



Terraprobe

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

**FOUNDATION INVESTIGATION REPORT
TRILLIUM OVERHEAD, HIGHWAY 406 SBL
HIGHWAY 406 TWINNING
PORT ROBINSON ROAD TO EAST MAIN STREET
AGREEMENT No. 2008-E-0016, W.P. 280-99-00, SITE: 34-464/2
GEOCRES No. 30M3-256**

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File No. 1-09-4135
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**FOUNDATION INVESTIGATION REPORT
TRILLIUM OVERHEAD, HIGHWAY 406 SBL
HIGHWAY 406 TWINNING
ONTARIO**

AGREEMENT No. 2008-E-0016, W.P. 280-99-00, SITE: SITE: 34-464/2

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PART 1: FACTUAL INFORMATION

1 INTRODUCTION

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

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

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

2 SITE DESCRIPTION & PHYSIOGRAPHY

The site is located where the Trillium Railway crosses the existing Highway 406 at a signalized at grade intersection with Highway 406 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 basins¹.

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

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

3 SITE INVESTIGATION AND FIELD TESTING

The site investigation and field testing for this project were carried out between November 17, 2009 and January 13, 2010 and consisted of drilling and sampling six boreholes to depths ranging from 12.7 m to 32.6 m. The boreholes were numbered SBL 12+360CL, SBL 12+410CL, TS1, TS2, TS3, and TS4 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
TS1	28.0/154.6	Hole sealed to 28.0 m with bentonite, piezometer with 1.5 m slotted screen installed with filter sand to 25.0 m and bentonite seal from 25.0 m to ground surface.
TS4	28.3/154.1	Hole sealed to 28.4 m with bentonite, piezometer with 3.0 m slotted screen installed with filter sand to 24.7 m and bentonite seal from 24.7 m to ground surface.
SBL 12+360CL	12.2/170.7	Piezometer with 3.0 m slotted screen installed with filter sand to 9.0 m, bentonite seal from 9.0 m to 8.4 m, drill cuttings from 8.4 m to 0.6 m and bentonite seal from 0.6 m to ground surface.
SBL 12+410CL	12.2/170.3	Piezometer with 1.5 m slotted screen installed with filter sand to 10.3 m, bentonite seal from 10.3 m to 10.0 m, drill cuttings from 10.0 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. 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, unconfined compression test 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, silty clay fill and native overburden deposits of silty clay, clayey silt to silty clay till, sand, and sandy gravel to gravel and sand till. These soils are underlain by bedrock consisting primarily of dolostone and shale of the Salina formation.



5.1 Topsoil

Topsoil ranging from 40 mm to 380 mm in thickness was encountered at this site. Topsoil thickness may vary between and beyond the boreholes.

5.2 Fill – Silty Clay

Silty clay fill material was encountered across this site extending to depths ranging from 0.7 m (Elev.182.2) to 2.1 m (Elev.181.2) below ground surface.

A sample of this fill material was subjected to a grain size analysis and the results are presented in Figure B1. These results show a grain size distribution consisting of 3% gravel, 7% sand, 58% silt and 32% clay size particles.

A sample of the fill was also subjected to an Atterberg Limits test and the results are presented in Figure B2. The index values from this test are summarized below:

Liquid Limit:	31%
Plastic Limit:	18%
Plasticity Index:	13%
Natural Moisture Content:	15%

These values are characteristic of clayey soils of low plasticity.

Standard Penetration tests in the silty clay fill gave 'N' values that ranged from 2 to 21 blows for 0.3 m penetration. Based on these results the fill is considered to have a soft to very stiff consistency. The moisture content of samples of this fill ranged from 15% to 41% by weight.

5.3 Silty Clay

A major silty clay deposit was encountered across the site. This deposit was fully penetrated in some of the boreholes where it was found to extend to depths ranging from 14.7 m to 15.7 m below ground surface or to elevations ranging from 168.1 m to 166.9 m. The approach boreholes were terminated in this deposit at depths of 12.7 m (Elev. 170.2 m) and 13.6 m (Elev. 168.9 m).

The grain size distribution plots of tested samples of the silty clay are presented in Figures B3 to B6 inclusive. These results show a grain size distribution consisting of 0-7% gravel, 1-6% sand, 36-83% silt and 16-62% clay size particles.

Samples were also subjected to Atterberg Limits tests and the results are illustrated on the plasticity charts, Figures B7 to B10 inclusive. The index values from these tests are summarized below:

Liquid Limit:	25-52%
Plastic Limit:	16-24%
Plasticity Index:	8-28%
Natural Moisture Content:	16-33%

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 10 to 61 blows for 0.3 m penetration. Field vane tests gave in-situ undrained shear strengths ranging from 48 kPa to in excess of 100 kPa. An unconfined compression test gave an undrained shear strength of 85 kPa and laboratory vane tests on relatively undisturbed Shelby tube samples gave undrained shear strengths ranging from 70 kPa to 92 kPa. These values indicate that the consistency of the silty clay is generally stiff to hard with infrequent firm zones. Moisture content of samples of the silty clay range from 10% to 33% by weight and the unit weight of selected samples ranged from 20.4 to 20.7 kN/m³

The variation of undrained shear strength with elevation is depicted in Figure B16. The plot illustrates a trend of decreasing shear strength with depth. 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 50 kPa at Elev. 170.0 m. Below Elev. 170.0 m the trend indicates increasing undrained shear strength with depth.

The Atterberg Limits tests results are also plotted against elevation, Figure B17. These results illustrate that the natural moisture contents are generally at or below the plastic limit up to Elev. 178.0 m. Below Elev. 178.0 the moisture content is slightly above the plastic limit and below Elev. 173.0 m the plot illustrates a further increase in moisture content with depth.

Consolidation tests were also performed on Shelby tube samples retrieved from Boreholes SBL 12+360CL and SBL 12+410CL and the results are presented in Figures B18 to B23. These results indicate an estimated preconsolidation pressure that ranges between 300 kPa and 500 kPa.

5.4 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 25.4 m to 27.1 m below ground surface or to elevations of 155.7 m to 157.0 m.

The grain size distribution plots of tested samples from these till deposits are depicted in Figure B11. These results show a grain size distribution consisting of 1-20% gravel, 15-39% sand, 38-57% silt and 15-27% clay size particles. Till soils will also contain random cobble and boulder inclusions.

Samples were also subjected to Atterberg Limits tests and the results are plotted on the plasticity charts, Figures B12 to B13. The index values from these tests are summarized below:

Liquid Limit:	17-24%
Plastic Limit:	11-15%
Plasticity Index:	5-10%
Natural Moisture Content:	9-18%

These values are characteristic of clayey soils of low plasticity.



Standard Penetration tests in these deposits yielded 'N' values ranging from 10 to more than 100 blows per 0.3 m penetration but generally the recorded 'N' values ranged from 22 to more than 100 blows for 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 stiff to hard consistency. The moisture content of samples from these deposits varies from 2% to 18% by weight.

5.5 Sand

Discontinuous layers of sand and gravel to gravelly sand were encountered at this site. These deposits are approximately 0.8 m to 2.4 m thick and extend to depths ranging from 24.8 m (Elev. 157.8 m) to 26.2 m (Elev. 157.1 m) below ground surface.

Two samples from these strata were subjected to a grain size distribution tests and the results are illustrated in Figure B14. These results show a grain size distribution consisting of 31-32 % gravel, 56-57 % sand and 12 % silt size particles.

Standard Penetration tests in these deposits gave 'N' values that ranged from 40 to more than 100 blows per 0.3 m penetration. Based on these results the deposits are considered to have a dense to very dense relative density. The moisture content of samples from these strata ranged from 5% to 14% by weight.

5.6 Sandy Gravel to Gravel and Sand Till

A deposit of sandy gravel to gravel and sand till was encountered across the site overlying the bedrock surface. Cobbles were also encountered in this deposit. This stratum extends to depths ranging from 28.4 m to 29.4 m below ground surface or to elevations ranging from 153.8 m to 154.2 m.

Samples from these deposits were subjected to grain size distribution tests and the results are illustrated in Figure B15. These results show a grain size distribution consisting of 45-51 % gravel, 26-41 % sand, 14-18 % silt and 5 % clay size particles. Till soils will also contain random cobble and boulder inclusions.

Standard Penetration tests in these deposits gave 'N' values that ranged from 77 to more than 100 blows per 0.3 m penetration indicating a dense to very dense relative density. The moisture content of samples from these strata ranged from 1% to 10% by weight.



5.7 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	TS1	28.4	154.2
	TS2	29.4	153.9
North Abutment	TS3	28.7	153.8
	TS4	28.4	154.1

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 20% to 100%. The RQD values ranged widely from 0% to 78% 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.

5.8 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)
TS1	January 19, 2010	10.6	172.0
	January 27, 2010	10.4	172.2
	February 08, 2010	10.5	172.1
TS4	January 11, 2010	9.4	173.0
	January 19, 2010	9.9	172.5
	January 27, 2010	10.2	172.2
	February 08, 2010	10.4	172.0
SBL 12+360CL	November 19, 2009	5.0	177.9
	November 30, 2009	2.6	180.3
	December 07, 2009	2.4	180.5
	December 15, 2009	2.3	180.6
	January 04, 2010	2.1	180.8
	January 11, 2010	2.1	180.8
SBL 12+410CL	November 30, 2009	1.7	180.8
	December 07, 2009	1.4	181.1
	December 15, 2009	1.3	181.2

The ground water table was estimated based on the recorded water levels in the standpipe piezometers, our review of moisture contents of the retrieved samples and the change in colour of the soil matrix from brown to grey. This interpretation indicates an estimated ground water table of Elev. ± 181.0 m.



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

5.9 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 and DBW Drilling Limited of Ajax, 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 supervision. 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.

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5.9 Miscellaneous

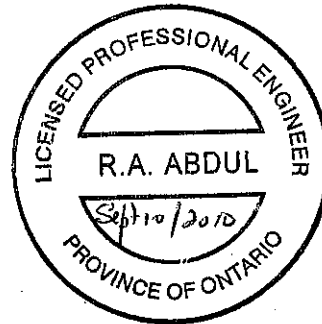
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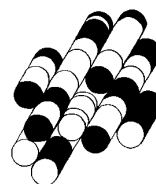
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APPENDICES

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
TV	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
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
μ	1	COEFFICIENT OF FRICTION

MECHANICAL PROPERTIES OF SOIL

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

PHYSICAL PROPERTIES OF SOIL

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

EXPLANATORY SHEET FOR CORE LOG

Column Number

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

Joint (discontinuity) Characteristics

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

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

9. Roughness:

RU = Rough Undulating
SU = Smooth Undulating
LU = Slicksided Undulating

RP = Rough Planar
SP = Smooth Planar
LP = Slicksided 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 ϕ

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

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

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

13. Strength of rock material:

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

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

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

15. Run number and Core Recovery

(i) Drill run number

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

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

Rock Mass Classification (after Deare)

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

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

18. Water recovery, level and tests:

(i) percentage drill water recovery

(ii) water level depth

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

LIMITATIONS AND RISK

Procedures

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

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

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

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

Changes In Site And Scope

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

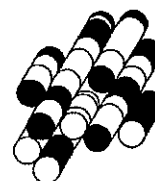
The design advice is based on the factual data obtained from this investigation made at the site by Terraprobe and are intended for use by the owner and its retained designers in the design phase of the project. If there are changes to the project scope and development features, or there is any additional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

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

APPENDIX A

Record of Borehole Sheets Core Logs and Core Photos

Terraprobe Inc.



RECORD OF BOREHOLE No SBL 12+360CL

1 OF 2

METRIC

W.P. 280-99-00 LOCATION Coords: N:4763866.5 E:327470.3 ORIGINATED BY AW
 DIST HWY 406 BOREHOLE TYPE Hollow Stem Augers COMPILED BY DB
 DATUM Geodetic DATE 11.17.09 CHECKED BY RA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT		UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)			
182.9	Ground Surface							20 40 60 80 100	10 20 30				GR SA SI CL
182.9	40mm TOPSOIL		1	SS	19			○ UNCONFINED + FIELD VANE					
182.2	FILL - Silty Clay, trace to some sand, trace gravel, trace organics, very stiff, dark brown, moist							● QUICK TRIAXIAL × LAB VANE					
0.7	SILTY CLAY trace sand, stiff to very stiff, brown, moist		2	SS	25		182					47	0 1 50 49
			3	SS	14		181						
			4	SS	23		180					41	0 1 52 47
			5	SS	18		179						
			6	SS	15		178						
			7	SS	19		177						
			8	SS	12		175						0 3 65 32
			9	SS	10		174	2.0 +					
			10	TW	PH		172	1.1 +				20.7	0 2 74 24
			11	SS	21		171	1.7 +	1.2 +				0 1 83 16
170.2	End of Borehole							1.6 +	2.4 >>>				
12.7	Water level at 9.8m (not stabilized) and hole open to full depth on completion. Consolidation test performed on TW 10.												

Continued Next Page

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

ONTARIO MOT 1-09-4135 TRILLIUM RAILRD.GPJ ONTARIO MOT.GDT 05/18/10

RECORD OF BOREHOLE No SBL 12+360CL

2 OF 2

METRIC

W.P. 280-99-00 LOCATION Coords: N:4763866.5 E:327470.3 ORIGINATED BY AW
DIST HWY 406 BOREHOLE TYPE Hollow Stem Augers COMPILED BY DB
DATUM Geodetic DATE 11.17.09 CHECKED BY RA

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w _p	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL																					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa																													
	<p>Piezometer installation consists of a 19mm diameter, Schedule 40 PVC pipe with a 3.0m slotted screen.</p> <p>Water Level Readings:</p> <table border="1"> <thead> <tr> <th>Date</th> <th>Depth(m)</th> <th>Elevation(m)</th> </tr> </thead> <tbody> <tr> <td>Nov.19.09</td> <td>5.0</td> <td>177.9</td> </tr> <tr> <td>Nov.30.09</td> <td>2.6</td> <td>180.3</td> </tr> <tr> <td>Dec.07.09</td> <td>2.4</td> <td>180.5</td> </tr> <tr> <td>Dec.15.09</td> <td>2.3</td> <td>180.6</td> </tr> <tr> <td>Jan.04.10</td> <td>2.1</td> <td>180.8</td> </tr> <tr> <td>Jan.11.10</td> <td>2.1</td> <td>180.8</td> </tr> </tbody> </table>	Date	Depth(m)	Elevation(m)	Nov.19.09	5.0	177.9	Nov.30.09	2.6	180.3	Dec.07.09	2.4	180.5	Dec.15.09	2.3	180.6	Jan.04.10	2.1	180.8	Jan.11.10	2.1	180.8															
Date	Depth(m)	Elevation(m)																																			
Nov.19.09	5.0	177.9																																			
Nov.30.09	2.6	180.3																																			
Dec.07.09	2.4	180.5																																			
Dec.15.09	2.3	180.6																																			
Jan.04.10	2.1	180.8																																			
Jan.11.10	2.1	180.8																																			

ONTARIO MOT 1-08-4135 TRILLIUM RAILRD.GPJ ONTARIO MOT.GDT 05/14/10

RECORD OF BOREHOLE No TS1

1 OF 3

METRIC

W.P. 280-99-00 LOCATION Coords: N:4763965.7 E:327459.1 ORIGINATED BY MP
DIST HWY 406 BOREHOLE TYPE Hollow Stem Augers / Casing and Washboring / NQ Rock Coring COMPILED BY DB
DATUM Geodetic DATE 01.11.10 - 01.13.10 CHECKED BY RA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							WATER CONTENT (%)			
182.6	Ground Surface						20	40	60	80	100							
0.0	380mm TOPSOIL																	
182.2			1	SS	2													
0.4	FILL - Silty Clay, some organics, trace sand, soft, black, moist																	
181.9			2	SS	20													
0.7	SILTY CLAY trace sand, stiff to hard, brown, damp to moist																	
			3	SS	23													
			4	SS	37											0 3 65 32		
			5	SS	38													
			6	SS	26													
			7	SS	22											0 3 66 31		
			8	SS	24													
			9	SS	17													
						</												

Continued Next Page

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

RECORD OF BOREHOLE No TS1

2 OF 3

METRIC

W.P. 280-99-00 LOCATION Coords: N:4763865.7 E:327459.1 ORIGINATED BY MP
DIST HWY 406 BOREHOLE TYPE Hollow Stem Augers / Casing and Washboring / NQ Rock Coring COMPILED BY DB
DATUM Geodetic DATE 01.11.10 - 01.13.10 CHECKED BY RA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		WATER CONTENT (%)					
								20 40 60 80 100		W _p	W	W _L			
								○ UNCONFINED + FIELD VANE							
								● QUICK TRIAXIAL × LAB VANE							
								20 40 60 80 100		10 20 30					
166.9	CLAYEY SILT TO SILTY CLAY some sand to sandy, trace to some gravel, hard, brown, damp to moist (GLACIAL TILL) occasional to frequent cobbles		14	SS	16										
15.7															
			15	SS	164									12 24 48 16	
			16	SS	110										
			17	SS	100/ 10cm										
161.8	SAND gravelly, some silt, frequent cobbles, very dense, grey, wet														
20.8															
161.0	CLAYEY SILT some gravel, trace sand, hard, brown, damp (GLACIAL TILL)		18	SS	175									32 56 (12)	
21.6															
160.2	SAND gravelly, trace silt, occasional cobbles, dense to very dense, grey, moist to wet														
22.4															
			19	SS	98										
			20	SS	40										
157.8	CLAYEY SILT sandy, trace gravel, hard, brown, damp (GLACIAL TILL)													Jan.12	
24.8															Jan.13
			21	SS	38									1 23 57 19	
155.7	SAND AND GRAVEL trace to some silt, frequent cobbles, very dense, grey / brown, moist (GLACIAL TILL)														
26.9															
			22	SS	100/ 13cm										
154.2	BEDROCK		1	RUN	NQ									RUN#1 TCR=75% SCR=16% RQD=16%	
28.4															RUN#2 TCR=100% SCR=90% RQD=76%
			2	RUN	NQ										

ONTARIO MOT 1-09-4135 TS BRIDGE GPJ ONTARIO MOT GDT 05/19/10

Continued Next Page

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

RECORD OF BOREHOLE No TS1

3 OF 3

METRIC

W.P. 280-99-00 LOCATION Coords: N:4763865.7 E:327459.1 ORIGINATED BY MP
 DIST HWY 406 BOREHOLE TYPE Hollow Stem Augers / Casing and Washboring / NQ Rock Coring COMPILED BY DB
 DATUM Geodetic DATE 01.11.10 - 01.13.10 CHECKED BY RA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE												
							20	40	60	80	100	10	20	30	kN/m ³	GR SA SI CL				
151.4	BEDROCK - INTERBEDDED DOLOSTONE AND SHALE Unweathered, thinly laminated, grey, medium strength, argillaceous with unweathered, laminated, white, very low strength gypsum and calcite layers / veins and frequent unweathered, white, low strength, coarse grained calcitic vugs. End of Borehole 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. 19.10 10.6 172.0 Jan. 27.10 10.4 172.2 Feb. 08.10 10.5 172.1 Borehole sealed with bentonite slurry from 31.2m to 28.1m and from 25.0m to ground surface.		3	RUN	NQ	152										RUN#3 TCR=96% SCR=81% RQD=72%				
31.2																				

CORE LOG



Terraprobe

Project	Highway 406 Twinning	Orientation	Vertical	Ground Elevation	182.6m	Datum	Geodetic	Borehole No.	TS1
Location	Welland, Ontario	Date Started	January 13, 2010	Completed	January 13, 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								WEATHERING	STRENGTH	FRACTURE FREQUENCY	RUN NO. CORE RECOVERY %	R Q D %	CORE SIZE/CASING	UNCONFINED COMPRESSIVE STRENGTH MPa	UNIT WEIGHT (kN/m ³)
				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	
155.1	27.5																		
154.6	28.0		Overburden, see Borehole Log TS1																
154.5	28.1		Overburden, SAND AND GRAVEL TILL																
154.2	28.4		frequent cobbles, see Borehole Log TS1																
154.1	28.5			1	B	F	VC	SP	T	0 to 1				#1 TCR 75 SCR 16	16	NQ			
				1	B	F	C	SP	T										
				1	B	F	VC	SP	T										
				1	B	F	C	SP	T										
				1	B	F	VC	SP	T										
153.6	29.0		SALINA FORMATION BEDROCK																
				1	B	F	VC	SP	T										
				1	B	F	M	SP	T	0 to 1				#2 TCR 100 SCR 90	76	NQ			
153.1	29.5		INTERBEDDED DOLOSTONE AND SHALE																
			Unweathered, thinly laminated, grey, medium strength, argillaceous with unweathered, laminated, white, very low strength gypsum and calcite layers / veins and frequent unweathered, white, low strength, coarse grained calcitic vugs.	1	B	F	VC	SP	T										
				1	B	F	C	SP	T										
				1	B	F	VC	SP	T										
152.6	30.0			1	B	F	M	SP	T										
				1	B	F	VC	SP	T										
				1	B	F	VC	SP	T										
152.1	30.5			1	B	F	M	SP	T	0 to 1				#3 TCR 96 SCR 81	72	NQ			
				1	B	F	VC	SP	T										
151.6	31.0																		
151.4	31.2		End of Core Log																
151.1	31.5		<u>Rubblelized zones of:</u> 28.40-28.50m; 28.68-28.78m; 28.98-29.01m; 29.67-29.69m; 29.80-29.82m; 30.25-30.35m.																
150.6	32.0		Rubble indicated by 'a'.																
150.1	32.5																		
149.6	33.0																		
149.1	33.5																		

Remarks:

LEGEND:

	Interbedded Dolostone and Shale
	Sand and Gravel Till
	Rubble

RECORD OF BOREHOLE No TS2

1 OF 3

METRIC

W.P. 280-99-00 LOCATION Coords: N:4763881.2 E:327466.3 ORIGINATED BY PK
DIST HWY 406 BOREHOLE TYPE Hollow Stem Augers / NQ Rock Coring COMPILED BY DB
DATUM Geodetic DATE 11.30.09 - 12.08.09 CHECKED BY RA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)
183.3	Ground Surface							20 40 60 80 100								
0.0	FILL - Silty Clay, trace sand, trace gravel, trace organics, stiff to very stiff, dark brown / brown, damp to moist		1	SS	12		183									
			2	SS	12		182								3 7 58 32	
			3	SS	21											
181.2	SILTY CLAY trace sand, trace gravel, very stiff to hard, brown, damp to moist		4	SS	32		181								Nov.30 Dec.03	
2.1			5	SS	61		180									
			6	SS	25		179									
			7	SS	25		178									
			8	SS	21		177								1 3 66 30	
			9	SS	15		176									
							175									
							174								0 3 67 30	
							173									
							172									
							171									
							170									
							169									
				12	SS	14										
				13	SS	14										
			14	SS	18									7 1 66 26		
			15	TW	PH											

Continued Next Page

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

ONTARIO MOT. 1-09-4135 TRILLIUM RAILRD.GPJ ONTARIO MOT.GDT 05/14/10

RECORD OF BOREHOLE No TS2

2 OF 3

METRIC

W.P. 280-99-00 LOCATION Coords: N:4763881.2 E:327466.3 ORIGINATED BY PK
DIST HWY 406 BOREHOLE TYPE Hollow Stem Augers / NQ Rock Coring COMPILED BY DB
DATUM Geodetic DATE 11.30.09 - 12.08.09 CHECKED BY RA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL						
168.1 15.2	SILTY CLAY trace to some sand, trace gravel, very stiff to hard, brown, damp to moist (GLACIAL TILL) ---- frequent wet sand and gravel inclusions ----		16	SS	22										8 15 50 27 Dec.03 Dec.04	
			17	SS	26											
			18	SS	121											
			19	SS	47											
162.5 20.8	SAND gravelly, some silt, dense, brown, wet		20	SS	50										31 57 (12)	
160.9 22.4	CLAYEY SILT and sand, trace gravel, very stiff, brown, damp (GLACIAL TILL)		21	SS	30										7 39 38 16	
159.4 23.9	SAND gravelly, trace silt, dense, grey, moist to wet		22	SS	47										Dec.04 Dec.07	
157.1 26.2	CLAYEY SILT sandy, trace gravel, hard, brown, damp (GLACIAL TILL)		23	SS	61											
156.2 27.1	SAND AND GRAVEL some silt, trace to some clay, occasional cobbles, very dense, brown / grey, moist (GLACIAL TILL)		24	SS	77											
153.9 29.4	BEDROCK		25	SS	155/ 18cm										Dec.07 Dec.08	

ONTARIO MOT 1-09-4135 TRILLIUM RAILRD.GPJ ONTARIO MOT.GDT 05/14/10

Continued Next Page

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

CORE LOG



Terraprobe

Project	Highway 406 Twinning	Orientation	Vertical	Ground Elevation	183.3m	Datum	Geodetic	Borehole No.	TS2
Location	Welland, Ontario	Date Started	December 8, 2009	Completed	December 8, 2009	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								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			
154.8	28.5																				
154.3	29.0																				
153.9	29.4		Overburden, see Borehole Log TS2																		
153.8	29.5	a		1	B	F	VC	SP	T												
			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	C	SP	T	0 to 1				#1 TCR 74 SCR 60	28	NQ					
152.8	30.5																				
152.3	31.0	a		1	B	F	VC	SP	T	0 to 1											
151.8	31.5	a		1	B	F	VC	RU	S	0 to 5				#2 TCR 100 SCR 98	78	NQ					
151.3	32.0			1	B	F	M	SP	T	0 to 1											
150.8	32.5		End of Core Log																		
150.3	33.0		<u>Rubble zones at:</u> 29.40-29.65m; 30.90-30.95m; 31.43-31.47m. Rubble indicated by 'a'.																		
149.8	33.5		<u>Highly fractured zones at:</u> 29.65-30.00m.																		
149.3	34.0		<u>Slightly weathered zones at:</u> 31.43-31.47m.																		
148.8	34.5																				

Remarks:

LEGEND:

- Interbedded Dolostone and Shale
- Rubble

RECORD OF BOREHOLE No TS3

1 OF 3

METRIC

W.P. 280-99-00 LOCATION Coords: N:4763891.8 E:327445.1 ORIGINATED BY LY
DIST HWY 406 BOREHOLE TYPE Hollow Stem Augers / NQ Rock Coring COMPILED BY DB
DATUM Geodetic DATE 12.15.09 - 12.16.09 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 ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	W _p	W	W	W	W _L	W _L		
182.5	Ground Surface																
0.0	FILL - Silty Clay, trace sand, trace gravel, trace organics, firm, brown, moist		1	SS	5		182										
181.8			2	SS	46		181										
0.7	SILTY CLAY trace sand, very stiff to hard, brown, damp to moist		3	SS	39		180										0 2 36 62
			4	SS	32		179										
			5	SS	36		178										
			6	SS	44		177										0 6 61 33
			7	SS	46		176										
			8	SS	28		175										
			9	SS	29		174										0 3 64 33
			10	SS	19		173										
			11	TW	PH		172										Dec.15 Dec.16
			12	SS	18		171										0 3 69 28
			13	SS	18		170										
			14	SS	26		169										
167.8							168										
14.7																	

ONTARIO MOT 1-09-4135 TRILLUM RAILRD.GPJ ONTARIO MOT.GDT 05/14/10

Continued Next Page

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

METRIC

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

DEPTH (m)	SOIL TYPE	SS (%)	SC (%)	RC (%)
161.7	CLAYEY SILT TO SILTY CLAY some sand to sandy, trace to some gravel, occasional cobbles, hard, brown, damp (GLACIAL TILL)	15	SS	73
160.6	SAND gravelly, trace silt, very dense, grey, moist	16	SS	83
159.1	CLAYEY SILT trace sand, trace gravel, occasional cobbles, very stiff, brown, damp (GLACIAL TILL)	17	SS	66
157.7	SAND and gravel, trace silt, very dense, grey, moist	18	SS	53
156.2	SILTY CLAY trace sand, trace gravel, occasional cobbles, hard, brown, moist (GLACIAL TILL)	19	SS	82
153.8	SANDY GRAVEL some silt, trace clay, frequent cobbles, very dense, brown, moist (GLACIAL TILL)	20	SS	21
153.8	BEDROCK	21	SS	83
153.8	BEDROCK	22	SS	31
153.8	BEDROCK	23	SS	102
153.8	BEDROCK	1	RUN	NQ

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

RECORD OF BOREHOLE No TS3

3 OF 3

METRIC

W.P. 280-99-00 LOCATION Coords: N:4763891.8 E:327445.1 ORIGINATED BY LY
DIST HWY 406 BOREHOLE TYPE Hollow Stem Augers / NQ Rock Coring COMPILED BY DB
DATUM Geodetic DATE 12.15.09 - 12.16.09 CHECKED BY RA

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES		20	40	60	80	100	w_p	w	w_L		
							SHEAR STRENGTH kPa					WATER CONTENT (%)				
							○ UNCONFINED + FIELD VANE									
							● QUICK TRIAXIAL × LAB VANE									
							20	40	60	80	100	10	20	30		
149.9	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.		2	RUN	NQ											SCR=56% RQD=22%
32.6			3	RUN	NQ											RUN#3 TCR=92% SCR=82% RQD=34%
	End of Borehole															
	Unable to push vane beyond 13.3m and 14.4m.															
	No sample recovery at SS19.															
	Borehole sealed with bentonite slurry to ground surface.															

ONTARIO MOT 1-09-4135 TRILLIUM RAILRD.GPJ ONTARIO MOT.GDT 05/14/10

CORE LOG



Terraprobe

Project	Highway 406 Twinning	Orientation	Vertical	Ground Elevation	182.5m	Datum	Geodetic	Borehole No.	TS3
Location	Welland, Ontario	Date Started	December 16, 2009	Completed	December 16, 2009	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								WEATHERING	STRENGTH	FRACTURE FREQUENCY	RUN NO.	CORE RECOVERY %	R Q D %	CORE SIZE/CASING	MPa UNCONFINED COMPRESSIVE STRENGTH	UNIT WEIGHT (kN/m ³)
				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		
155.0	27.5																			
			Overburden, see Borehole Log TS3																	
154.5	28.0		Overburden, SANDY GRAVEL TILL frequent cobbles, see Borehole Log TS3																	
154.0	28.5																			
153.8	28.7																			
153.5	29.0																			
			SALINA FORMATION BEDROCK	1	B	F	VC	RP	T	0 to 1										
153.0	29.5		INTERBEDDED DOLOSTONE AND SHALE Unweathered, thinly laminated, grey, medium strength, argillaceous with unweathered, laminated, white, very low strength gypsum and calcite layers / veins and frequent unweathered, white, low strength, coarse grained calcitic vugs.	1	B	F	VC	SP	T											
				1	B	F	C	SP	T											
				1	B	F	VC	SP	T											
152.5	30.0			1	B	F	C	RP	T	0 to 1										
				1	B	F	VC	RP	T											
152.0	30.5			1	B	F	C	SP	T											
151.5	31.0			1	B	F	VC	RP	S	0 to 5										
151.0	31.5			1	B	F	C	SP	T											
				1	B	F	VC	SP	T	0 to 1										
				1	B	F	C	SP	T											
150.5	32.0			1	B	F	C	SP	T											
150.0	32.5																			
149.9	32.6																			
			End of Core Log Rubble indicated by 'e'. Rubble indicated																	

Remarks:

LEGEND:

	Interbedded Dolostone and Shale
	Sandy Gravel Till
	Rubble

RECORD OF BOREHOLE No TS4

1 OF 3

METRIC

W.P. 280-99-00 LOCATION Coords: N:4763903.8 E:327455.3 ORIGINATED BY LY
DIST HWY 406 BOREHOLE TYPE Hollow Stem Augers / Casing and Washboring / NQ Rock Coring COMPILED BY DB
DATUM Geodetic DATE 12.17.09 - 12.22.09 CHECKED BY RA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
182.4	Ground Surface													
0.0	FILL - Silty Clay, trace sand, trace gravel, trace organics, firm, brown, moist		1	SS	6		182							
181.7			2	SS	51		181							
0.7	SILTY CLAY trace sand, stiff to hard, brown, damp to moist		3	SS	36		180							
			4	SS	39		179							
			5	SS	52		178							
			6	SS	29		177							
			7	SS	26		176							
			8	SS	16		175							
			9	TW	PH		174							
			10	SS	14		173							
			11	SS	27		172							
			12	SS	13		171							
			13	SS	17		170							
							169							
							168							

Continued Next Page

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

RECORD OF BOREHOLE No TS4

2 OF 3

METRIC

W.P. 280-99-00 LOCATION Coords: N:4763903.8 E:327455.3 ORIGINATED BY LY
DIST HWY 406 BOREHOLE TYPE Hollow Stem Augers / Casing and Washboring / NQ Rock Coring COMPILED BY DB
DATUM Geodetic DATE 12.17.09 - 12.22.09 CHECKED BY RA

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W _p	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20					
164.3	CLAYEY SILT TO SILTY CLAY some sand, some gravel, frequent cobbles, stiff to hard, brown, damp (GLACIAL TILL)		14	SS	10								16 19 49 16
164.3			15	SS	100/ 28cm								
164.3			16	SS	77								
164.3			17	SS	80								
164.3			18	SS	76								
164.3			19	SS	100/ 28cm								
164.3			20	SS	25								
164.3			21	SS	100/ 25cm								
164.3			22	SS	100/ 18cm								45 41 (14)
164.3			1	RUN	NQ								Dec.21 RUN#1 TCR=90% SCR=72% RQD=41%
164.3													RUN#2

Continued Next Page

+ 3, X 3: Numbers refer to
Sensitivity

○ 3% STRAIN AT FAILURE



ONTARIO MOT 1-09-4135 TS BRIDGE.GPJ ONTARIO MOT.GDT 05/20/10

RECORD OF BOREHOLE No TS4

3 OF 3

METRIC

W.P. 280-99-00 LOCATION Coords: N:4763903.8 E:327455.3 ORIGINATED BY LY
DIST HWY 406 BOREHOLE TYPE Hollow Stem Augers / Casing and Washboring / NQ Rock Coring COMPILED BY DB
DATUM Geodetic DATE 12.17.09 - 12.22.09 CHECKED BY RA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					W _p W W _L					
								20	40	60	80	100						
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE					WATER CONTENT (%)					
								20	40	60	80	100		10	20	30		
	BEDROCK (continued)						152											TCR=99% SCR=92% RQD=43%
	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		2	RUN	NQ													
150.4			3	RUN	NQ		151											RUN#3 TCR=83% SCR=79% RQD=31%
32.0	End of Borehole																	
	Unable to push vane beyond 8.8m, 11.4m and 14.9m.																	
	No sample recovery at SS12 and SS13. Sampler redriven and disturbed sample collected.																	
	Resistance to augering at 23.2m, 25.0m and 27.1m.																	
	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)																	
	Jan.11.10 9.4 173.0																	
	Jan.19.10 9.9 172.5																	
	Jan.27.10 10.2 172.2																	
	Feb.08.10 10.4 172.0																	

ONTARIO MOT 1-09-4135 TRILLIUM RAILRD.GPJ ONTARIO MOT.GDT 05/14/10

CORE LOG



Terraprobe

Project	Highway 406 Twinning	Orientation	Vertical	Ground Elevation	182.4m	Datum	Geodetic	Borehole No.	TS4
Location	Welland, Ontario	Date Started	December 22, 2009	Completed	December 22, 2009	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								WEATHERING	STRENGTH	FRACTURE FREQUENCY	RUN NO.	CORE RECOVERY %	R Q D %	CORE SIZE/CASING	UNCONFINED COMPRESSIVE STRENGTH MPa	UNIT WEIGHT (kN/m³)
				No. OF SETS	JOINT TYPE	ORIENTATION	SPACING	ROUGHNESS	FILLING	APERTURE										
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19		
154.9	27.5																			
154.4	28.0																			
154.0	28.4		Overburden, see Borehole Log TS4																	
153.9	28.5		SALINA FORMATION BEDROCK	1	B	F	VC	SP	T											
				1	B	F	C	SP	T											
			INTERBEDDED DOLOSTONE AND SHALE	1	B	F	VC	SP	T											
153.4	29.0		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 90 SCR 72	41	NQ				
152.9	29.5																			
152.4	30.0			1	B	F	C	SP	T											
				1	B	F	VC	SP	T											
151.9	30.5			1	B	F	C	SP	T	0 to 1				#2 TCR 99 SCR 92	43	NQ				
151.4	31.0			1	B	F	VC	SU	T											
				1	B	F	C	SP	T											
				1	B	F	VC	SP	T											
				1	B	F	C	SP	T											
150.9	31.5			1	B	F	C	SP	T	0 to 1				#3 TCR 83 SCR 79	31	NQ				
				1	B	F	VC	SP	T											
				1	B	F	C	SP	T											
150.4	32.0		End of Core Log																	
			Rubblelized zones at: 28.40-28.60m; 28.75-28.85m; 30.95-30.98m; 31.16-31.18m; 31.60-31.64m. Rubble indicated by 'a'.																	
149.9	32.5		Highly fractured zone at: 30.27-30.42m.																	
149.4	33.0																			
148.9	33.5																			

Remarks:

LEGEND:

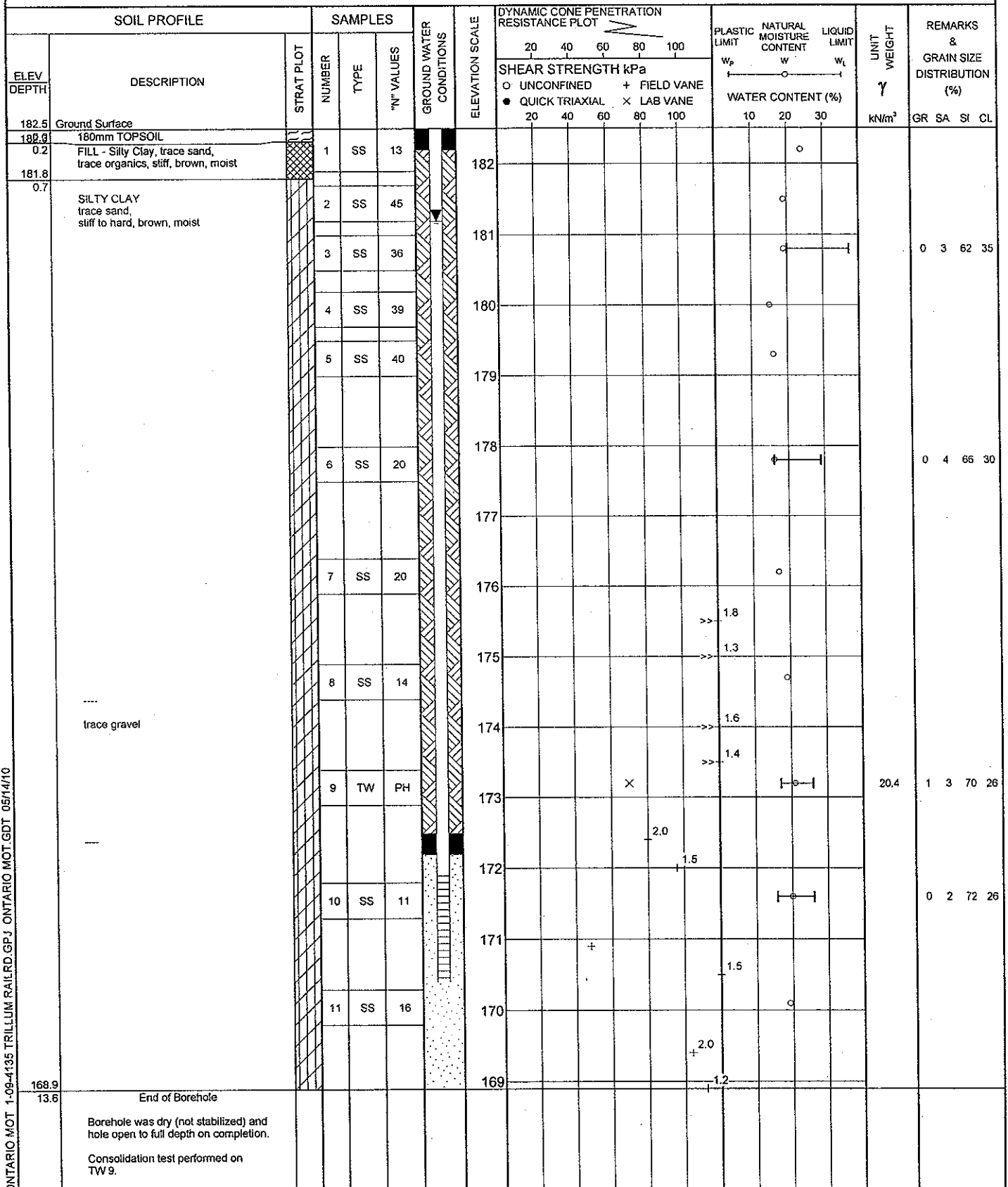
- Interbedded Dolostone and Shale
- Rubble

RECORD OF BOREHOLE No SBL 12+410CL

1 OF 2

METRIC

W.P. 280-99-00 LOCATION Coords: N:4763911.8 E:327444.8 ORIGINATED BY PK
DIST HWY 406 BOREHOLE TYPE Hollow Stem Augers COMPILED BY DB
DATUM Geodetic DATE 11.18.09 CHECKED BY RA



Continued Next Page

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

ONTARIO MOT 1-09-4135 TRILLIUM RAIL RD.GPJ ONTARIO MOT.GDT 05/14/10

RECORD OF BOREHOLE No SBL 12+410CL

2 OF 2

METRIC

W.P. 280-99-00 LOCATION Coords: N:4763911.8 E:327444.8 ORIGINATED BY PK
DIST HWY 406 BOREHOLE TYPE Hollow Stem Augers COMPILED BY DB
DATUM Geodetic DATE 11.18.09 CHECKED BY RA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100	w_p	w	w_L		
	<p>No sample recovery at SS8. Sampler redriven and disturbed sample collected.</p> <p>Piezometer installation consists of a 19mm diameter, Schedule 40 PVC pipe with a 1.52m slotted screen.</p> <p>Water Level Readings: Date Depth(m) Elevation(m) Nov.30.09 1.7 180.8 Dec.07.09 1.4 181.1 Dec.15.09 1.3 181.2</p>																

ONTARIO MOT 1-09-4135 TRILLIUM RAILRD.GPJ ONTARIO MOT.GDT 05/14/10

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



Bedrock Core Sample

Borehole: TS1

Runs: 1, 2 & 3

Depth: 28.1m – 31.2m



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



Bedrock Core Sample

Borehole: TS2

Runs 1 & 2

Depth: 29.4m – 32.5m



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



Bedrock Core Sample

Borehole: TS3

Runs: 1, 2 & 3

Depth: 28.0m – 32.6m



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



Bedrock Core Sample

Borehole: TS4

Runs: 1, 2 & 3

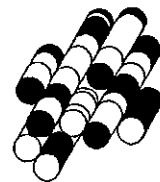
Depth: 28.4m – 32.0m



APPENDIX B

Laboratory Test Results

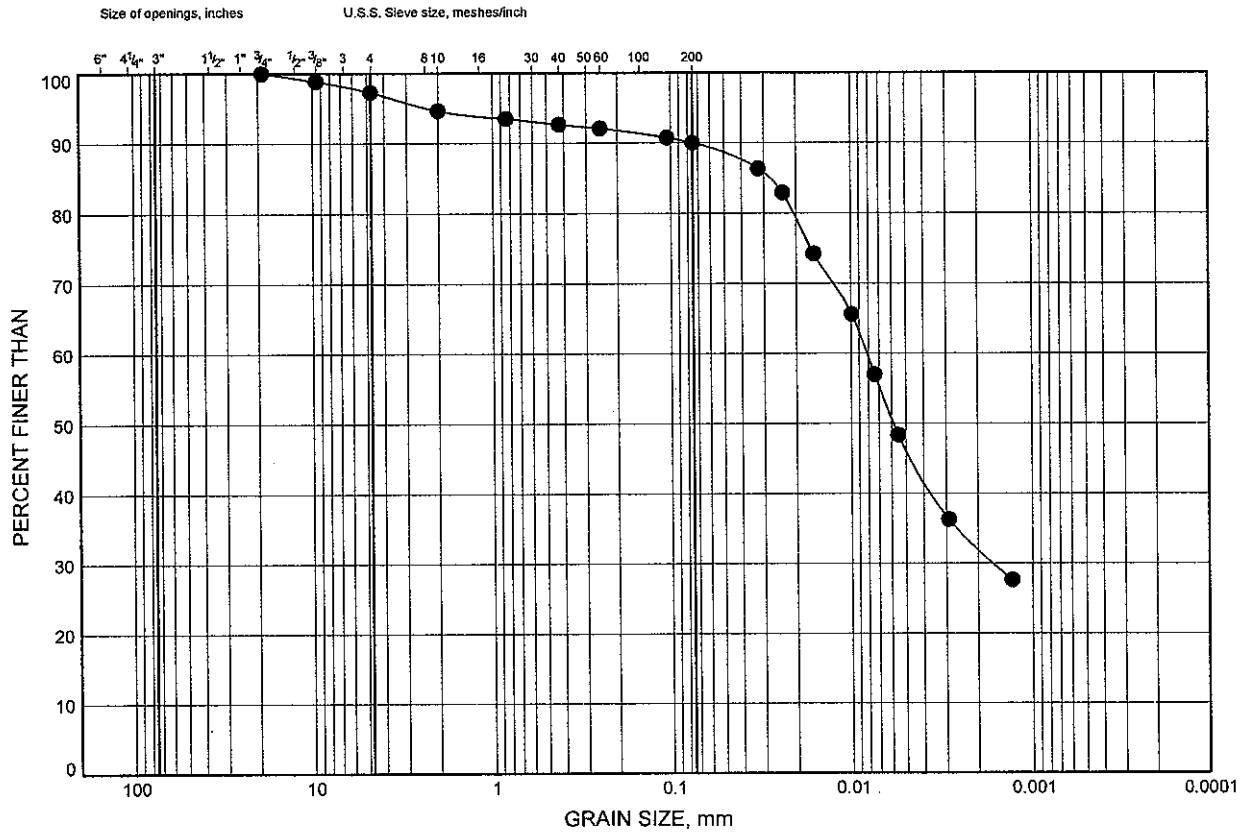
Terraprobe Inc.



GRAIN SIZE DISTRIBUTION

FIGURE B1

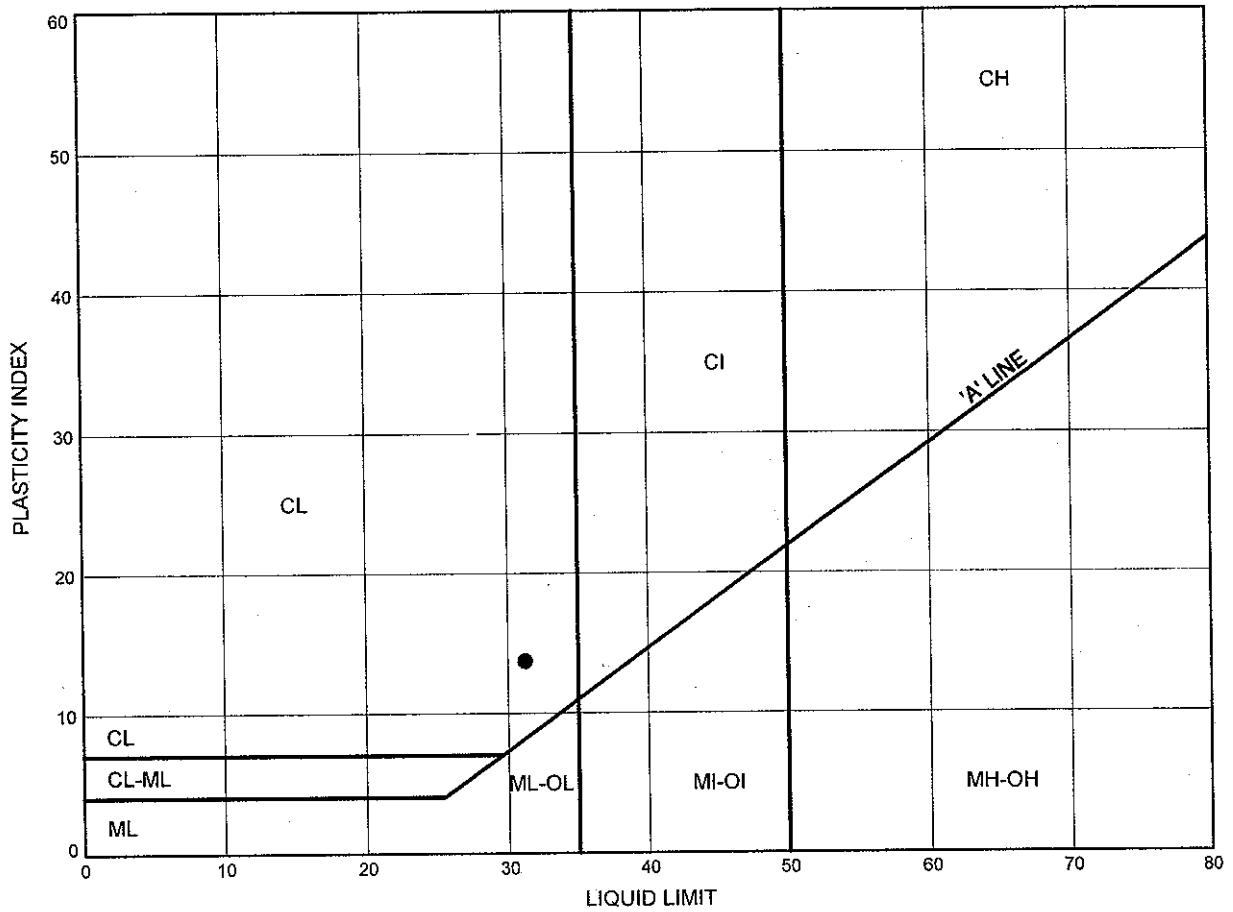
FILL - Silty Clay



ATTERBERG LIMITS TEST RESULTS

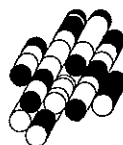
FIGURE B2

FILL - Silty Clay



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	TS2	1.0	182.3

Date May 2010
Project 1-09-4135

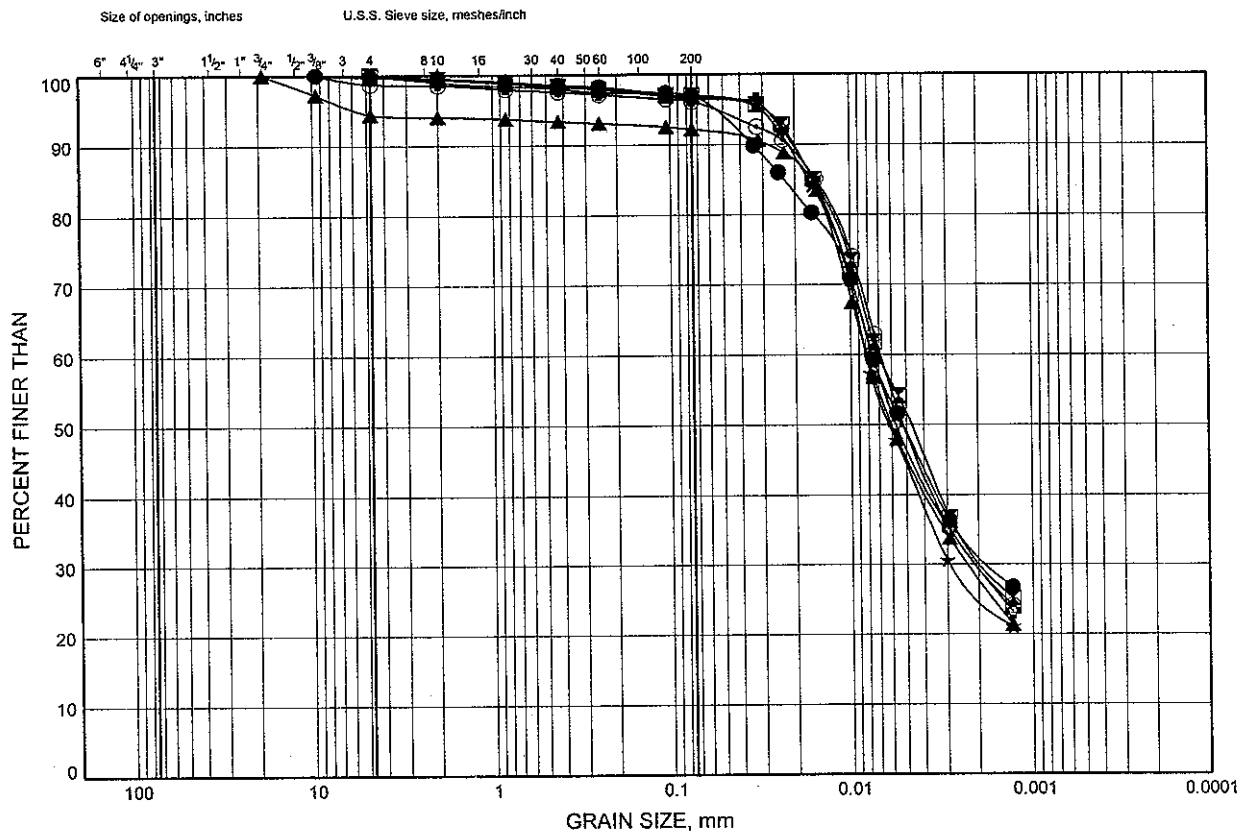


Prep'd DB
Chkd. HA

GRAIN SIZE DISTRIBUTION

FIGURE B3

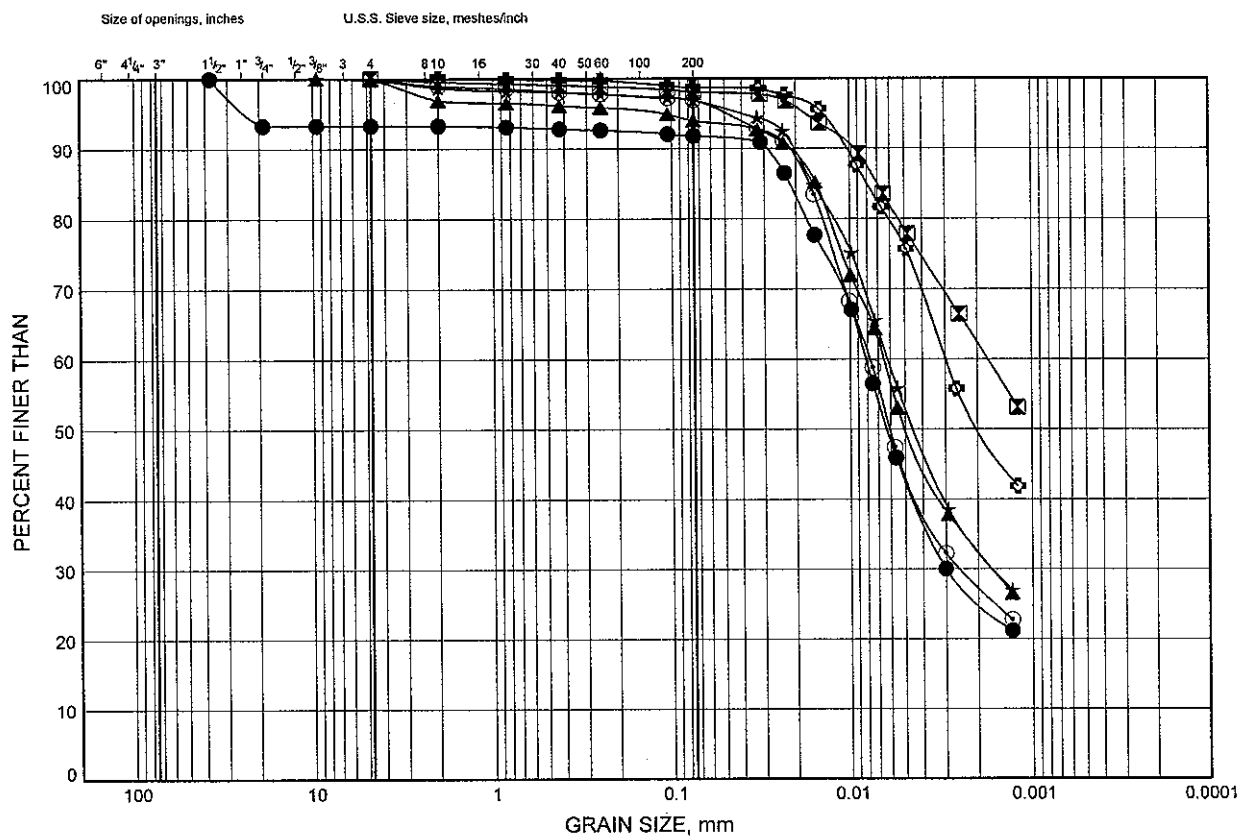
SILTY CLAY



GRAIN SIZE DISTRIBUTION

FIGURE B4

SILTY CLAY



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

SYMBOL BOREHOLE DEPTH (m) ELEVATION (m)

●	TS2	13.9	169.4
⊠	TS3	1.7	180.8
▲	TS3	4.0	178.5
★	TS3	6.3	176.2
⊙	TS3	10.9	171.6
⊛	TS4	1.0	181.4

Date May 2010

Project 1-09-4135



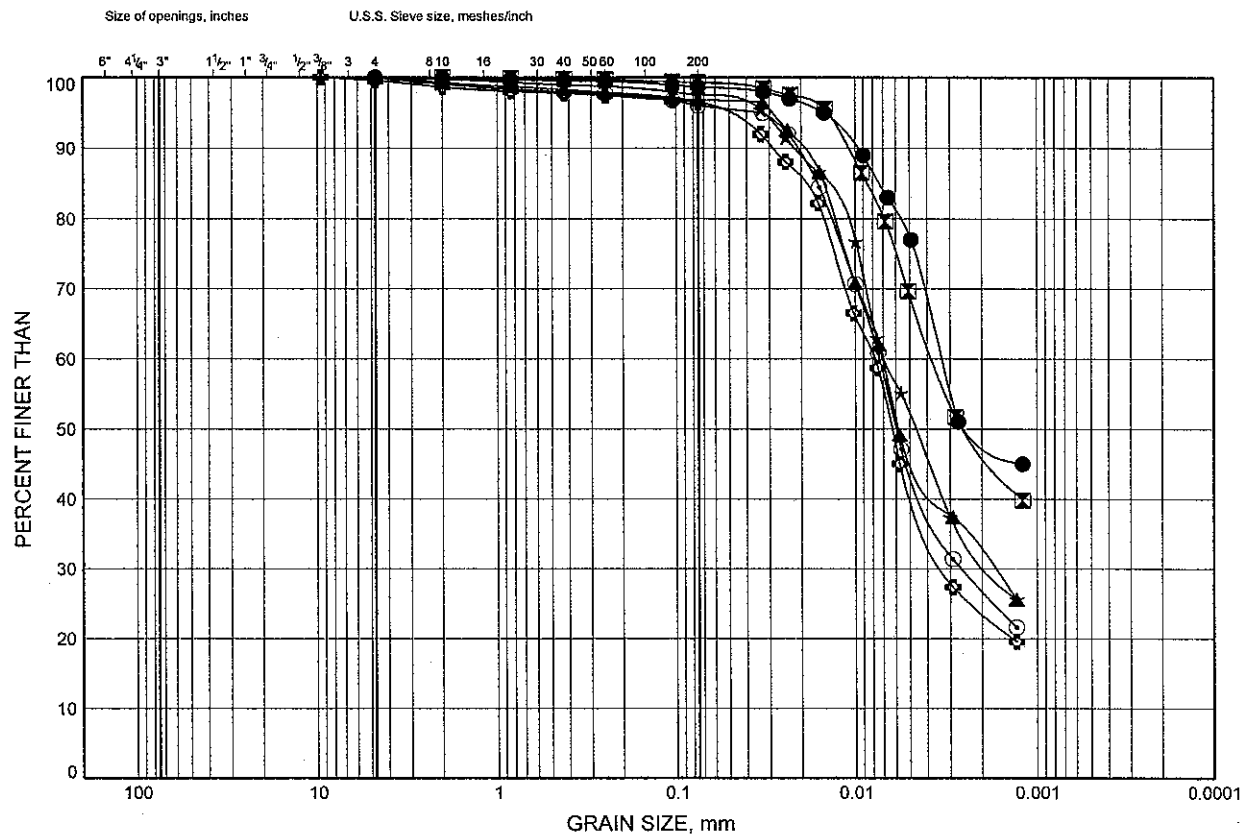
Prep'd DB

Chkd. HA

GRAIN SIZE DISTRIBUTION

FIGURE B5

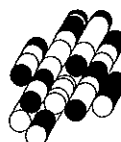
SILTY CLAY



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

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	SBL 12+360CL	1.0	181.9
⊠	SBL 12+360CL	3.2	179.7
▲	SBL 12+360CL	7.8	175.1
★	TS4	3.2	179.2
⊙	TS4	6.3	176.1
⊛	TS4	9.3	173.1

Date May 2010
Project 1-09-4135

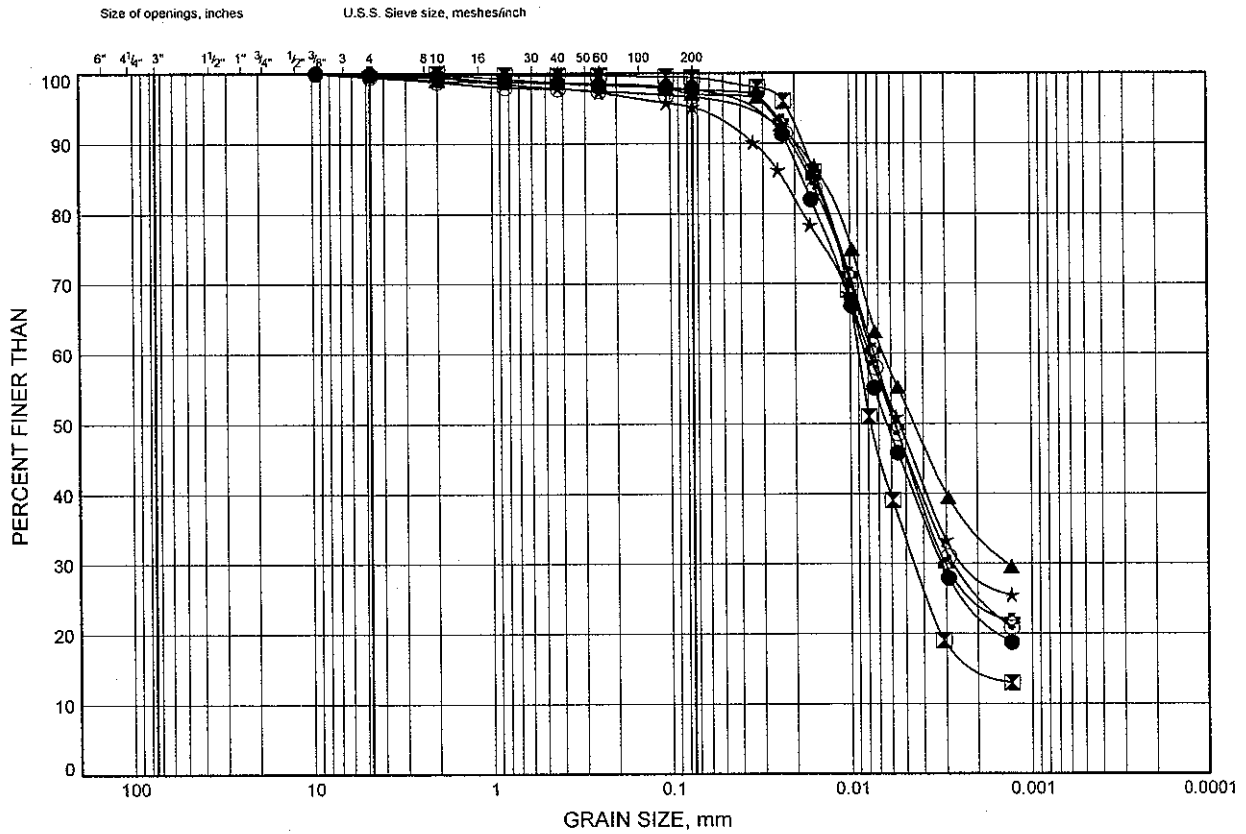


Prep'd DB
Chkd. HA

GRAIN SIZE DISTRIBUTION

FIGURE B6

SILTY CLAY

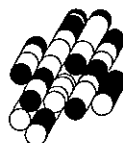


COBBLE SIZE	COARSE	FINE	COARSE	MEDIUM	FINE	SILT and CLAY
	GRAVEL		SAND			FINE GRAINED

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	SBL 12+360CL	10.9	172.0
⊠	SBL 12+360CL	12.4	170.5
▲	SBL 12+410CL	1.7	180.8
★	SBL 12+410CL	4.7	177.8
⊙	SBL 12+410CL	9.3	173.2
⊛	SBL 12+410CL	10.9	171.6

Date May 2010

Project 1-09-4135



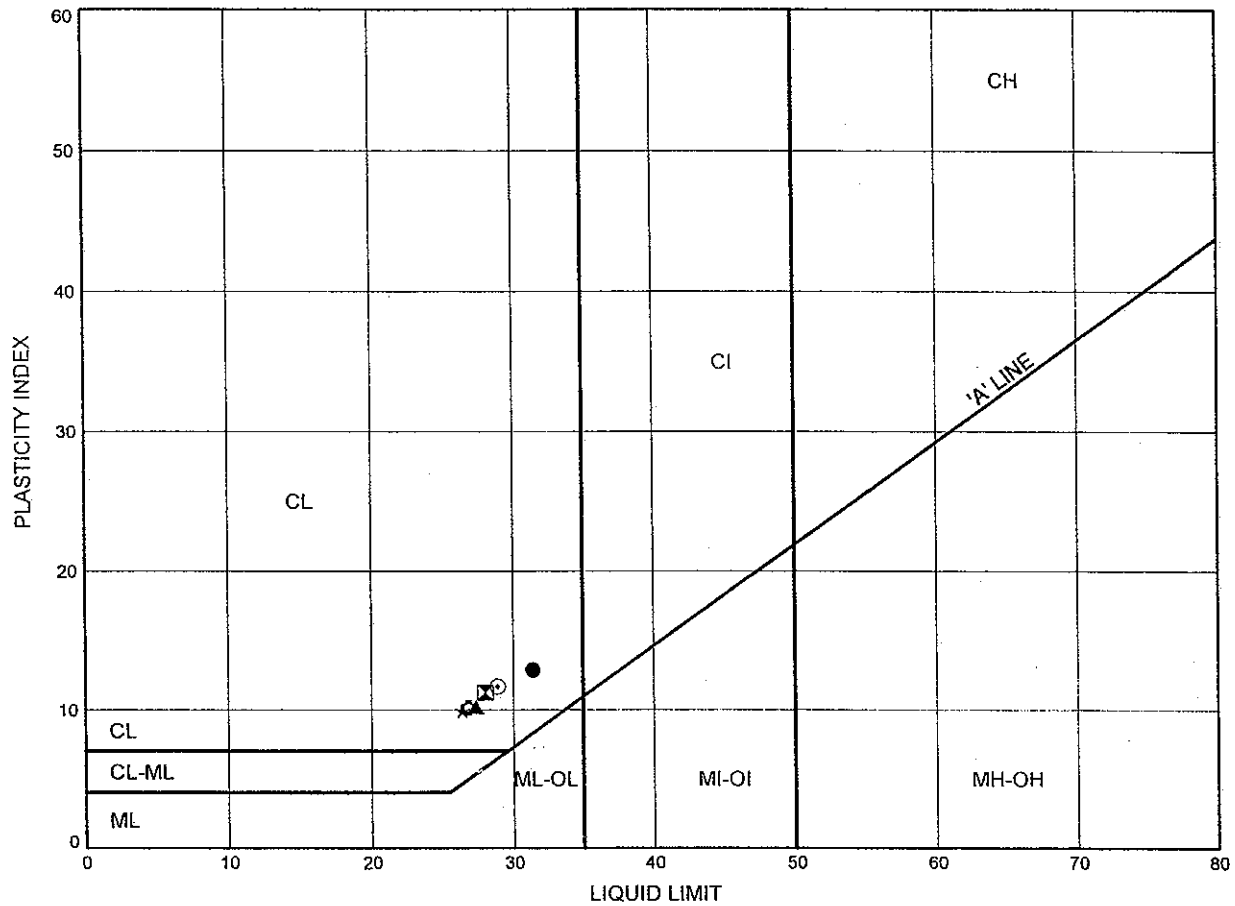
Prep'd DB

Chkd. HA

ATTERBERG LIMITS TEST RESULTS

FIGURE B7

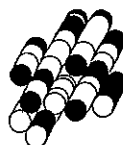
SILTY CLAY



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	TS1	2.5	180.1
⊠	TS1	4.7	177.9
▲	TS1	9.3	173.3
★	TS1	13.9	168.7
⊙	TS2	5.5	177.8
⊛	TS2	9.3	174.0

Date May 2010

Project 1-09-4135



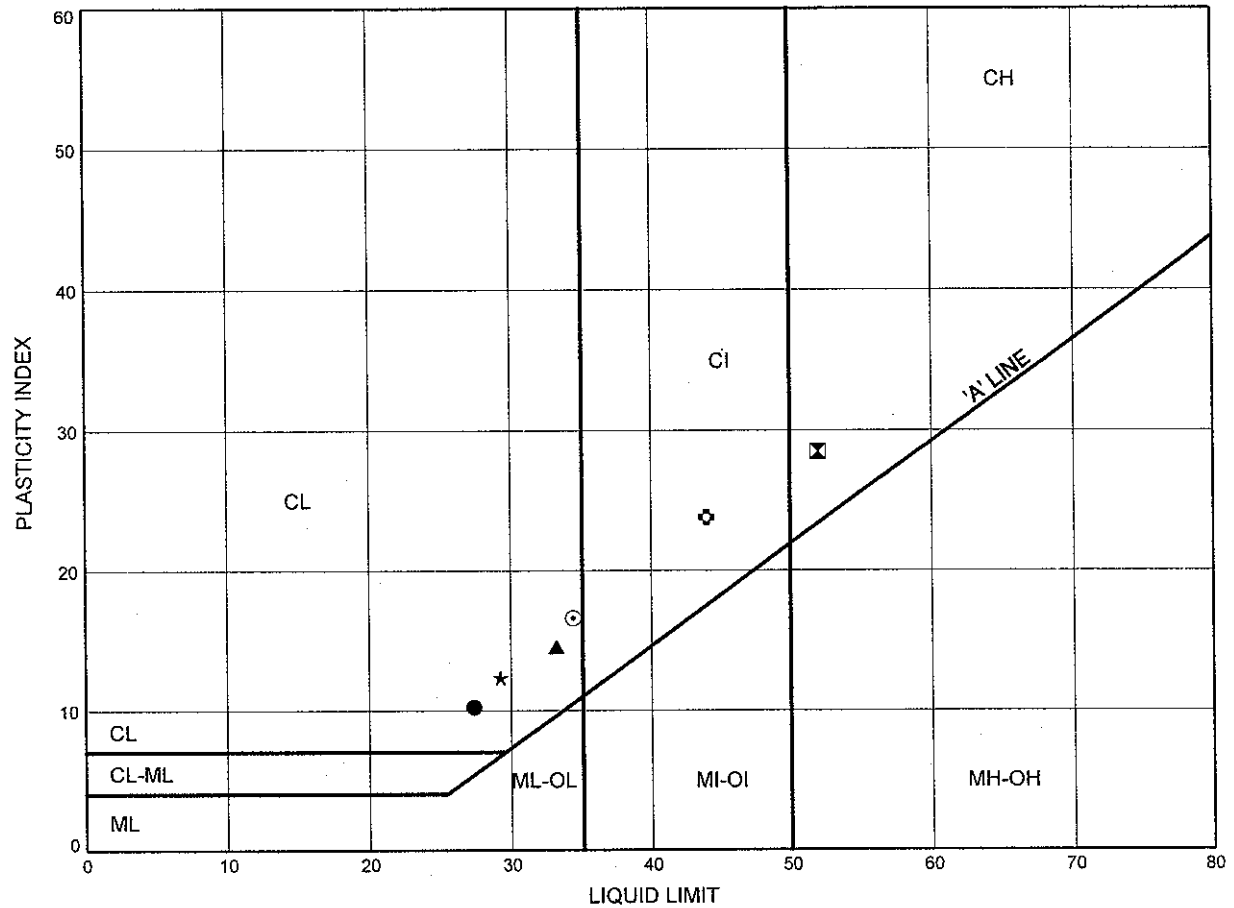
Prep'd DB

Chkd. HA

ATTERBERG LIMITS TEST RESULTS

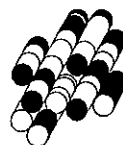
FIGURE B8

SILTY CLAY



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	TS2	13.9	169.4
⊠	TS3	1.7	180.8
▲	TS3	4.0	178.5
★	TS3	6.3	176.2
⊙	TS3	10.9	171.6
⊛	TS4	1.0	181.4

Date May 2010
Project 1-09-4135

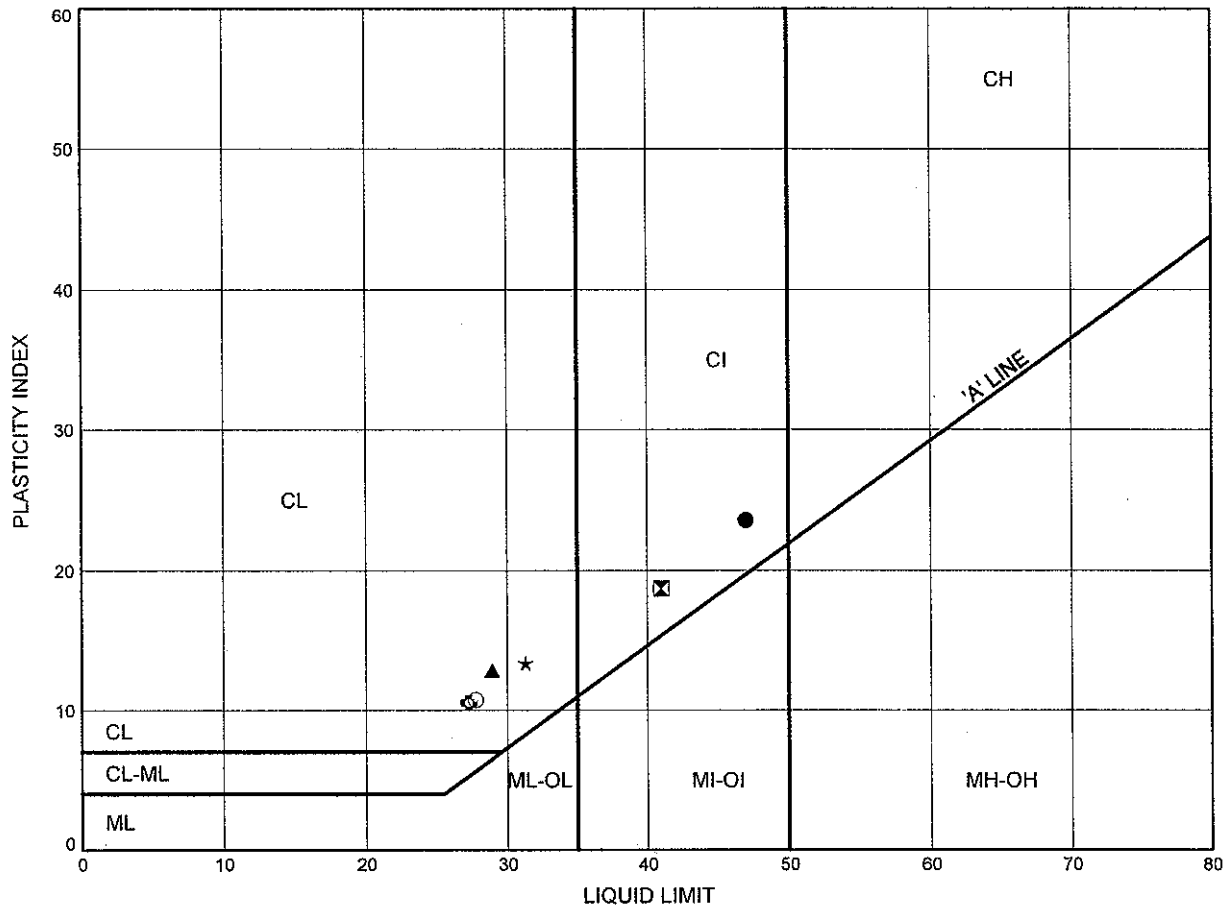


Prep'd DB
Chkd. HA

ATTERBERG LIMITS TEST RESULTS

FIGURE B9

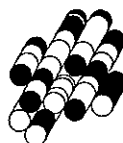
SILTY CLAY



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	SBL 12+360CL	1.0	181.9
⊠	SBL 12+360CL	3.2	179.7
▲	SBL 12+360CL	7.8	175.1
★	TS4	3.2	179.2
⊙	TS4	6.3	176.1
⊗	TS4	9.3	173.1

Date May 2010

Project 1-09-4135



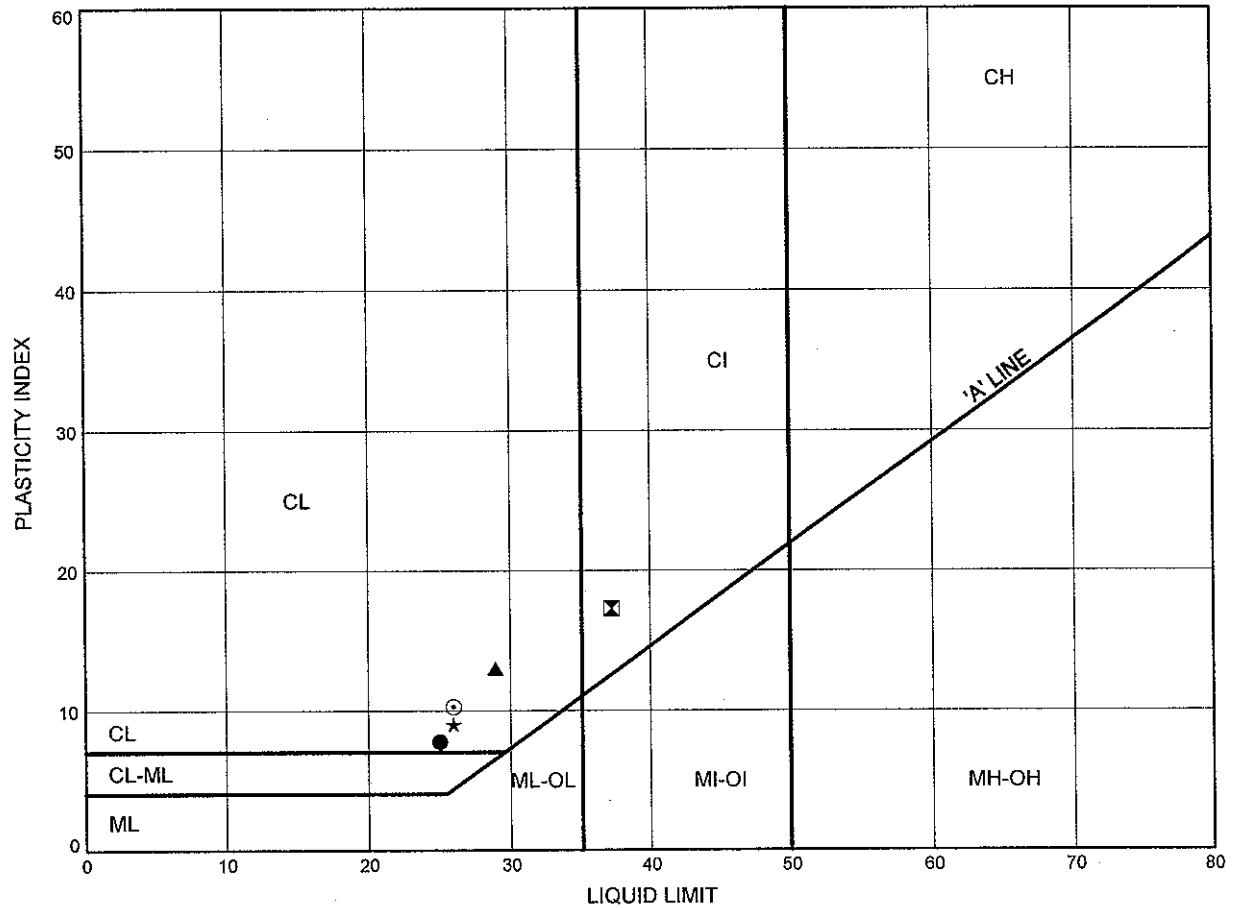
Prep'd DB

Chkd. HA

ATTERBERG LIMITS TEST RESULTS

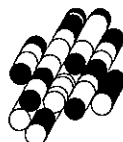
FIGURE B10

SILTY CLAY



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	SBL 12+360CL	12.4	170.5
⊠	SBL 12+410CL	1.7	180.8
▲	SBL 12+410CL	4.7	177.8
★	SBL 12+410CL	9.3	173.2
⊙	SBL 12+410CL	10.9	171.6

Date May 2010
Project 1-09-4135

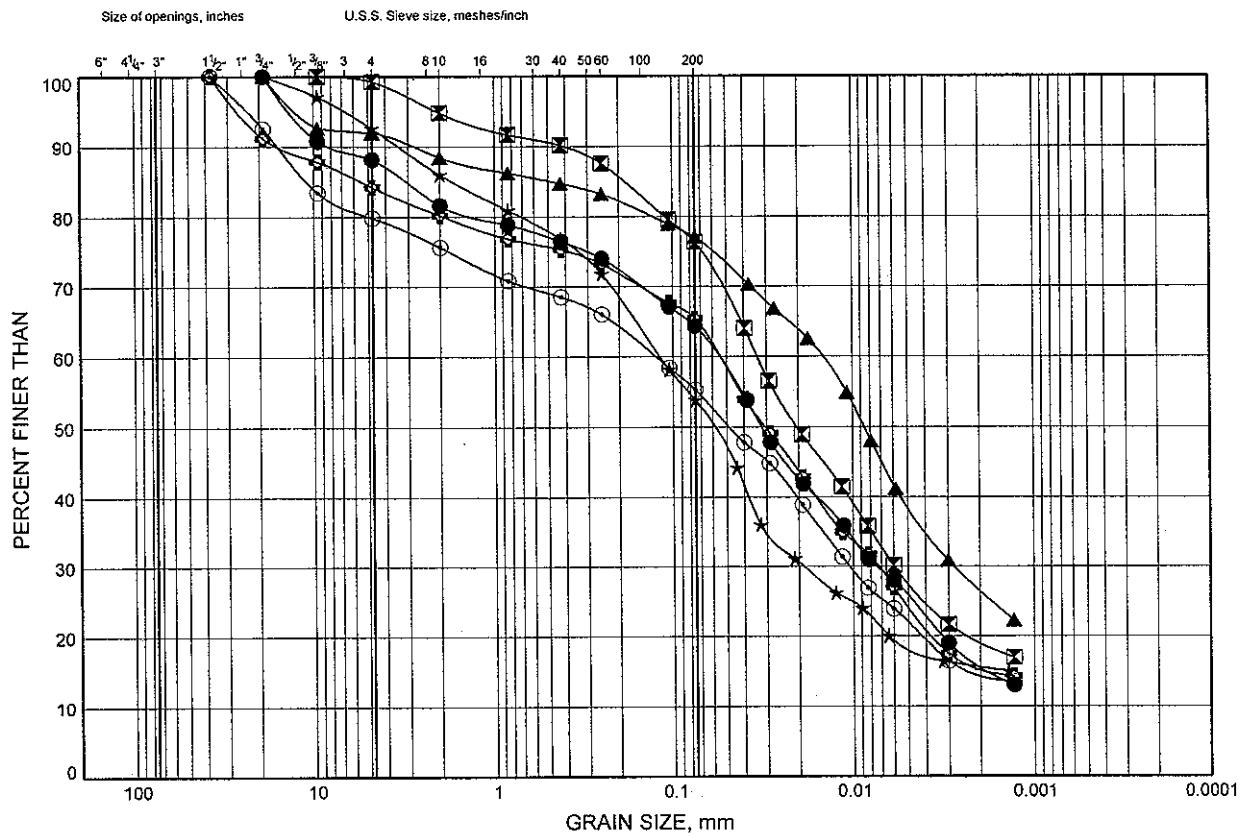


Prep'd DB
Chkd. HA

GRAIN SIZE DISTRIBUTION

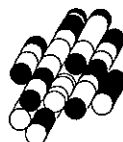
FIGURE B11

CLAYEY SILT TO SILTY CLAY TILL



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	TS1	17.0	165.6
⊠	TS1	26.1	156.5
▲	TS2	15.4	167.9
★	TS2	23.1	160.2
⊙	TS3	18.5	164.0
⊕	TS4	15.4	167.0

Date May 2010
Project 1-09-4135

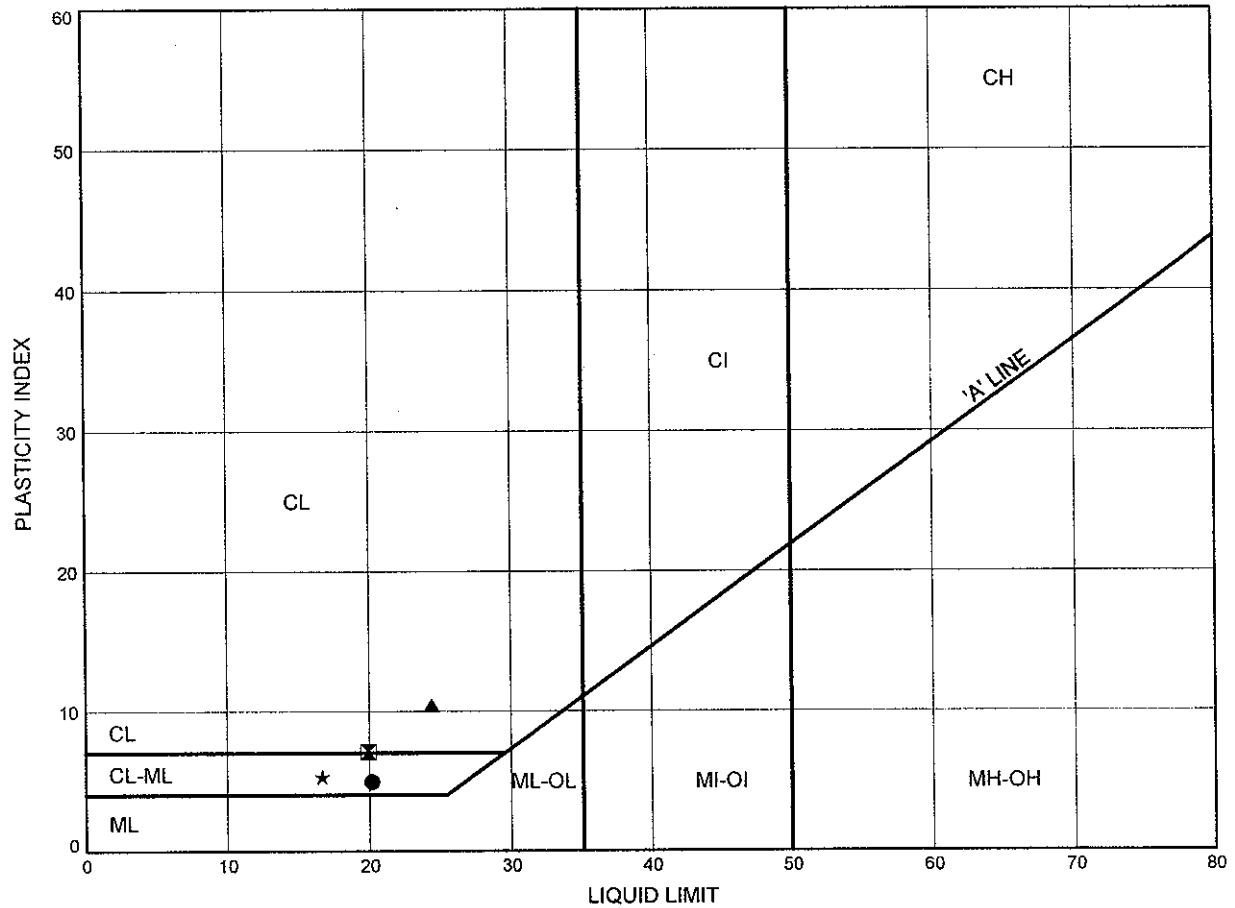


Prep'd DB
Chkd. HA

ATTERBERG LIMITS TEST RESULTS

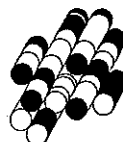
FIGURE B12

CLAYEY SILT TO SILTY CLAY TILL



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	TS1	17.0	165.6
⊠	TS1	26.1	156.5
▲	TS2	15.4	167.9
★	TS2	23.1	160.2

Date May 2010
Project 1-09-4135

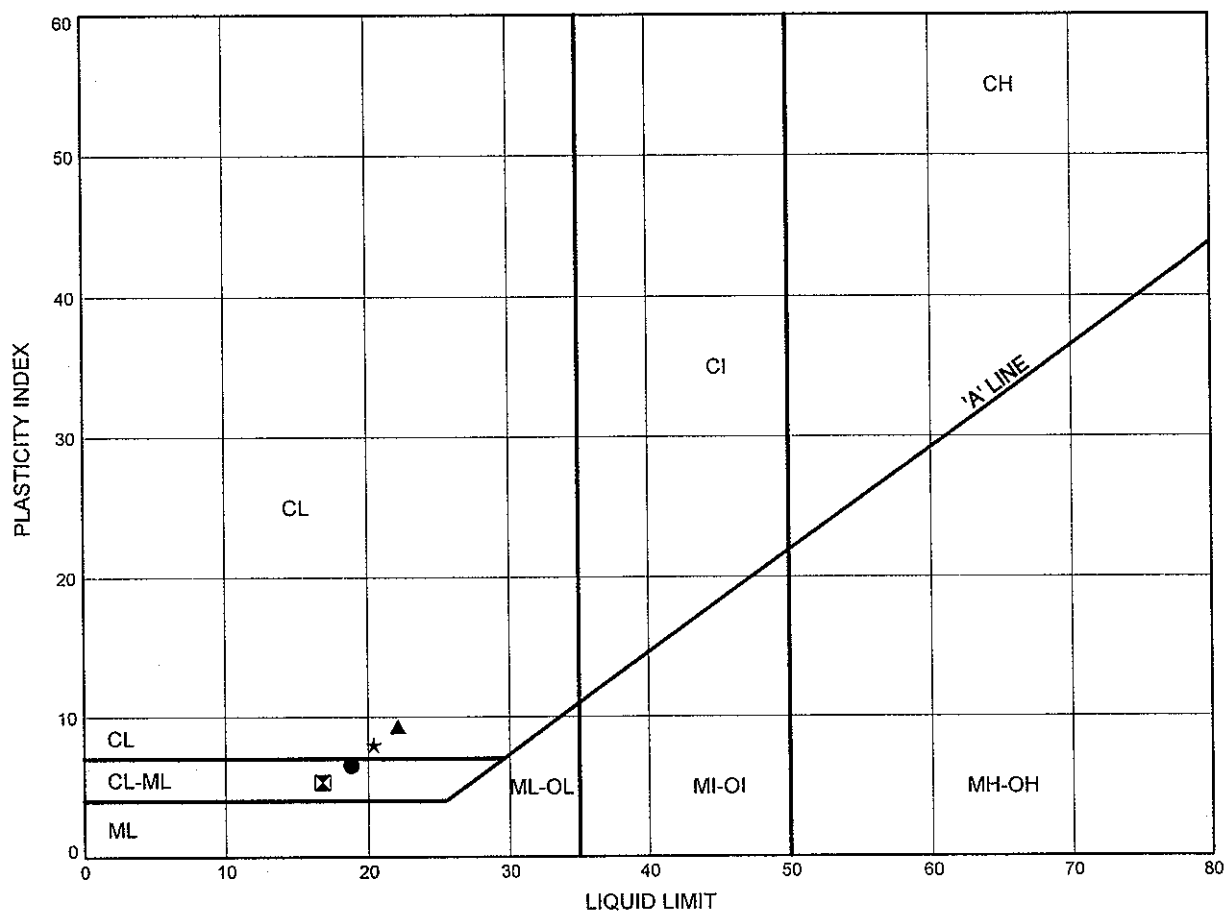


Prep'd DB
Chkd. HA

ATTERBERG LIMITS TEST RESULTS

FIGURE B13

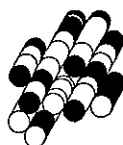
CLAYEY SILT TO SILTY CLAY TILL



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	TS3	18.5	164.0
⊠	TS3	23.1	159.4
▲	TS3	26.1	156.4
★	TS4	15.4	167.0

Date May 2010

Project 1-09-4135



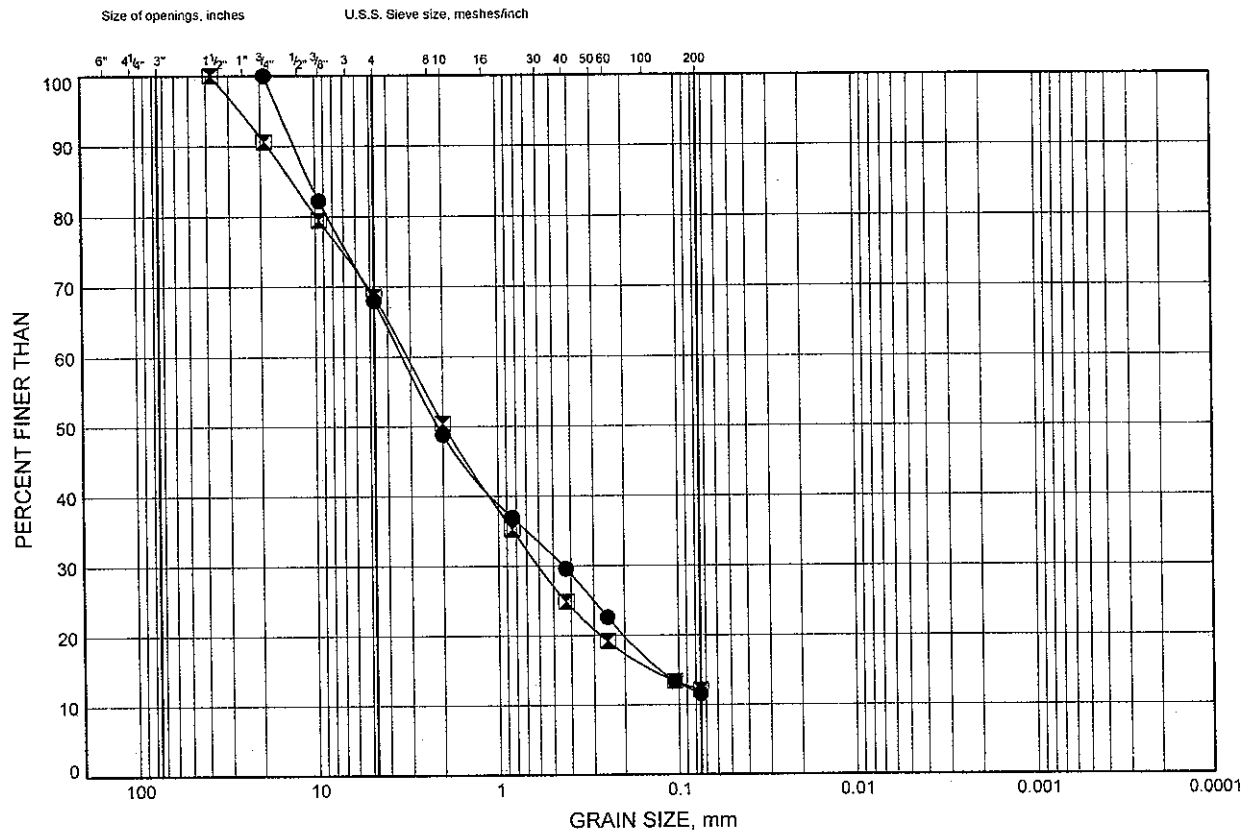
Prep'd DB

Chkd. HA

GRAIN SIZE DISTRIBUTION

FIGURE B14

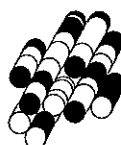
SAND



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

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	TS1	21.4	161.2
◻	TS2	21.5	161.8

Date May 2010
Project 1-09-4135

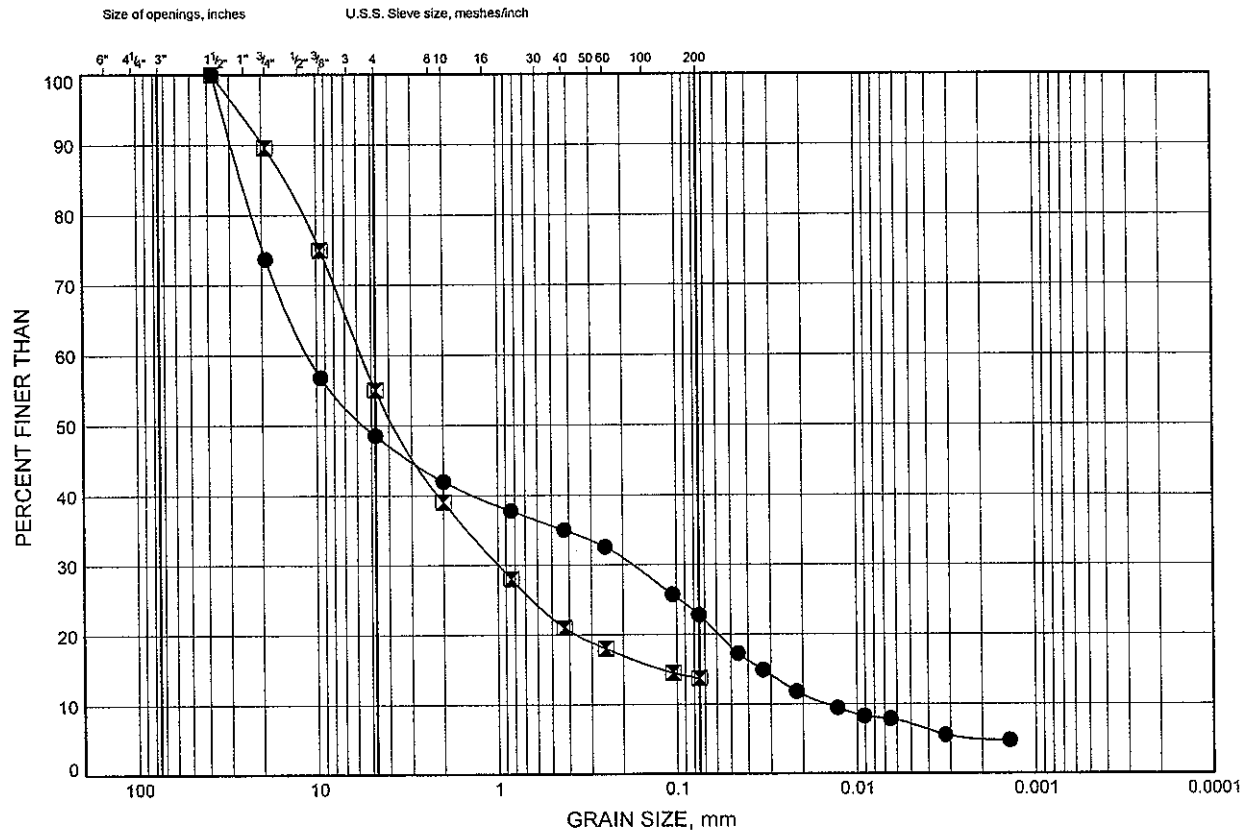


Prep'd DB
Chkd HA

GRAIN SIZE DISTRIBUTION

FIGURE B15

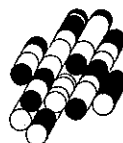
SANDY GRAVEL TO GRAVEL AND SAND TILL



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	TS3	27.6	154.9
⊠	TS4	27.5	154.9

Date May 2010

Project 1-09-4135



Prep'd DB

Chkd. HA

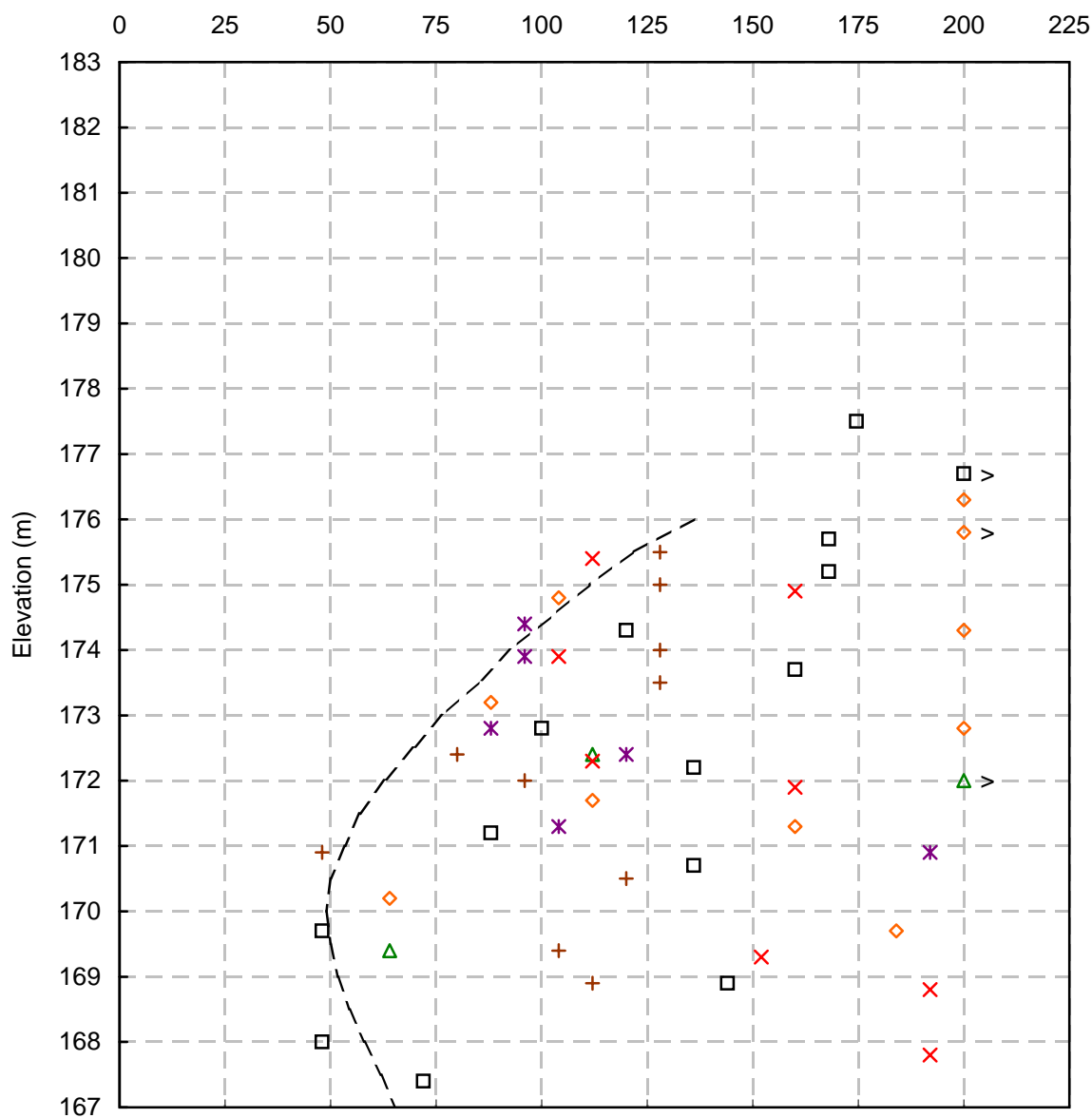
CORRECTED UNDRAINED SHEAR STRENGTH

FIGURE B16

HWY 406 TWINNING - TRILLIUM OVERHEAD (SBL)

Silty Clay

Corrected Cu (kPa)



□ TS1 ◇ TS2 ▲ TS3 × TS4 × SBL 12+360 CL + SBL 12+410 CL

Field Shear Vane Correction

Morris & Williams (1994)

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

Applied Correction Factors

0.87 (Elev.>177m)

1.00 (Elev.<177m)

Project No. : 1-09-4135

Date : September, 2010



Terraprobe Inc.

Prepared By : HW

Checked By : RA

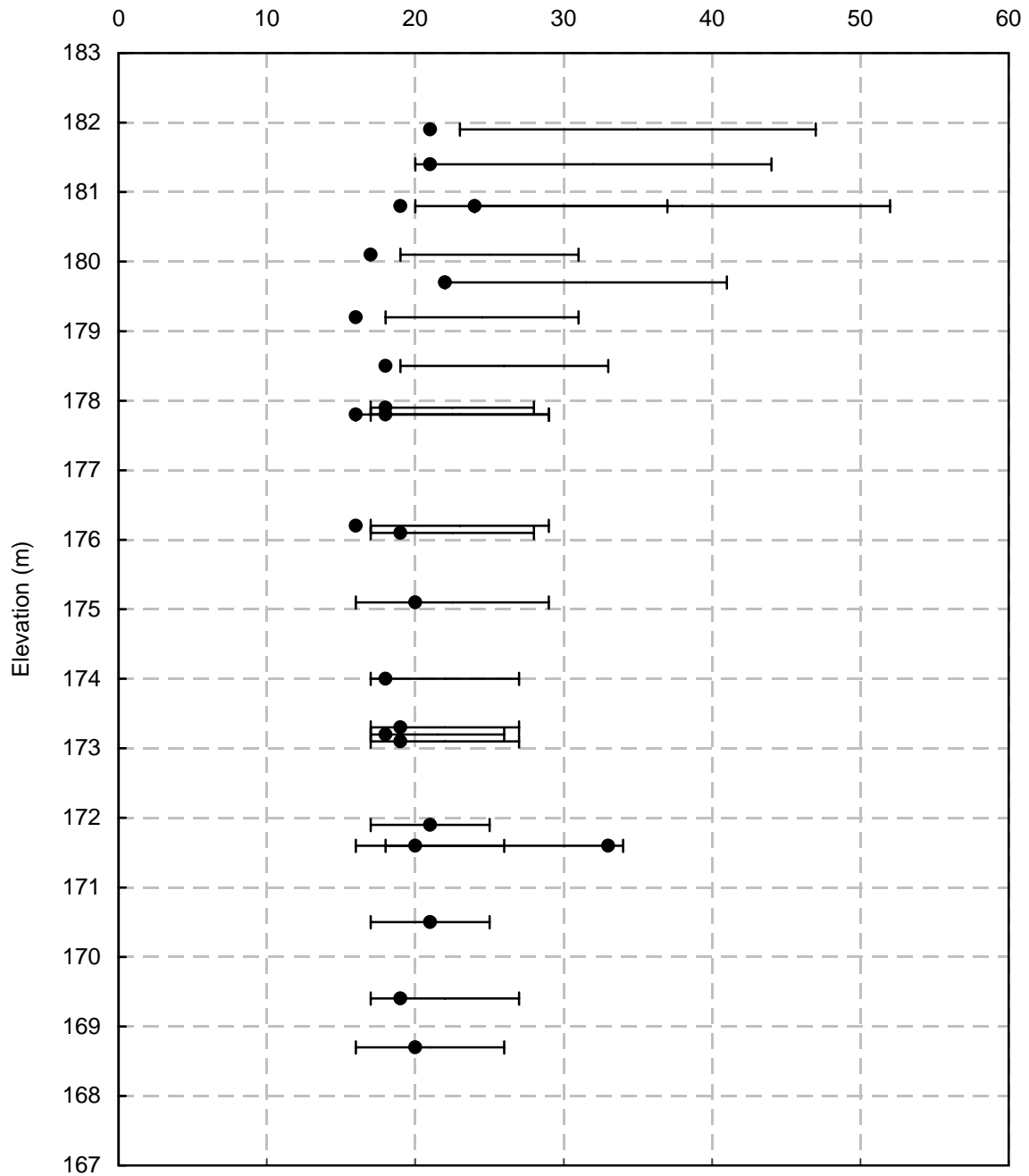
ATTERBERG LIMITS AND WATER CONTENTS

FIGURE B17

HWY 406 TWINNING - TRILLIUM OVERHEAD (SBL)

Silty Clay

Atterberg Limits & Water Contents (%)



Project No. : 1-09-4135

Date : September, 2010

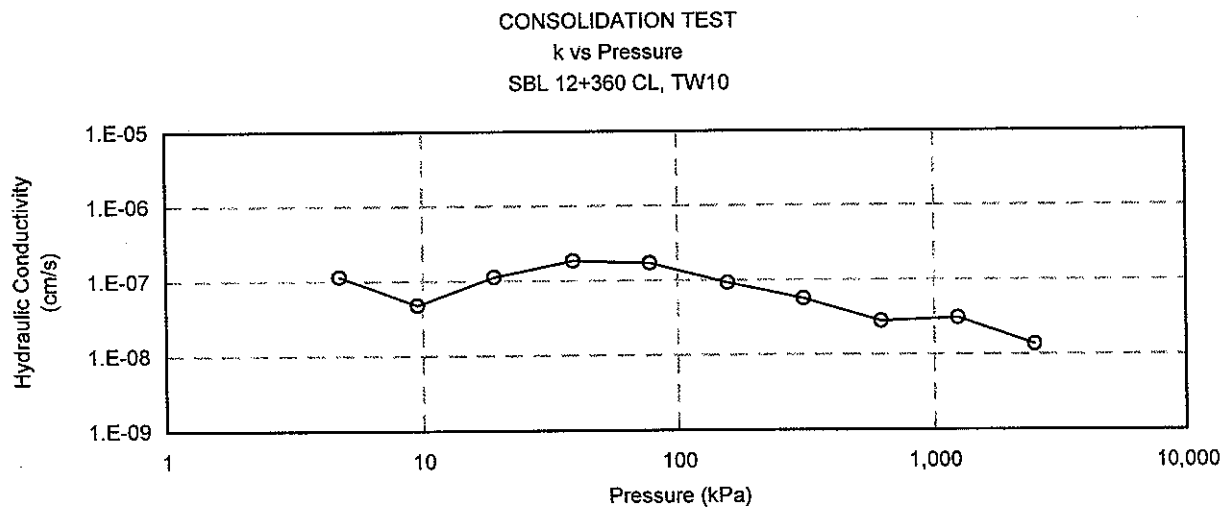
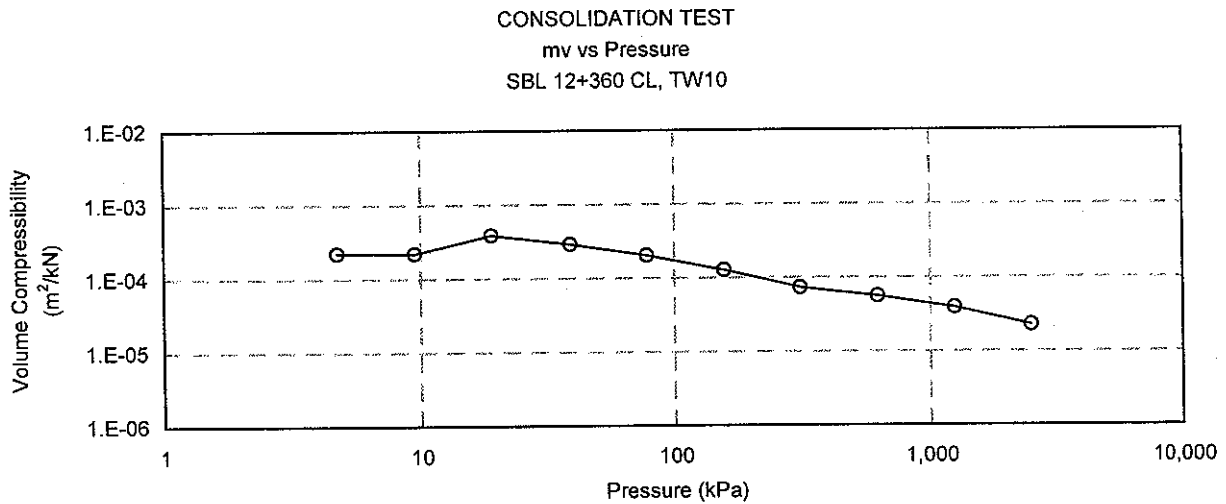
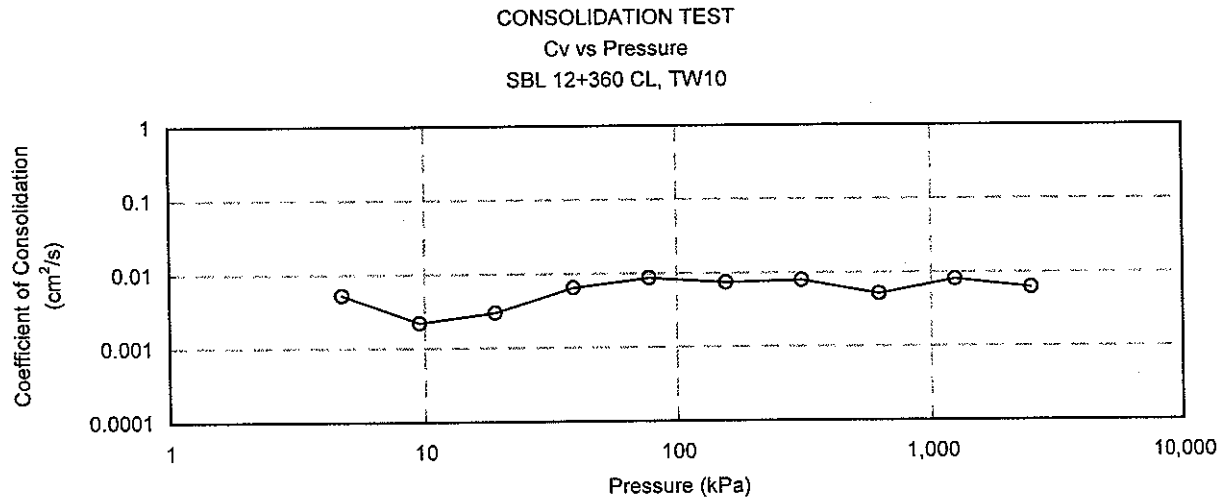


Terraprobe Inc.

Prepared By : HW

Checked By : RA

C:\Documents and Settings\Hongliu\My Documents\Project 2009\1-09-4135 - HWY 406 Foundations\Bridges\1-09-4135 Soil Parameter Estimation-TS1.xls



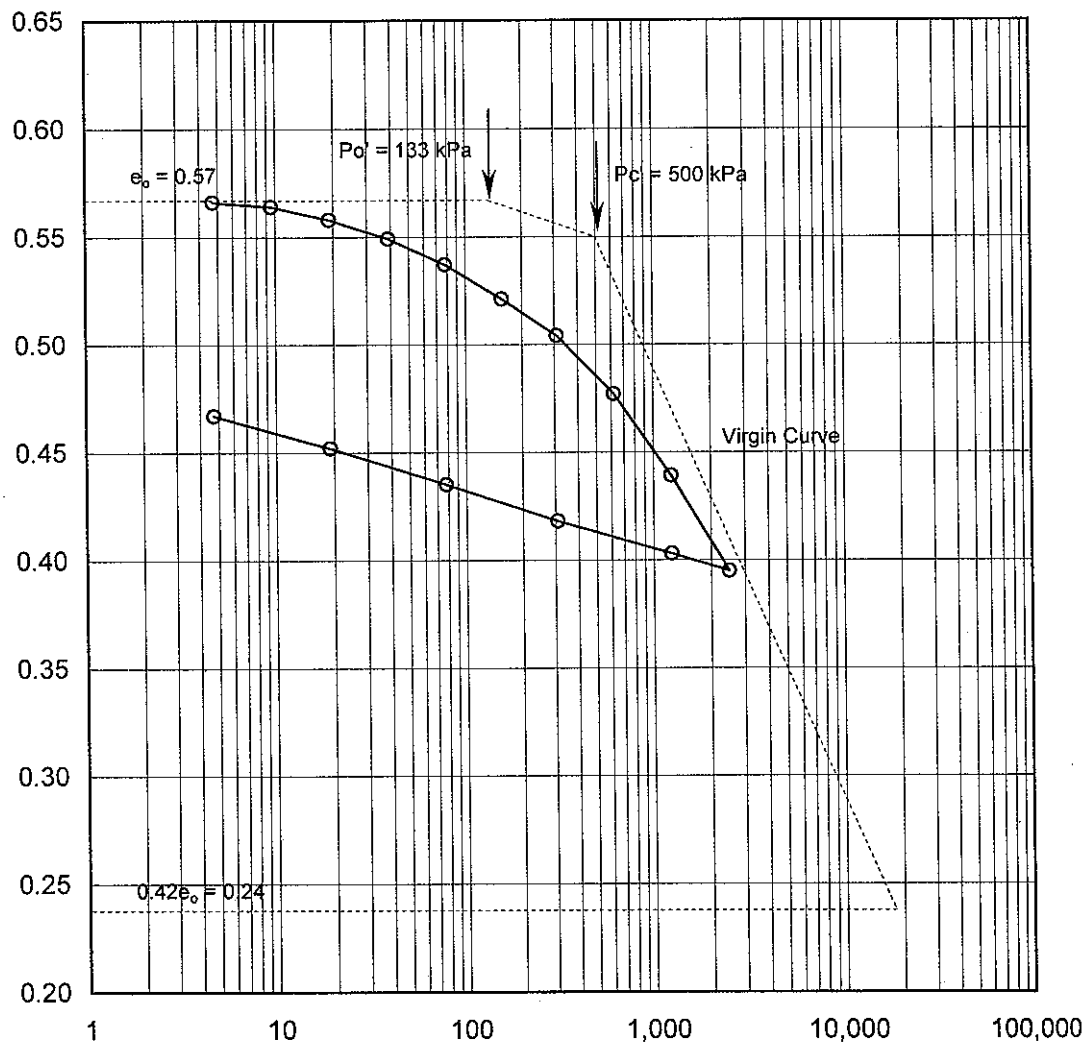
Project No. : 1-09-4135
Date : May 2010



Terraprobe Inc.

Prepared By : HW
Checked By : RA

CONSOLIDATION TEST
e vs Pressure
SBL 12+360 CL, TW10



Soil Type : Silty Clay

$e_o =$	0.57	$\omega_L =$	25%	$P_o' =$	133 kPa
$\omega =$	21%	$\omega_p =$	17%	$P_c' =$	500 kPa
$\gamma =$	20.7 kN/m ³	PI =	8%	Cc =	0.201
Gs =	2.74			Cr =	0.030

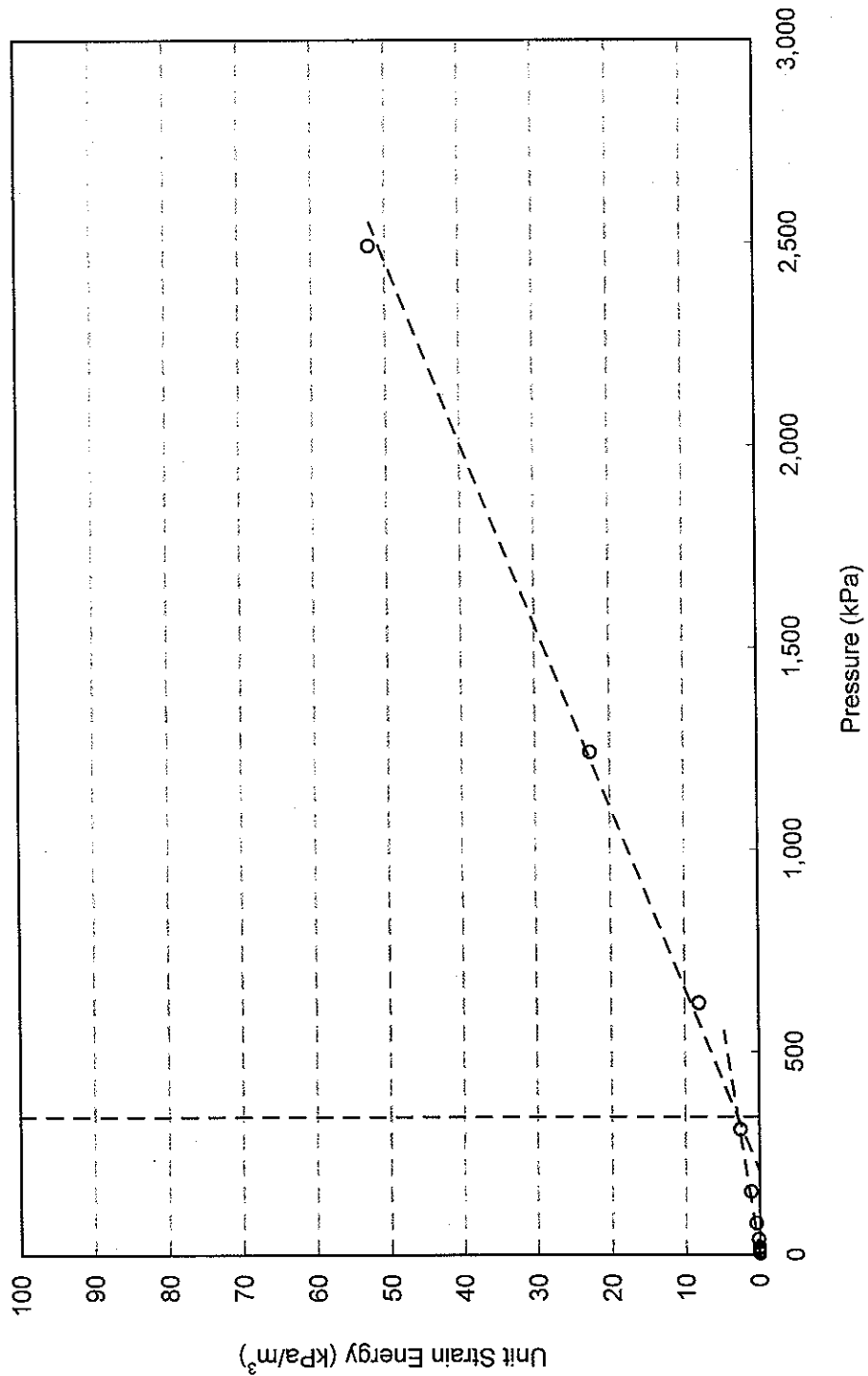
Project No. : 1-09-4135
Date : May 2010



Terraprobe Inc.

Prepared By : HW
Checked By : RA

CONSOLIDATION TEST
Unit Strain Energy vs Pressure
SBL 12+360 CL, TW10



$P_c = 340 \text{ kPa}$

Project No. : 1-09-4135

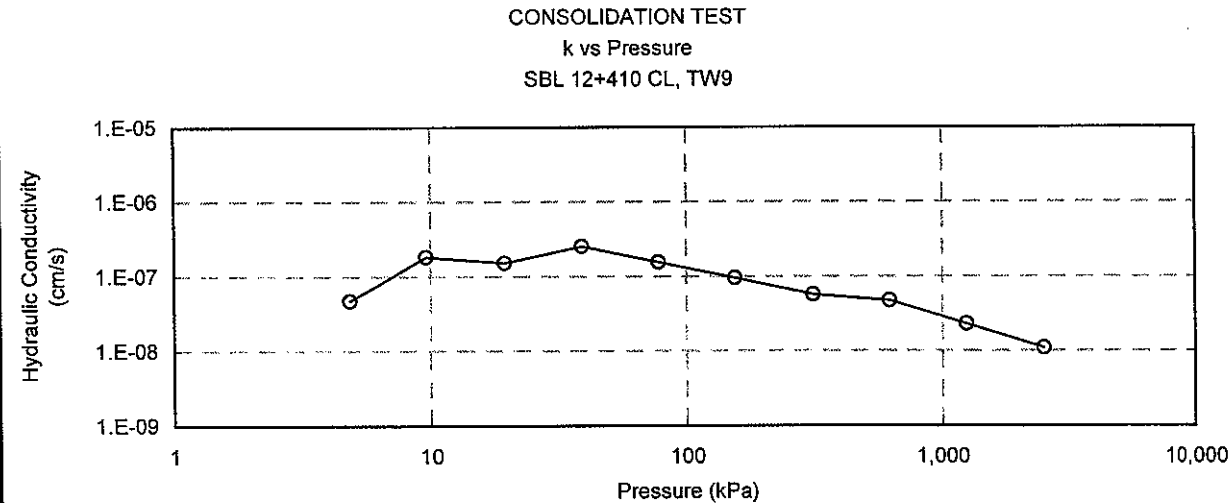
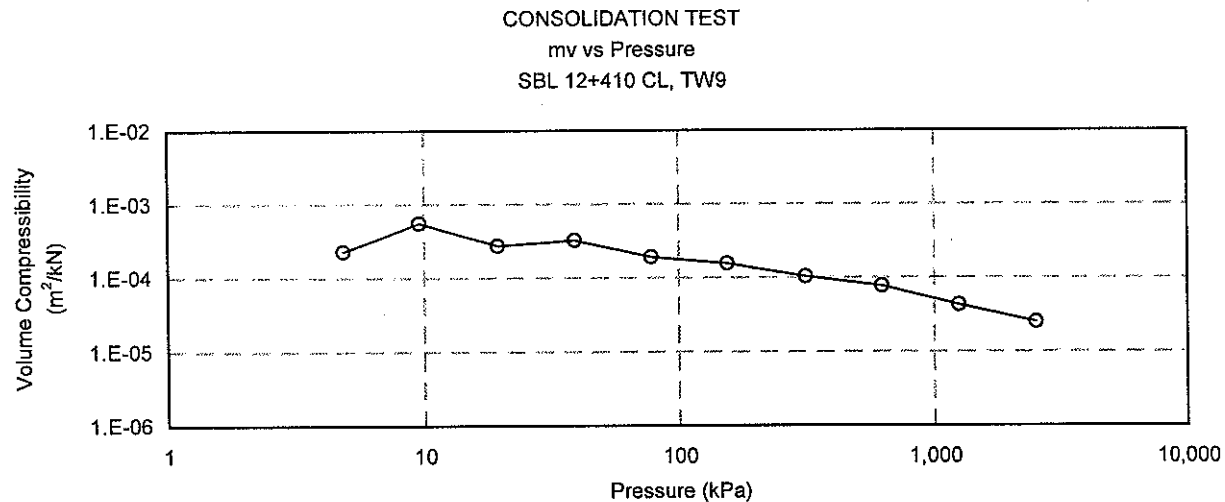
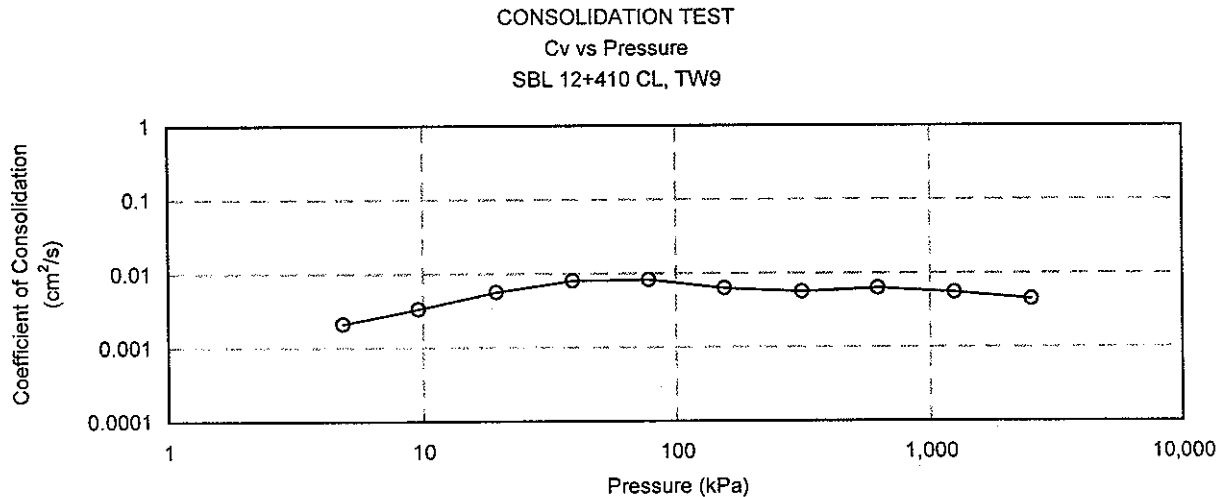
Date : May 2010



Terraprobe Inc.

Prepared By : HW

Checked By : RA



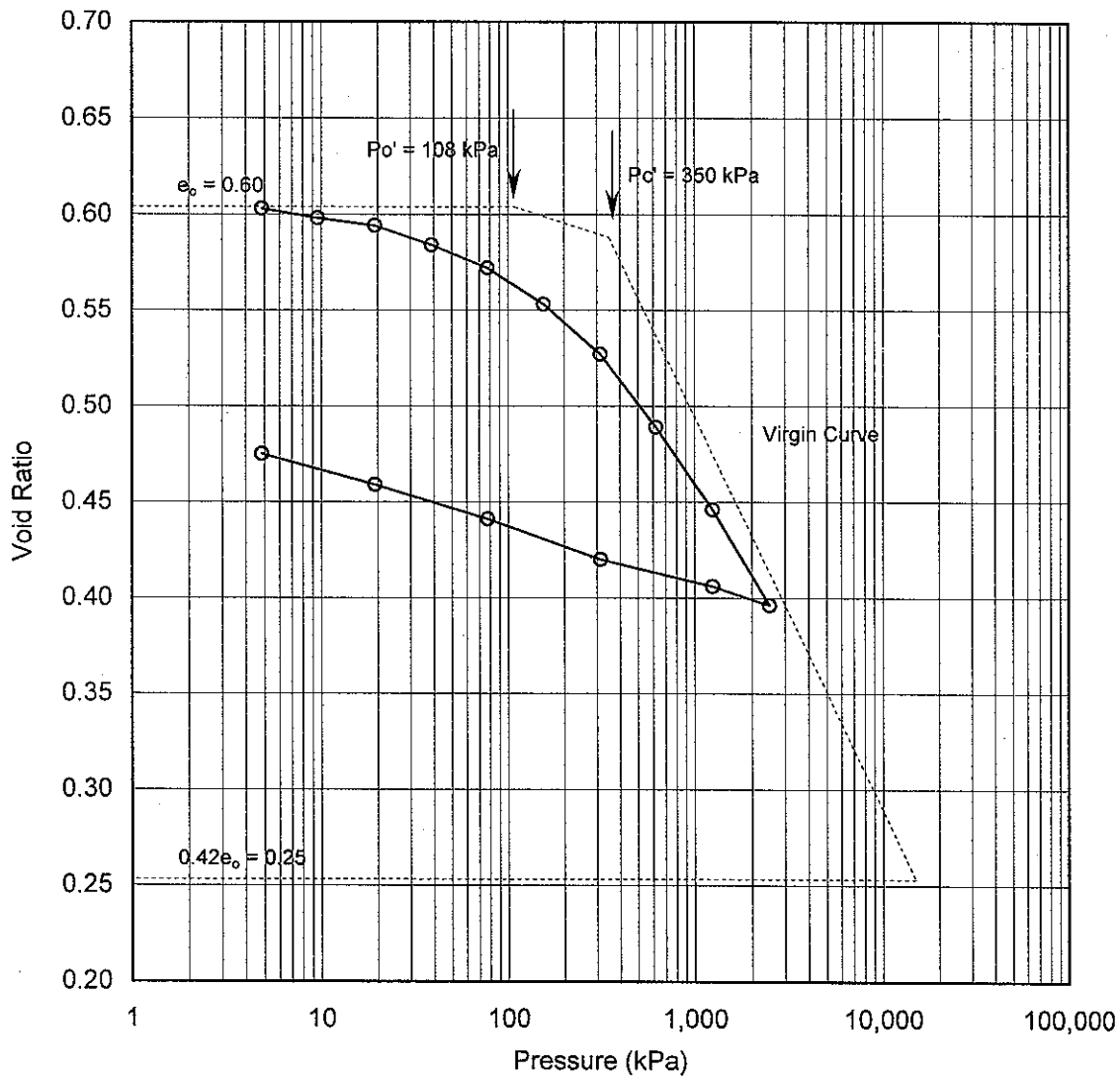
Project No. : 1-09-4135
Date : May 2010



Terraprobe Inc.

Prepared By : HW
Checked By : RA

CONSOLIDATION TEST
e vs Pressure
SBL 12+410 CL, TW9



Soil Type : Silty Clay

$e_o =$	0.60	$\omega_L =$	26%	$Po' =$	108 kPa
$\omega =$	21%	$\omega_P =$	17%	$Pc' =$	350 kPa
$\gamma =$	20.4 kN/m ³	PI =	9%	Cc =	0.205
Gs =	2.76			Cr =	0.031

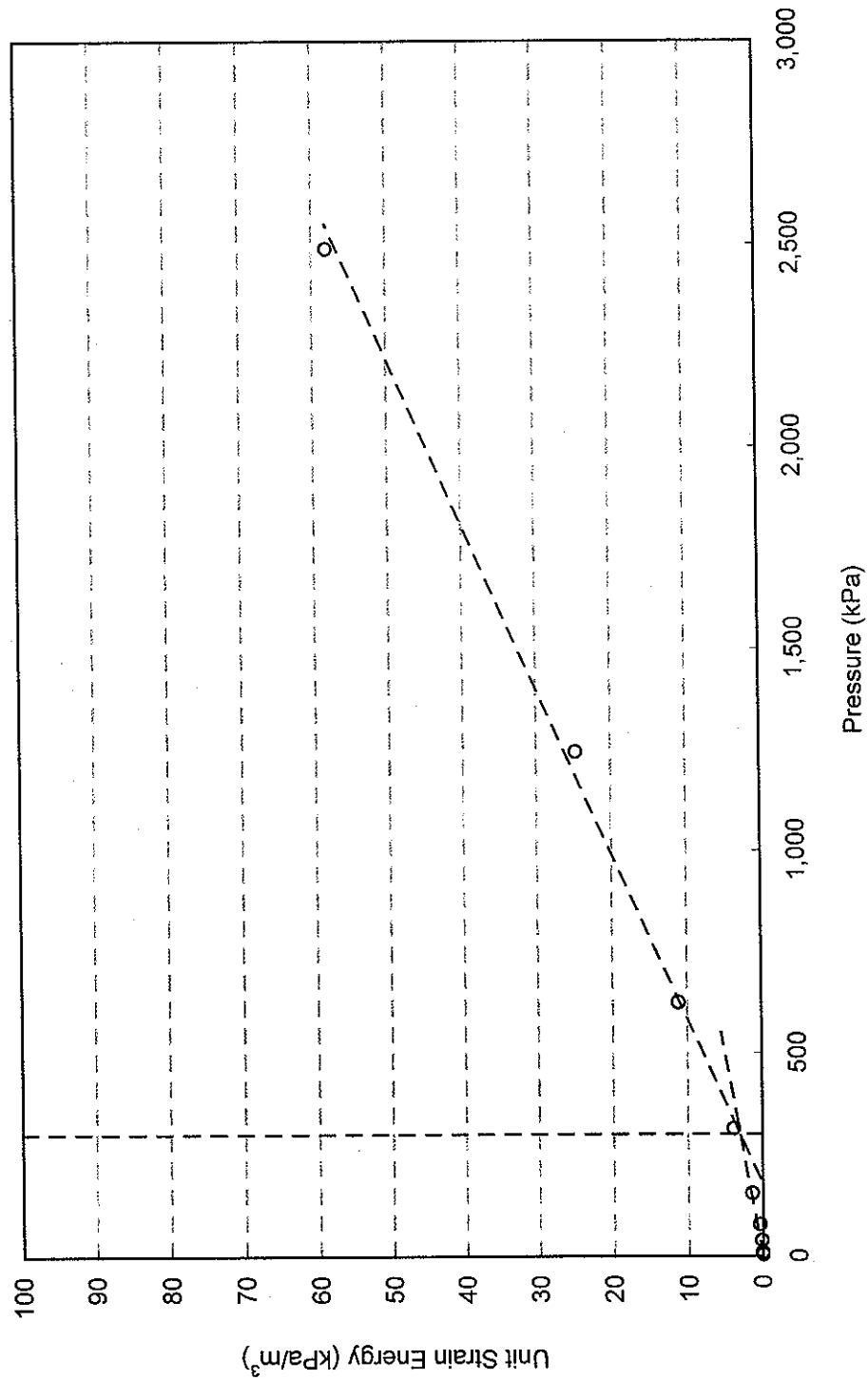
Project No. : 1-09-4135
Date : May 2010



Terraprobe Inc.

Prepared By : HW
Checked By : RA

CONSOLIDATION TEST
Unit Strain Energy vs Pressure
SBL 12+410 CL, TW9



$P_c = 300 \text{ kPa}$

Project No. : 1-09-4135

Date : May 2010



Terraprobe Inc.

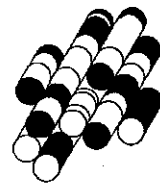
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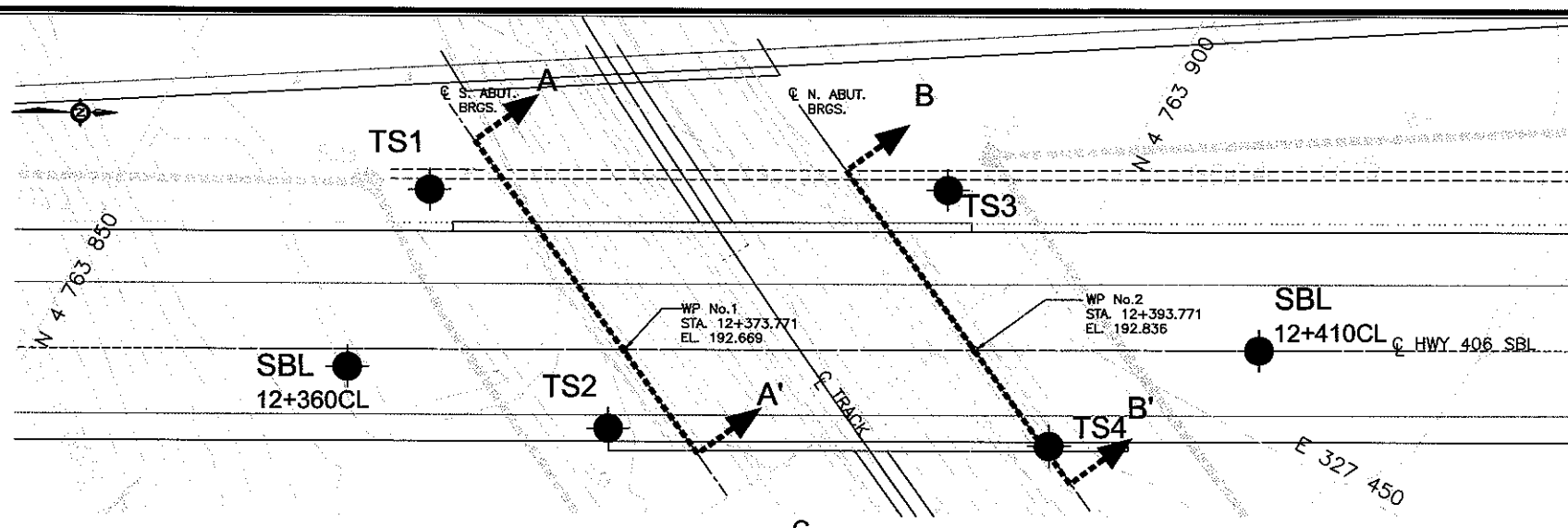
Checked By : RA

APPENDIX C

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

Terraprobe Inc.





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

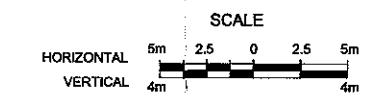
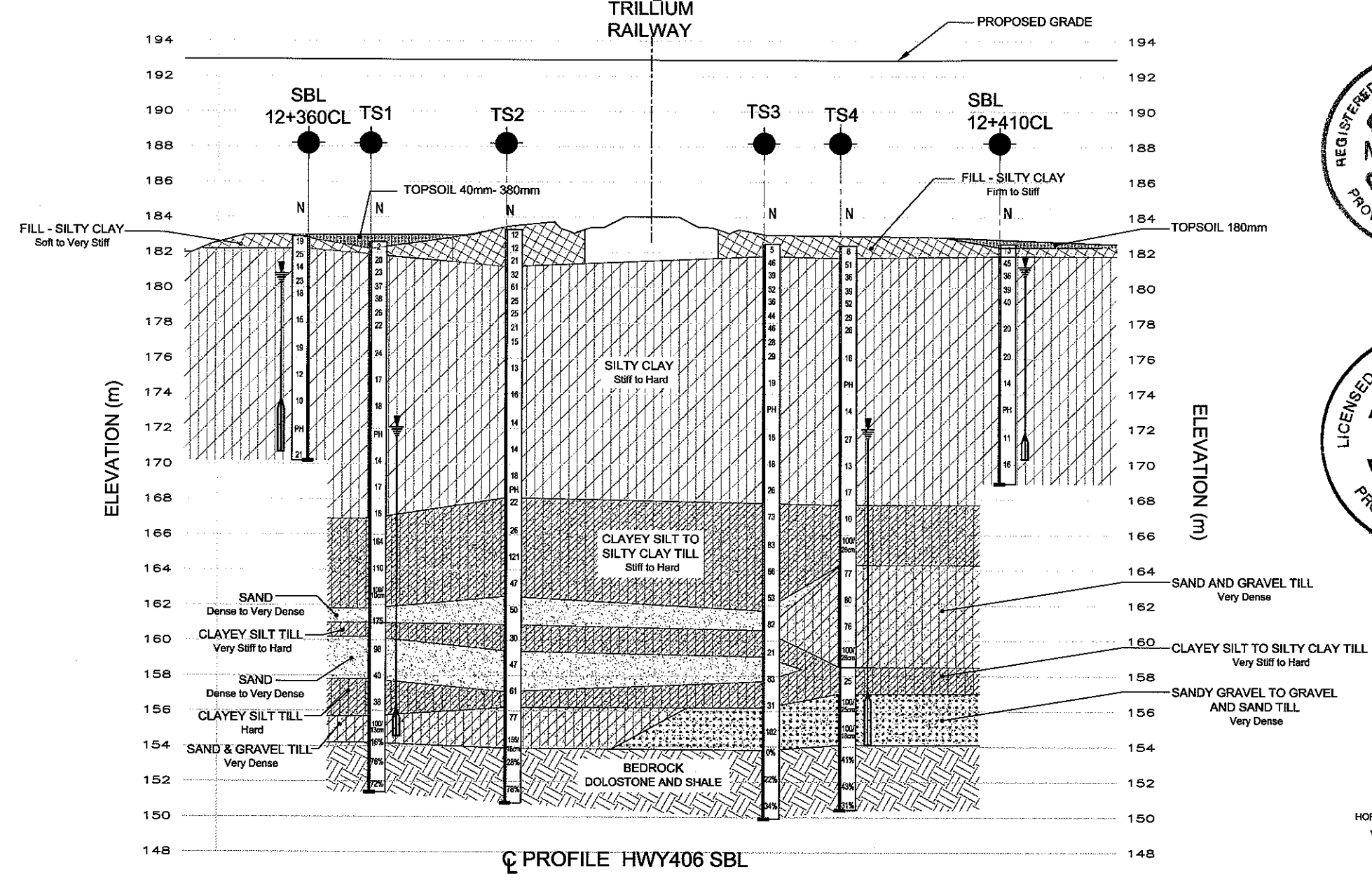
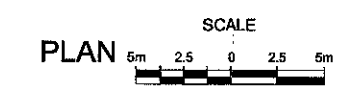
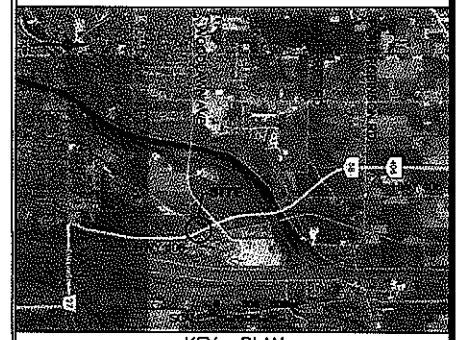
CONT No
WP No 280-99-00

HIGHWAY 406
TRILLIUM RAILWAY OVERHEAD
HWY 406 SBL
BOREHOLE LOCATIONS AND STRATA

SHEET
1 OF

Giffels Associates Limited
Consulting Engineers and Architects
An IBI Group Company

Terraprobe Inc.
Consulting Geotechnical & Environmental Engineering
Construction Materials Engineering, Inspection & Testing
10 Bram Court - Brampton Ontario L6W 3R6 (905) 766-2650



KEY PLAN

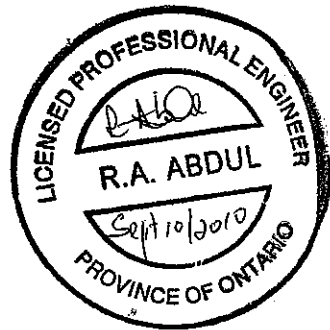
LEGEND

- 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
TS1	182.6	4 763 865.734	327 459.138
TS2	183.3	4 763 881.218	327 466.305
TS3	182.5	4 763 891.786	327 445.116
TS4	182.4	4 763 903.796	327 455.276
SBL 12+360CL	182.9	4 763 866.470	327 470.275
SBL 12+410CL	182.5	4 763 911.779	327 444.758

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	GEORES 30M3-256



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

CONT No
WP No 280-99-00

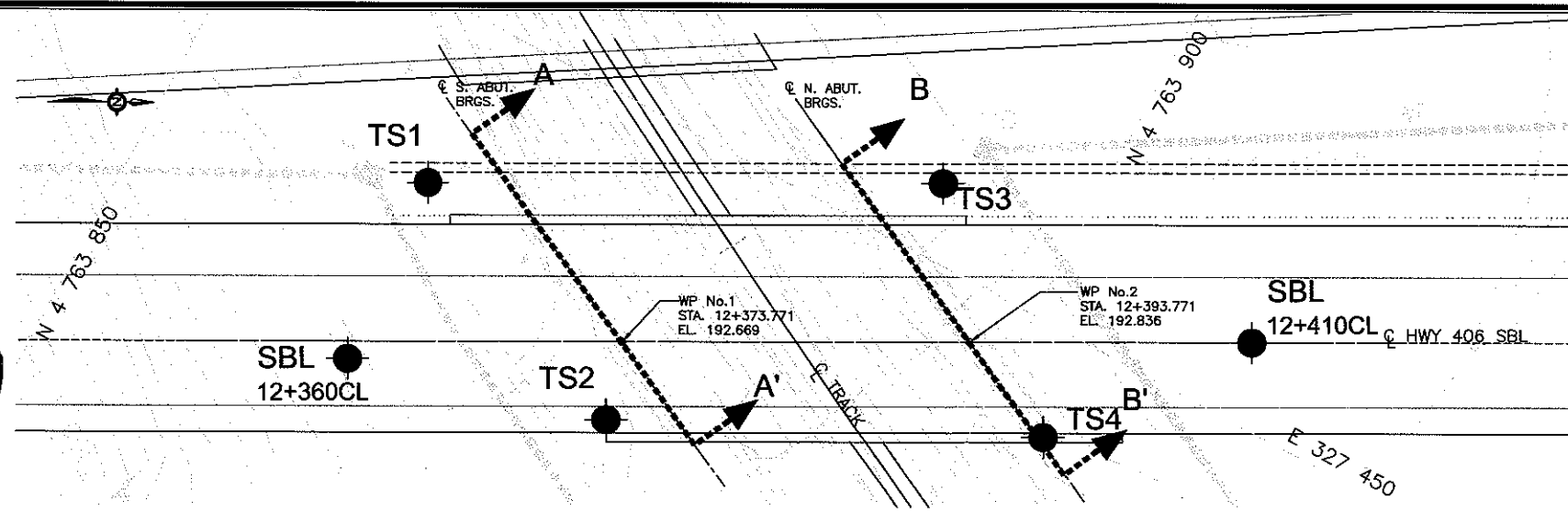
HIGHWAY 406
TRILLIUM RAILWAY OVERHEAD
HWY 406 SBL
BOREHOLE LOCATIONS AND SOIL STRATA



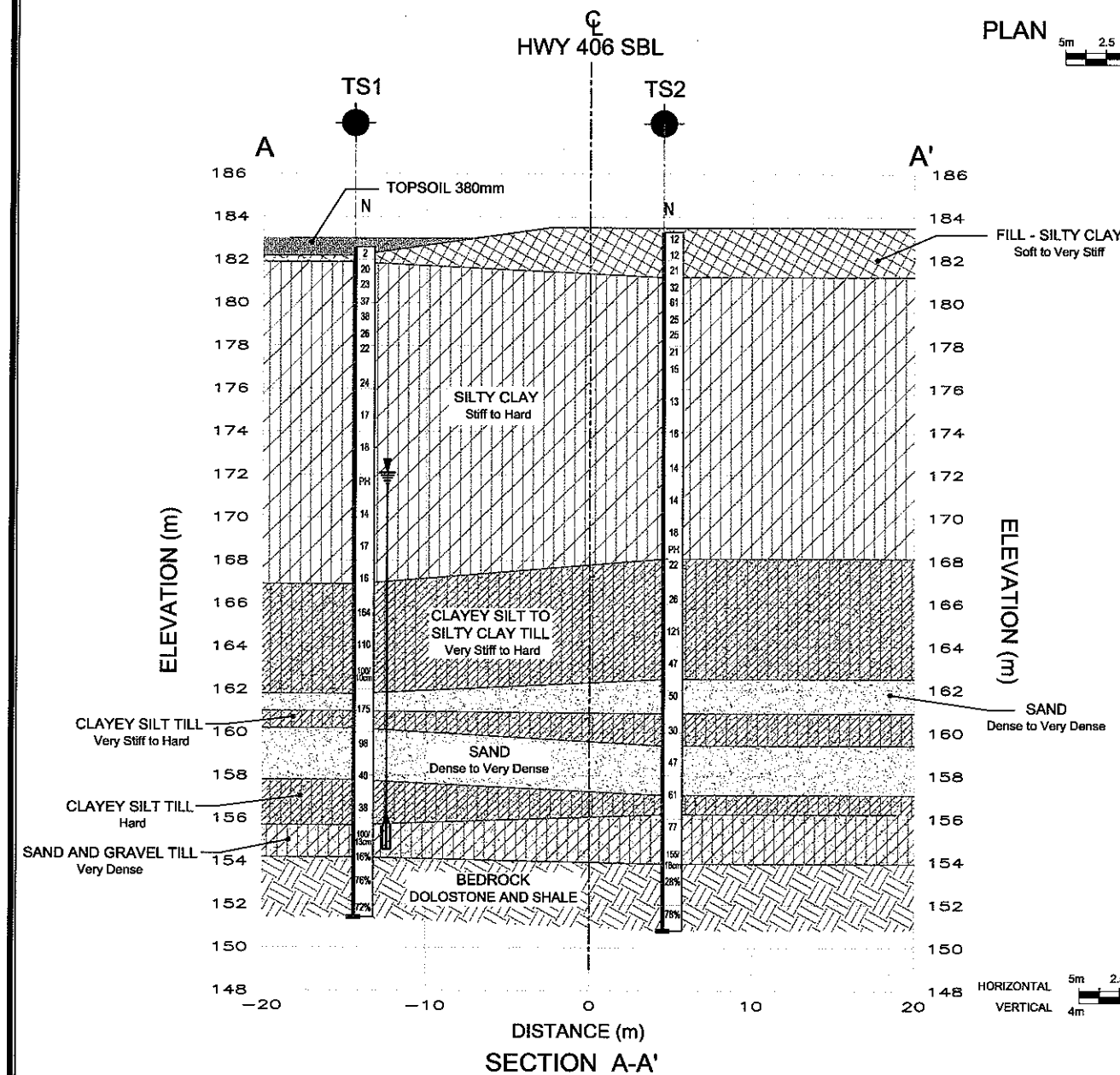
SHEET
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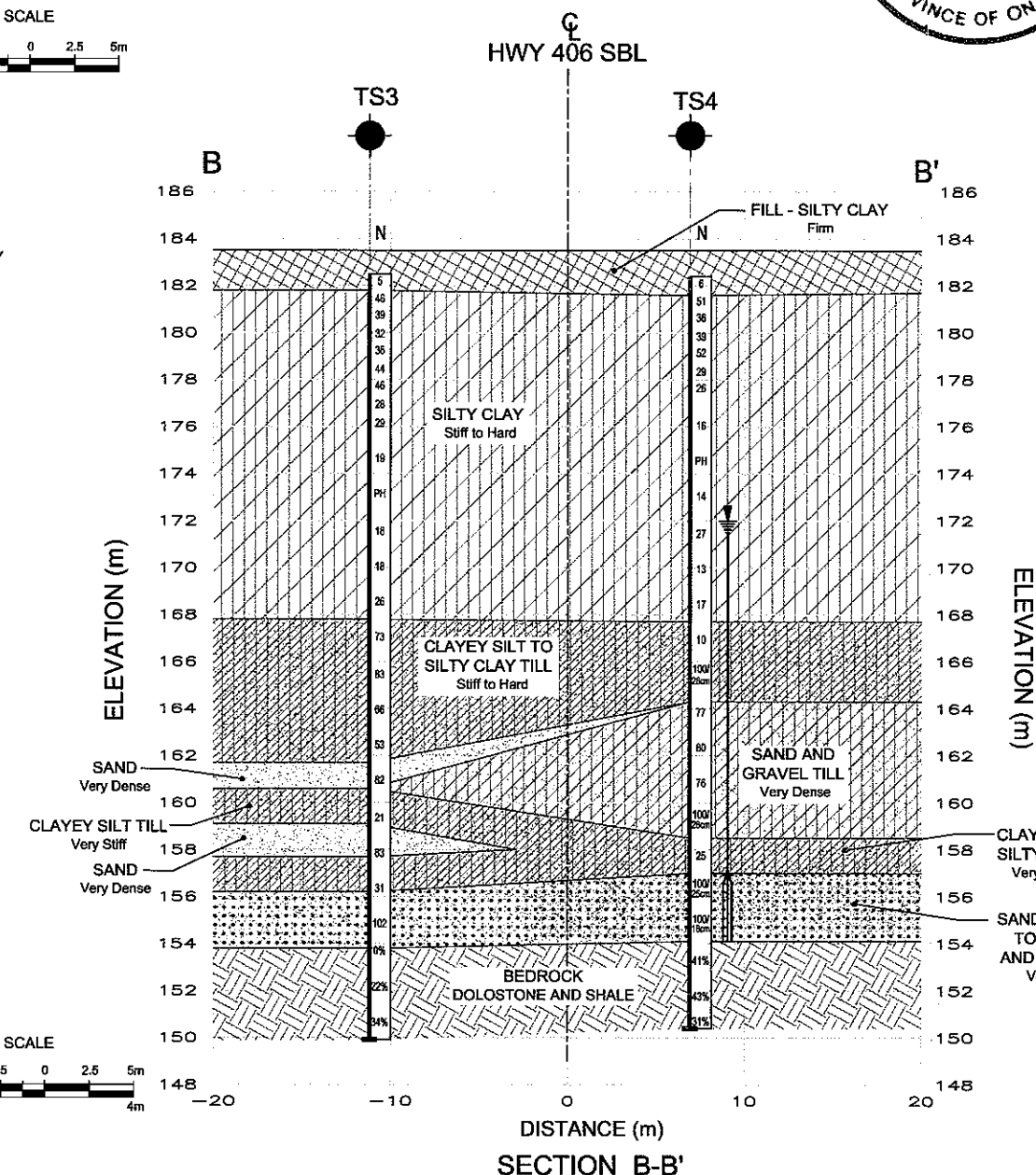
Terraprobe Inc.
Consulting Geotechnical & Environmental Engineering
Construction Materials Engineering, Inspection & Testing
10 Bram Court - Brampton Ontario L6W 3R6 (905) 798-2850



PLAN
SCALE
5m 2.5 0 2.5 5m



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



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 (MAY 2010)
	Piezometer
	90% Rock Quality Designation
	Auger Refusal

No	ELEV.	COORDINATES	
		NORTHING	EASTING
TS1	182.6	4 763 865.734	327 459.138
TS2	183.3	4 763 881.218	327 466.305
TS3	182.5	4 763 891.786	327 446.116
TS4	182.4	4 763 903.796	327 455.276
SBL 12+360CL	182.9	4 763 866.470	327 470.275
SBL 12+410CL	182.5	4 763 911.779	327 444.768

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	GEORES	30M3-256	