Terraprobe

Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

FOUNDATION INVESTIGATION REPORT

RAMP 406S - WOODLAWN E/W BRIDGE AT TRILLIUM RAILWAY

HIGHWAY 406 TWINNING

PORT ROBINSION ROAD TO EAST MAIN STREET

AGREEMENT No. 2008-E-0016, W.P. 280-99-00, SITE: 34-464/4

GEOCRES NO. 30M3-257

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

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

File No. 1-09-4135
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Terraprobe Inc.
10 Bram Court
Brampton, Ontario
L6W 3R6
Phone: (905) 796 2650
Fax: (905) 796 2250

Distribution:

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TABLE OF CONTENTS

Part 1

Appendices

FOUNDATION INVESTIGATION REPORT

406S - WOODLAWN E/W RAMP OVER TRILLIUM RAILWAY

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ONTARIO

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PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual findings obtained from a foundation investigation conducted at the bridge site on the proposed 406S - Woodlawn Road E/W Ramp at Trillium Railway in the City of Welland, Ontario.

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

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

2 SITE DESCRIPTION & PHYSIOGRAPHY

The site is located where the Trillium Railway crosses the existing Highway 406 at a signalized at grade intersection about 250 m south of Woodlawn Road in the City of Welland, Regional Municipality of Niagara, Ontario.

At this site Highway 406 is a two-lane highway with gravel shoulders carrying both north and south bound traffic. The Trillium Railway consists of a single track that crosses Highway 406 at an approximately east to west orientation then heads north where it intersects Daimler Parkway.

The topography is generally flat and vegetation at this site consists primarily of deciduous trees and wild bush. There is a small east to west flowing watercourse located approximately 40 m south of the Trillium Railway track. This watercourse flows under Highway 406 via a 3.0 m x 1.5 m concrete box culvert which will be replaced.

The site is located between the Niagara Escarpment and Lake Erie in the physiographic region of Southern Ontario referred to as the Haldimand Clay Plain. The Haldimand Clay Plain is best described as falling into a series of parallel belts with the highest ground adjacent to the Escarpment. Generally this region is flat and poorly drained although it includes several distinctive

landforms such as dunes, cobble, clay and sand beaches, limestone pavements and back-shore wetland basins[1].

The Niagara Region is underlain by a sequence of very gently south-dipping dolostones, limestones, shales and sandstones overlying Precambrian basement rock. The key elements in the bedrock geology of the region are the multiple layers of softer sedimentary limestones, shale, sandstone and dolostone.

The bedrock unit at this site is the Salina Formation of Upper Silurian Age[2]. This unit consists essentially of easily weathered, grey, very finely crystalline, laminated argillaceous dolostone with grey, calcareous shale partings and gypsum veins and lenses of varying thicknesses.

3 SITE INVESTIGATION AND FIELD TESTING

The site investigation and field testing for this project were carried out between November 04, 2009 and January 18, 2010 and consisted of drilling and sampling six boreholes to depths ranging from 13.6 m to 33.0 m. The boreholes were numbered S-EW 10+050CL, S-EW 10+110CL, TSEW1, TSEW2, TSEW3, and TSEW4 and their approximate locations are shown on the attached Borehole Locations and Soil Strata Drawing in Appendix C.

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

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

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

[1] Chapman and Putnam, "The Physiography of South Ontario", 3rd Edition, 1984.
[2] Ontario Division of Mines, "Quaternary Geology Of The Welland Area", Preliminary Map P.796, 1972.

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

Table 3.1 – Piezometer Installation Details

Piezometer Location	Piezometer Details	
	Tip Depth/ Elevation (m)	Completion Details
TSEW2	24.2/159.1	Hole sealed with bentonite from 25.0 m to 24.4 m, piezometer with 1.5 m slotted screen installed with filter sand to 21.6 m and bentonite seal from 21.6 m to ground surface.
TSEW4	22.9/160.6	Hole sealed to 23.2 m with bentonite, piezometer with 1.5 m slotted screen installed with filter sand to 20.4 m and bentonite seal from 20.4 m to ground surface.
S-EW 10+050CL	12.2/171.2	Piezometer with 3.0 m slotted screen installed with filter sand to 8.5 m, bentonite seal from 8.5 m to 8.2 m, drill cuttings from 8.2 m to 0.5 m and bentonite seal from 0.5 m to ground surface.
S-EW 10+110CL	12.2/170.2	Piezometer with 3.0 m slotted screen installed with filter sand to 8.5 m, bentonite seal from 8.5 m to 7.9 m, drill cuttings from 7.9 m to 0.3 m and bentonite seal from 0.3 m to ground surface.

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

4 LABORATORY TESTING

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

5 DESCRIPTION OF SUBSURFACE CONDITIONS

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

In general, the site is underlain by topsoil, fill material (sand and gravel, sand, silty clay) and native overburden deposits of silty clay, clayey silt to silty clay till, silty sand till and sand and gravel till. These soils are underlain by bedrock consisting primarily of dolostone and shale of the Salina formation.

5.1 Topsoil

Topsoil ranging in thickness from 30 mm to 250 mm was encountered at this site. Topsoil thickness may vary between and beyond the boreholes.

5.2 Fill – Sand and Gravel

Granular fill material consisting of sand and gravel and sand was encountered at this site. The fill material is approximately 700 mm thick and extends to elevations ranging from 182.8 m to 182.6 m.

Two samples of the fill material were subjected to grain size distribution tests and the results are illustrated in Figure B1. These results show a grain size distribution consisting of 10-30% gravel, 30-76% sand, 14-25% silt and 15% clay size particles.

Standard Penetration tests in this granular fill gave 'N' values that ranged from 6 to 32 blows per 0.3 m penetration. Based on these results the fill is considered to have a loose to dense relative density. The moisture content of samples of this fill ranges from 1% to 29% by weight.

5.3 Fill – Silty Clay

Silty clay fill material was encountered at this site extending to depths ranging from 0.7 m (Elev.182.7) to 2.1 m (Elev.181.4) below ground surface.

A sample of this silty clay fill was subjected to a grain size analysis and the results are presented in Figure B2. These results show a grain size distribution consisting of 3% gravel, 11% sand, 48% silt and 38% clay size particles.

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

Liquid Limit:	39%
Plastic Limit:	20%
Plasticity Index:	19%
Natural Moisture Content:	18%

These values are characteristic of clayey soils of intermediate plasticity.

Standard Penetration tests in the silty clay fill gave 'N' values that ranged from 4 to 29 blows for 0.3 m penetration. Based on these results the fill is considered to have a firm to very stiff consistency. The moisture content of samples of this fill ranged from 11% to 26% by weight.

5.4 Silty Clay

A major silty clay deposit was encountered across the site. This deposit was fully penetrated in some of the boreholes where it was found to extend to depths of 14.7 m below ground surface or to elevations ranging from 168.6 m to 168.8 m. The approach boreholes were terminated in this deposit at depths of 13.6 m (Elev. 169.8 m) and 14.0 m (Elev. 168.4 m).

The grain size distribution plots of tested samples of the silty clay are presented in Figures B4 to B8 inclusive. These results show a grain size distribution consisting of 0-4% gravel, 1-13% sand, 37-75% silt and 21-61% clay size particles.

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

Liquid Limit:	25-58%
Plastic Limit:	15-25%
Plasticity Index:	7-33%
Natural Moisture Content:	16-22%

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

Standard Penetration tests in this stratum gave 'N' values that ranged from 3 to 42 blows for 0.3 m penetration. Field vane tests gave in-situ undrained shear strengths ranging from 64 kPa to in excess of 100 kPa and laboratory vane tests on relatively undisturbed Shelby tube samples gave undrained shear strengths ranging from 56 kPa to 113 kPa. These values indicate that the consistency of the silty clay is generally stiff to hard with infrequent firm zones. The moisture content of samples of the silty clay range from 6% to 24% by weight and the unit weight of selected samples ranges from 20.4 to 20.8 kN/m^3

The variation of undrained shear strength with elevation is depicted in Figure B18. The plot illustrates a wide scatter in the data with no obvious trend with depth. An interpreted dashed line is shown representing a lower bound trend with depth, for the data. The upper portion of this deposit up to about Elev. 176.0 m is estimated to have a relatively high undrained shear strength i.e. in excess of 100 kPa. Below Elev. 176.0 m the undrained shear strength decreases with depth and is about 55 kPa at Elev. 170.5 m. Below Elev. 170.5 m the trend indicates increasing undrained shear strength.

The Atterberg Limits tests results are also plotted against elevation, Figure B19. These results illustrate that the natural moisture contents are generally at or below the plastic limit up to Elev. 177.0 m. Below Elev. 177.0 the moisture content is slightly above the plastic limit with a trend of increasing moisture content below Elev. 174.0 m.

Consolidation tests were also performed on Shelby tube samples retrieved from Boreholes TSEW3 and S-EW 10+050CL and the results are presented in Figures B20 to B25. These results indicate estimated preconsolidation pressures that range between 230 kPa and 400 kPa.

5.5 Clayey Silt to Silty Clay Till

Discontinuous layers of clayey silt to silty clay till were encountered across the site extending to depths ranging from 26.9 m (Elev. 156.6 m) to 28.0 m (Elev. 155.5 m) below ground surface.

The grain size distribution plots of tested samples from these till deposits are presented in Figure B14. These results show a grain size distribution consisting of 3-28% gravel, 2-28% sand,

32-63% silt and 18-33% clay size particles. Till soils will also contain random cobble and boulder inclusions.

Samples were also subjected to Atterberg Limits tests and the results are presented in Figure B15. The index values from these tests are summarized below:

Liquid Limit:	20-31%
Plastic Limit:	12-16%
Plasticity Index:	8-16%
Natural Moisture Content:	8-26%

These values are characteristic of clayey soils of low plasticity.

Standard Penetration tests in these deposits yielded 'N' values ranging from 15 to more than 100 blows per 0.3 m penetration. Field vane tests were also attempted in these deposits and the results (no-turn on vane) indicate undrained shear strengths more than 100 kPa. Based on these results the clayey silt to silty clay till is considered to have a very stiff to hard consistency. The moisture content of samples from these deposits varies from 1% to 26% by weight.

5.6 Silty Sand Till

A silty sand till deposit was encountered at this site extending to depths ranging from 24.0 m (Elev. 159.5 m) to 25.4 m (Elev. 157.9 m) below ground surface.

The results of grain size distribution tests conducted on samples obtained from this deposit are illustrated in Figure B16. These results show grain size distributions consisting of 15-35% gravel, 31-45% sand, 28-32% silt and 6-9% clay size particles. Till soils will also contain random cobble and boulder inclusions.

The blow counts from Standard Penetration tests conducted in this deposit ranged from 30 to more than 100 blows per 0.3 m penetration indicating a dense to very dense relative density. The moisture content of samples from this deposit ranged from 4% to 17% by weight.

5.7 Sand and Gravel Till

A deposit of sand and gravel till was encountered across the site overlying the bedrock surface. Occasional cobbles were also encountered in this deposit. This stratum extends to depths ranging from 29.5 m to 29.7 m below ground surface or to elevations of 153.6 m to 154.0 m.

Samples retrieved from this deposit were subjected to grain size distribution tests and the results are illustrated in Figure B17. These results show a grain size distribution consisting of 34-42 % gravel, 37-44 % sand, 14-22 % silt and 7 % clay size particles. Till soils will also contain random cobble and boulder inclusions.

Standard Penetration tests in this deposit gave 'N' values that ranged from 18 to more than 100 blows per 0.3 m penetration. Based on these results the deposit is considered to have a compact to very dense relative density. The moisture content of samples from this stratum ranged from 2% to 16% by weight.

5.8 Bedrock (Salina Formation)

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

Table 5.1 – Depth to Bedrock

Location	BH Number	Depth to Bedrock (m)	Top of Bedrock Elevation (m)
South Abutment	TSEW1	29.7	153.8
	TSEW2	29.6	153.7
North Abutment	TSEW3	29.7	153.6
	TSEW4	29.5	154.0

The bedrock is described as unweathered and its colour is generally grey. It is thinly laminated with white unweathered gypsum and calcite veins. Total core recovery in the bedrock ranged from 59% to 100%. The RQD values ranged widely from 0% to 84% but generally most of the RQD values were below 50%. Rubble and highly fractured zones were observed in the rock cores which contributed to the relatively low RQD values. The core data reveals that there is generally no trend of improving rock quality with depth. Based on these results the rock quality is considered to be very poor to poor with occasional zones of fair to good quality rock.

5.9 Water Levels

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

Table 5.2 – Water Level Measurements

Borehole	Date	Water Levels	
		Depth (m)	Elevation (m)
TSEW2	January 11, 2010	8.5	174.8
	January 19, 2010	8.6	174.7
	January 27, 2010	8.8	174.5
	February 08, 2010	8.8	174.5
TSEW4*	-	-	-
S-EW 10+050CL	December 08, 2009	2.4	181.0
	December 15, 2009	2.4	181.0
	January 04, 2010	2.4	181.0
	January 11, 2010	2.4	181.0
S-EW 10+110CL	November 09, 2009	2.7	179.7
	November 20, 2009	1.1	181.3
	November 30, 2009	1.6	180.8
	December 08, 2009	1.3	181.1
	January 04, 2010	1.3	181.1

* Piezometer destroyed after installation.

The ground water table was estimated based on the recorded water levels in the standpipe piezometers and our review of moisture contents of the retrieved samples. This interpretation indicates an estimated ground water table of Elev. ±181.0 m.

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

5.10 Miscellaneous

The drilling, sampling and in-situ testing operations were conducted with track 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

The boreholes were advanced using hollow-stem augers and casing and washboring methods. Rock cores were retrieved by NQ size diamond coring techniques.

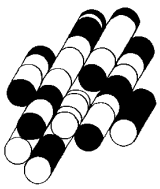
Messrs. Lucas Yu, E.I.T, Marc Paoliello, E.I.T, Alexander Winkelmann, E.I.T, and Phil Khuu, B.A.T, carried out the field work. The laboratory testing was performed at Terraprobe's Brampton laboratory and the Mississauga laboratory of Golder Associates. The report was written by Rehman Abdul, P.Eng. and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

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

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

APPENDICES

TERRAPROBE INC.



LIMITATIONS AND RISK

Procedures

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

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

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

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

Changes In Site And Scope

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

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

EXPLANATION OF TERMS USED IN REPORT

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

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
σ	kPa	TOTAL NORMAL STRESS
σ'	kPa	EFFECTIVE NORMAL STRESS
τ	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
ε	%	LINEAR STRAIN
$\varepsilon_1, \varepsilon_2, \varepsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
μ	1	COEFFICIENT OF FRICTION

MECHANICAL PROPERTIES OF SOIL

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

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m³	DENSITY OF SOLID PARTICLES
γ_s	kN/m³	UNIT WEIGHT OF SOLID PARTICLES
ρ_w	kg/m³	DENSITY OF WATER
γ_w	kN/m³	UNIT WEIGHT OF WATER
ρ	kg/m³	DENSITY OF SOIL
γ	kN/m³	UNIT WEIGHT OF SOIL
ρ_d	kg/m³	DENSITY OF DRY SOIL
γ_d	kN/m³	UNIT WEIGHT OF DRY SOIL
ρ_{sat}	kg/m³	DENSITY OF SATURATED SOIL
γ_{sat}	kN/m³	UNIT WEIGHT OF SATURATED SOIL
ρ'	kg/m³	DENSITY OF SUBMERGED SOIL
γ'	kN/m³	UNIT WEIGHT OF SUBMERGED SOIL

e	1,%	VOID RATIO
n	1,%	POROSITY
w	1,%	WATER CONTENT
S_r	%	DEGREE OF SATURATION
w_L	%	LIQUID LIMIT
w_p	%	PLASTIC LIMIT
w_s	%	SHRINKAGE LIMIT
I_p	%	PLASTICITY INDEX = $(w_L - w_p)$
I_L	1	LIQUIDITY INDEX = $(w - w_p)/I_p$
I_c	1	CONSISTENCY INDEX = $(w_L - w)/I_p$
e_{max}	1,%	VOID RATIO IN LOOSEST STATE
e_{min}	1,%	VOID RATIO IN DENSEST STATE
I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
D	mm	GRAIN DIAMETER
D_n	mm	n PERCENT - DIAMETER
C_u	1	UNIFORMITY COEFFICIENT
h	m	HYDRAULIC HEAD OR POTENTIAL
q	m^3/s	RATE OF DISCHARGE
v	m/s	DISCHARGE VELOCITY
i	1	HYDRAULIC GRADIENT
k	m/s	HYDRAULIC CONDUCTIVITY
j	kN/m³	SEEPAGE FORCE

EXPLANATORY SHEET FOR CORE LOG

Column Number

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

Joint (discontinuity) Characteristics

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

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

9. Roughness:

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

10. Filling:

	Approximate φ
T = Tight, hard, non-softened	
O = Oxidation surface staining only	25 - 35
SA = Slightly altered; clay-free	25 - 30
S = Sandy particles; clay-free	25 - 30
Si = Sandy and silty, minor clay	20 - 25
NC = Non-softening Clays; 5mm	16 - 24
SC = Swelling Clay fillings; 5mm	6 - 12

11. Aperture: estimated size of joint opening.
12. Degree of weathered rock material:

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

13. Strength of rock material:

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

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

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

15. Run number and Core Recovery
(i) Drill run number
(ii) Total Core Recovery is the total length of core pieces, irrespective of their individual lengths obtained in a core run, and expressed as a percentage of the length of that core run.
16. Rock Quantity Designation (RQD): The total length of those pieces of sound core which are 0.01 metres or greater in length in a core run, expressed as a percentage of the total length of that core run. Sound pieces of rock are those pieces separated by natural breaks and not machine breaks or subsequent artificial breaks.

Rock Mass Classification (after Deare)

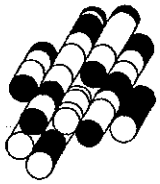
RQD (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
DESCRIPTION	VERY POOR	POOR	FAIR	GOOD	EXCELLENT

17. Core and Casing sizes: changes of core and casing sizes are indicated.
18. Water recovery, level and tests:
(i) percentage drill water recovery
(ii) water level depth
(iii) positions and results of tests, e.g., permeability and packer tests

APPENDIX A

Record of Borehole Sheets, Core Logs and Core Photos

Terraprobe Inc.



RECORD OF BOREHOLE No S-EW 10+050CL 1 OF 2 METRIC

W.P. 280-99-00 LOCATION Coords: N:4763920.4 E:327494.1 ORIGINATED BY AW

DIST HWY 406 BOREHOLE TYPE Hollow Stem Augers COMPILED BY DB

DATUM Geodetic DATE 11.24.09 - 11.25.09 CHECKED BY RA

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
183.4	Ground Surface										
183.3 / 0.1	120mm TOPSOIL										
182.7 / 0.7	FILL - Silty Clay, trace sand, trace gravel, trace organics, very stiff, brown, moist		1	SS	29		183				
	SILTY CLAY trace sand, occasional gravel inclusions, stiff to hard, brown, damp to moist		2	SS	30		182				
			3	SS	31						
			4	SS	30		181				
			5	SS	20		180				0 1 69 30
			6	SS	18		179				Nov.24 / Nov.25
			7	SS	20		178				0 2 65 33
			8	SS	15		177				
			9	TW	PH		176	1.2; >>1.8		20.4	0 3 70 27
			10	SS	13		175	1.5			1 4 68 27
			11	SS	15		174	1.5; 1.4			
169.8 / 13.6	End of Borehole						173	1.3			
	Water level at 7.6m (not stabilized) and hole open to full depth on completion.						172				
	Consolidation test performed on TW9.						171				
							170	1.3			

Continued Next Page

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

RECORD OF BOREHOLE No S-EW 10+050CL 2 OF 2 METRIC

W.P. 280-99-00 LOCATION Coords: N:4763920.4 E:327494.1 ORIGINATED BY AW

DIST HWY 406 BOREHOLE TYPE Hollow Stem Augers COMPILED BY DB

DATUM Geodetic DATE 11.24.09 - 11.25.09 CHECKED BY RA

SOIL PROFILE			SAMPLES						DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100	PLASTIC LIMIT w_P	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w_L	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE		SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100		WATER CONTENT (%) 10 20 30			GR SA SI CL
	Piezometer installation consists of a 19mm diameter, Schedule 40 PVC pipe with a 3.0m slotted screen. Water Level Readings: Date Depth(m) Elevation(m) Dec.08.09 2.4 181.0 Dec.15.09 2.4 181.0 Jan.04.10 2.4 181.0 Jan.11.10 2.4 181.0													

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

RECORD OF BOREHOLE No TSEW1 1 OF 3 METRIC

W.P. 280-99-00 LOCATION Coords: N:4763922.8 E:327487.0 ORIGINATED BY AW

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

DATUM Geodetic DATE 01.06.10 - 01.18.10 CHECKED BY RA

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
183.5	Ground Surface										
183.0	30mm TOPSOIL										
182.8	FILL - Sand and Gravel, silty, some clay, dense, moist to wet		1	SS	32		183		○		30 30 25 15
0.7	SILTY CLAY trace sand, trace gravel, stiff to hard, brown, damp to moist		2	SS	16				○		
			3	SS	27		182		○ — 50		0 3 40 57
			4	SS	40		181		○		
			5	SS	34				○		
			6	SS	34		180		○ —		0 2 66 32
			7	SS	42		179		○		
			8	SS	23		178		○		
			9	SS	24				○ —		1 3 70 26
			10	SS	21		177		○		
			11	SS	16		176		○		
			12	TW	PH		175	>> 1.1	>>		2 3 66 29
			13	SS	13		174	1.5	○ —		
			14	SS	13		173	>> 1.2			
168.8							172	1.9			
14.7								>> 3			
							171	1.2	○ —		1 2 70 27
							170	>> 2.8	○		
							169	1.5			

Continued Next Page

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

RECORD OF BOREHOLE No TSEW1 2 OF 3 METRIC

W.P. 280-99-00 LOCATION Coords: N:4763922.8 E:327487.0 ORIGINATED BY AW

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

DATUM Geodetic DATE 01.08.10 - 01.18.10 CHECKED BY RA

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	SILTY CLAY TO CLAYEY SILT trace sand, trace gravel, very stiff to hard, brown, damp to moist (GLACIAL TILL)		15	SS	25		168	>>	○		
							167				
			16	SS	60		166		○		
			17	SS	69		165		○		
164.2											
19.3	SILTY SAND trace to some gravel, trace clay, very dense, brown, moist to wet (GLACIAL TILL)		18	SS	115/ 20cm		164		○		
							163				
			19	SS	66		162		○		Jan.08 Jan.14
							161				
			20	SS	52		160		○		
159.5											
24.0	SILTY CLAY sandy, trace gravel, hard, brown, damp to moist (GLACIAL TILL)		21	SS	35		159		○		
							158				
			22	SS	48		157		⊢○⊣		5 21 41 33
156.6											
26.9	SAND AND GRAVEL some silt, dense to very dense, grey, moist to wet (GLACIAL TILL)		23	SS	49		156		○		
							155				
			24	SS	85		154		○		42 44 (14) Jan.15 Jan.18
153.8											
29.7	BEDROCK										

Continued Next Page

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

RECORD OF BOREHOLE No TSEW1 3 OF 3 METRIC

W.P. 280-99-00 LOCATION Coords: N:4763922.8 E:327487.0 ORIGINATED BY AW

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

DATUM Geodetic DATE 01.08.10 - 01.18.10 CHECKED BY RA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
	BEDROCK - INTERBEDDED DOLOSTONE AND SHALE Unweathered, thinly laminated, grey, medium strength, argillaceous with unweathered, laminated, white, very low strength gypsum and calcite layers / veins and frequent unweathered, white, low strength, coarse grained calcitic vugs.		1	RUN	NQ		153				RUN#1 TCR=89% SCR=75% RQD=54%
			2	RUN	NQ		152				RUN#2 TCR=93% SCR=81% RQD=52%
150.8							151				
32.7	End of Borehole Borehole sealed with bentonite slurry to ground surface. No sample recovery at SS16 and SS17. Sampler redriven and disturbed sample collected. Resistance to augering at 19.8m and 23.8m. Unable to push vane beyond 6.6m and 15.7m and 26.4m.										

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

CORE LOG

Terraprobe

Project: Highway 406 Twinning	Orientation: Vertical	Ground Elevation: 183.5m	Datum: Geodetic	Borehole No.: TSEW1
Location: Welland, Ontario	Date Started: January 18, 2010	Completed: January 18, 2010	Logged By: AW	Sheet 1 of 1
W.P.: 280-99-00	Drilling Agency: DBW	Drill Type: Track-Mount	Core Barrel & Bit Design: NQ	Project No.: 1-09-4135

ELEVATION (m)	DEPTH (m)	SYMBOL	GENERAL DESCRIPTION	Joint Characteristics: No. OF SETS	JOINT TYPE	ORIENTATION	SPACING	ROUGHNESS	FILLING	APERTURE	WEATHERING	STRENGTH	FRACTURE FREQUENCY	RUN NO. CORE RECOVERY %	R Q D %	CORE SIZE/CASING	UNCONFINED COMPRESSIVE STRENGTH MPa	UNIT WEIGHT (KN/m³)
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
154.0	29.5		Overburden, see Borehole Log TSEW1															
153.5	30.0		SALINA FORMATION BEDROCK INTERBEDDED DOLOSTONE AND SHALE Unweathered, thinly laminated, grey, medium strength, argillaceous with unweathered, laminated, white, very low strength gypsum and calcite layers / veins and frequent unweathered, white, low strength, coarse grained calcitic vugs.	1	B	F	VC	SU	T									
				1	B	F	C	SP	T					#1 TCR 89 SCR 75	54	NQ		
153.0	30.5			1	B	F	VC	SP	T									
152.5	31.0			1	B	F	C	SU	T									
				1	B	F	C	SP	T									
				1	B	F	VC	RP	T									
152.0	31.5			1	B	F	C	RP	T									
				1	B	F	VC	RP	T	0 to 1				#2 TCR 93 SCR 81	52	NQ		
151.5	32.0			1	B	F	C	SP	T									
151.0	32.5																	
150.5	33.0		End of Core Log Rubbilized zones at: 29.70-29.85m; 30.45-30.50m; 31.20-31.25m; 31.35-31.45m; Rubble indicated by '◁'.															
150.0	33.5																	
149.5	34.0																	
149.0	34.5																	
148.5	35.0																	

Remarks:

LEGEND:
- Interbedded Dolostone and Shale
- Rubble

RECORD OF BOREHOLE No TSEW2 1 OF 3 METRIC

W.P. 280-99-00 LOCATION Coords: N:4763936.1 E:327490.9 ORIGINATED BY AW

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

DATUM Geodetic DATE 01.05.10 - 01.07.10 CHECKED BY RA

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
183.3	Ground Surface								
0.0	FILL - Sand, some gravel, some silt, compact, brown, wet		1	SS	25		183		10 76 (14)
182.6									
0.7	SILTY CLAY trace sand, occasional gravel inclusions, stiff to hard, brown, moist		2	SS	26		182		0 1 43 56
			3	SS	40				
			4	SS	31		181		0 2 37 61
			5	SS	26		180		
			6	SS	24				
			7	SS	22		179		
			8	SS	25		178		0 2 68 30
	--- dark brown		9	SS	20		177		
			10	TW	PH		176		commence casing and washboring
			11	SS	12		175		1 3 66 30
			12	SS	22		174		Jan.05
	--- reddish brown		13	SS	23		173		Jan.06
			14	SS	13		172		
168.6							171		
14.7							170		
							169		

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

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

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

58

1.5 1.1 1.3 2.4 1.2

Continued Next Page

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

RECORD OF BOREHOLE No TSEW2 2 OF 3 METRIC

W.P. 280-99-00 LOCATION Coords: N:4763936.1 E:327490.9 ORIGINATED BY AW

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

DATUM Geodetic DATE 01.05.10 - 01.07.10 CHECKED BY RA

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE; 20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	SILTY CLAY TO CLAYEY SILT trace to some sand, trace gravel, occasional cobbles, hard, brown, damp to moist (GLACIAL TILL)		15	SS	36		168				
			16	SS	74		167				
			17	SS	70		166				
			18	SS	129		165				
162.9							164				
20.4	SILTY SAND trace clay, trace gravel, occasional cobbles, very dense, brown, moist to wet (GLACIAL TILL)		19	SS	76		163				
			20	SS	52		162				
			21	SS	104		161				
157.9							160				
25.4	SILTY CLAY trace sand, trace gravel, occasional cobbles, hard, reddish brown, moist (GLACIAL TILL)		22	SS	33		159				3 2 63 32
156.4							158				
26.9	SAND AND GRAVEL silty, trace clay, occasional cobbles, compact to very dense, grey, moist to wet (GLACIAL TILL)		23	SS	29		157				
			24	SS	100/ 10cm		156				Jan.06
153.7							155				
29.6	BEDROCK						154				Jan.07

Continued Next Page

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

RECORD OF BOREHOLE No TSEW2 3 OF 3 METRIC

W.P. 280-99-00 LOCATION Coords: N:4763936.1 E:327490.9 ORIGINATED BY AW

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

DATUM Geodetic DATE 01.05.10 - 01.07.10 CHECKED BY RA

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	BEDROCK - INTERBEDDED DOLOSTONE AND SHALE Unweathered, thinly laminated, grey, medium strength, argillaceous with unweathered, laminated, white, very low strength gypsum and calcite layers / veins and frequent unweathered, white, low strength, coarse grained calcitic vugs.		1	RUN	NQ		153				RUN#1 TCR=92% SCR=76% RQD=43%
			2	RUN	NQ		152				RUN#2 TCR=100% SCR=88% RQD=15%
150.8							151				
32.5	End of Borehole										

No sample recovery at SS15, SS19, SS20, SS21, and SS23. 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)
Jan.11.10	8.5	174.8
Jan.19.10	8.6	174.7
Jan.27.10	8.8	174.5
Feb.08.10	8.8	174.5

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

CORE LOG

Terraprobe

Project: Highway 406 Twinning	Orientation: Vertical	Ground Elevation: 183.3m	Datum: Geodetic	Borehole No.: TSEW2
Location: Welland, Ontario	Date Started: January 7, 2010	Completed: January 7, 2010	Logged By: AW	Sheet 1 of 1
W.P.: 280-99-00	Drilling Agency: GW	Drill Type: Track-Mount	Core Barrel & Bit Design: NQ	Project No.: 1-09-4135

ELEVATION (m)	DEPTH (m)	SYMBOL	GENERAL DESCRIPTION	Joint Characteristics: No. OF SETS	JOINT TYPE	ORIENTATION	SPACING	ROUGHNESS	FILLING	APERTURE	WEATHERING	STRENGTH	FRACTURE FREQUENCY	RUN NO. CORE RECOVERY %	R Q D %	CORE SIZE/CASING	UNCONFINED COMPRESSIVE STRENGTH MPa	UNIT WEIGHT (KN/m³)
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
154.3	29.0		Overburden, see Borehole Log TSEW2															
153.8	29.5		Sand and Gravel TILL, see Borehole Log TSEW2															
			SALINA FORMATION BEDROCK	1	B	F	VC	SP	T	0 to 1								
153.3	30.0		INTERBEDDED DOLOSTONE AND SHALE Unweathered, thinly laminated, grey, medium strength, argillaceous with unweathered, laminated, white, very low strength gypsum and calcite layers / veins and frequent unweathered, white, low strength, coarse grained calcitic vugs.	1	B	F	M	SP	T	0 to 1				#1 TCR 92 SCR 76	43	NQ		
152.8	30.5			1	B	F	VC	RU	T	0 to 2								
152.3	31.0			1	B	F	C	SU	T	0 to 1								
				1	B	F	VC	SU	T	0 to 1								
				1	B	F	C	SP	T	0 to 3								
				1	B	F	VC	SP	T	0 to 1								
151.8	31.5													#2 TCR 100 SCR 88	15	NQ		
151.3	32.0			1	B	F	C	SP	T	0 to 1								
150.8	32.5		End of Core Log															
150.3	33.0		Rubbilized zones at: 29.60-29.76m; 30.43-30.48m; 30.83-30.90m; 31.03-31.23m. Rubble indicated by '<'.															
149.8	33.5		Highly fractured zones at: 29.76-30.11m; 30.33-30.43m.															
149.3	34.0		Slightly weathered zone at: 30.33-30.43m.															
148.8	34.5																	

Remarks:

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

RECORD OF BOREHOLE No TSEW3 1 OF 3 METRIC

W.P. 280-99-00 LOCATION Coords: N:4763960.8 E:327478.6 ORIGINATED BY LY

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

DATUM Geodetic DATE 12.08.09 - 12.10.09 CHECKED BY RA

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
183.3	Ground Surface										
0.0 / 182.6	FILL - Sand and Gravel, trace silt, loose, grey, dry		1	SS	6		183				
0.7 / 182.0	FILL - Silty Clay, some sand, some gravel, firm, grey, damp to moist		2	SS	5						
1.3	SILTY CLAY trace sand, trace gravel, stiff to very stiff, brown, moist		3	SS	18		182				
			4	SS	18		181				
			5	SS	24		180		45		0 2 46 52
			6	SS	24		179				
			7	SS	12						1 4 61 34
			8	SS	10		178				
			9	SS	14		177				
			10	SS	16		176				
			11	SS	9		175				
			12	SS	9		174	>>			0 4 64 32
			13	TW	PH		173				4 5 67 24
			14	SS	12		172	>> 1.3 >>			
168.6 / 14.7							171	×		20.8	2 2 75 21
							170				3 3 70 24
							169	+			

Continued Next Page

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

RECORD OF BOREHOLE No TSEW3 2 OF 3 METRIC

W.P. 280-99-00 LOCATION Coords: N:4763960.8 E:327478.6 ORIGINATED BY LY

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

DATUM Geodetic DATE 12.08.09 - 12.10.09 CHECKED BY RA

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	SILTY CLAY TO CLAYEY SILT trace sand, trace gravel, occasional cobbles, very stiff to hard, brown, damp to moist (GLACIAL TILL)		15	SS	15		168	○			
							167	>>			
			16	SS	52		166		○		
			17	SS	54		165		○		
164.0											Dec.08
19.3	SILTY SAND some gravel to gravelly, trace clay, occasional cobbles, dense to very dense, brown, moist (GLACIAL TILL)		18	SS	72		164		○		Dec.09 15 45 32 8
			19	SS	30		163		○		
			20	SS	59		162		○		35 31 28 6
			21	SS	42		161		○		
157.9											
25.4	SILTY CLAY sandy, gravelly, occasional cobbles, hard, brown, moist (GLACIAL TILL)		22	SS	100/ 25cm		160		○		28 22 32 18
156.4											
26.9	SAND AND GRAVEL silty, trace clay, compact, brown, moist (GLACIAL TILL)		23	SS	18		157		○		34 37 22 7
153.6							156				
29.7	BEDROCK						155				Dec.09 Dec.10
							154				

Continued Next Page

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

RECORD OF BOREHOLE No TSEW3 3 OF 3 METRIC

W.P. 280-99-00 LOCATION Coords: N:4763960.8 E:327478.6 ORIGINATED BY LY

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

DATUM Geodetic DATE 12.08.09 - 12.10.09 CHECKED BY RA

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (20 40 60 80 100): ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	BEDROCK - INTERBEDDED DOLOSTONE AND SHALE Unweathered, thinly laminated, grey, medium strength, argillaceous with unweathered, laminated, white, very low strength gypsum and calcite layers / veins and frequent unweathered, white, low strength, coarse grained calcitic vugs.		1	RUN	NQ		153				RUN#1 TCR=59% SCR=54% RQD=13%
			2	RUN	NQ		152				RUN#2 TCR=79% SCR=58% RQD=46%
150.5							151				
32.8	End of Borehole Consolidation test performed on TW 13. Borehole sealed with bentonite slurry to ground surface. Unable to push vane beyond 10.5m and 16.6m.										

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

CORE LOG

Terraprobe

Project: Highway 406 Twinning	Orientation: Vertical	Ground Elevation: 183.3m	Datum: Geodetic	Borehole No.: TSEW3
Location: Welland, Ontario	Date Started: December 10, 2009	Completed: December 10, 2009	Logged By: AW	Sheet 1 of 1
W.P.: 280-99-00	Drilling Agency: DDSI	Drill Type: Truck Mount	Core Barrel & Bit Design: NQ	Project No.: 1-09-4135

ELEVATION (m)	DEPTH (m)	SYMBOL	GENERAL DESCRIPTION	Joint Characteristics: No. OF SETS	JOINT TYPE	ORIENTATION	SPACING	ROUGHNESS	FILLING	APERTURE	WEATHERING	STRENGTH	FRACTURE FREQUENCY	RUN NO. CORE RECOVERY %	R Q D %	CORE SIZE/CASING	UNCONFINED COMPRESSIVE STRENGTH MPa	UNIT WEIGHT (KN/m³)
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
154.3	29.0																	
153.8	29.5		Overburden, see Borehole Log TSEW3															
			SALINA FORMATION BEDROCK															
153.3	30.0		INTERBEDDED DOLOSTONE AND SHALE Unweathered, thinly laminated, grey, medium strength, argillaceous with unweathered, laminated, white, very low strength gypsum and calcite layers / veins and frequent unweathered, white, low strength, coarse grained calcitic vugs.	1	B	F	VC	RP	T	0 to 4				#1 TCR 59 SCR 54	13	NQ		
152.8	30.5																	
152.3	31.0			1	B	F	VC	RP	Si	10								
				1	B	F	C	RU	T	0 to 3								
151.8	31.5			1	B	F	C	SP	T									
				1	B	F	VC	SP	T									
				1	B	F	C	RU	T									
				1	B	F	VC	RU	T									
151.3	32.0			2	BC	FV	C	SP	T	0 to 1				#2 TCR 79 SCR 58	46	NQ		
150.8	32.5			2	BC	FV	VC	SP	T									
				1	B	F	C	RP	T									
150.3	33.0		End of Core Log Rubbilized zones at: 30.90-31.00m; 31.45-31.60m; 31.75-31.80m. Rubble indicated by 'c'. Highly fractured zones at: 32.30-32.55m.															
149.8	33.5																	
149.3	34.0																	
148.8	34.5																	

Remarks:

LEGEND:
- Interbedded Dolostone and Shale
- Rubble

RECORD OF BOREHOLE No TSEW4 1 OF 3 METRIC

W.P. 280-99-00 LOCATION Coords: N:4763951.2 E:327473.9 ORIGINATED BY PK

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

DATUM Geodetic DATE 12.02.09 - 12.07.09 CHECKED BY RA

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
183.5	Ground Surface								
0.0	FILL - Silty Clay, some sand, trace gravel, trace organics, stiff to very stiff, dark brown / brown, moist		1	SS	11		183		
			2	SS	18				3 11 48 38
	firm		3	SS	6		182		
181.4									
2.1	SILTY CLAY trace sand, trace gravel, stiff to very stiff, brown, damp to moist		4	SS	14		181		0 1 54 45
			5	SS	18		180		
			6	SS	19				
	some sand		7	SS	18		179		1 13 55 31
			8	SS	13		178		
			9	SS	11		177		
			10	SS	7		176		2 3 70 25
			11	SS	3		175		0 6 63 31
			12	SS	8		174		
			13	SS	9		173		1 2 70 27
			14	TW	PH		172		
168.8							171		
14.7							170		
							169		

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100

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

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

1.8 2.1 1.2 1.3 41

Continued Next Page

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

RECORD OF BOREHOLE No TSEW4 2 OF 3 METRIC

W.P. 280-99-00 LOCATION Coords: N:4763951.2 E:327473.9 ORIGINATED BY PK

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

DATUM Geodetic DATE 12.02.09 - 12.07.09 CHECKED BY RA

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
164.2	SILTY CLAY trace to some sand, trace to some gravel, occasional cobbles, very stiff, brown, damp to moist (GLACIAL TILL)		15	SS	21		168		○		
			16	SS	29		167		○		
			17	SS	25		166		⊢○⊣		18 15 42 25
19.3							165				
	SILTY SAND gravelly, trace clay, occasional cobbles, very dense, brown, damp (GLACIAL TILL)		18	SS	70		164		○		22 38 31 9
			19	SS	81		163		○		
			20	SS	68		162		○		29 31 31 9 Dec.02 --- Dec.04
			21	SS	68		161		○		
158.1							160				
25.4	SILTY CLAY sandy, trace to some gravel, occasional cobbles, hard, brown, damp to moist (GLACIAL TILL)		22	SS	31		159		○		
			23	SS	73		158		⊢○⊣		9 28 39 24
155.5							157				
28.0	SAND AND GRAVEL silty, trace clay, occasional cobbles, compact, grey, damp to moist (GLACIAL TILL)		24	SS	25		156		○		
154.0							155				
29.5	BEDROCK		25	SS	100/5cm		154		○		Dec.04 --- Dec.07

Continued Next Page

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

RECORD OF BOREHOLE No TSEW4 3 OF 3 METRIC

W.P. 280-99-00 LOCATION Coords: N:4763951.2 E:327473.9 ORIGINATED BY PK

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

DATUM Geodetic DATE 12.02.09 - 12.07.09 CHECKED BY RA

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (20 40 60 80 100): ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	BEDROCK - INTERBEDDED DOLOSTONE AND SHALE Unweathered, thinly laminated, grey, medium strength, argillaceous with unweathered, laminated, white, very low strength gypsum and calcite layers / veins and frequent unweathered, white, low strength, coarse grained calcitic vugs.		1	RUN	NQ		153				RUN#1 TCR=69% SCR=66% RQD=0%
			2	RUN	NQ		152				RUN#2 TCR=80% SCR=70% RQD=0%
			3	RUN	NQ						RUN#3 TCR=100% SCR=100% RQD=59%
150.5			4	RUN	NQ		151				RUN#4 TCR=99% SCR=99% RQD=84%
33.0	End of Borehole Resistance to augering at 26.7m. No sample recovery at SS24. Sampler redriven and disturbed sample collected. Borehole sealed with bentonite slurry from 33.0m to 23.2m. 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) Piezometer destroyed after installation.										

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

CORE LOG

Terraprobe

Project: Highway 406 Twinning	Orientation: Vertical	Ground Elevation: 183.5m	Datum: Geodetic	Borehole No.: TSEW4
Location: Welland, Ontario	Date Started: December 7, 2009	Completed: December 7, 2009	Logged By: AW	Sheet 1 of 1
W.P.: 280-99-00	Drilling Agency: DDSI	Drill Type: Truck Mount	Core Barrel & Bit Design: NQ	Project No.: 1-09-4135

ELEVATION (m)	DEPTH (m)	SYMBOL	GENERAL DESCRIPTION	Joint Characteristics: No. OF SETS	JOINT TYPE	ORIENTATION	SPACING	ROUGHNESS	FILLING	APERTURE	WEATHERING	STRENGTH	FRACTURE FREQUENCY	RUN NO. CORE RECOVERY %	R Q D %	CORE SIZE/CASING	UNCONFINED COMPRESSIVE STRENGTH MPa	UNIT WEIGHT (KN/m³)
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
154.5	29.0																	
			Overburden, see Borehole Log TSEW4															
154.0	29.5																	
			SALINA FORMATION BEDROCK															
153.5	30.0		INTERBEDDED DOLOSTONE AND SHALE Unweathered, thinly laminated, grey, medium strength, argillaceous with unweathered, laminated, white, very low strength gypsum and calcite layers / veins and frequent unweathered, white, low strength, coarse grained calcitic vugs.	1	B	F	C	RP	T	0 to 5				#1 TCR 69 SCR 66	0	NQ		
153.0	30.5			1	B	F	C	SP	T	0 to 1								
				1	B	F	VC	SP	T									
152.5	31.0			1	B	F	C	SP	T	0 to 1				#2 TCR 80 SCR 70	0	NQ		
152.0	31.5			1	B	F	VC	SP	T									
				1	B	F	VC	SP	T					#3 TCR 100 SCR 100	59	NQ		
151.5	32.0			1	B	F	C	SP	T	0 to 1								
151.0	32.5			1	B	F	M	SP	T	0 to 1				#4 TCR 99 SCR 99	84	NQ		
150.5	33.0		End of Core Log															
			Rubbilized zone at:															
150.0	33.5		30.81-30.86m.															
			Rubble indicated by 'r'.															
149.5	34.0		Highly fractured zone at:															
			31.56-31.66m.															
149.0	34.5																	

Remarks:

LEGEND:
- Interbedded Dolostone and Shale
- Rubble

RECORD OF BOREHOLE No S-EW 10+110CL 1 OF 2 METRIC

W.P. 280-99-00 LOCATION Coords: N:4763976.0 E:327471.7 ORIGINATED BY MP

DIST HWY 406 BOREHOLE TYPE Hollow Stem Augers COMPILED BY DB

DATUM Geodetic DATE 11.04.09 CHECKED BY RA

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
182.4	Ground Surface										
182.2 / 0.2	250mm TOPSOIL										
181.7 / 0.5	FILL - Silty Clay, trace sand, trace gravel, trace organics, firm, brown, moist		1	SS	4		182				
0.7	SILTY CLAY trace sand, occasional gravel inclusions, stiff to hard, brown, damp to moist		2	SS	13		181				
			3	SS	18						0 1 60 39
			4	SS	18		180				
			5	SS	21		179				
			6	SS	12		178				
			7	SS	12		177				
			8	SS	10		176				
			9	TW	PH		175				
			10	TW	PH		174	+ 1.8			
			11	TW	PH		173	>> + 1.2			
							172	>> + 1.6			
							171	>> + 1.4			
							170	>>			1 3 69 27
							169	>> + 1.5			
168.4 / 14.0	End of Borehole							>>			

Continued Next Page

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

RECORD OF BOREHOLE No S-EW 10+110CL 2 OF 2 METRIC

W.P. 280-99-00 LOCATION Coords: N:4763976.0 E:327471.7 ORIGINATED BY MP

DIST HWY 406 BOREHOLE TYPE Hollow Stem Augers COMPILED BY DB

DATUM Geodetic DATE 11.04.09 CHECKED BY RA

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

Borehole was open and dry (not stabilized) upon completion of drilling.

Consolidation test performed on TW11.

No sample recovery at TW9 and TW10.

Piezometer installation consists of a 19mm diameter, Schedule 40 PVC pipe with a 3.0m slotted screen.

Water Level Readings:

Date	Depth(m)	Elevation(m)
Nov.09.09	2.7	179.7
Nov.20.09	1.1	181.3
Nov.30.09	1.6	180.8
Dec.08.09	1.3	181.1
Jan.04.10	1.3	181.1

$+^3, \times^3$: Numbers refer to Sensitivity

$\bigcirc^{3\%}$ STRAIN AT FAILURE

Bedrock Core Sample
Borehole: TSEW1
Runs: 1 & 2
Depth: 29.7m – 32.7m

Bedrock Core Sample
Borehole: TSEW2
Runs: 1 & 2
Depth: 29.4m – 32.5m

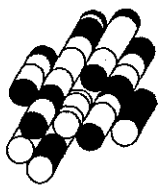
Bedrock Core Sample
Borehole: TSEW3
Runs 1 & 2
Depth: 29.7m – 32.8m

Bedrock Core Sample
Borehole: TSEW4
Runs: 1, 2, 3 & 4
Depth: 29.5m – 33.0m

APPENDIX B

Laboratory Test Results

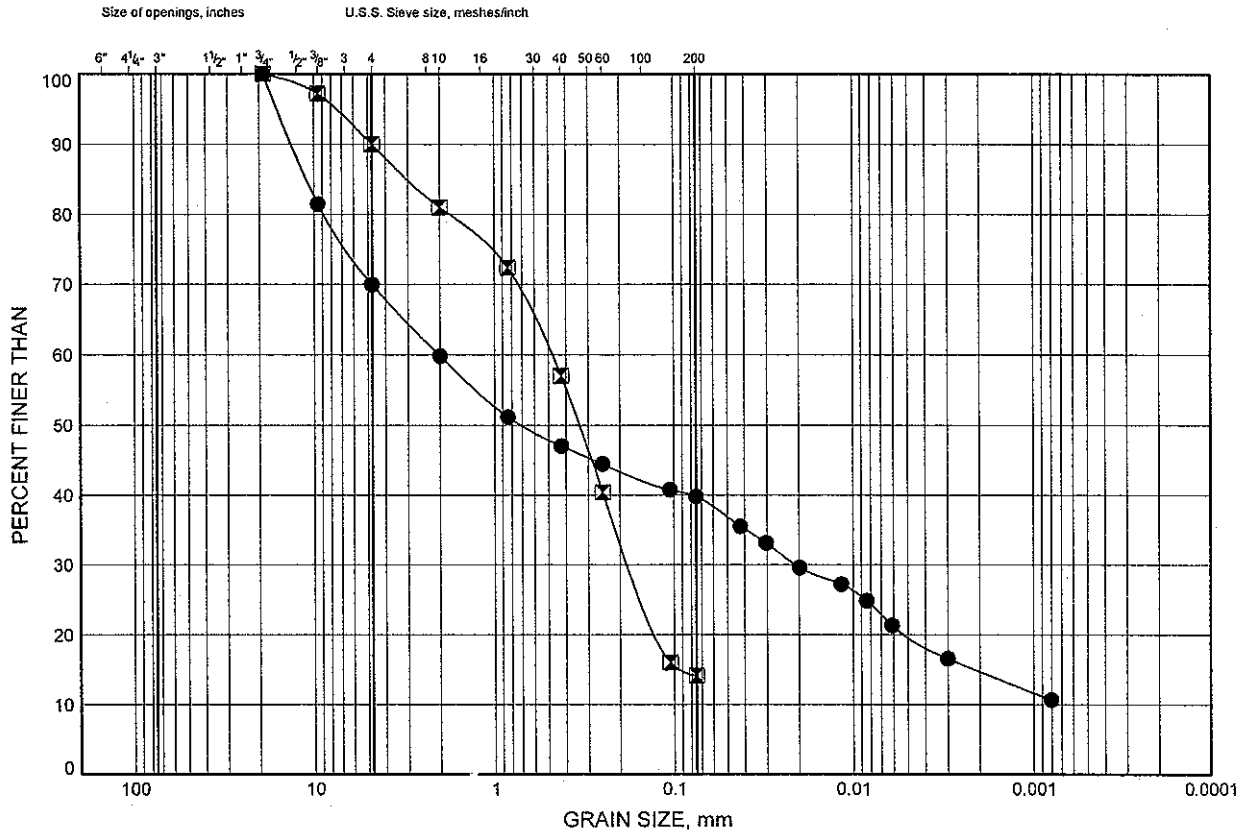
Terraprobe Inc.



GRAIN SIZE DISTRIBUTION

FIGURE B1

FILL - Sand and Gravel to Sand



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

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	TSEW1	0.3	183.2
⊠	TSEW2	0.3	183.0

Date May 2010

Project 1-09-4135

Prep'd DB

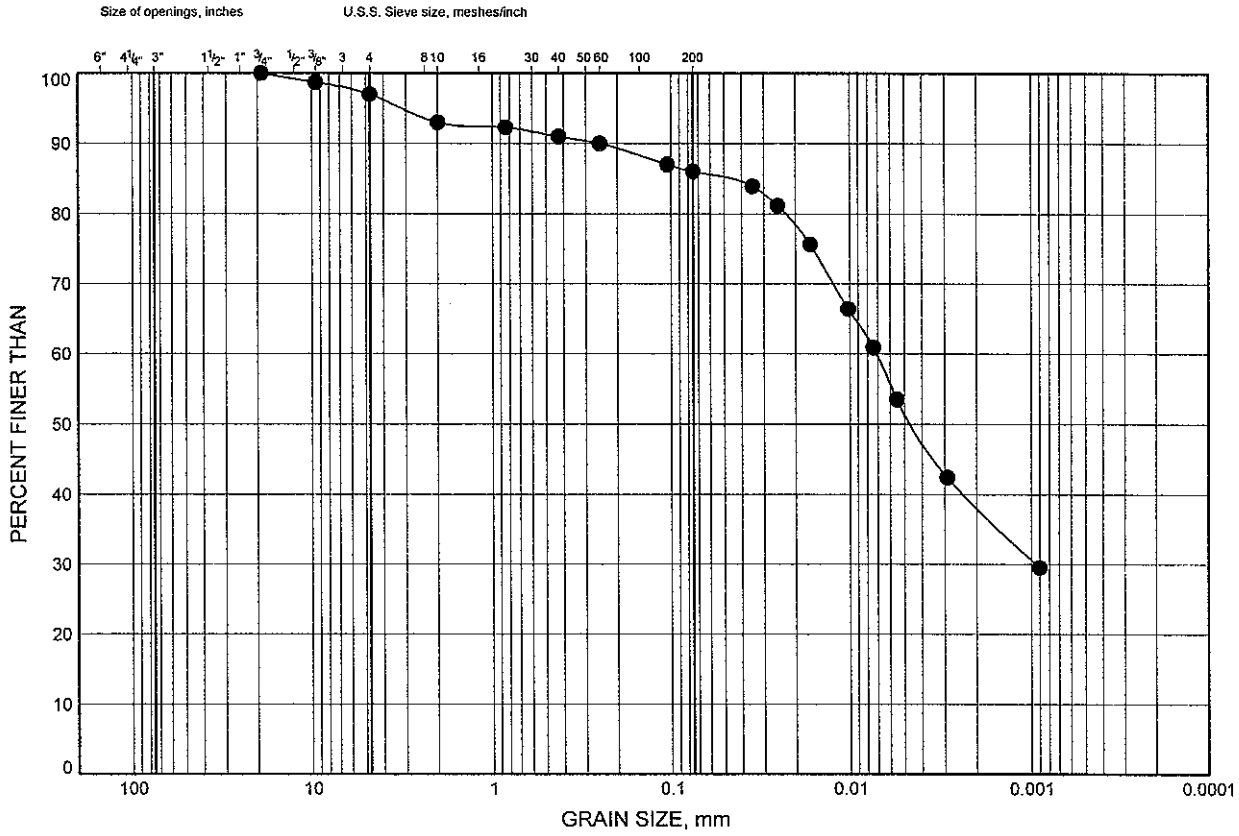
Chkd. HA

GSD 1-09-4135 TSEW BRIDGE.GPJ 05/25/10

GRAIN SIZE DISTRIBUTION

FIGURE B2

FILL - Silty Clay



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

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	TSEW4	1.0	182.5

Date May 2010

Project 1-09-4135

Prep'd DB

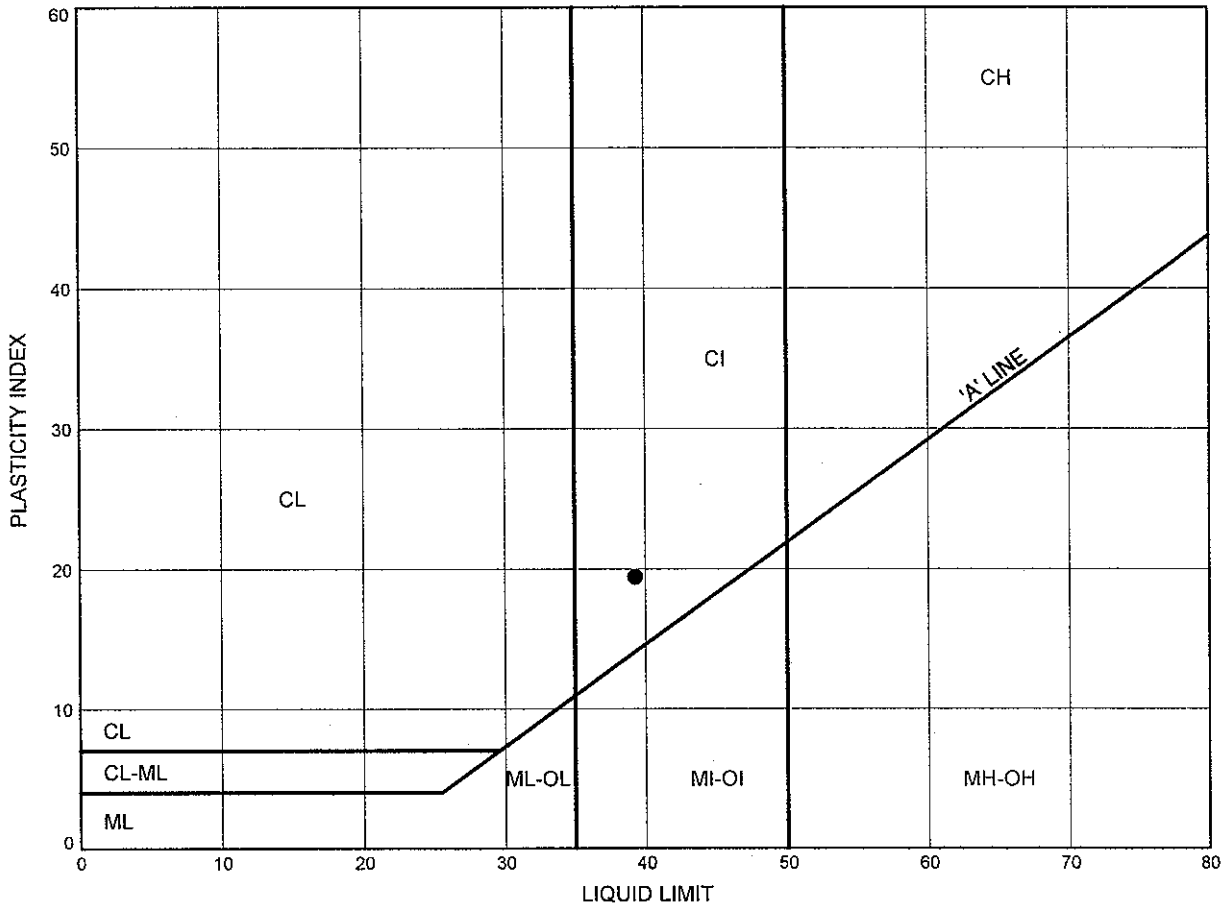
Chkd. HA

GSD 1-09-4135 TSEW BRIDGE.GPJ 05/25/10

ATTERBERG LIMITS TEST RESULTS

FIGURE B3

FILL - Silty Clay



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	TSEW4	1.0	182.5

Date May 2010

Project 1-09-4135

Prep'd DB

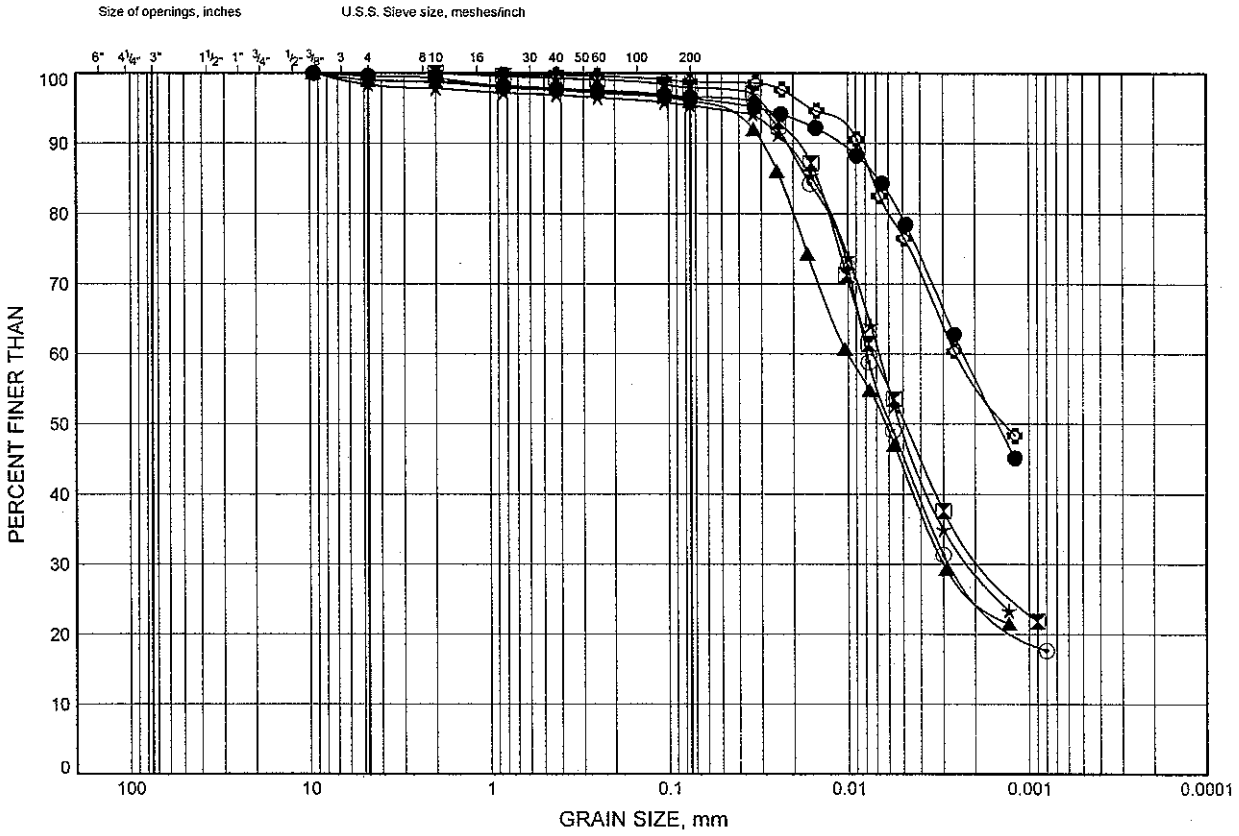
Chkd. HA

ALTR 1-09-4135 TSEW BRIDGE.GPJ 05/25/10

GRAIN SIZE DISTRIBUTION

FIGURE B4

SILTY CLAY



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

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	TSEW1	1.7	181.8
⊠	TSEW1	4.0	179.5
▲	TSEW1	6.3	177.2
★	TSEW1	9.3	174.2
⊙	TSEW1	12.4	171.1
✿	TSEW2	1.0	182.3

Date May 2010

Project 1-09-4135

Prep'd DB

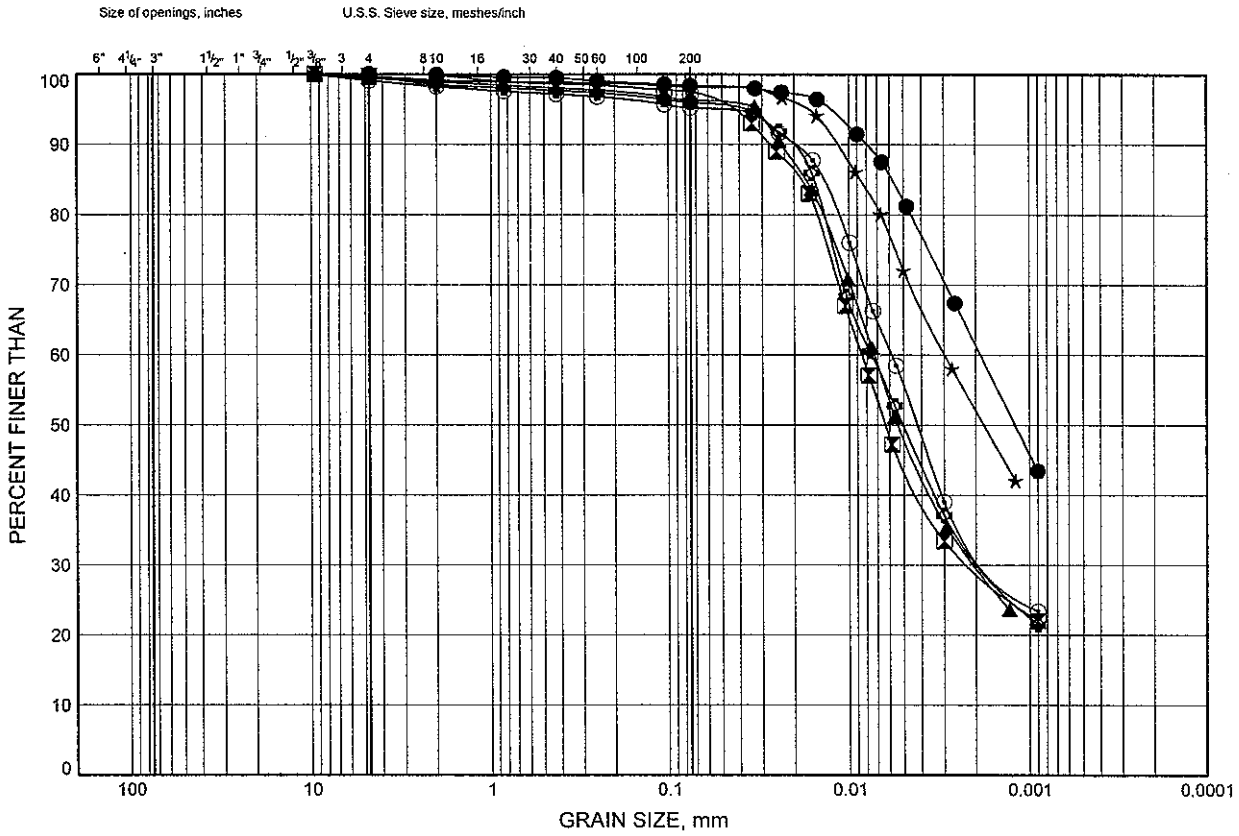
Chkd. HA

GSD 1-09-4135 TSEW BRIDGE.GPJ 05/25/10

GRAIN SIZE DISTRIBUTION

FIGURE B5

SILTY CLAY



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

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	TSEW2	2.5	180.8
⊠	TSEW2	5.5	177.8
▲	TSEW2	9.3	174.0
★	TSEW3	3.2	180.1
⊙	TSEW3	4.7	178.6
✿	TSEW3	9.3	174.0

Date May 2010

Project 1-09-4135

Prep'd DB

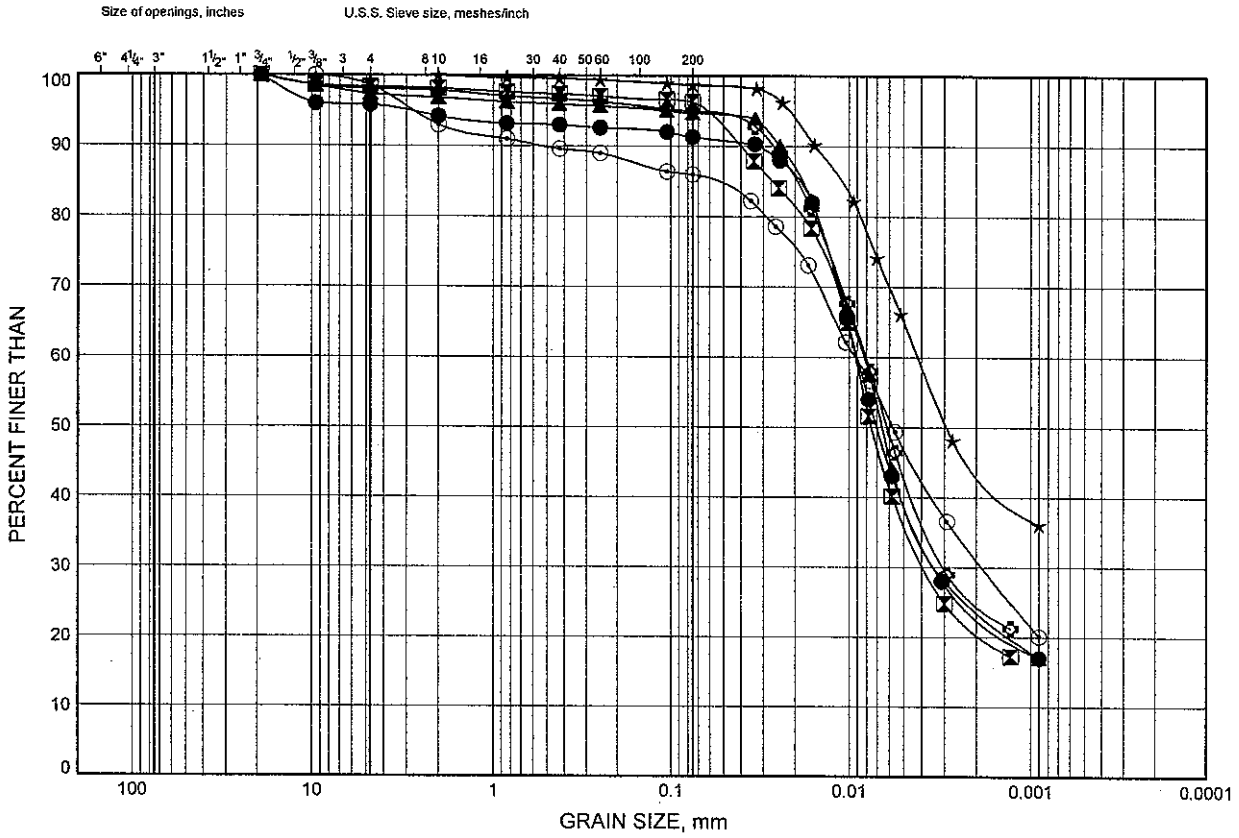
Chkd. HA

GSD 1-09-4135 TSEW BRIDGE.GPJ 05/25/10

GRAIN SIZE DISTRIBUTION

FIGURE B6

SILTY CLAY



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

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	TSEW3	10.9	172.4
⊠	TSEW3	12.4	170.9
▲	TSEW3	13.9	169.4
★	TSEW4	2.5	181.0
⊙	TSEW4	4.7	178.8
✿	TSEW4	7.8	175.7

Date May 2010

Project 1-09-4135

Prep'd DB

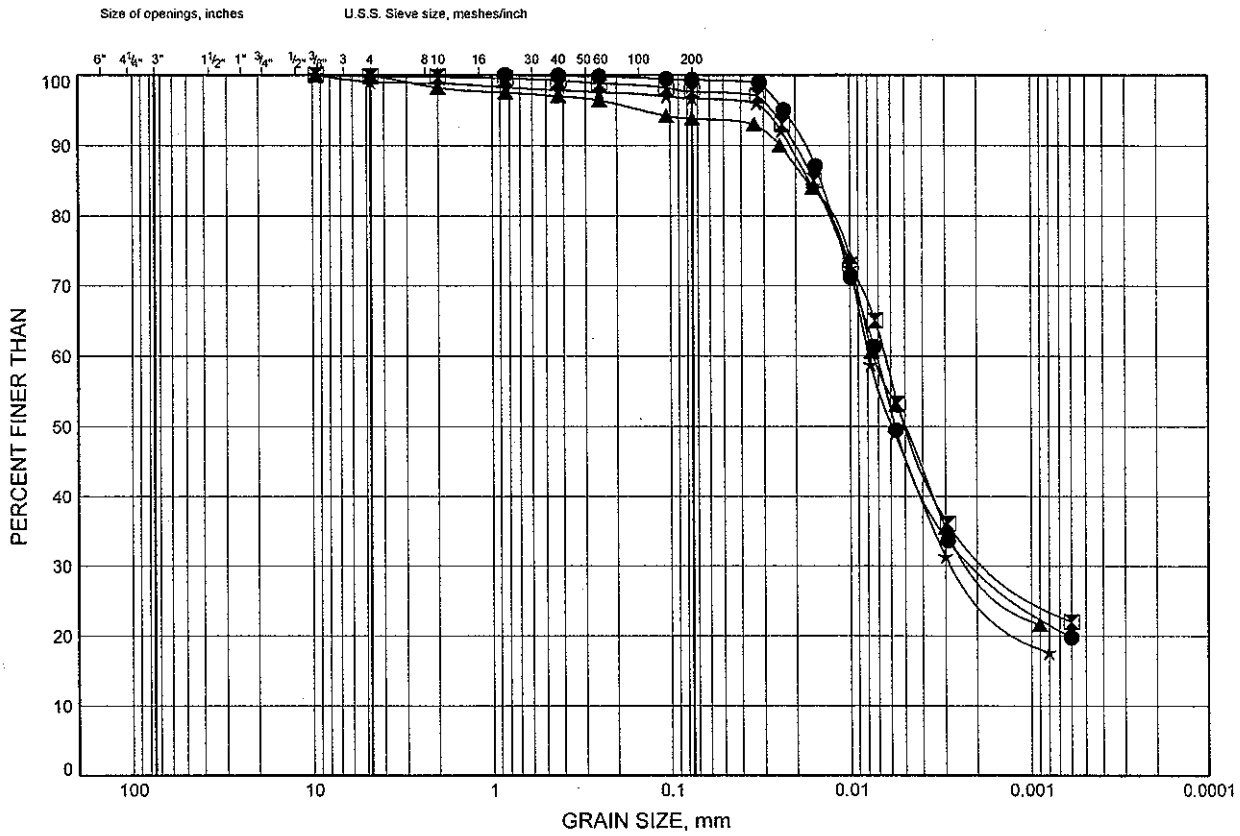
Chkd. HA

GSD 1-09-4135 TSEW BRIDGE.GPJ 05/25/10

GRAIN SIZE DISTRIBUTION

FIGURE B7

SILTY CLAY



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

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	S-EW 10+050CL	3.2	180.2
⧓	S-EW 10+050CL	6.3	177.1
▲	TSEW4	9.3	174.2
★	TSEW4	12.4	171.1

Date May 2010

Project 1-09-4135

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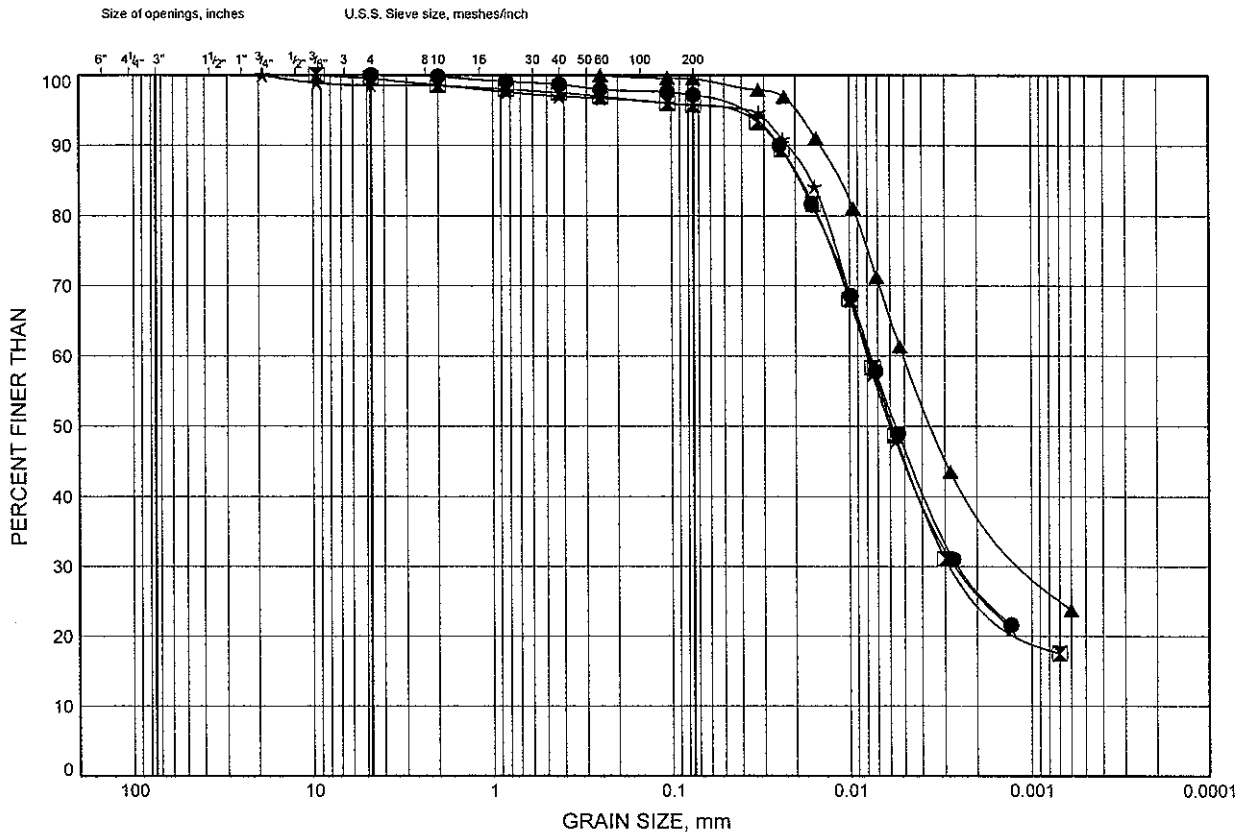
GSD 1-09-4135 TSEW BRIDGE.GPJ 05/25/10

GRAIN SIZE DISTRIBUTION

FIGURE B8

SILTY CLAY



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

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	S-EW 10+050CL	9.3	174.1
⧓	S-EW 10+050CL	10.9	172.5
▲	S-EW 10+110CL	1.7	180.7
★	S-EW 10+110CL	12.4	170.0

Date May 2010

Project 1-09-4135

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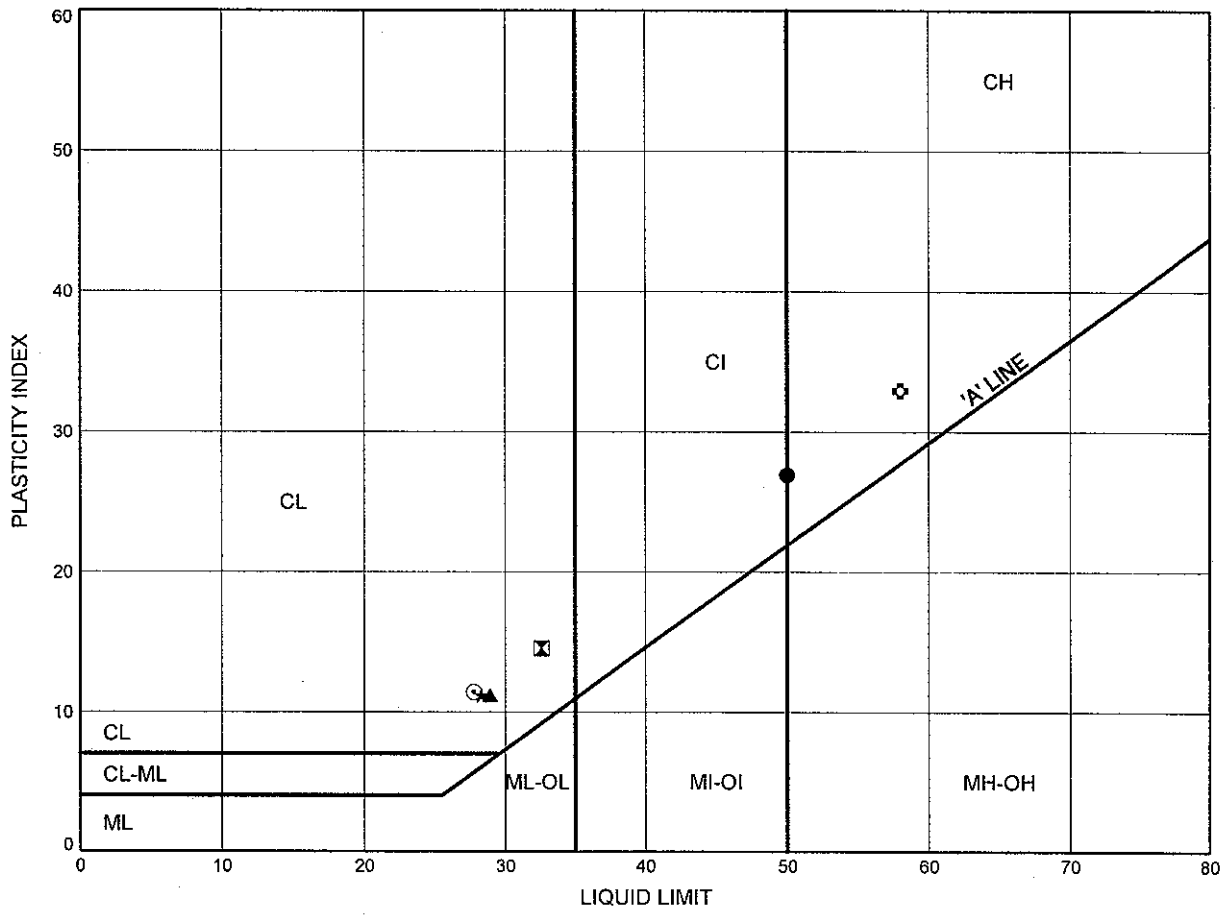
GSD 1-09-4135 TSEW BRIDGE.GPJ 05/25/10

ATTERBERG LIMITS TEST RESULTS

FIGURE B9

SILTY CLAY



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	TSEW1	1.7	181.8
⊠	TSEW1	4.0	179.5
▲	TSEW1	6.3	177.2
★	TSEW1	9.3	174.2
⊙	TSEW1	12.4	171.1
✿	TSEW2	1.0	182.3

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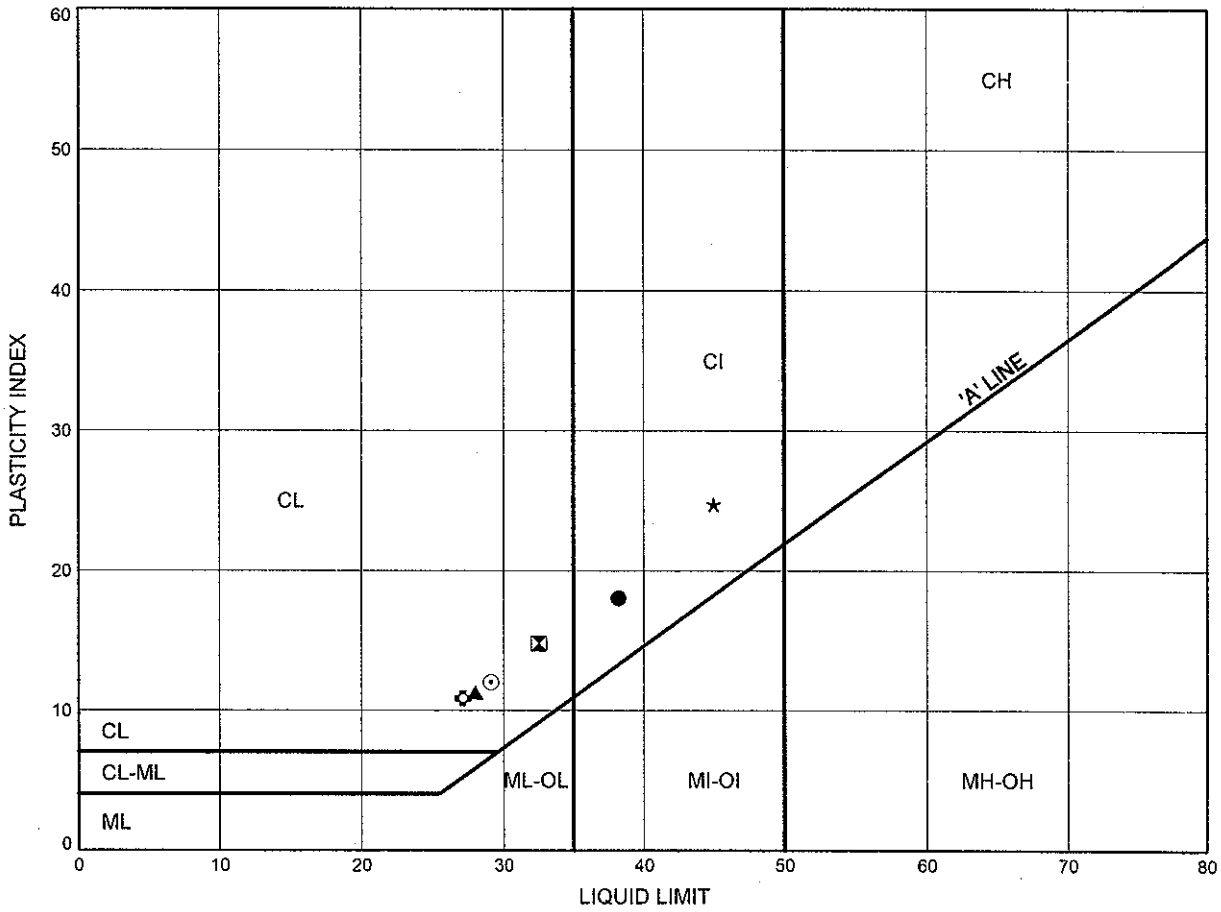
ATTERBERG LIMITS TEST RESULTS

FIGURE B10

SILTY CLAY



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	TSEW2	2.5	180.8
⊠	TSEW2	5.5	177.8
▲	TSEW2	9.3	174.0
★	TSEW3	3.2	180.1
⊙	TSEW3	4.7	178.6
✿	TSEW3	9.3	174.0

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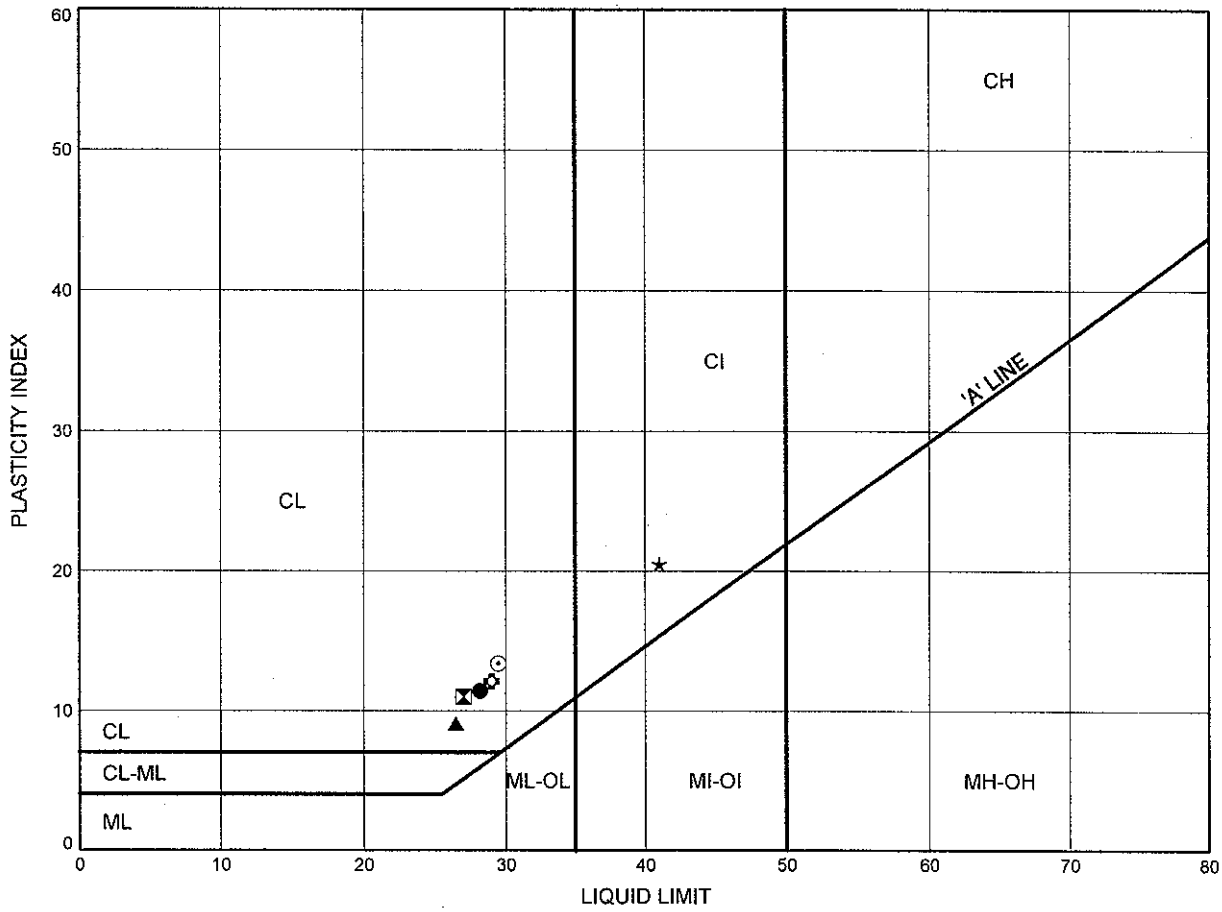
ATTERBERG LIMITS TEST RESULTS

FIGURE B11

SILTY CLAY



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	TSEW3	10.9	172.4
⊠	TSEW3	12.4	170.9
▲	TSEW3	13.9	169.4
★	TSEW4	2.5	181.0
⊙	TSEW4	4.7	178.8
✿	TSEW4	7.8	175.7

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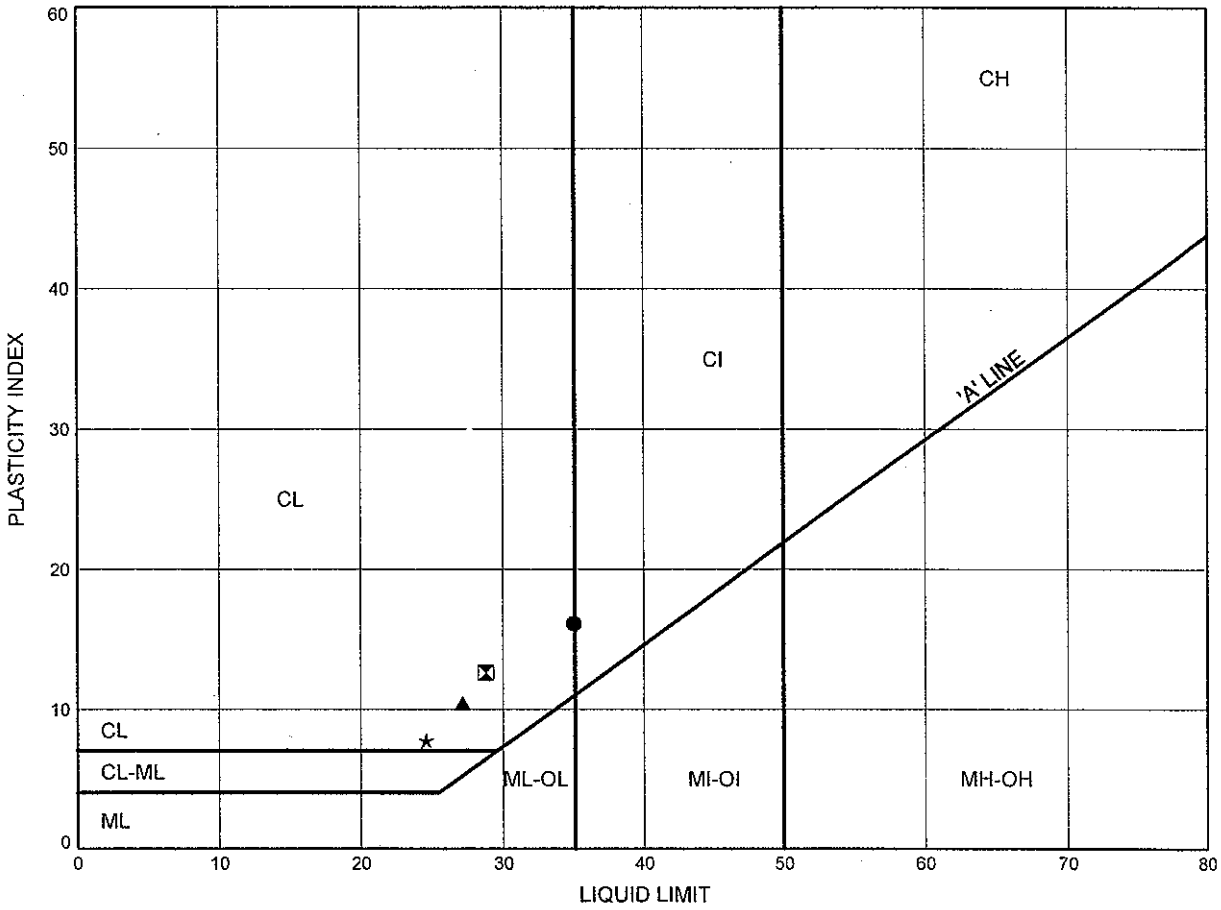
ATTERBERG LIMITS TEST RESULTS

FIGURE B12

SILTY CLAY



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	S-EW 10+050CL	3.2	180.2
⊠	S-EW 10+050CL	6.3	177.1
▲	TSEW4	9.3	174.2
★	TSEW4	12.4	171.1

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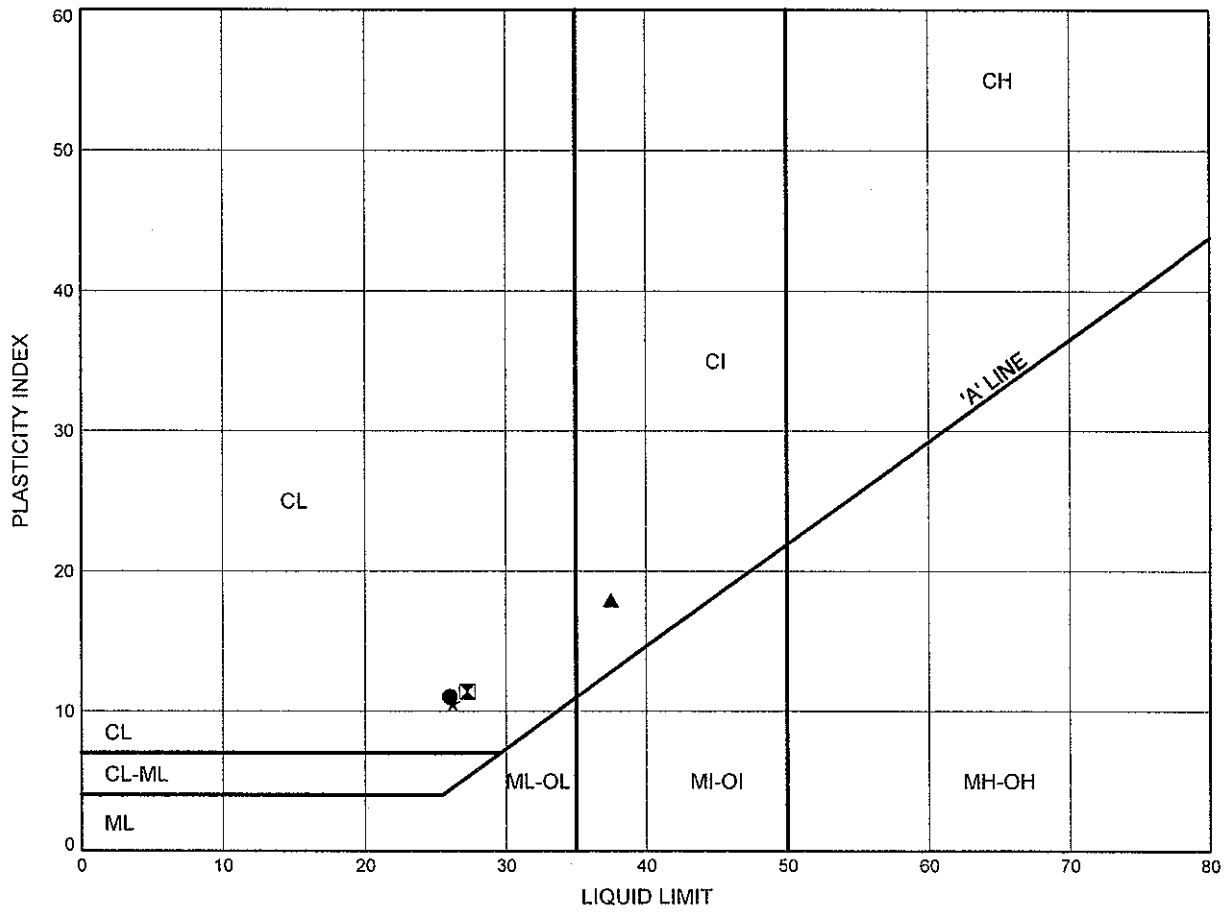
ATTERBERG LIMITS TEST RESULTS

FIGURE B13

SILTY CLAY



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	S-EW 10+050CL	9.3	174.1
⧓	S-EW 10+050CL	10.9	172.5
▲	S-EW 10+110CL	1.7	180.7
★	S-EW 10+110CL	12.4	170.0

Date May 2010

Project 1-09-4135

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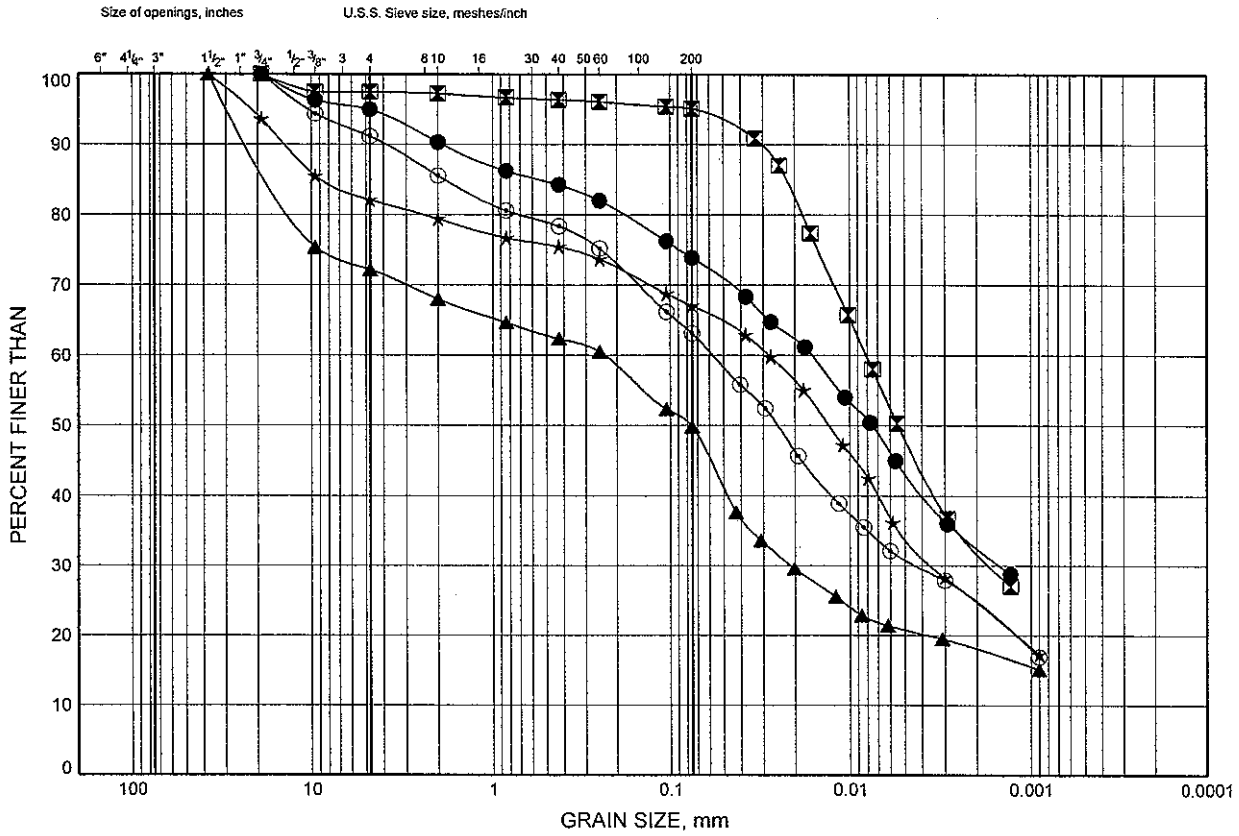
Chkd. HA

ALTR 1-09-4135 TSEW BRIDGE.GPJ 05/25/10

GRAIN SIZE DISTRIBUTION

FIGURE B14

SILTY CLAY TO CLAYEY SILT TILL



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

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	TSEW1	26.1	157.4
⊠	TSEW2	26.1	157.2
▲	TSEW3	26.1	157.2
★	TSEW4	18.5	165.0
⊙	TSEW4	26.1	157.4

Date May 2010

Project 1-09-4135

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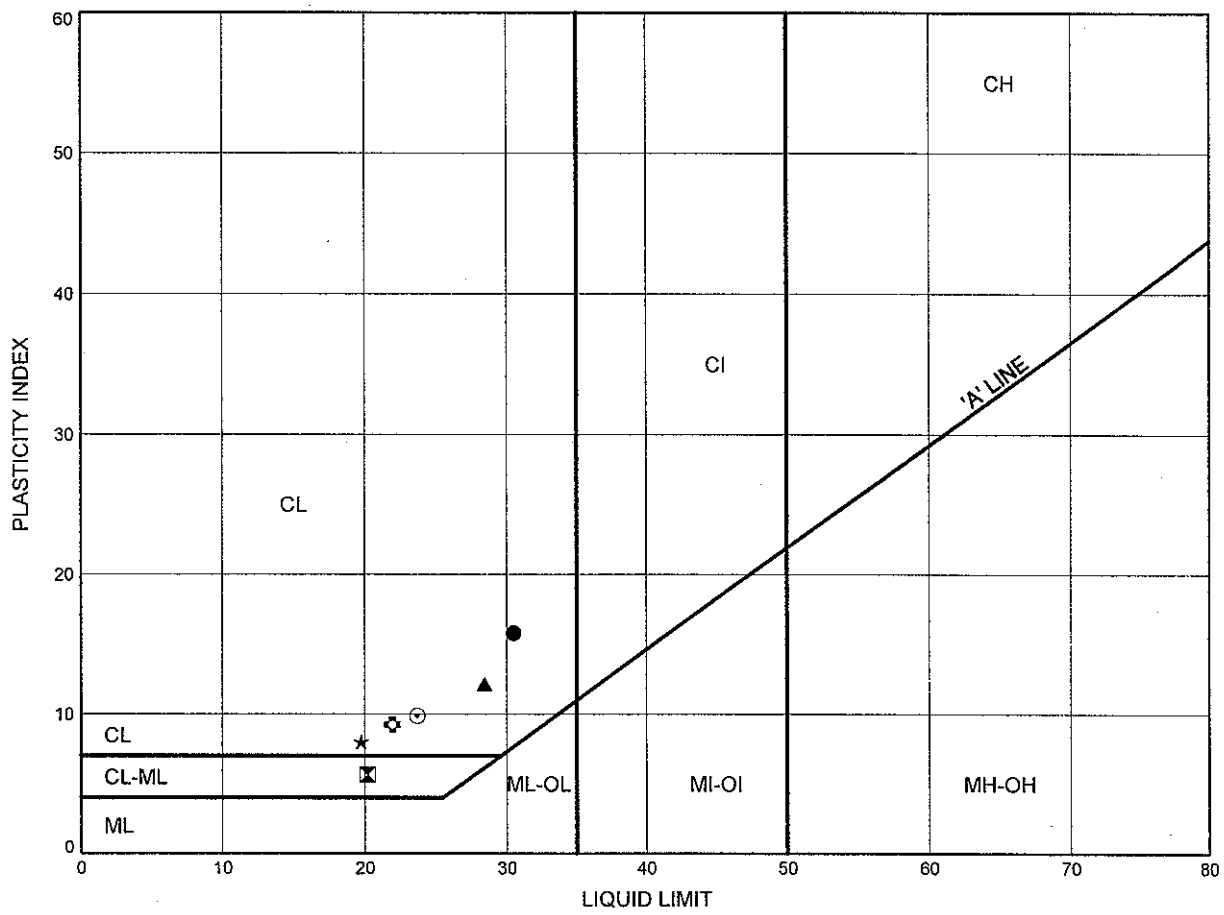
ATTERBERG LIMITS TEST RESULTS

FIGURE B15

SILTY CLAY TO CLAYEY SILT TILL



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	TSEW1	26.1	157.4
⊠	TSEW2	18.5	164.8
▲	TSEW2	26.1	157.2
★	TSEW3	26.1	157.2
⊙	TSEW4	18.5	165.0
✿	TSEW4	26.1	157.4

Date May 2010

Project 1-09-4135

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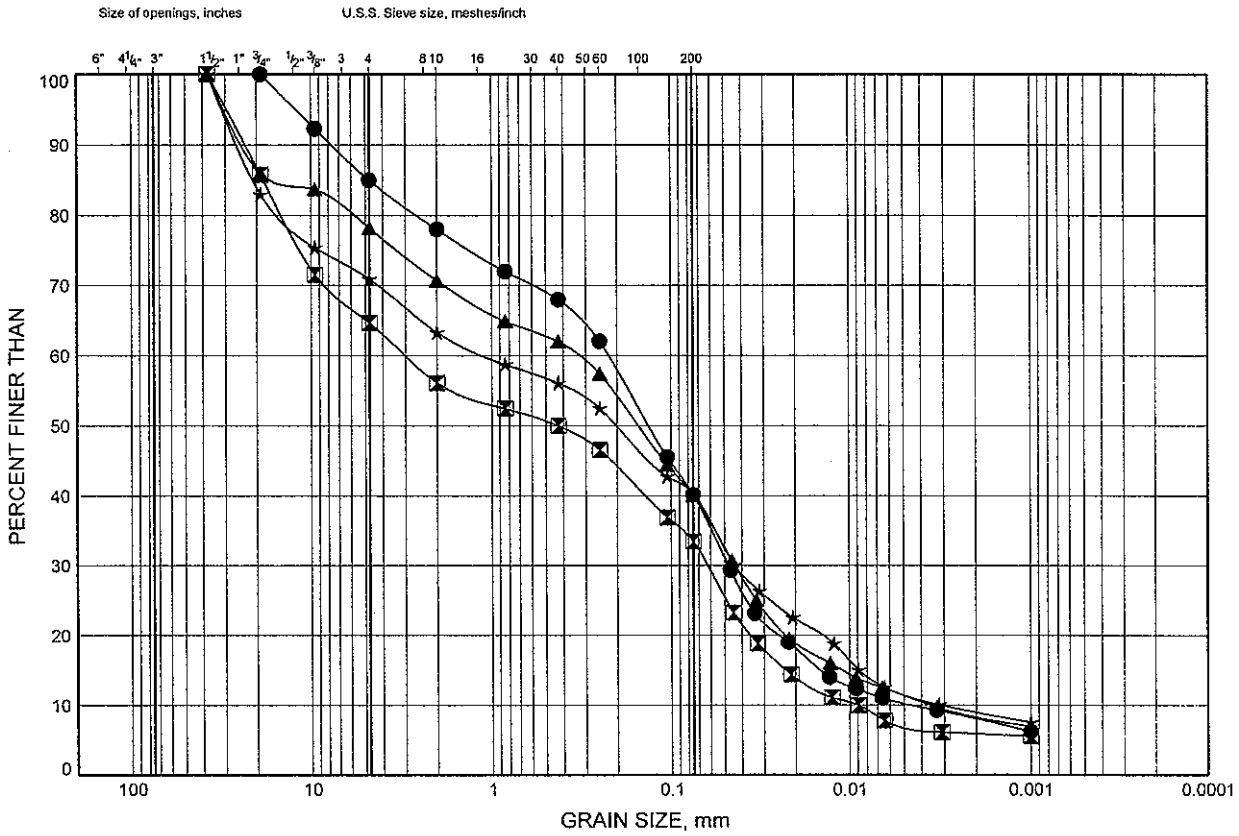
ALTR 1-09-4135 TSEW BRIDGE.GPJ 05/25/10

GRAIN SIZE DISTRIBUTION

FIGURE B16

SILTY SAND TILL



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

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	TSEW3	20.0	163.3
⊠	TSEW3	23.1	160.2
▲	TSEW4	20.0	163.5
★	TSEW4	23.1	160.4

Date May 2010

Project 1-09-4135

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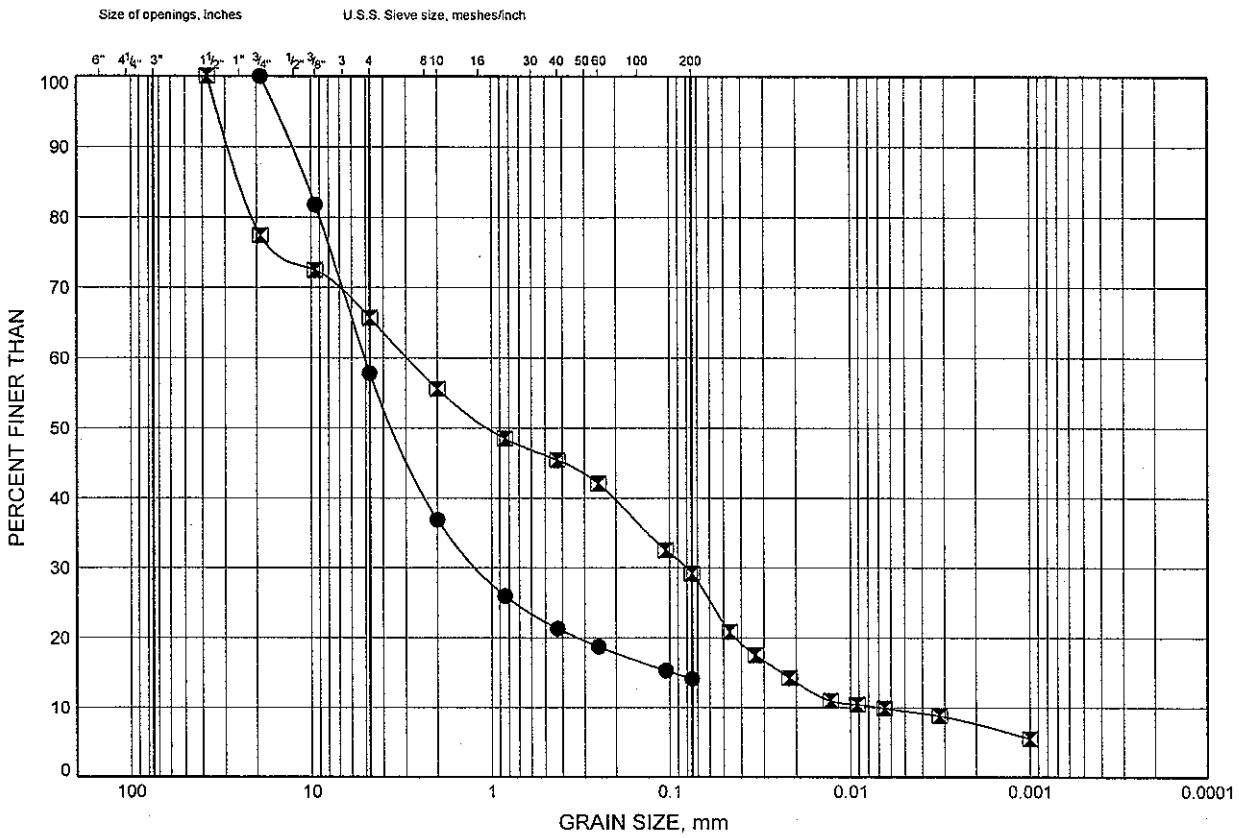
GSD 1-09-4135 TSEW BRIDGE.GPJ 05/25/10

GRAIN SIZE DISTRIBUTION

FIGURE B17

SAND AND GRAVEL TILL



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

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	TSEW1	29.2	154.4
⊠	TSEW3	27.6	155.7

Date May 2010

Project 1-09-4135

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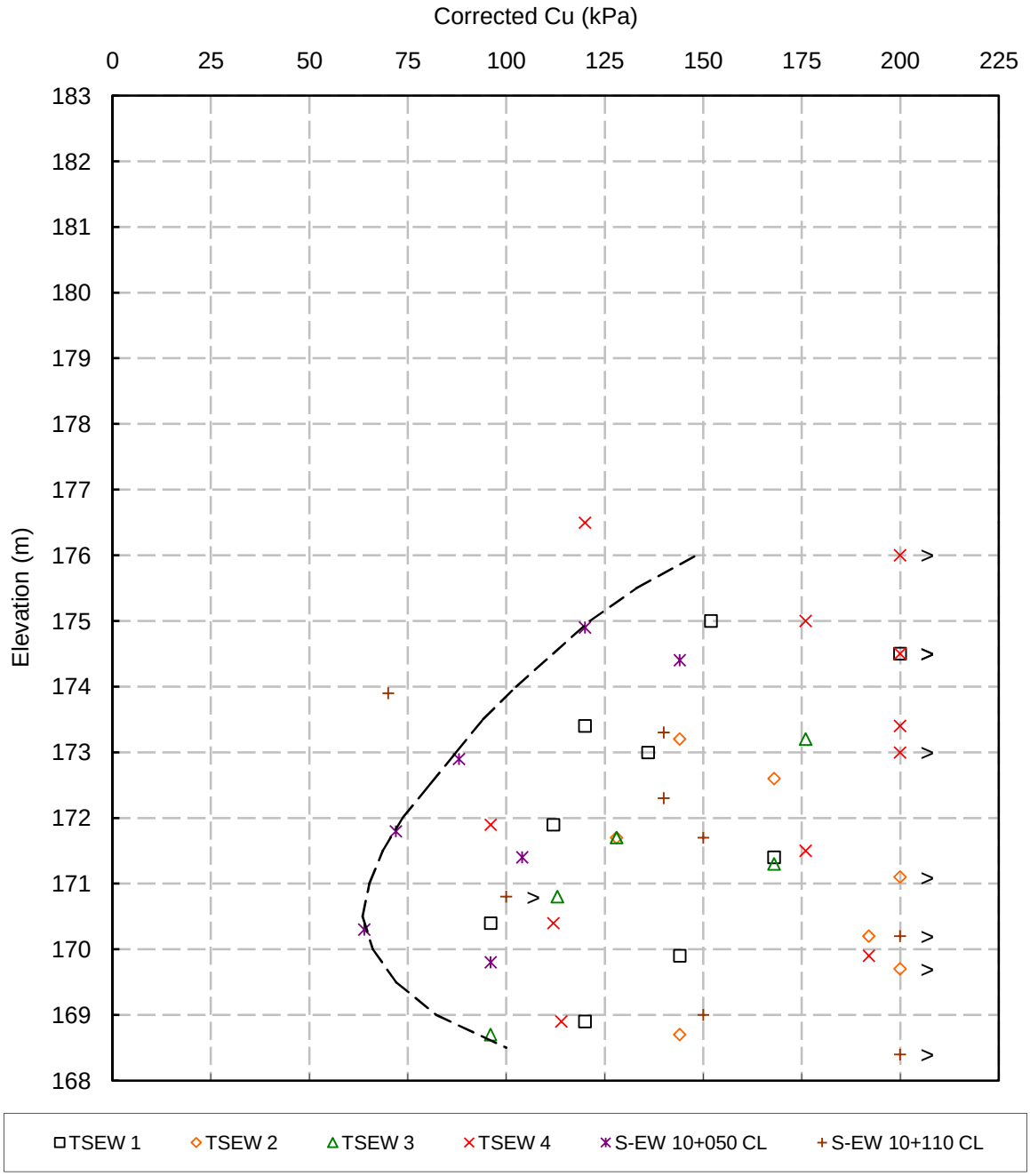
Chkd. HA

GSD 1-09-4135 TSEW BRIDGE.GPJ 05/25/10

CORRECTED UNDRAINED SHEAR STRENGTH	FIGURE B18

HWY 406 TWINNING - WOODLAWN S-EW RAMP

Silty Clay



Field Shear Vane Correction

Morris & Williams (1994)

(μ = 1.18 EXP(-0.08 Ip) + 0.57)

Applied Correction Factors

0.88 (Elev.>177m)

1.00 (Elev.<177m)

Project No. : 1-09-4135

Date : September, 2010

Terraprobe Inc.

Prepared By : HW

Checked By : RA

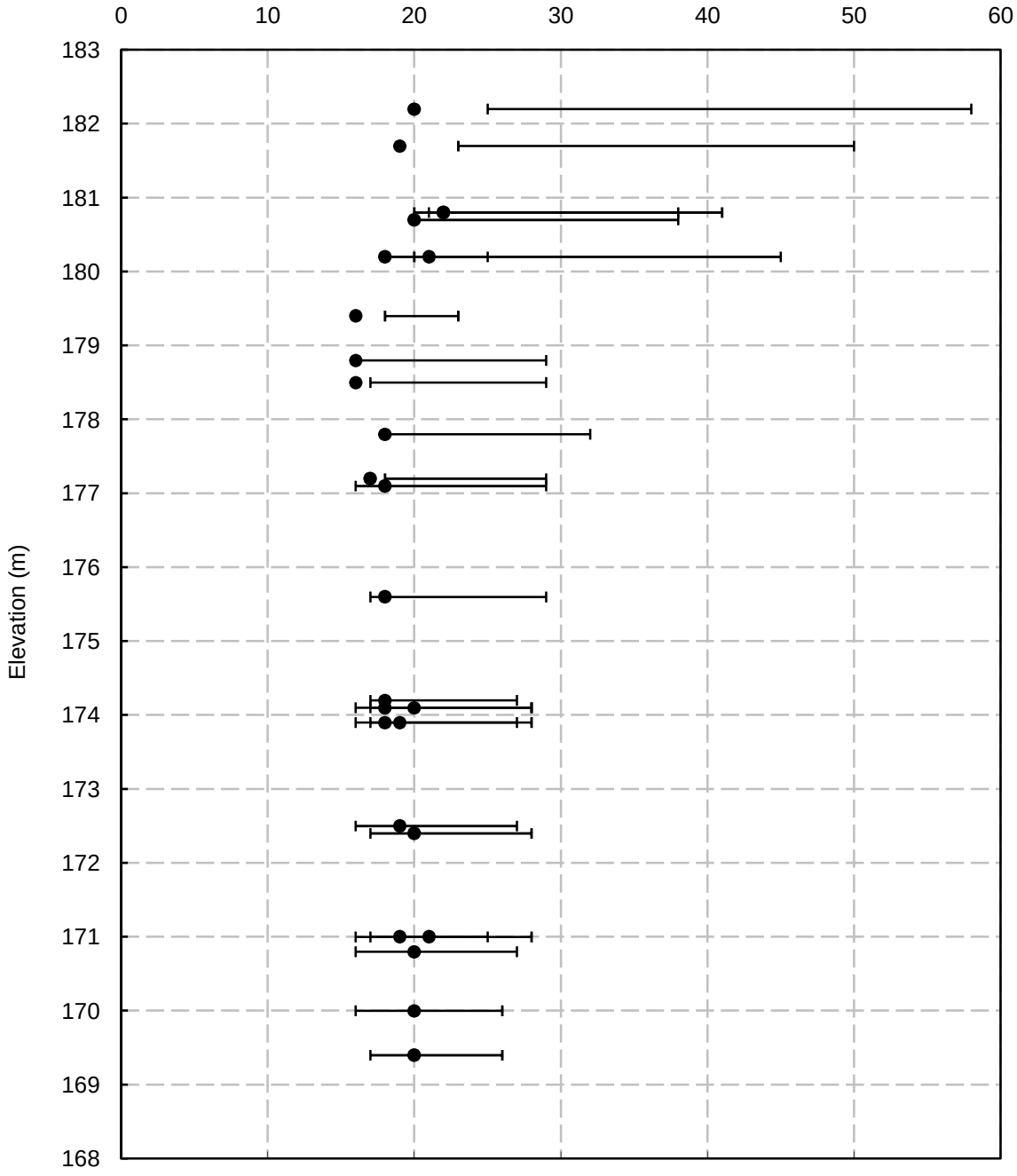
C:\Documents and Settings\HongliuMy Documents\Templates\Analysis\Soil Parameter Estimation.xls

ATTERBERG LIMITS AND WATER CONTENTS	FIGURE B19

HWY 406 TWINNING - WOODLAWN S-EW RAMP

Silty Clay

Atterberg Limits & Water Contents (%)



Project No. : 1-09-4135

Date : September, 2010

Terraprobe Inc.

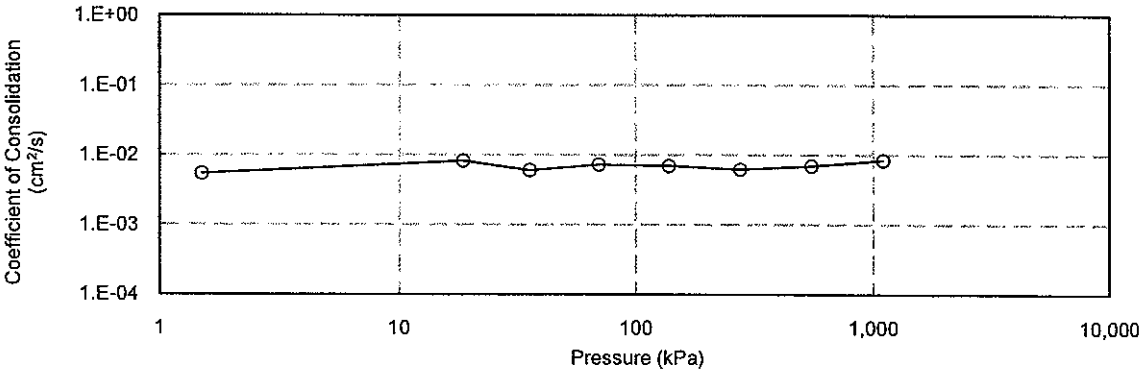
Prepared By : HW

Checked By : RA

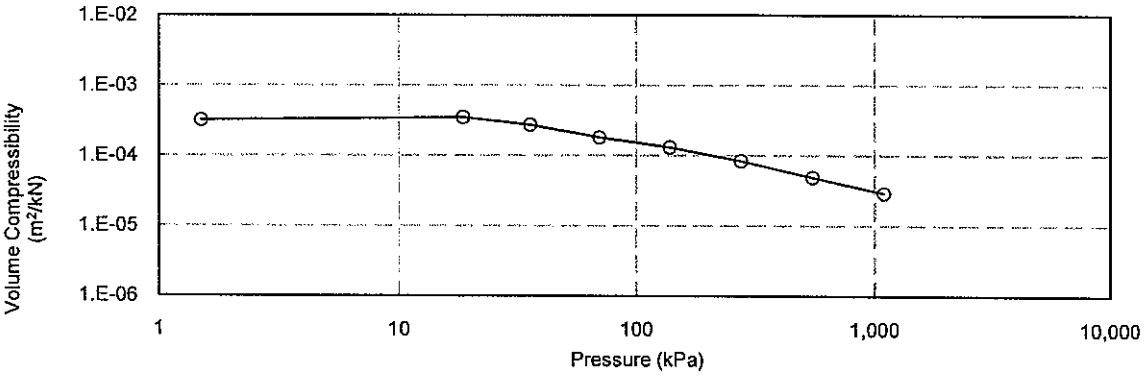
C:\Documents and Settings\Hongliu\My Documents\Templates\Analysis\Soil Parameter Estimation.xls

HWY 406 TWINNING - WOODLAWN S-EW RAMP	FIGURE B20

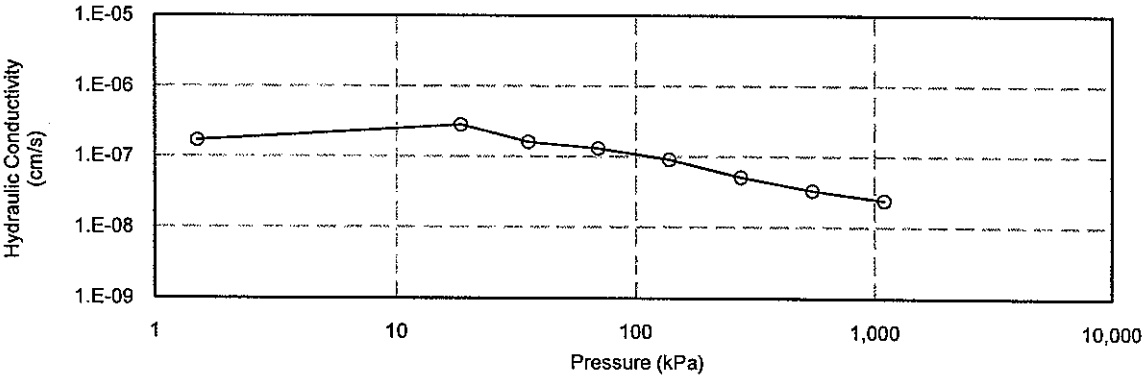
CONSOLIDATION TEST
Cv vs Pressure
TSEW 3, TW13



CONSOLIDATION TEST
mv vs Pressure
TSEW 3, TW13



CONSOLIDATION TEST
k vs Pressure
TSEW 3, TW13



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

Terraprobe Inc.

Prepared By : HW
Checked By : RA

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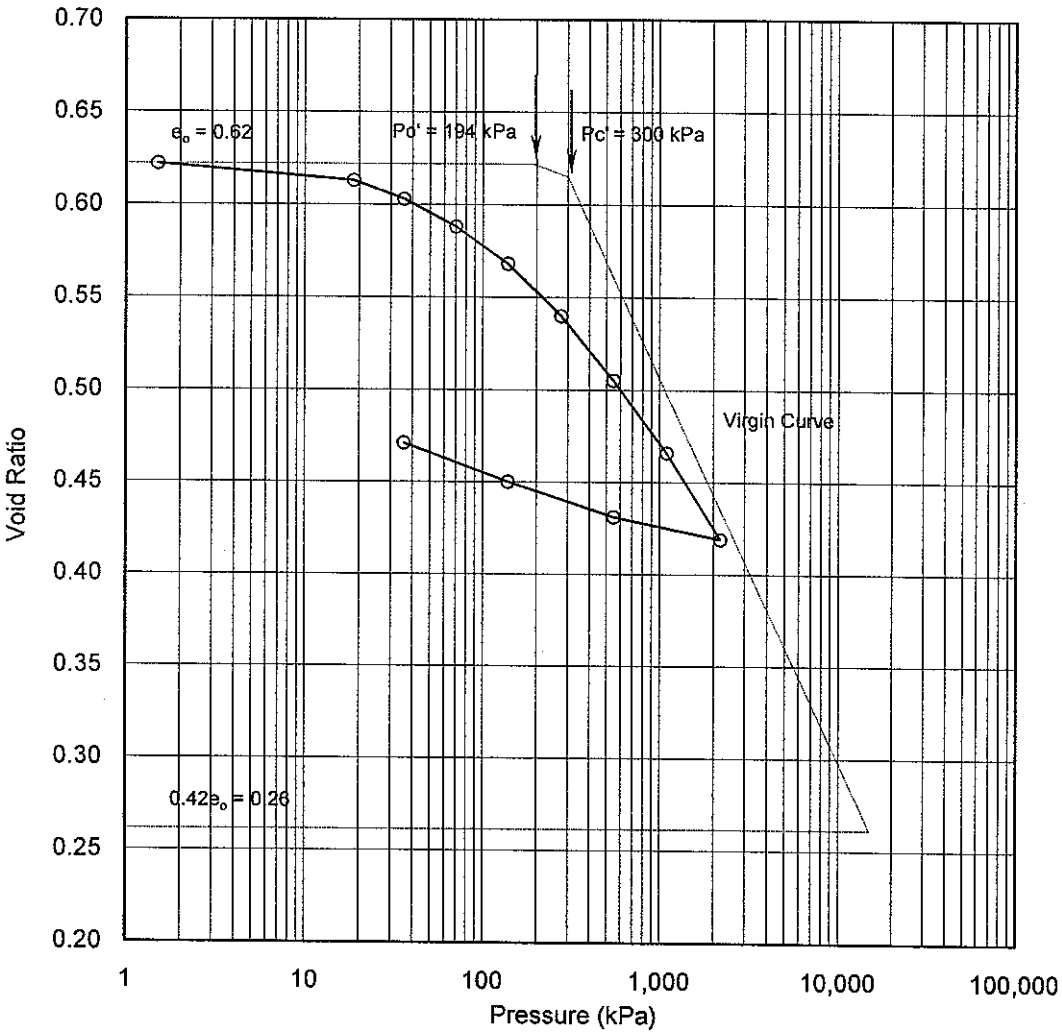
HWY 406 TWINNING - WOODLAWN S-EW RAMP	FIGURE B21

CONSOLIDATION TEST
e vs Pressure
TSEW 3, TW13



Soil Type :	Silty Clay				
e_o =	0.62	ω_L =	27%	Po' =	194 kPa
ω =	20%	ω_P =	16%	Pc' =	300 kPa
γ =	20.8 kN/m^3	PI =	10%	Cc =	0.208
Gs =	2.75			Cr =	0.037

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

Terraprobe Inc.

Prepared By : HW
Checked By : RA

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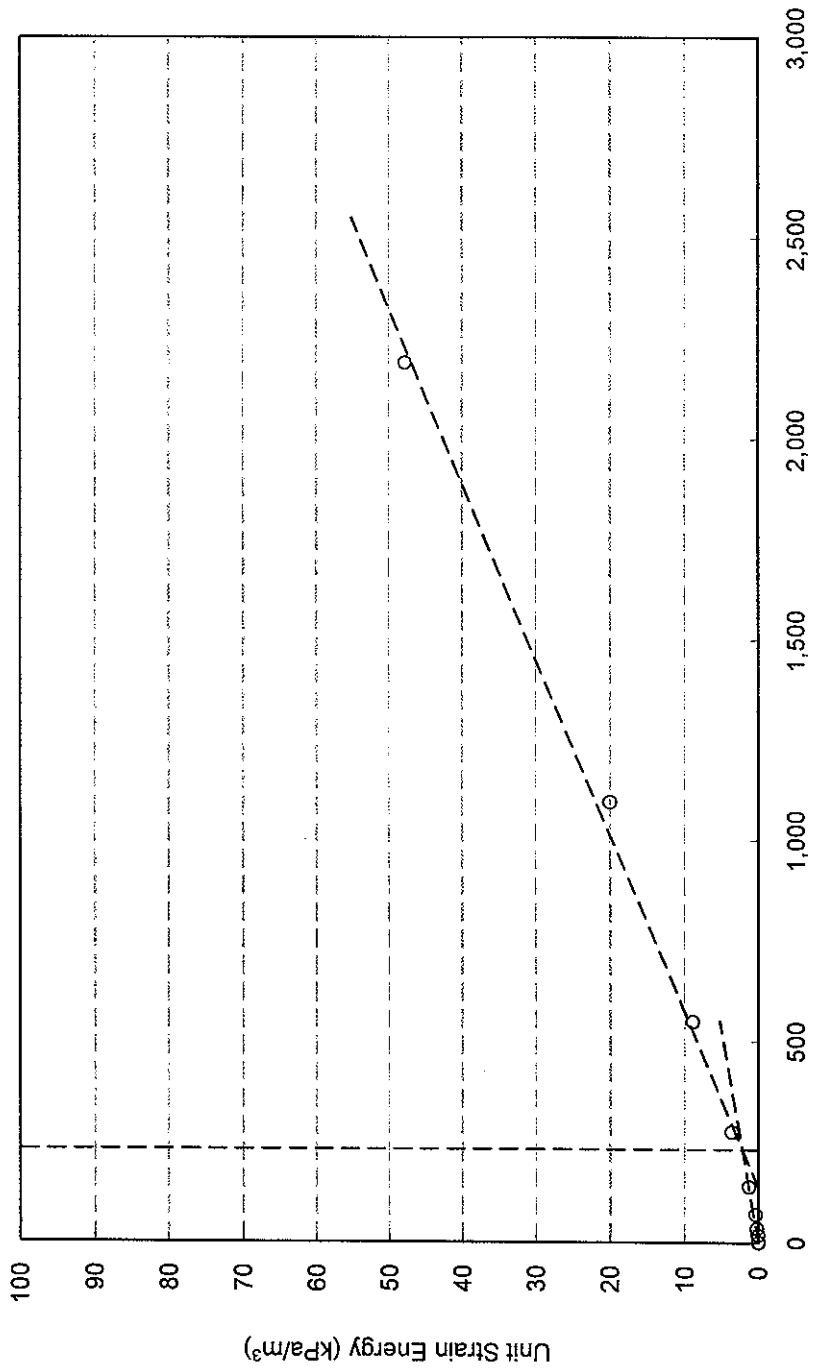
HWY 406 TWINNING - WOODLAWN S-EW RAMP	FIGURE B22



Project No. : 1-09-4135

Date : September 2010

Terraprobe Inc.

Prepared By : HW

Checked By : RA

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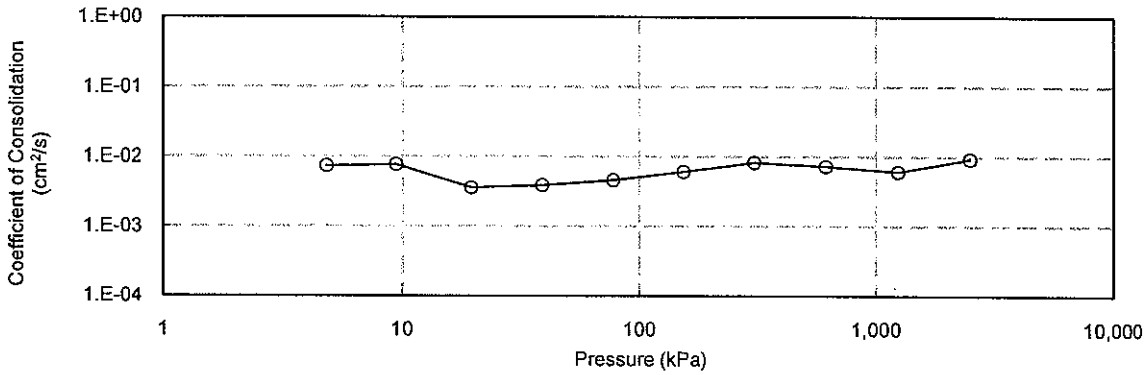
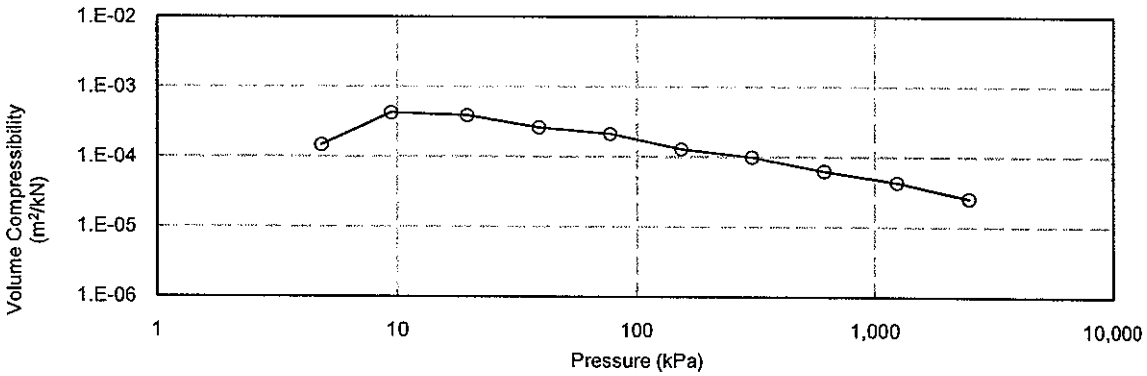
HWY 406 TWINNING - WOODLAWN S-EW RAMP	FIGURE B23

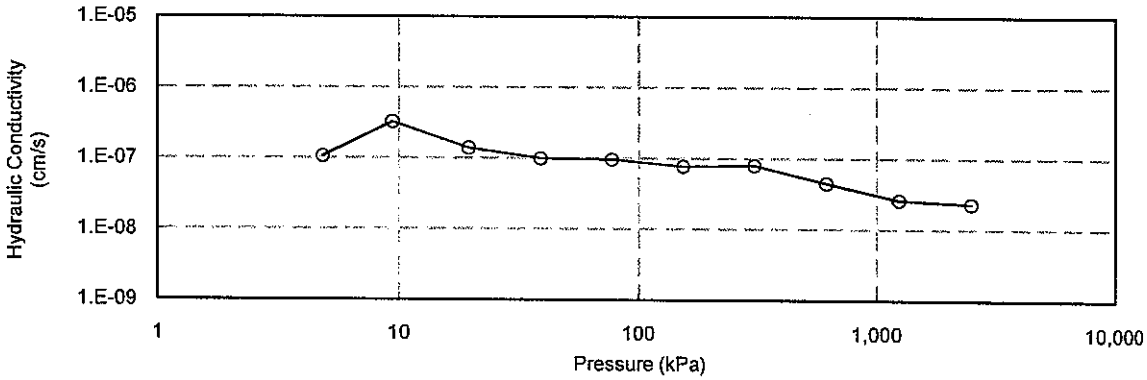
CONSOLIDATION TEST
Cv vs Pressure
SEW 10+050 CL, TW9



CONSOLIDATION TEST
mv vs Pressure
SEW 10+050 CL, TW9



CONSOLIDATION TEST
k vs Pressure
SEW 10+050 CL, TW9



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

Terraprobe Inc.

Prepared By : HW
Checked By : RA

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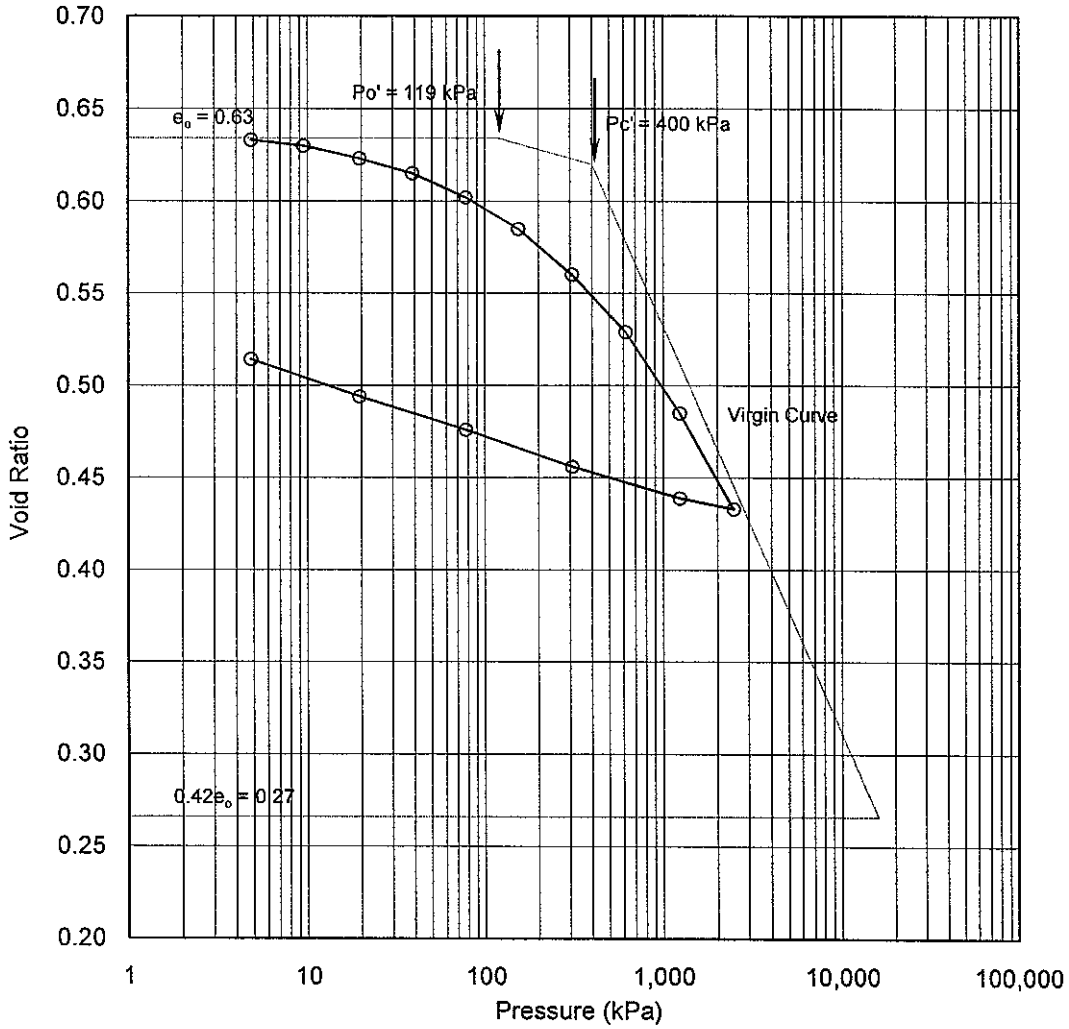
HWY 406 TWINNING - WOODLAWN S-EW RAMP	FIGURE B24

CONSOLIDATION TEST
e vs Pressure
SEW 10+050 CL, TW9



Soil Type :	Silty Clay				
e_o =	0.63	ω_L =	27%	Po' =	119 kPa
ω =	22%	ω_P =	16%	Pc' =	400 kPa
γ =	20.4 kN/m^3	PI =	11%	Cc =	0.221
Gs =	2.78			Cr =	0.027

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

Terraprobe Inc.

Prepared By : HW
Checked By : RA

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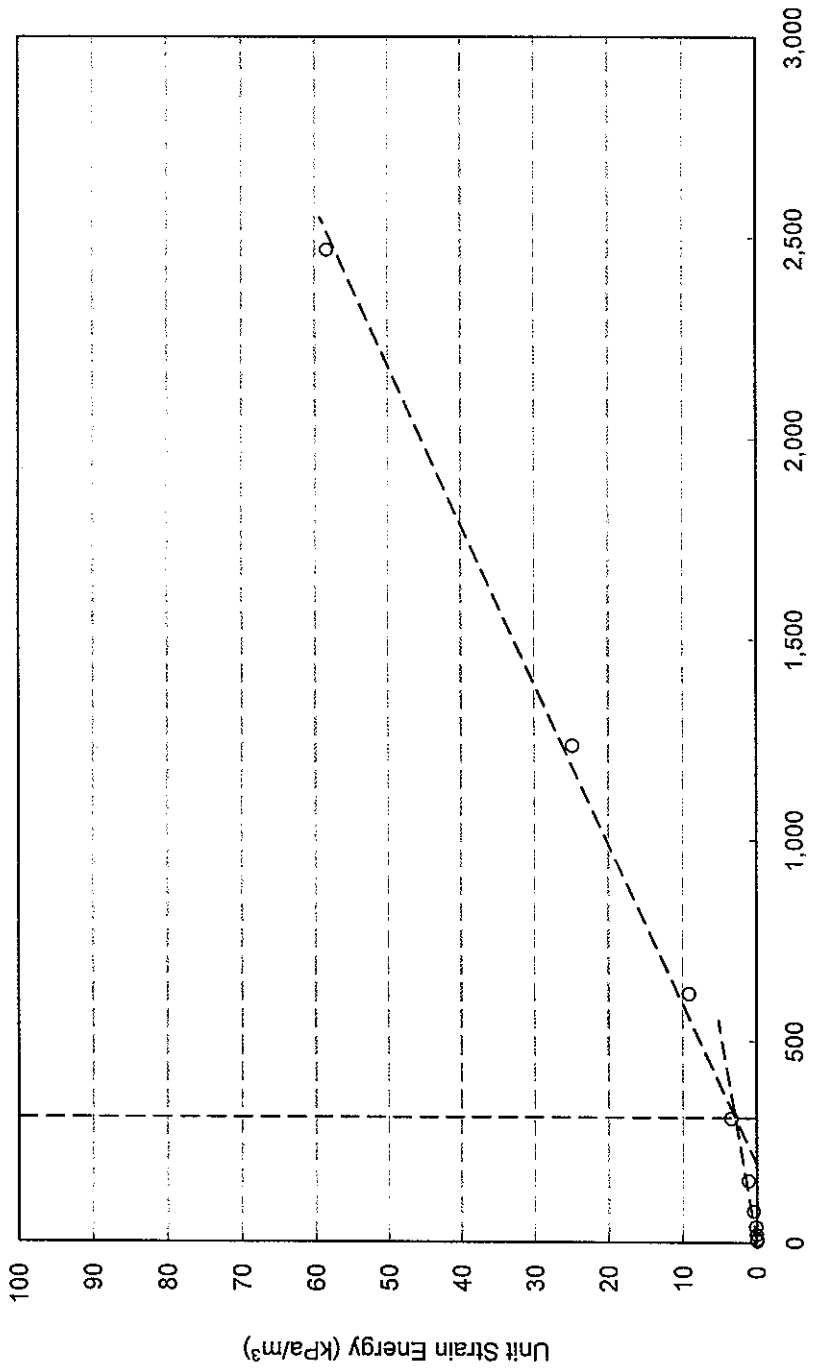
HWY 406 TWINNING - WOODLAWN S-EW RAMP	FIGURE B25



Project No. : 1-09-4135

Date : September 2010

Terraprobe Inc.

Prepared By : HW

Checked By : RA

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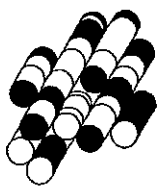
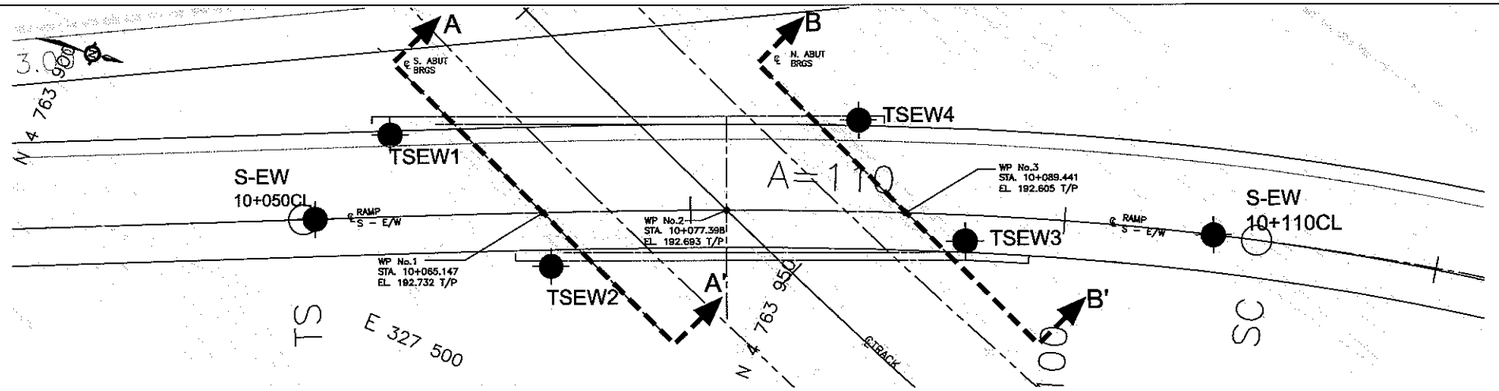
APPENDIX C

Drawings titles "Borehole Locations and Soil Strata"

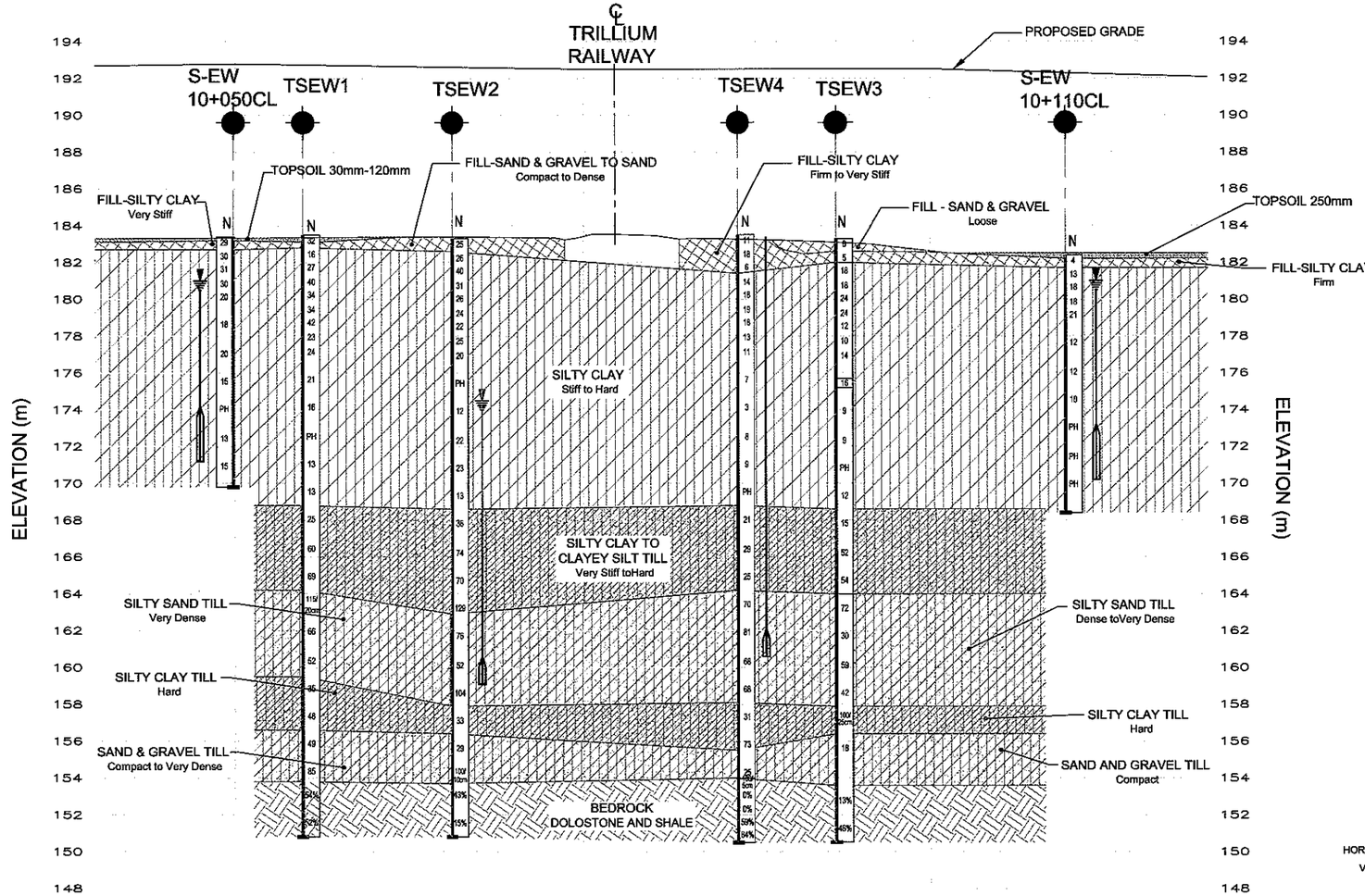
Terraprobe Inc.





PLAN

SCALE
5m 2.5 0 2.5 5m



℄ PROFILE 406S-WOODLAWN E/W RAMP

SCALE
HORIZONTAL 5m 2.5 0 2.5 5m
VERTICAL 4m 4m

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

REGISTERED PROFESSIONAL ENGINEER
M. TANOS
17.9.2010
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
R.A. ABDUL
31/9/17/2010
PROVINCE OF ONTARIO

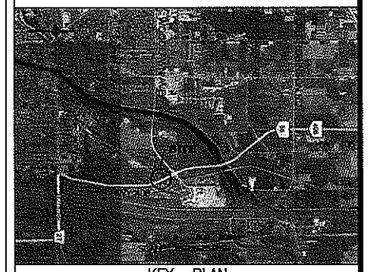
CONT No
WP No 280-99-00

HIGHWAY 406
406S-WOODLAWN E/W RAMP
TRILLIUM RAILWAY OVERHEAD
BOREHOLE LOCATIONS AND STRATA

SHEET 1 OF

Giffels Associates Limited
Consulting Engineers and Architects
An IBI Group Company

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



KEY PLAN

LEGEND

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

No	ELEV.	COORDINATES	
		NORTHING	EASTING
TSEW1	183.5	4 763 922.8	327 487.0
TSEW2	183.3	4 763 936.1	327 490.9
TSEW3	183.3	4 763 960.8	327 478.6
TSEW4	183.5	4 763 951.2	327 473.9
S-EW 10+050CL	183.4	4 763 920.4	327 494.1
S-EW 10+110CL	182.4	4 763 976.0	327 471.7

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

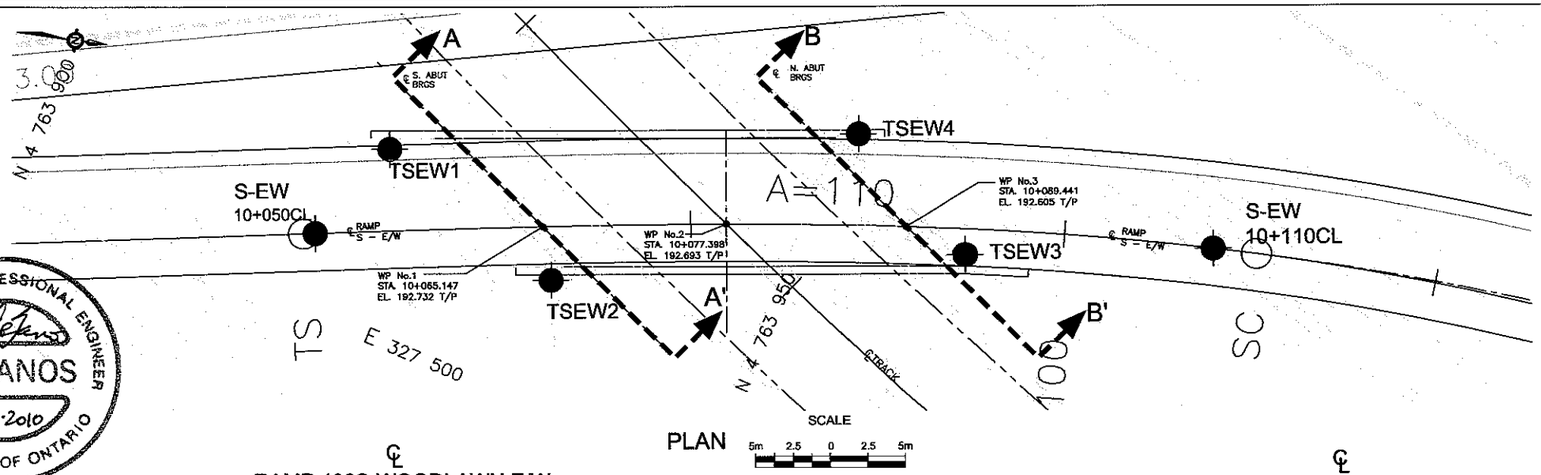
This drawing is for subsurface information only.Surface details and features are for conceptual illustration.

REVISIONS	DATE	BY	DESCRIPTION

DESIGN R.A	CODE CHBDC2006	LOAD	DATE SEPT. 2010
DRAWN K.C	CHK R.A	STRUCT 34-464/4	GEOCRES 30M3-257

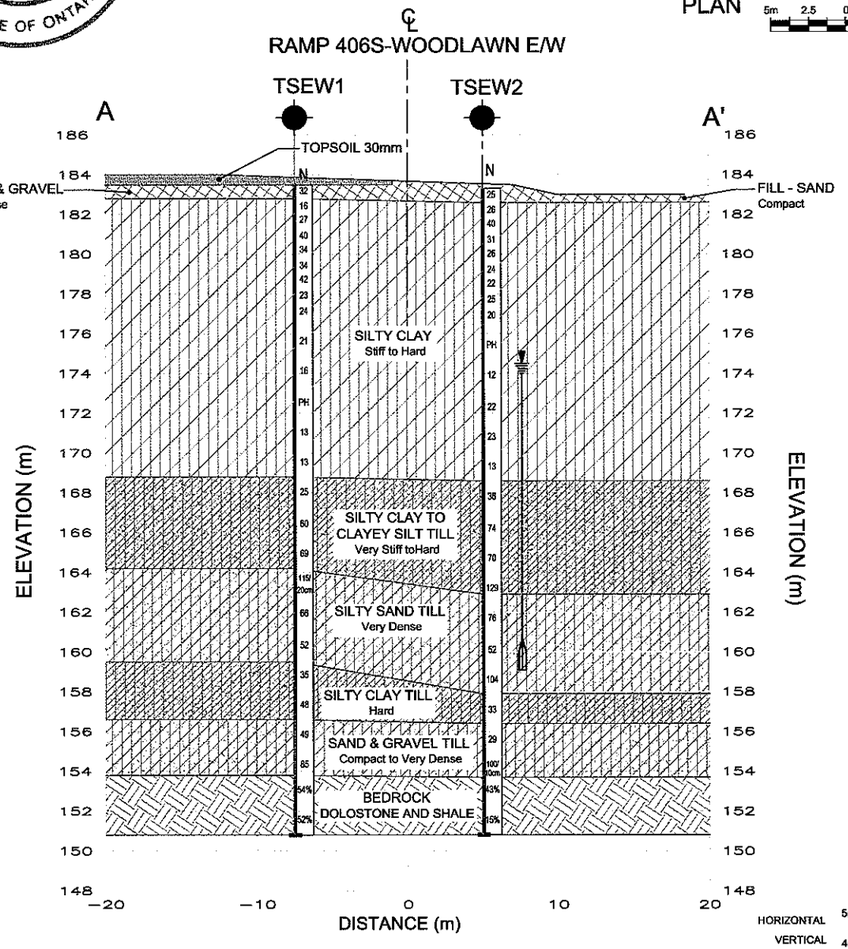
C:\Userfiles\Documents\1-09-4135 HWY 406 BRIDGES\1-09-4135 TRILLIUM RWY BRIDGE.dwg, KAWAL

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

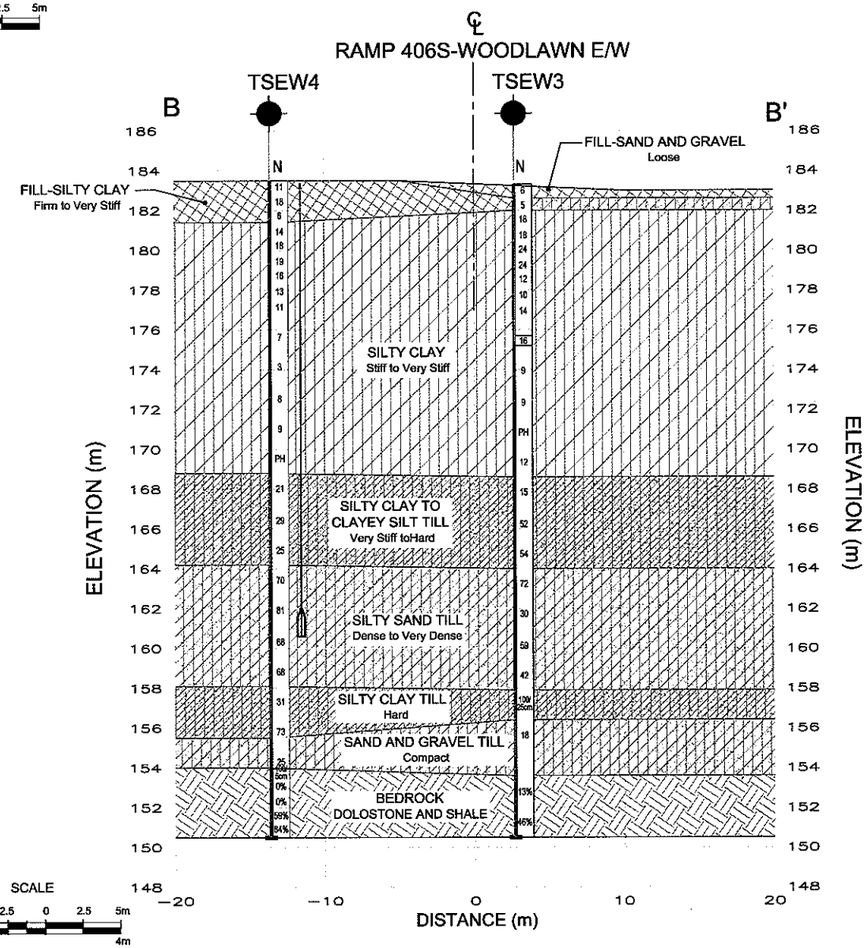


REGISTERED PROFESSIONAL ENGINEER
M. TANOS
17-9-2010
PROVINCE OF ONTARIO

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



SECTION A-A'



SECTION B-B'

SCALE
HORIZONTAL 5m 2.5 0 2.5 5m
VERTICAL 4m 4m

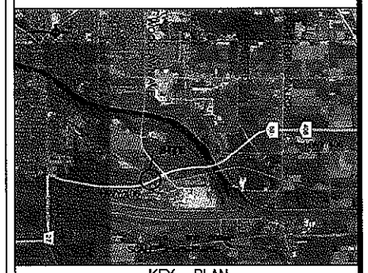
CONT No
WP No 280-99-00

HIGHWAY 406
406S-WOODLAWN E/W RAMP
TRILLIUM RAILWAY OVERHEAD
BOREHOLE LOCATIONS AND STRATA

SHEET 1 OF

Giffels Associates Limited
Consulting Engineers and Architects
An IBI Group Company

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



KEY PLAN

LEGEND

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

No	ELEV.	COORDINATES	
		NORTHING	EASTING
TSEW1	183.5	4 763 922.8	327 487.0
TSEW2	183.3	4 763 936.1	327 490.9
TSEW3	183.3	4 763 960.8	327 478.6
TSEW4	183.5	4 763 951.2	327 473.9
S-EW 10+050CL	183.4	4 763 920.4	327 494.1
S-EW 10+110CL	182.4	4 763 976.0	327 471.7

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

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

REVISIONS			
DATE	BY	DESCRIPTION	

DESIGN R.A	CODE CHBDC2006	LOAD	DATE SEPT. 2010
DRAWN K.C	CHK R.A	STRUCT 34-464/4	GEOCRES 30M3-257

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