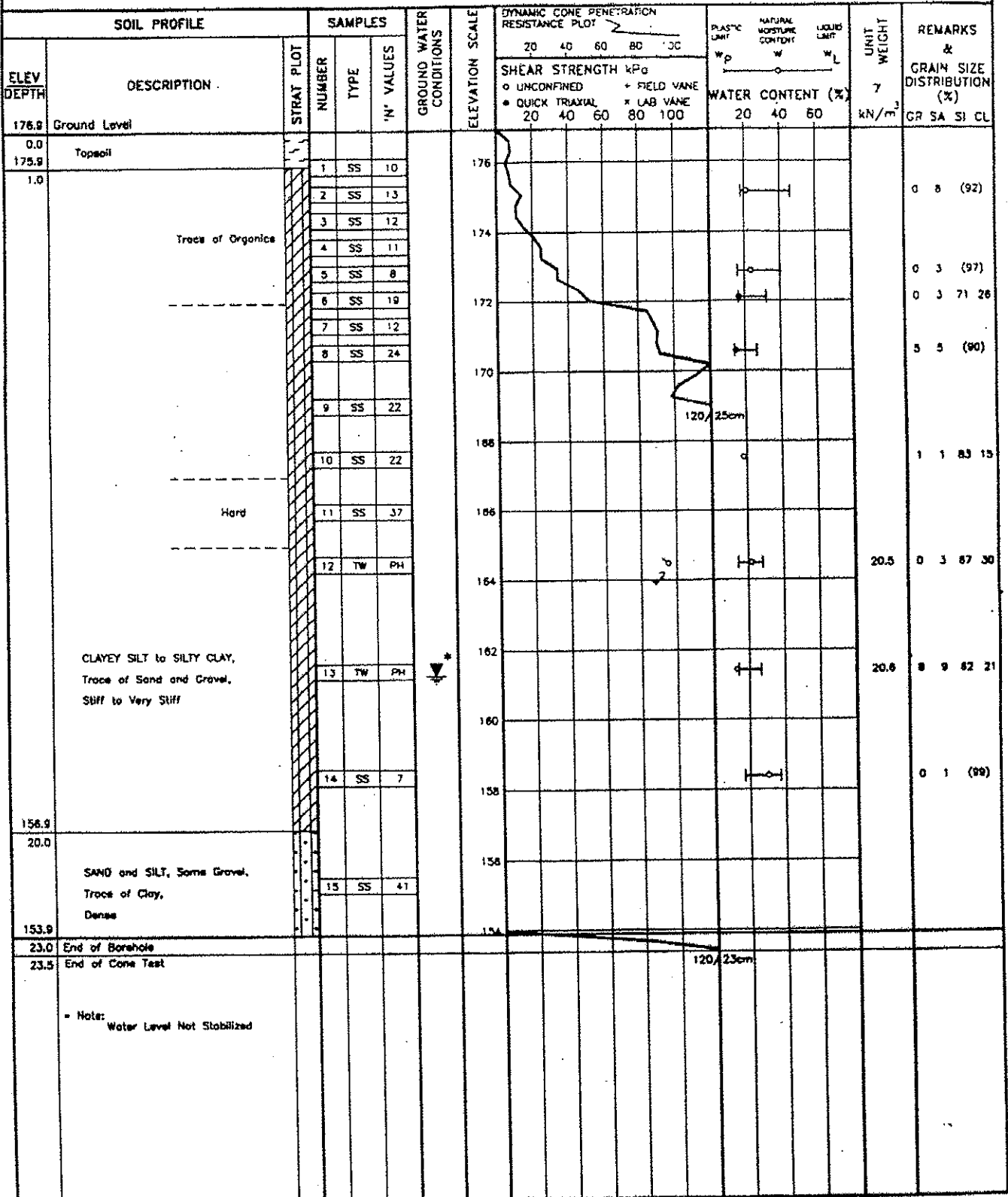
20  
15-25 (%) STRAIN AT FAILURE  
10

# RECORD OF BOREHOLE No 204

1 OF 1

METRIC

W.P. 171 - 90 - 01 LOCATION CO - ORGS. N 4 784 925.5; E 327 187.5 ORIGINATED BY P. V.  
DIST 4 HWY 406 BOREHOLE TYPE CONTINUOUS FLIGHT AUGER (H. S.) & CONE TEST COMPILED BY M. Y.  
DATUM GEODETIC DATE 87 11 17 to 87 11 18 CHECKED BY P. V.



# RECORD OF BOREHOLE No 205

1 OF 1

METRIC

W.P. 171 - 90 - 01 LOCATION CO - ORDS. N 4 765 038.5; E 327 121.0 ORIGINATED BY S.M. M.  
DIST 4 HWY 406 BOREHOLE TYPE WASH BORE NX CASING, BXL ROCK CORE & CONE TEST COMPILED BY M.J.  
DATUM GEODETIC DATE 88.11.16 to 88.11.23 CHECKED BY P.P.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT 7 KN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20 40 60 80 100	20 40 60 80 100					
173.3	Water Level												
0.0													
164.0	Canal Bed												
9.3	Organic Silt		1	SS									0 14 60 28
			2	SS	97								29 14 41 16
			3	SS	71								
	CLAYEY SILT to SILTY CLAY. With Occasional Silt Seams. Some Sand and Gravel. Hard to Very SUFF		4	SS	28								
			5	SS	22								15 52 26 7
156.8			6	SS	38								
16.5			7	SS	69								
	SAND and SILT. Some Gravel. Trace of Clay. Very Dense												
151.9			8	SS	91								80 26 11 3
21.4			9	RC	83%								RC 0%
			10	RC	REC								RC 14%
			11	RC	REC								RC 0%
149.8			12	RC	50%								RC 22%
	DOLOSTONE BEDROCK												
23.5	End of Borehole												

+J, x, s; Numbers refer to  
Sensitivity

20  
15-0-5 (X) STRAIN AT FAILURE  
10

# RECORD OF BOREHOLE No 206

1 OF 1

METRIC

W.P. 121 - 90 - 01 LOCATION CO - ORDS. N 4 764 998.0; E 327 139.5 ORIGINATED BY S.W.  
 DIST 4 HWY 406 BOREHOLE TYPE WASH BORE NX CASING & CONE TEST COMPILED BY U.V.  
 DATUM GEOIDETIC DATE 88 11 23 CHECKED BY F.P.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PASTIC UNIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	SOLID UNIT W <sub>s</sub>	UNIT WEIGHT 7 kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20					
173.3	Water Level												
0.0													
163.3	Concl Bed												
10.0	Organic Silt		1	SS									
	CLAYEY SILT to SILTY CLAY, Some Sand and Gravel, Hard		2	SS	56								
			3	SS	48								
	Firm to Very Stiff		4	SS	6								
			5	SS	23								
154.8			6	SS	44								14 20 45 21
18.7	End of Borehole												

+3, x3, Numbers refer to  
Sensitivity

20  
15-20 (X) STRAIN AT FAILURE  
10

# RECORD OF BOREHOLE No 207

1 OF 1

METRIC

W.P. 171 - 90 - 01 LOCATION CO - ORDS. N 4 784 989.5; E 327 147.5 ORIGINATED BY S.M.  
 DIST 4 HWY 406 BOREHOLE TYPE WASH BORE NX CASING & CONE TEST COMPILED BY M.L.  
 DATUM GEODETTIC DATE 88.11.24 CHECKED BY J.D.

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL MOISTURE CONTENT		UNIT WEIGHT $\gamma$ KN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20 40 60 80 100	20 40 60 80 100	W <sub>p</sub> W W <sub>L</sub>		
173.3	Water Level											
0.0												
182.8	Canal Bed											
10.4	Organic Silt		1	SS	38							0 12 85 23
	CLAYEY SILT to SILTY CLAY, Some Sand and Gravel, Hard		2	SS	47							
			3	SS	47							
	Firm		4	SS	7							0 20 80 20 0 38 52 10
135.8			5	SS								
17.5	End of Borehole											

+3, x<sup>5</sup> Numbers refer to  
Sensitivity

20  
13-5 (X) STRAIN AT FAILURE  
10

CONT No  
WP No 171-90-01

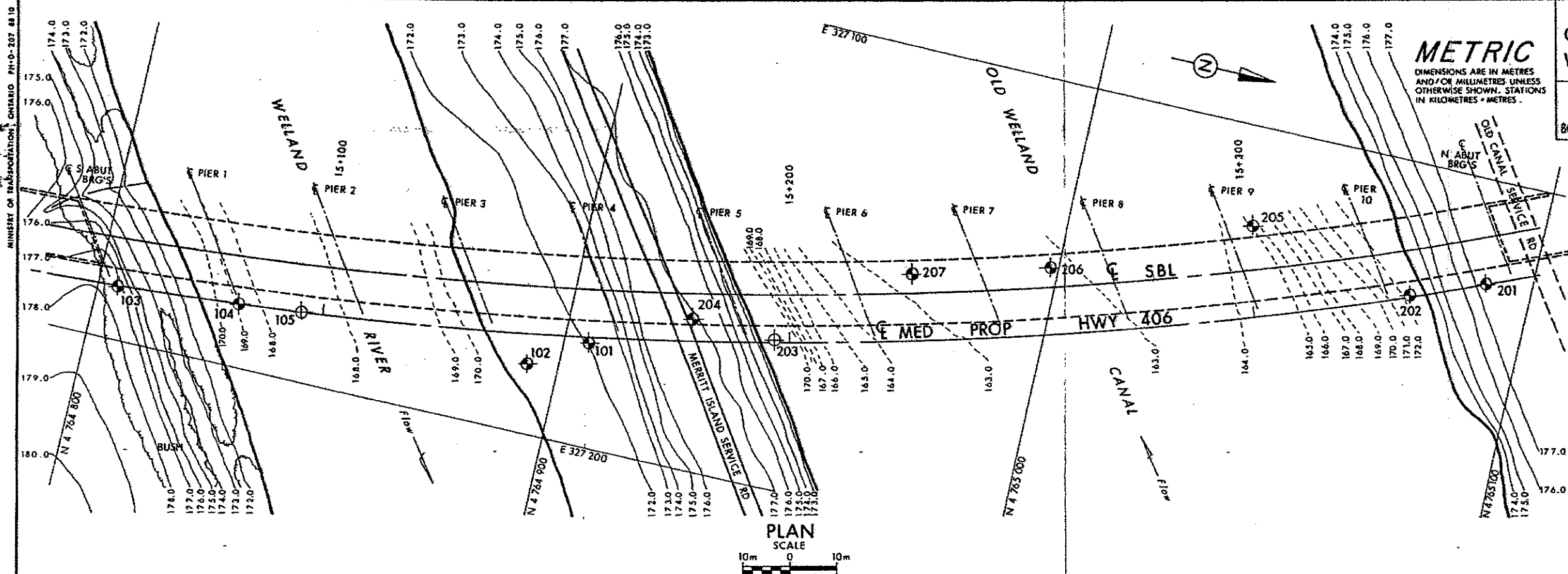
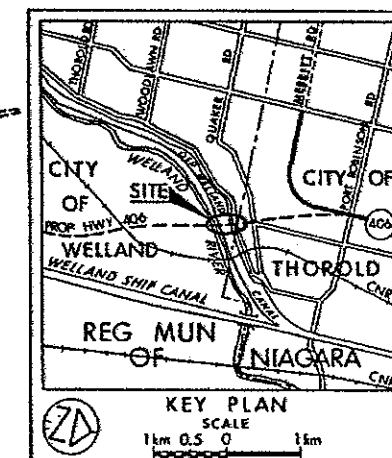
WELLAND RIVER &  
OLD WELLAND CANAL  
BORE HOLE LOCATIONS & SOIL STRATA



SHEET

**METRIC**

DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES UNLESS  
OTHERWISE SHOWN. STATIONS  
IN KILOMETRES - METRES.



**LEGEND**

- Bore Hole
- ⊕ Dynamic Cone Penetration Test (Cone)
- ⊕ Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- W.L. at time of investigation
- Head
- ARTESIAN CONDITION
- Encountered

No	ELEVATION	CO-ORDINATES	
		NORTH	EAST
101	171.9	4 764 905.4	327 177.5
102	171.7	4 764 893.6	327 185.0
103	177.4	4 764 804.1	327 188.6
104	170.9	4 764 830.6	327 186.4
105	170.9	4 764 844.0	327 185.0
201	177.1	4 765 090.2	327 121.8
202	173.4	4 765 073.8	327 128.3
203	173.4	4 764 944.0	327 168.0
204	176.9	4 764 925.5	327 167.5
205	173.3	4 765 038.5	327 121.0
206	173.3	4 764 998.0	327 139.5
207	173.3	4 764 969.5	327 147.5

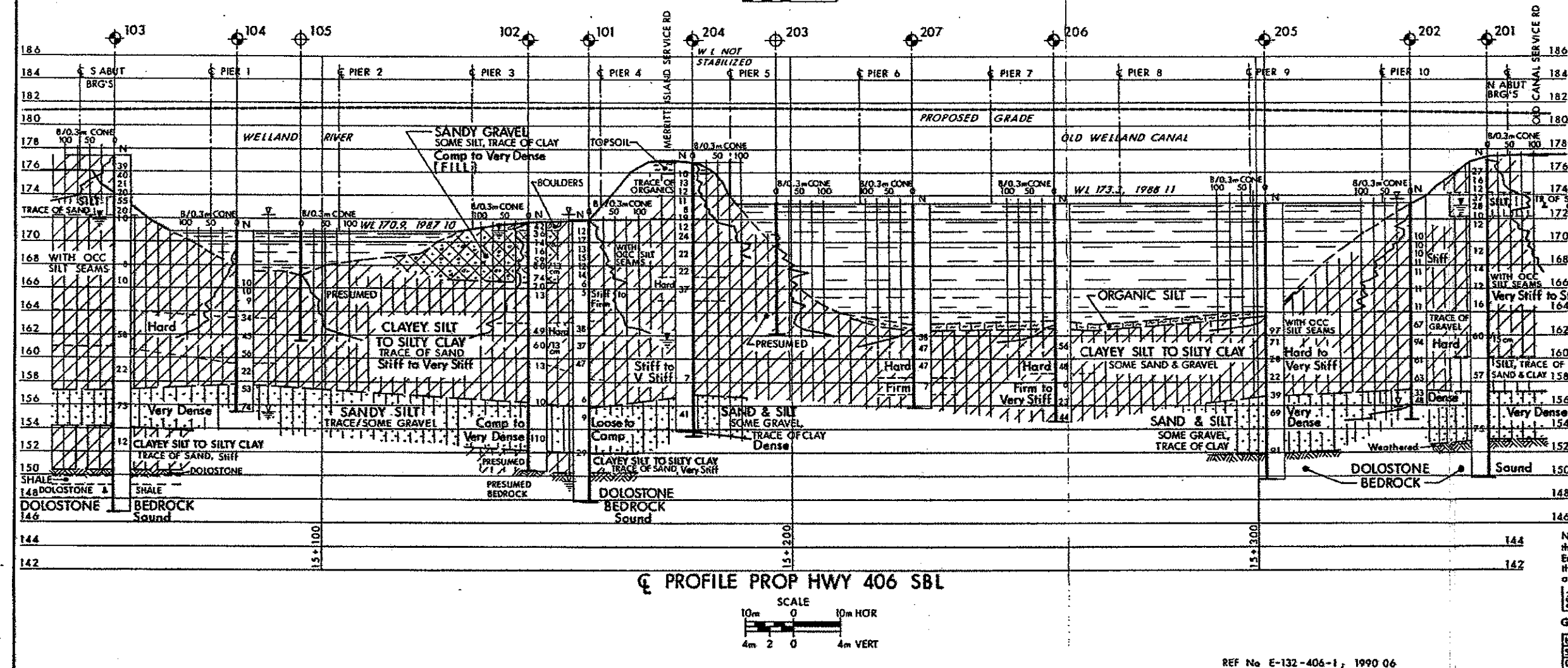
**NOTE**  
The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.

NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section 102-2 of Form 100.

DATE	BY	DESCRIPTION

Geocres No 30M3-192

HWY No 406 SBL	DIST 4
SUBAPD MV CHECKED 1991 05 06	SITE 34-304
DRAWN RS CHECKED 1991 05 06	DWG 2

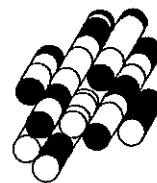


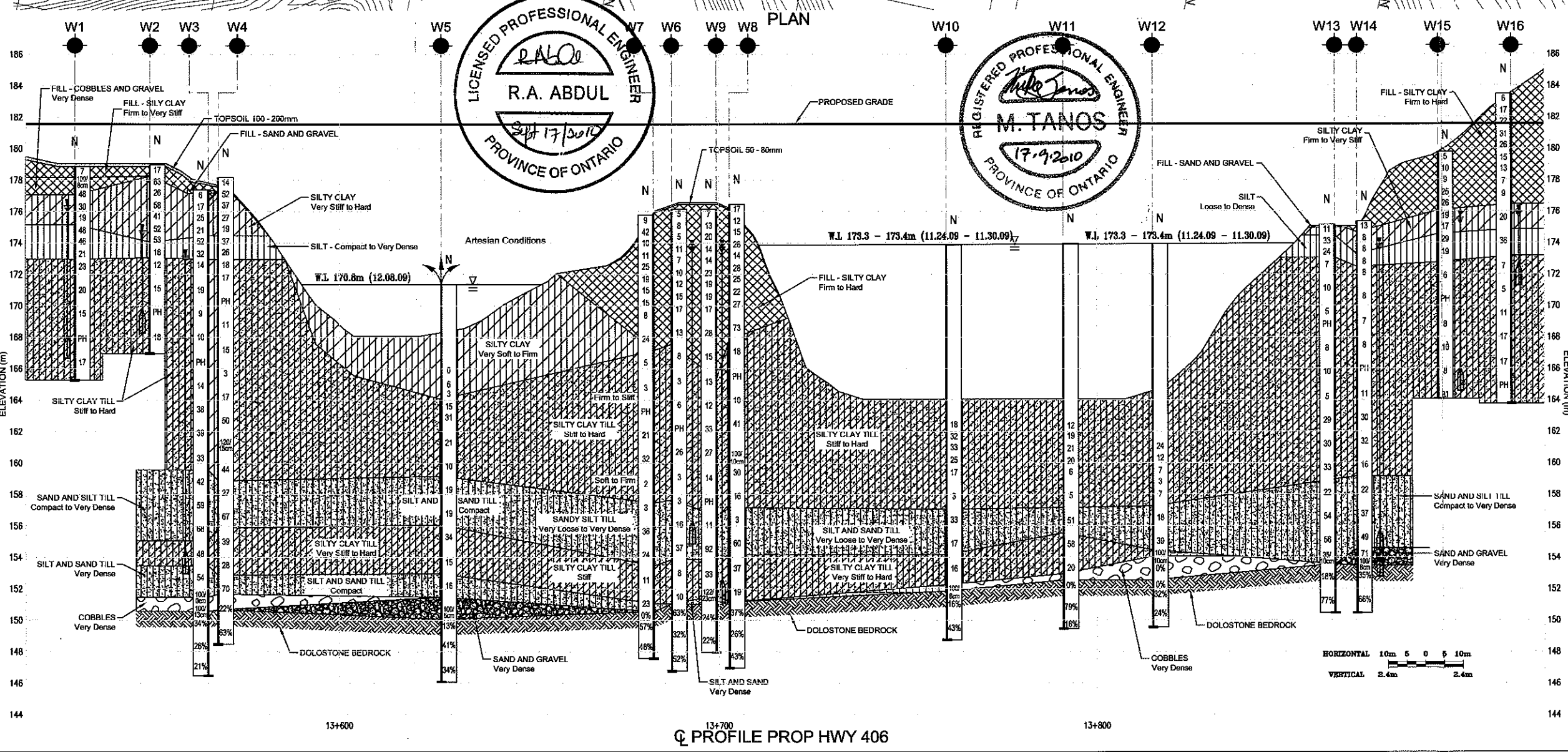
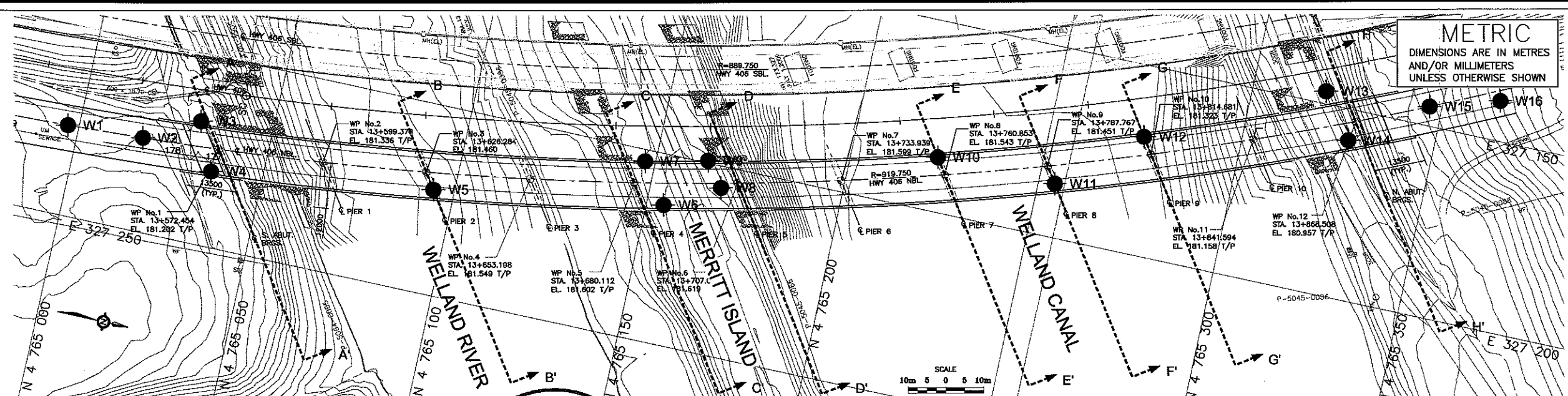


# **APPENDIX D**

## **Drawing**

**Terraprobe Inc.**





CONT No  
WP No 280-99-00

HIGHWAY 406  
OLD WELLAND CANAL /  
WELLAND RIVER BRIDGE  
BOREHOLE LOCATIONS AND SOIL STRATA

Giffels Associates Limited  
Consulting Engineers and Architects  
An IBI Group Company

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

KEY PLAN

●

Bore Hole

⊕

Dynamic Cone Penetration Test

⊙

Bore Hole And Cone

'N'

Blows/0.3m (Std Pen Test, 475 J/blow)

⊕

Blows/0.3m (60' Cone, 475 J/blow)

WL

WL at Time of Investigation

↑

WL in Piezometer (JAN. 2010)

90%

Rock Quality Designation

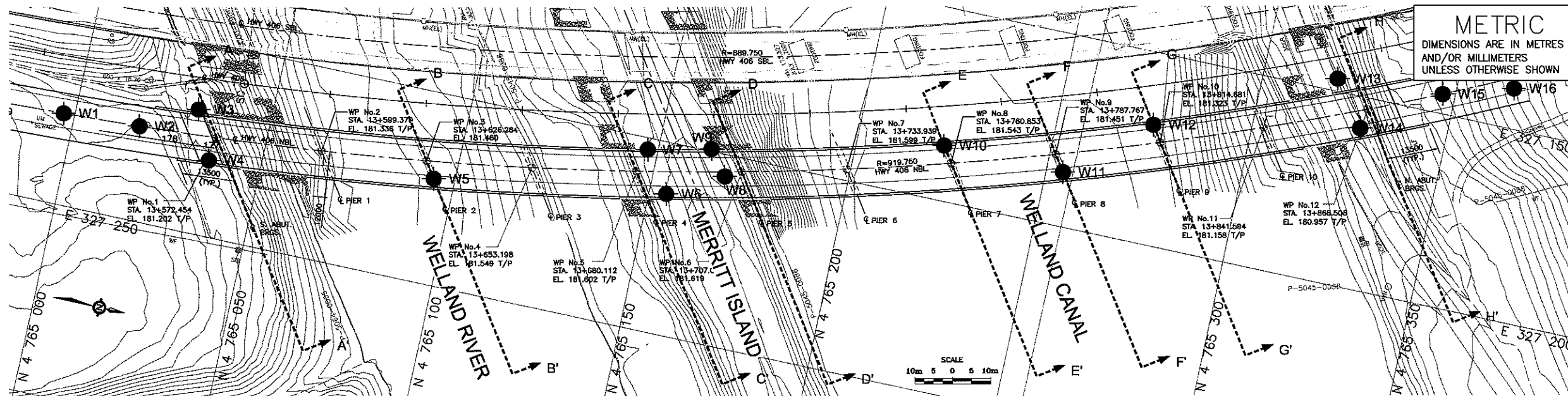
A/R

Auger Refusal

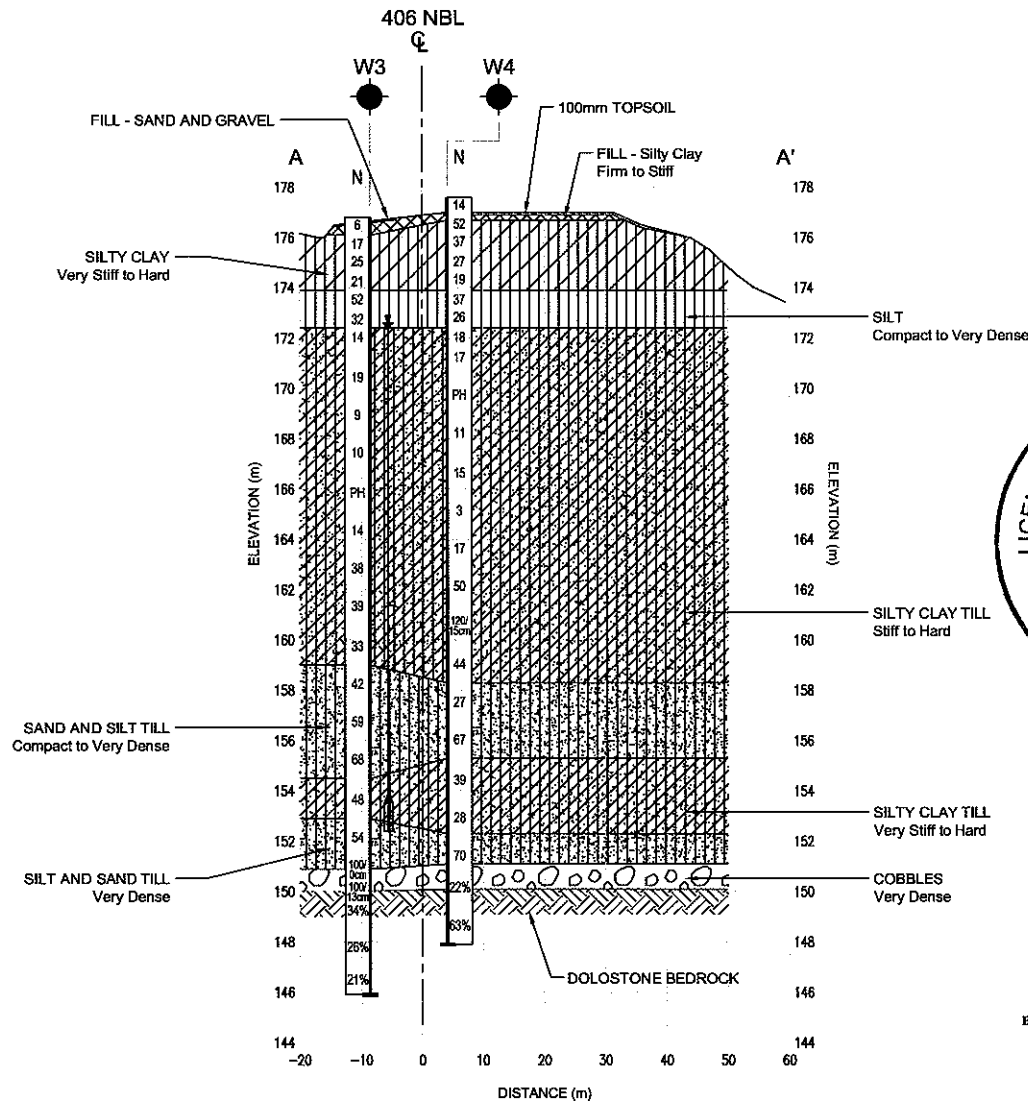
No	ELEV.	COORDINATES	
		NORTHING	EASTING
W1	178.3	4 764 997.1	327 226.3
W2	178.4	4 765 017.0	327 225.3
W3	176.8	4 765 031.1	327 217.8
W4	177.6	4 765 036.5	327 230.2
W5	170.8	4 765 094.5	327 222.4
W6	175.6	4 765 154.5	327 213.4
W7	175.2	4 765 147.3	327 203.1
W8	175.9	4 765 188.4	327 205.7
W9	175.6	4 765 163.6	327 199.4
W10	173.3	4 765 222.6	327 185.7
W11	173.4	4 765 254.3	327 185.9
W12	173.4	4 765 274.6	327 188.7
W13	174.6	4 765 319.2	327 146.7
W14	174.8	4 765 327.6	327 158.2
W15	179.2	4 765 346.7	327 144.9
W16	182.9	4 765 364.8	327 139.5

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.

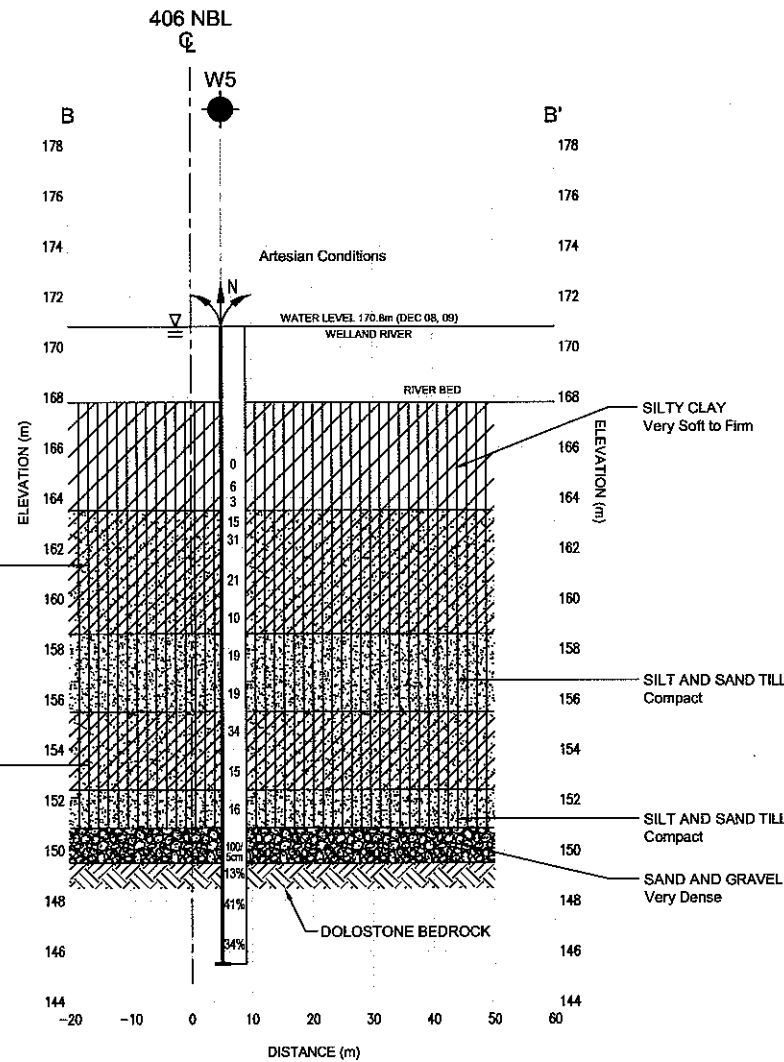
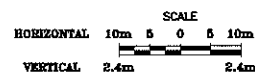
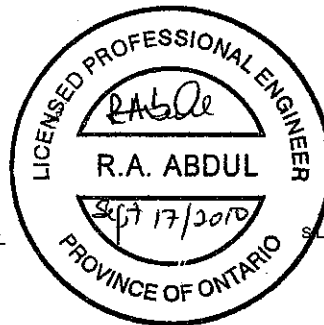
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DESIGN	R.A.	CODE	CHBDC2006
DRAWN	B.S.	CHK	R.A.
		STRUCT	34-304/1
			GEOCREG 30M3-192



PLAN

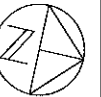


SECTION A-A'



SECTION B-B'

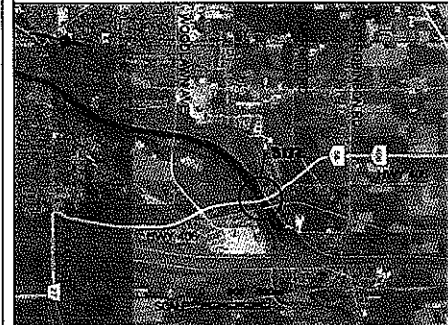
CONT No  
WP No 280-99-00



HIGHWAY 406  
OLD WELLAND CANAL /  
WELLAND RIVER BRIDGE  
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET  
2 OF 5

Giffels Associates Limited  
Consulting Engineers and Architects  
An IBI Group Company



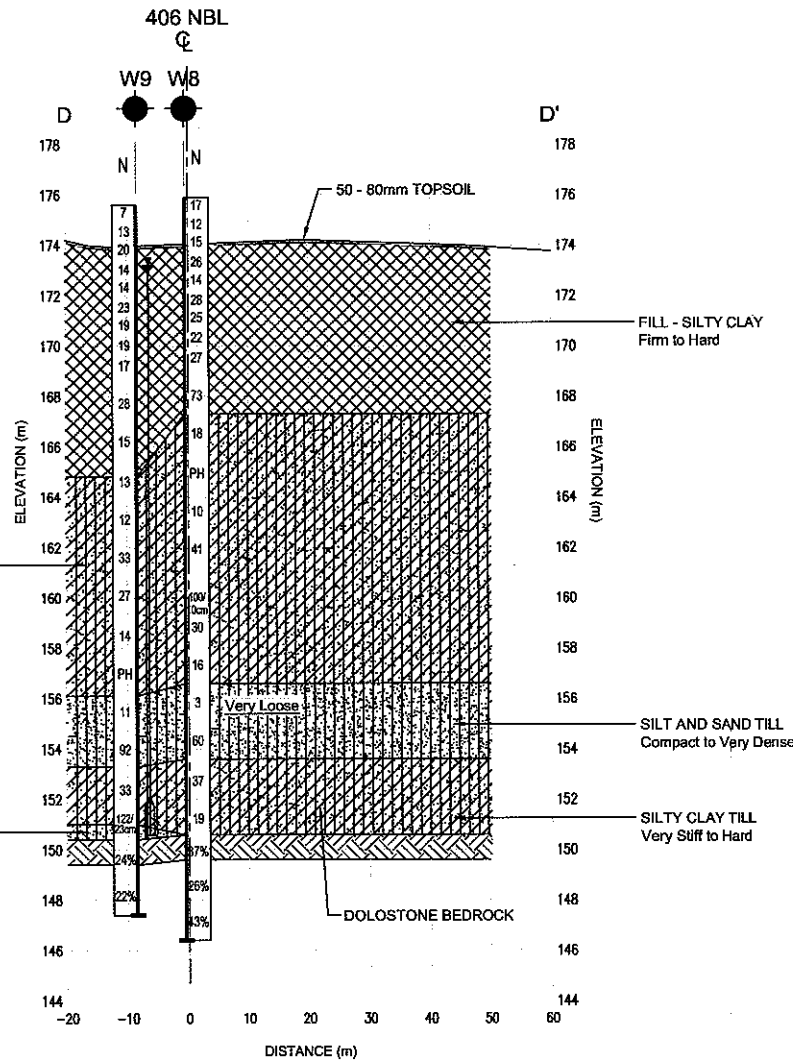
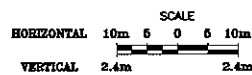
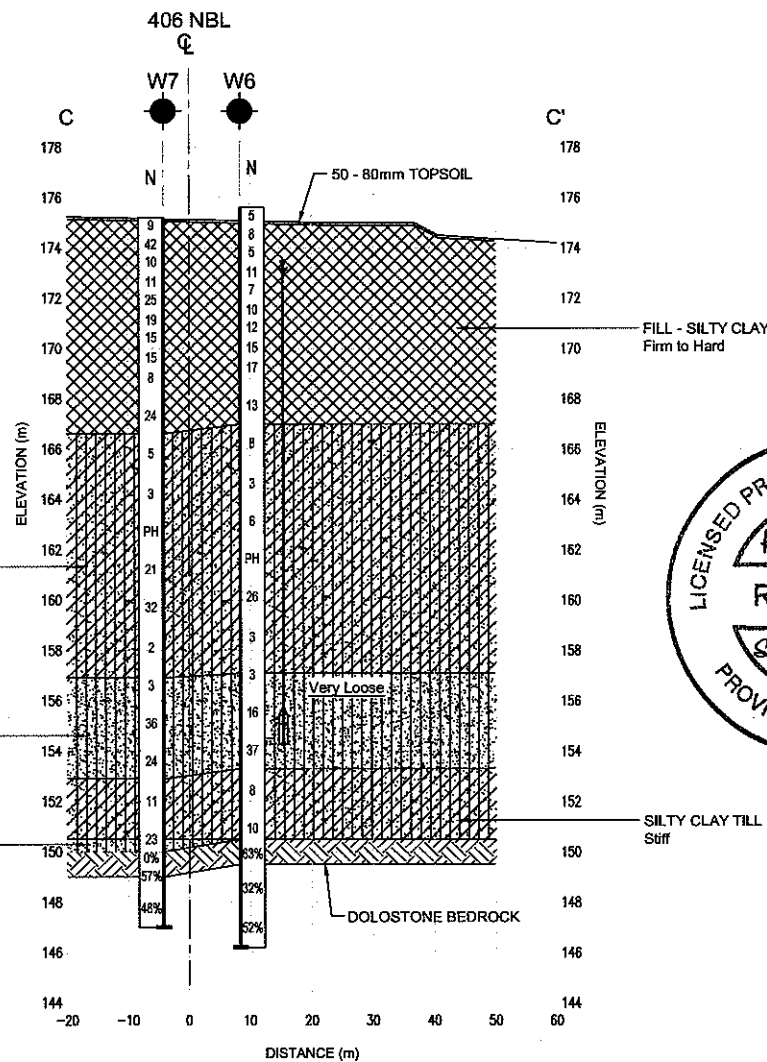
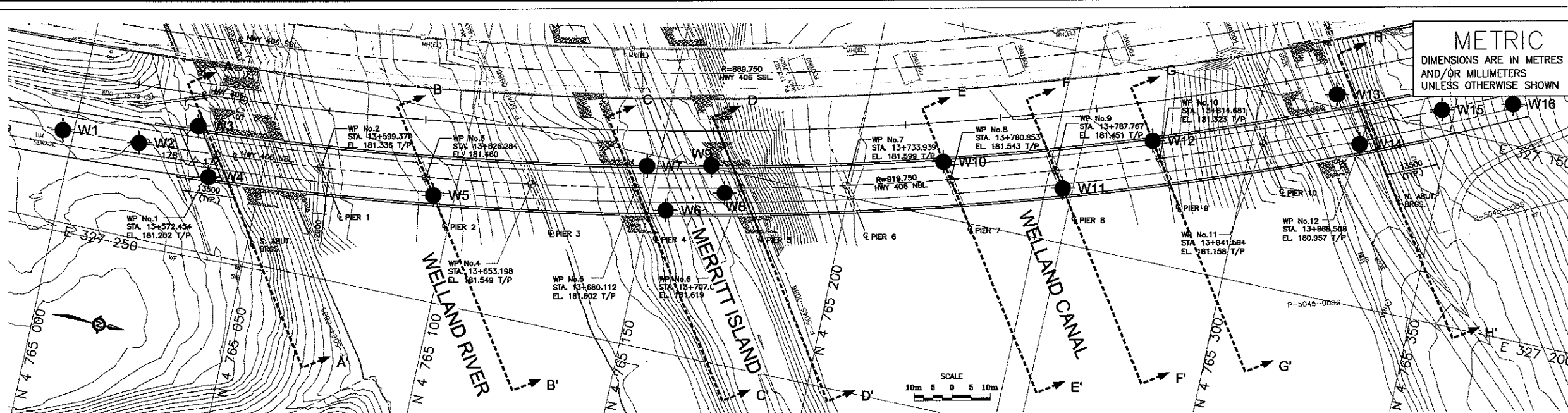
KEY PLAN

LEGEND	
	Bore Hole
	Dynamic Cone Penetration Test
	Bore Hole And Cone
	Blows/0.3m (Std Pen Test, 475 J/blow)
	Blows/0.3m (60' Cone, 475 J/blow)
	WL at Time of Investigation
	WL in Piezometer (JAN. 2010)
	Piezometer
	90% Rock Quality Designation
	A/R Auger Refusal

No	ELEV.	COORDINATES	
		NORTHING	EASTING
W1	178.3	4 764 997.1	327 226.3
W2	178.4	4 765 017.0	327 225.3
W3	176.8	4 765 031.1	327 217.8
W4	177.6	4 765 036.5	327 230.2
W5	170.8	4 765 094.5	327 222.4
W6	175.8	4 765 154.5	327 213.4
W7	175.2	4 765 147.3	327 203.1
W8	175.9	4 765 168.4	327 205.7
W9	175.6	4 765 163.6	327 199.4
W10	173.3	4 765 222.6	327 185.7
W11	173.4	4 765 254.3	327 185.9
W12	173.4	4 765 274.6	327 168.7
W13	174.6	4 765 319.2	327 146.7
W14	174.8	4 765 327.6	327 158.2
W15	179.2	4 765 346.7	327 144.9
W16	182.9	4 765 364.8	327 139.5

**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.

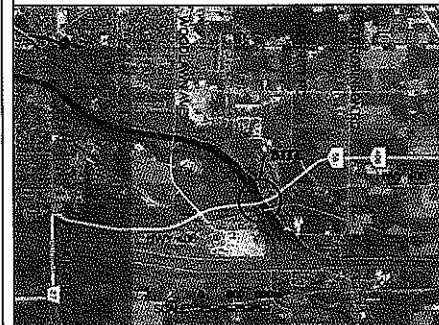
REVISIONS			
DATE	BY	DESCRIPTION	
DESIGN R.A.	CODE CHBDC2006	LOAD	DATE SEPT. 2010
DRAWN B.S.	CHK R.A.	STRUCT 34-304/1	GEOSCI 30M3-192



CONT No  
WP No 280-99-00

HIGHWAY 406  
OLD WELLAND CANAL /  
WELLAND RIVER BRIDGE  
BOREHOLE LOCATIONS AND SOIL STRATA

Giffels Associates Limited  
Consulting Engineers and Architects  
An IBI Group Company



KEY PLAN

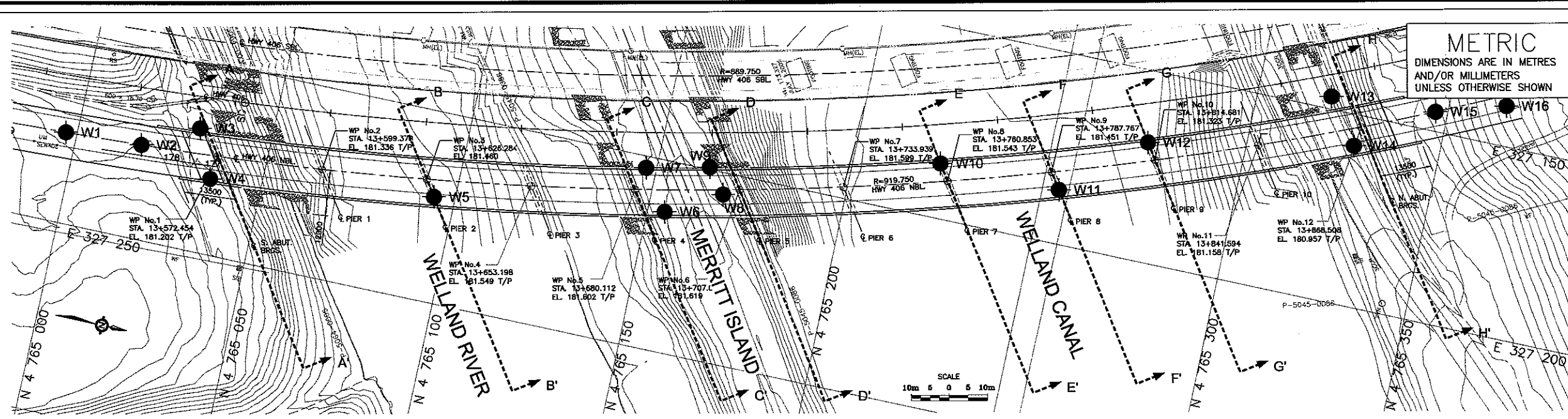
LEGEND	
	Bore Hole
	Dynamic Cone Penetration Test
	Bore Hole And Cone
	Blows/0.3m (Std Pen Test, 475 J/blow)
	Blows/0.3m (60' Cone, 475 J/blow)
	WL at Time of Investigation
	WL in Piezometer (JAN. 2010)
	Piezometer
	90% Rock Quality Designation
	A/R Auger Refusal

No	ELEV.	COORDINATES	
		NORTHING	EASTING
W1	178.3	4 764 997.1	327 226.3
W2	178.4	4 765 017.0	327 225.3
W3	178.8	4 765 031.1	327 217.8
W4	177.6	4 765 036.5	327 230.2
W5	170.8	4 765 094.5	327 222.4
W6	175.6	4 765 154.5	327 213.4
W7	175.2	4 765 147.3	327 203.1
W8	175.9	4 765 168.4	327 205.7
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REVISIONS			
DATE	BY	DESCRIPTION	
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DRAWN B.S.	CHK R.A.	STRUCT 34-304/1	GEOTECH 30M3-192





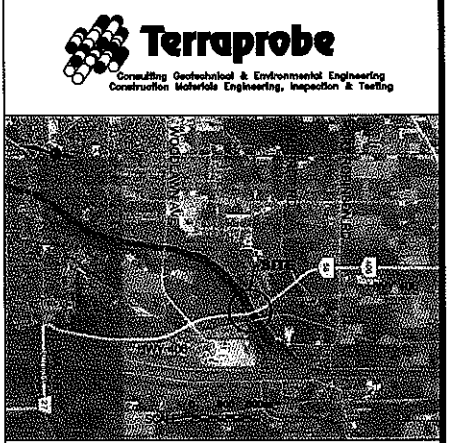
PLAN

CONT No  
WP No 280-99-00

HIGHWAY 406  
OLD WELLAND CANAL /  
WELLAND RIVER BRIDGE  
BOREHOLE LOCATIONS AND SOIL STRATA

Giffels Associates Limited  
Consulting Engineers and Architects  
An IBI Group Company

SHEET  
4 OF 5



KEY PLAN

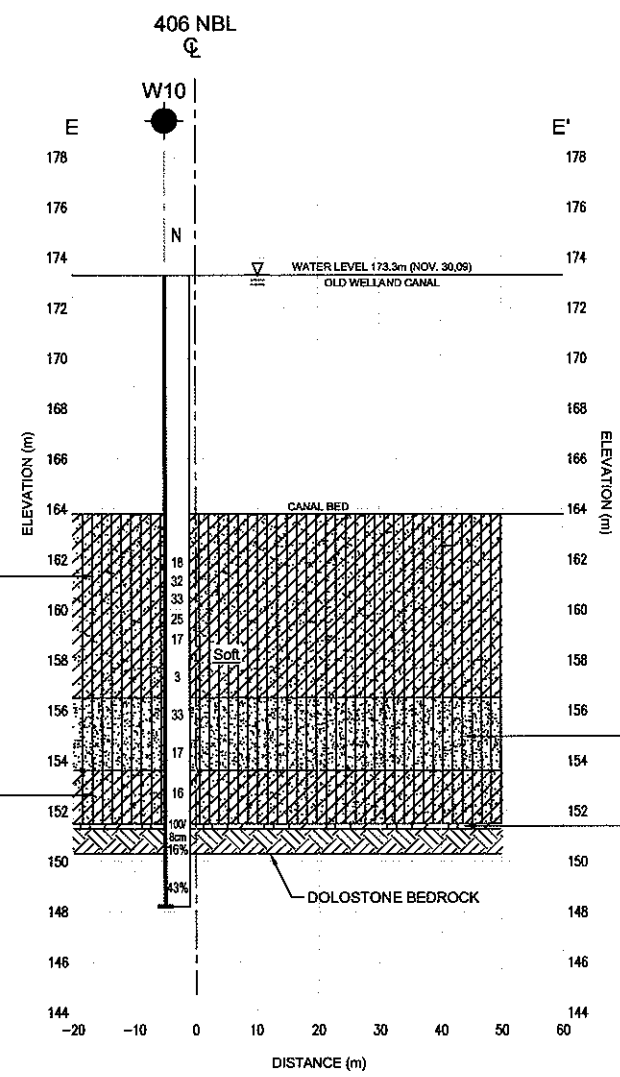
LEGEND

- Bore Hole
- Dynamic Cone Penetration Test
- Bore Hole And Cone
- Blows/0.3m (Std Pen Test, 475 J/blow)
- Blows/0.3m (60' Cone, 475 J/blow)
- WL at Time of Investigation
- WL in Piezometer (JAN. 2010)
- Piezometer
- 90% Rock Quality Designation
- A/R Auger Refusal

No	ELEV.	COORDINATES	
		NORTHING	EASTING
W1	178.3	4 764 997.1	327 226.3
W2	178.4	4 765 017.0	327 225.3
W3	176.8	4 765 031.1	327 217.8
W4	177.6	4 765 036.5	327 230.2
W5	170.8	4 765 094.5	327 222.4
W6	175.6	4 765 154.5	327 213.4
W7	175.2	4 765 147.3	327 203.1
W8	175.9	4 765 168.4	327 205.7
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NOTE  
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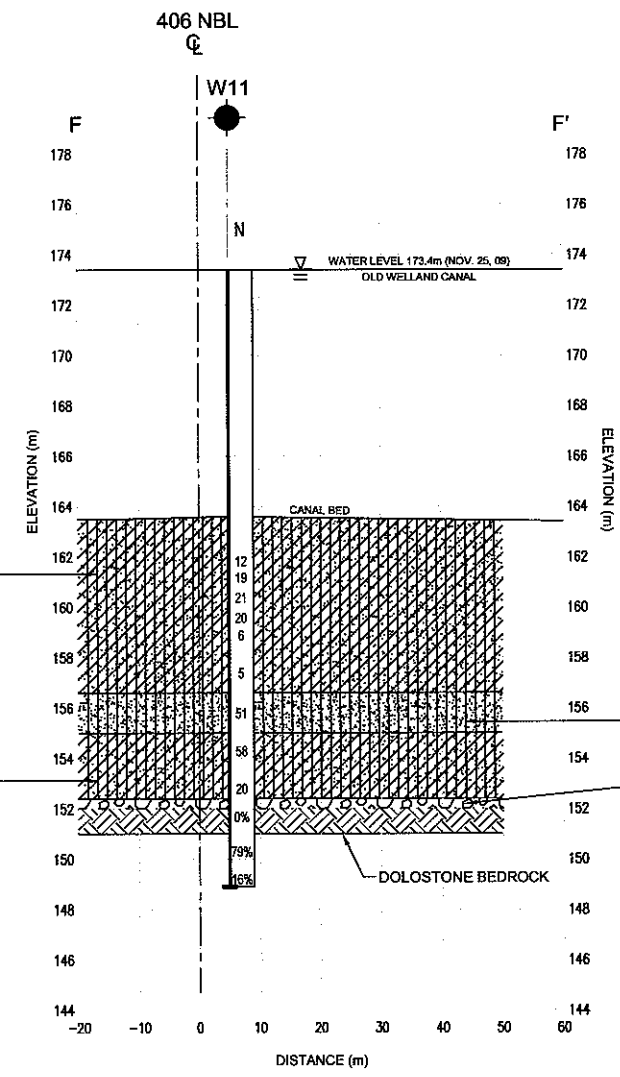
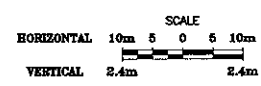
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DESIGN	R.A.	CODE	CHBDC2006
DRAWN	B.S.	CHK	R.A.
		STRUCT	34-304/1
			GEOCRES 30M3-192



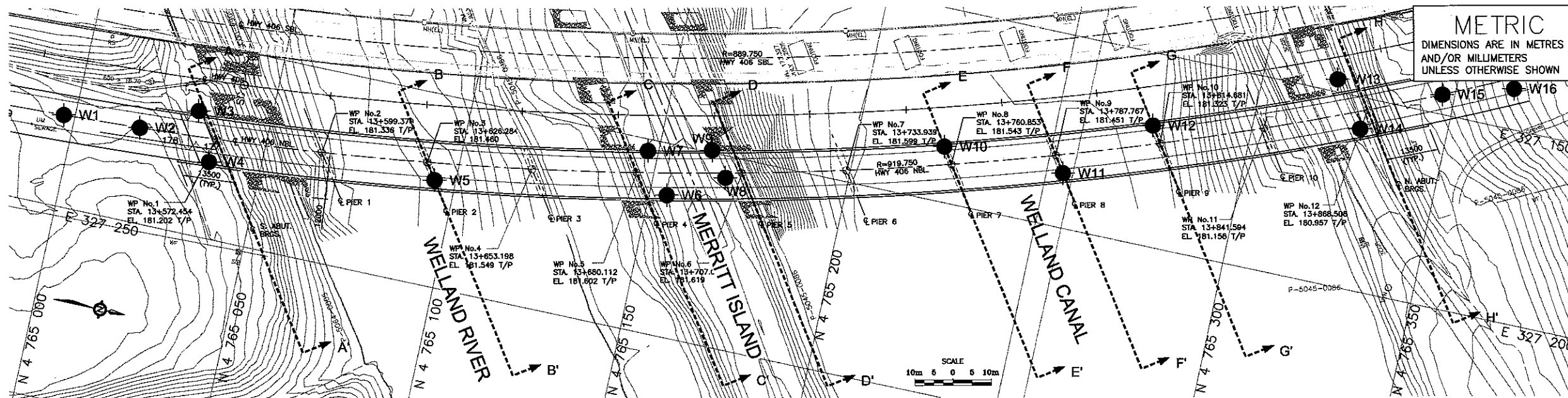
SECTION E-E'

REGISTERED PROFESSIONAL ENGINEER  
M. TANOS  
17.9.2010  
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER  
R.A. ABDUL  
3/17/2010  
PROVINCE OF ONTARIO



SECTION F-F'



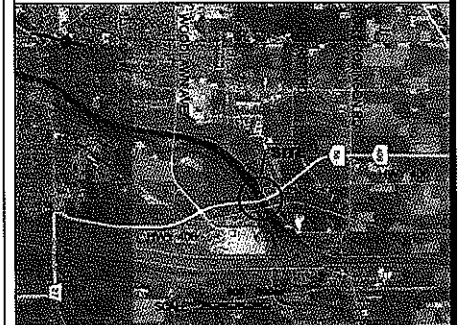
PLAN

CONT No  
WP No 280-99-00

HIGHWAY 406  
OLD WELLAND CANAL /  
WELLAND RIVER BRIDGE  
BOREHOLE LOCATIONS AND SOIL STRATA

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 (JAN. 2010)
- 90% Rock Quality Designation
- A/R Auger Refusal

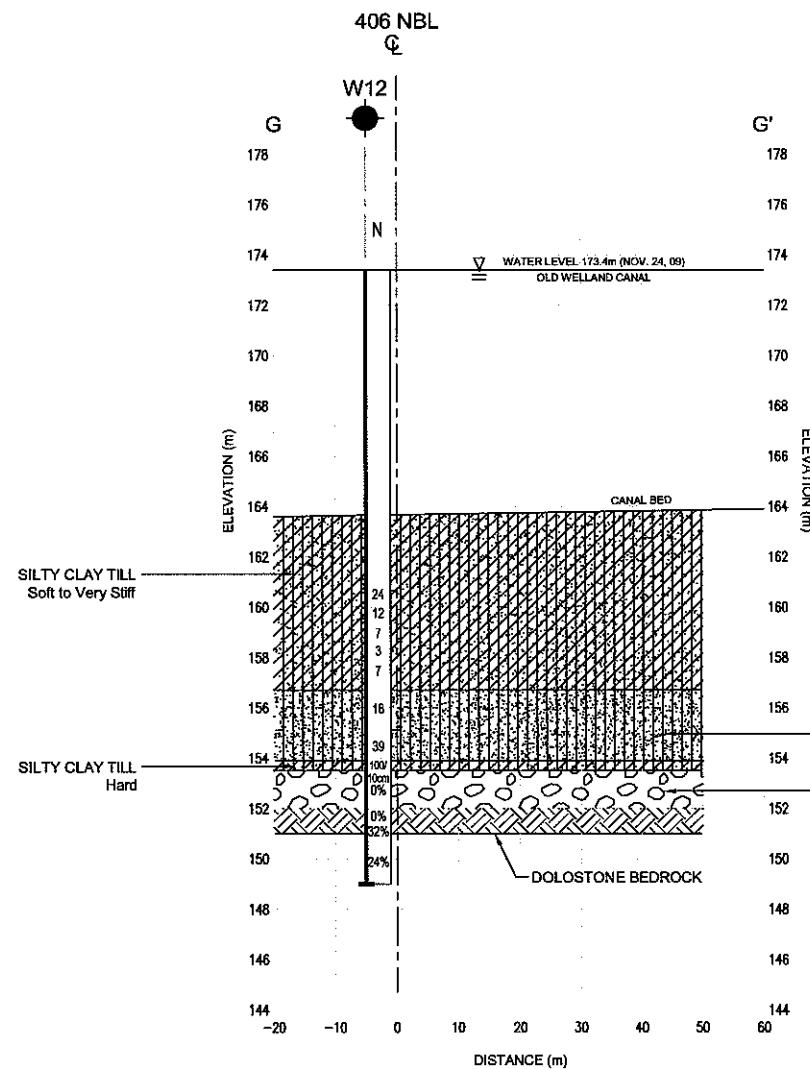
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		NORTHING	EASTING
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W2	178.4	4 765 017.0	327 225.3
W3	176.8	4 765 031.1	327 217.8
W4	177.6	4 765 036.5	327 230.2
W5	170.8	4 765 094.5	327 222.4
W6	175.6	4 765 154.5	327 213.4
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W15	179.2	4 765 346.7	327 144.9
W16	182.9	4 765 364.8	327 139.5

NOTE

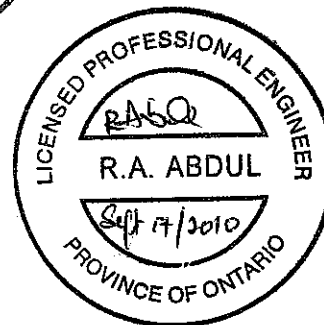
The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.

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REVISIONS	DATE	BY	DESCRIPTION
DESIGN	R.A.	CODE	CHBDC2006
DRAWN	B.S.	CHK	R.A.
		STRUCT	34-304/1
			GEOCRETS 30M3-192



SECTION G-G'

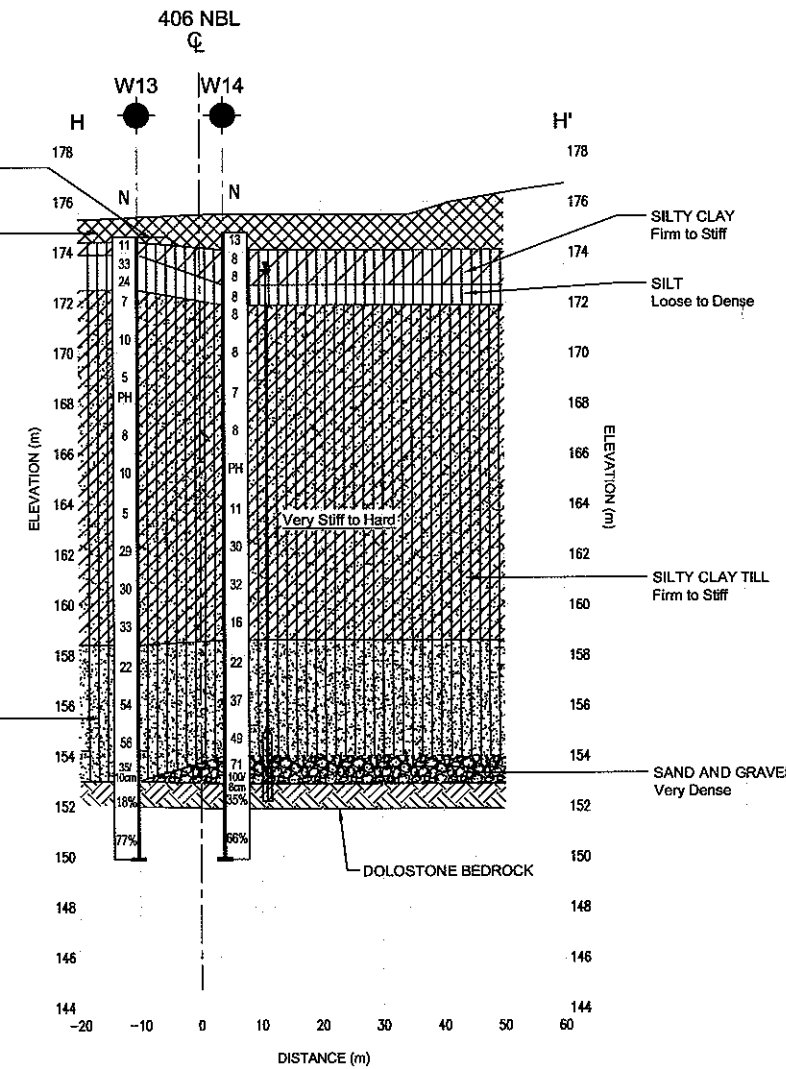


FILL - SAND AND GRAVEL

FILL - SILTY CLAY

SAND AND SILT TILL  
Compact to Very Dense

SCALE  
HORIZONTAL 10m 5 0 5 10m  
VERTICAL 2.4m 2.4m



SECTION H-H'