Terraprobe

Consulting Geotechnical & Environmental Engineering
Construction Materials Inspection & Testing

FOUNDATION INVESTIGATION REPORT
NOISE MITIGATION UPGRADE
HIGHWAY 406 TWINNING
PORT ROBINSION ROAD TO EAST MAIN STREET
AGREEMENT No. 2008-E-0016, W.P. 280-99-00
GEOCRES No. 30M3-267

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

Attention: Mr. Stephen Chiu, P.Eng.
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File No. 1-09-4135
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FOUNDATION INVESTIGATION REPORT
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PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual findings obtained from a foundation investigation conducted at a site where noise attenuation is required for residential properties in the vicinity of the Merritt Road interchange.

The purpose of this investigation was to explore the subsurface conditions at the site and based on the data obtained, to provide borehole and test pit location plans, records of boreholes, test pit logs, a stratigraphic profile, laboratory test results and a 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 on the east side of Highway 406 between the Merritt Road Interchange and the Old Welland Canal in the City of Thorold, Regional Municipality of Niagara. The alignment is adjacent to the proposed Highway 406 NBL (Sta. 14+175 to 14+434) and Ramp 406N-Merritt E/W (Sta. 10+000 to Sta. 10+125).

A noise berm was aligned parallel to and approximately 70 m west of the present Highway 406. The berm was approximately 395 m long with variable heights ranging from 3 m to 7.5 m. The berm's geometry was altered in the Advance Contract (Contract 2) to accommodate the proposed 406 NBL and the 406 S - Merritt Road E/W ramp. The adjustments included moving the toe of slope laterally to the east and regrading the berm's west slope to 3H:1V thereby resulting in a reduction in the berm height.

The topography in the area is generally flat to undulating with scattered man-made high ground areas. Vegetation at this site consists primarily of deciduous trees and wild bush. The area is a construction site.

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 units within the project limits consist of the Salina Formation and Guelph Formation of Upper Silurian Age[2]. The Salina Formation 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. The Guelph Formation consists essentially of unweathered, grey, laminated argillaceous dolostone.

3 SITE INVESTIGATION AND FIELD TESTING

The site investigation and field testing for this project were carried out between September 25, 2010 and October 03, 2010 and consisted of drilling and sampling five boreholes to depths ranging from 11.2 m to 15.1 m. Seven test pits were also dug to depths ranging from 4.4 m to 5.7 m on December 16, 2009 prior to the commencement of the Advance Contract (Contract 2). The approximate borehole and test pit locations are shown on the attached Borehole Locations and Soil Strata Drawing in Appendix D. Test pit photographs are provided 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. Test pit locations were established by referring to the staked centre line of Hwy. 406 NBL.

Access to the desired borehole locations was difficult due to the recently cut and relatively steep slopes. The boreholes were therefore relocated to be as close as feasible to the staked location while allowing safe operation of the drill rig. Utility clearances and permits were obtained by Terraprobe prior to drilling.

At the time of the field investigation the site was occupied by Dufferin Construction Company under MTO Contract No. 2010-2022. Therefore, the field work was undertaken on weekends to avoid interference with Dufferin's work and to ensure compliance with the Ministry of Labour requirements.

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.

[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.

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 clay slurry mixture after drilling was complete.

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
1	10.7/166.5	Piezometer with 3.0 m slotted screen installed with filter sand to 7.1 m, bentonite seal from 7.1 m to 6.4 m, silty clay cuttings from 6.4 m to 0.6 m and bentonite seal from 0.6 m to ground surface.
3	9.1/168.2	Hole sealed to 9.1 m with bentonite, piezometer with 3.0 m slotted screen installed with filter sand to 5.5 m, bentonite seal from 5.5 m to 4.9 m, silty clay cuttings from 4.9 m to 0.6 m and bentonite seal from 0.6 m to ground surface.
5	12.2/168.4	Hole sealed to 12.2 m with bentonite, piezometer with 3.0 m slotted screen installed with filter sand to 7.9 m, bentonite seal from 7.9 m to 7.3 m, silty clay cuttings from 7.3 m to 0.6 m and bentonite seal from 0.6 m to ground surface.

The drilling, sampling and in-situ testing operations were observed on a full time basis by members of Terraprobe's technical staff who logged the boreholes and processed the recovered soil 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, 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 and test pit logs in Appendix A. Details of the encountered soil stratigraphy are presented in this appendix and on the "Borehole Locations and Soil Strata" drawing in Appendix D. An overall description of the stratigraphy is given in the following paragraphs. However, the factual data presented in the Record of Borehole Sheets and test pit logs 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 and silt.

5.1 Topsoil

An 80 mm thick layer of topsoil was encountered in Boreholes 4 and 5. Topsoil thickness may vary between and beyond the boreholes.

5.2 Fill – Silty Clay

Some of the boreholes encountered silty clay fill material extending to depths ranging from 0.7 m (Elev. 179.9 m) to 1.8 m (Elev. 175.4 m) below ground surface. The test pits encountered fill that extended to depths ranging from 4.1 m to 5.4 m below grade.

Samples of this fill were subjected to grain size analysis and the results are illustrated in Figure B1. These results show a grain size distribution consisting of 0% gravel, 3-14% sand, 40-55% silt and 31-57% clay size particles.

The fill material was also subjected to Atterberg Limits tests and the results are plotted on the plasticity chart, Figure B2. The index values from these tests are summarized below:

Liquid Limit:	32-46%
Plastic Limit:	21-22%
Plasticity Index:	12-24%
Natural Moisture Content:	25-27%

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

Standard Penetration tests in the silty clay fill gave 'N' values that ranged from 3 to 14 blows for 0.3 m penetration. Based on these results the fill is considered to have a soft to stiff consistency. The moisture content of samples of this fill ranged from 15% to 27% by weight.

5.3 Silty Clay

A silty clay deposit was encountered at this site in all of the boreholes extending at least to borehole termination depths ranging from 11.2 m (Elev. 166.0 m) to 15.1 m (Elev. 165.0 m). In Boreholes 1 and 4 the silty clay is divided by a layer of silt. The test pits encountered silty clay at depths ranging from 4.1 m to 5.4 m below grade and this silty clay extended at least to the depths of excavation i.e. 4.4 m to 5.7 m below grade.

The grain size distribution curves of tested samples of the silty clay are presented in Figures B3 to B5 inclusive. These results show a grain size distribution consisting of 0-7% gravel, 0-13% sand, 31-81% silt and 18-68% clay size particles.

Samples of the silty clay were also subjected to Atterberg Limits tests and the results are illustrated on the plasticity chart, Figures B6 to B8 inclusive. The index values from these tests are summarized below:

Liquid Limit:	22-52%
Plastic Limit:	15-25%
Plasticity Index:	5-27%
Natural Moisture Content:	16-37%

These values indicate that the silty clay has a generally low to intermediate plasticity with clayey silt inclusions and infrequent zones of high plasticity.

Standard Penetration tests in this stratum gave 'N' values that ranged from 1 to 27 blows for 0.3 m penetration. Field vane tests gave in-situ undrained shear strengths ranging from 24 kPa to in excess of 100 kPa and laboratory vane tests on relatively undisturbed Shelby tube samples gave undrained shear strengths ranging from 22 kPa to 56 kPa. These values indicate that the consistency of the silty clay is generally firm to very stiff with infrequent soft zones. The moisture content of samples of the silty clay ranged from 16% to 37% by weight and the unit weight of selected samples ranged from 18.8 to 22.9 kN/m^3.

5.4 Silt

Boreholes 1 and 4 encountered a silt deposit. This stratum is approximately 1.6 m to 3.1 m thick and extends to depths ranging from 5.6 m (Elev. 171.6 m) to 11.7 m (Elev. 168.4 m) below ground surface.

The grain size distribution plots of tested samples of the silt are presented in Figure B9. These results show a grain size distribution consisting of 0% gravel, 1-2% sand, 92% silt and 6-7% clay size particles.

The deposit is considered to have a loose to dense relative density based on SPT 'N' values that ranged from 7 to 47 blows for 0.3 m penetration. The moisture content of samples from this deposit ranged from 21% to 25% by weight.

5.5 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 5.1.

Table 5.1 – Water Level Measurements

Borehole	Date	Water Levels	
		Depth (m)	Elevation (m)
1	October 03, 2010	6.9	170.3
	October 14, 2010	2.7	174.5
	October 20, 2010	2.6	174.6
3	October 03, 2010	1.9	175.4
	October 14, 2010	1.7	175.6
	October 20, 2010	1.8	175.5
5	September 25, 2010	4.5	176.1
	October 03, 2010	4.1	176.5
	October 14, 2010	4.0	176.6
	October 20, 2010	4.0	176.6

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 a phreatic surface that generally follows the ground surface topography. The water level exists at Elev. ±174.6 m at BH1 (Sta. 14+175) rising gently to Elev. ±175.5 m at BH3 (Sta. 14+300). The water level continues to rise northwards to BH5 (Sta. 14+475) where the recorded water level is Elev. ±176.6 m.

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

5.6 Miscellaneous

The drilling, sampling and in-situ testing operations were conducted with track-mounted drill rigs owned and operated by DBW Drilling Limited of Ajax, Ontario and Determination Drilling & Soil Investigations of Hamilton, Ontario. The test pits were excavated with a 9010 Case Excavator owned and operated by R & D Construction of Thorold, Ontario. The boreholes were advanced using solid stem auger drilling techniques.

Mr. Marc Paoliello, E.I.T. and Mr. Bob Racher, C.E.T, carried out the field work and the laboratory testing was performed at Terraprobe's Brampton laboratory. The report was written by Rehman Abdul, P.Eng. and reviewed by Michael Tanos, P.Eng.

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Report Reviewed by:
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APPENDICES

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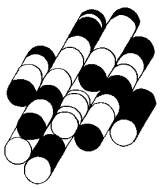

APPENDIX A

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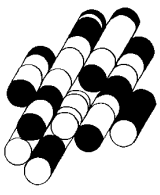


LIMITATIONS AND RISK

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

RECORD OF BOREHOLE No 1

1 OF 1 **METRIC**

W.P. 280-99-00 LOCATION Coords: N:4765596.7 E:326997.4 ORIGINATED BY MP

DIST HWY 406 BOREHOLE TYPE Solid Stem Augers COMPILED BY DB

DATUM Geodetic DATE 10.03.10 CHECKED BY RA

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
177.2	Ground Surface						177				
0.0	FILL - Silty Clay, some sand, trace organics, firm to stiff, brown, moist		1	SS	7						
			2	SS	14		176				0 14 55 31
175.4			3	SS	17						
1.8	SILTY CLAY trace sand, trace gravel, occasional silt seams and partings, stiff to very stiff, brown, moist		4	SS	20		175				1 2 58 39
			5	SS	14		174				
173.2								>>	1.4		
4.0	SILT trace clay, trace sand, dense, brown, wet		6	SS	47		173				0 1 92 7
171.6							172				
5.6	SILTY CLAY trace sand, trace gravel, stiff to very stiff, brown, moist		7	SS	14		171				7 6 60 27
								>>			
							170	>>			
			8	SS	17						
							169				
			9	SS	22		168				
							167				
166.0			10	SS	27						
11.2	End of Borehole						166				

Sampler wet at 4.6m.

Resistance to augering at 6.7m.

Water level at 8.5m (not stabilized) and hole open to full depth on completion.

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

Water Level Readings:

Date	Depth(m)	Elevation(m)
Oct.03.10	6.9	170.3
Oct.14.10	2.7	174.5
Oct.20.10	2.6	174.6

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

RECORD OF BOREHOLE No 2

1 OF 1 **METRIC**

W.P. 280-99-00 LOCATION Coords: N:4765647.1 E:326956.5 ORIGINATED BY MP

DIST HWY 406 BOREHOLE TYPE Solid Stem Augers COMPILED BY DB

DATUM Geodetic DATE 10.02.10 CHECKED BY RA

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
177.4	Ground Surface										
0.0	SILTY CLAY trace to some sand, occasional gravel inclusions, stiff to very stiff, brown, moist		1	SS	17		177				
			2	SS	22		176				
			3	SS	16						0 1 31 68
			4	SS	15		175				
			5	SS	13		174				
	--- frequent silt seams and partings ---		6	TW	PH		173			22.9	2 13 61 24
			7	SS	16		172				
			8	SS	20		171				1 2 62 35
			9	SS	18	▽	170				
			10	SS	15		169				0 1 71 28
165.4							168				
12.0	End of Borehole						167				
	Difficulty pushing shelby tube beyond 4.9m. Sampler wet at 6.1m. Water level at 10.1m (not stabilized) and hole open to full depth on completion.						166				

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

RECORD OF BOREHOLE No 3

1 OF 1 **METRIC**

W.P. 280-99-00 LOCATION Coords: N:4765693.3 E:326917.9 ORIGINATED BY MP

DIST HWY 406 BOREHOLE TYPE Solid Stem Augers COMPILED BY DB

DATUM Geodetic DATE 10.02.10 CHECKED BY RA

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L / WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
177.3	Ground Surface										
0.0	SILTY CLAY trace sand, frequent silt seams and partings from 4.0m to 7.1m, stiff to very stiff, brown, moist		1	SS	10		177				
			2	SS	14		176				
			3	SS	9		175				
	---- firm ----		4	SS	7						0 1 48 51
			5	SS	10		174				
			6	SS	20		173				0 1 81 18
			7	SS	12		172				
			8	SS	15		171				
			9	SS	16		170				0 2 74 24
166.1			10	SS	21		169				
11.2	End of Borehole						168				
	Sampler wet at 2.3m.						167				

Water level at 6.7m (not stabilized) and hole open to full depth on completion.

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

Water Level Readings:

Date	Depth(m)	Elevation(m)
Oct.03.10	1.9	175.4
Oct.14.10	1.7	175.6
Oct.20.10	1.8	175.5

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

RECORD OF BOREHOLE No 4

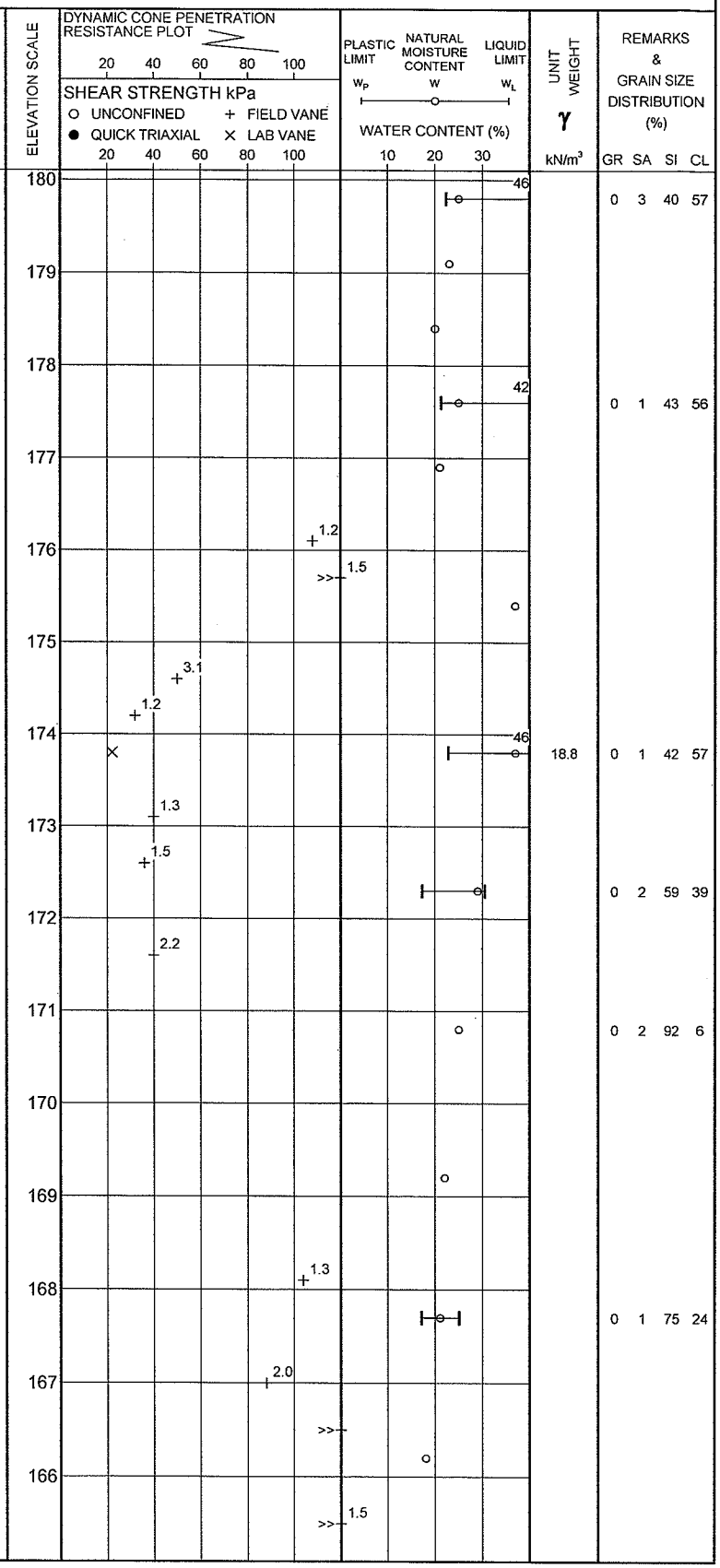
1 OF 2 **METRIC**

W.P. 280-99-00 LOCATION Coords: N:4765759.7 E:326896.0 ORIGINATED BY MP

DIST HWY 406 BOREHOLE TYPE Solid Stem Augers COMPILED BY DB

DATUM Geodetic DATE 09.25.10 CHECKED BY RA

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS
180.1	Ground Surface					
180.0	80mm TOPSOIL					
0.1	FILL - Silty Clay, trace sand, trace organics, soft, brown, moist		1	SS	3	
179.4						
0.7	SILTY CLAY trace sand, firm to very stiff, brown, moist		2	SS	16	
			3	SS	17	
			4	SS	8	
			5	SS	5	
	very soft		6	SS	1	
			7	TW	PH	
171.5						
8.6	SILT trace clay, trace sand, loose to compact, brown, wet		8	SS	2	
			9	SS	7	
			10	SS	10	
168.4						
11.7	SILTY CLAY trace sand, stiff to very stiff, brown, damp to moist		11	SS	7	
			12	SS	11	



UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR	SA	SI	CL
	0	3	40	57
	0	1	43	56
18.8	0	1	42	57
	0	2	59	39
	0	2	92	6
	0	1	75	24

Continued Next Page

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

RECORD OF BOREHOLE No 4

2 OF 2 **METRIC**

W.P. 280-99-00 LOCATION Coords: N:4765759.7 E:326896.0 ORIGINATED BY MP

DIST HWY 406 BOREHOLE TYPE Solid Stem Augers COMPILED BY DB

DATUM Geodetic DATE 09.25.10 CHECKED BY RA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (O 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
165.0 / 15.1	End of Borehole						165				
	Sampler wet at 9.1m.										
	Borehole was dry (not stabilized) and hole open to full depth on completion.										

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

RECORD OF BOREHOLE No 5

1 OF 2 **METRIC**

W.P. 280-99-00 LOCATION Coords: N:4765807.0 E:326859.2 ORIGINATED BY MP

DIST HWY 406 BOREHOLE TYPE Solid Stem Augers COMPILED BY DB

DATUM Geodetic DATE 09.25.10 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 (20 40 60 80 100) O UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × 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
180.6	Ground Surface										
180.5	80mm TOPSOIL										
0.1	FILL - Silty Clay, some sand, trace organics, stiff, brown, damp to moist		1	SS	9						
179.9											
0.7	SILTY CLAY trace sand, frequent silt seams and partings from 9.6m to 11.7m, occasional cobbles from 13.1m to 13.7m, firm to stiff, brown, damp to moist		2	SS	7		180				
			3	SS	14		179				
			4	SS	10		178				
			5	SS	7		177				0 0 50 50
			6	SS	3		176				
			7	SS	3		175				0 0 49 51
	soft to firm		8	SS	1		174				
			9	SS	2		173				0 2 64 34
			10	SS	2		172				0 2 78 20
			11	SS	5		171				
			12	SS	7		170				
166.0							169				
14.6	End of Borehole						168				
							167				
							166				

Continued Next Page

+3, ×3: Numbers refer to Sensitivity O3% STRAIN AT FAILURE

RECORD OF BOREHOLE No 5 2 OF 2 METRIC

W.P. 280-99-00 LOCATION Coords: N:4765807.0 E:326859.2 ORIGINATED BY MP

DIST HWY 406 BOREHOLE TYPE Solid Stem Augers COMPILED BY DB

DATUM Geodetic DATE 09.25.10 CHECKED BY RA

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P NATURAL MOISTURE CONTENT w LIQUID LIMIT w_L WATER CONTENT (%) 10 20 30	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	Sampler wet at 10.7m. Unable to push vane beyond 11.1m and 14.6m. Resistance to augering from 13.1m to 13.7m. Wet cave at 12.8m on completion. Piezometer installation consists of a 19mm diameter, Schedule 40 PVC pipe with a 3.0m slotted screen. Water Level Readings: Date Depth(m) Elevation(m) Sep.25.10 4.5 176.1 Oct.03.10 4.1 176.5 Oct.14.10 4.0 176.6 Oct.20.10 4.0 176.6										

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

Test Pit Logs (TP 6A - 6G)
Hwy 406 (Sta. 14+175 to Sta. 14+434)
Ramp 406 S-Merritt Rd E/W (Sta. 10+000 to Sta. 10+125)

Test Pit # TP 6A

0.00	-	2.40	Fill, Br Si(y) Cl, Tr Gr, Tr Cob, Moist to Wet
2.40	-	4.10	Fill, Dk Br Cl(y) Si, Some Org, Blk Stks, Some Wd, Some Roots, Moist to Wet
4.10	-	4.40	Gry/Br Si(y) Cl, Mott, Moist to Wet

Test Pit # TP 6B

0.00	-	1.90	Fill, Br Cl(y) Si, Some Gr, Some Cob, Moist
1.90	-	4.20	Fill, Dk Br Si(y) Cl, Some Org, Blk Stks, Some Wd, Some Roots, Moist to Wet
4.20	-	4.40	Tps
4.40	-	4.90	Br/Gry Si(y) Cl, Moist

Test Pit # TP 6C

0.00	-	2.20	Fill, Br Si(y) Cl, Tr Gr, Cob, Moist to Wet
2.20	-	4.20	Fill, Gry/Br Cl(y) Si, Tr to Some Sa, Tr Sh Rk, Moist to Wet
4.20	-	4.80	Tps, Some Wd (Stumps), Moist to Wet
4.80	-	5.20	Gry/Br Si(y) Cl, Mott, Moist

Test Pit # TP 6D

0.00	-	3.90	Fill, Br Cl(y) Si, Some Gr, Occ Cob, Tr Wd, Moist to Wet, Fr Wat @ 1.2
3.90	-	4.90	Fill, Gry/Br Cl(y) Si to Si Some Cl, Some Roots, Moist to Wet
4.90	-	5.10	Tps, Org M
5.10	-	5.30	Gry/Br Si(y) Sa, Tr Cl, Wet, Fr Wat @ 5.3

Test Pit # TP 6E

0.00	-	1.80	Fill, Br Si, Tr Cl, Tr Sa, Moist
1.80	-	4.40	Fill, Gry/Br Si, Some Cl, Some Org, Moist
4.40	-	4.60	Tps, Org M, Some Wd
4.60	-	4.90	Gry/Br Si(y) Cl, Mott, Moist

Test Pit # TP 6F

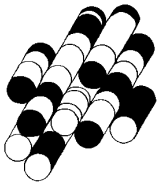
0.00	-	3.00	Fill, Br Cl(y) Si, Some Gr, Some Cob, Occ Blds, Moist
3.00	-	5.00	Fill, Gry/Br Sa and Si, Some Cl, Some Roots, Some Wd, Wet
5.00	-	5.30	Br/Gry Si(y) Cl, Moist

Test Pit # TP 6G

0.00	-	3.50	Fill, Br Cl(y) Si, Tr Gr, Occ Cob, Moist
3.50	-	4.60	Fill, Br Cl(y) Si, Tr to Some Org, Blk Stks, Tr Wd, Moist
4.60	-	5.40	Fill, Gry Cl(y) Si, Some Roots, Moist
5.40	-	5.70	Gry/Br Si(y) Cl, Moist

APPENDIX B

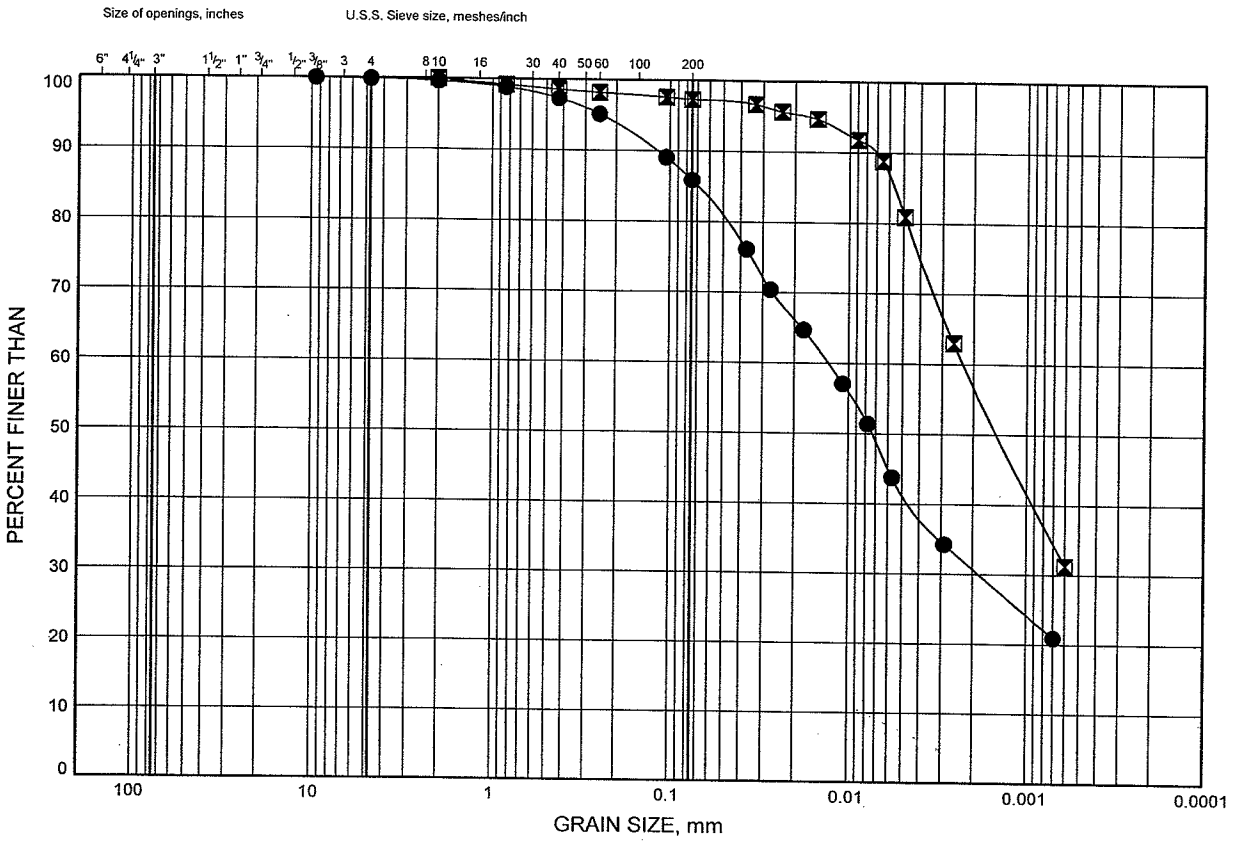
TERRAPROBE INC.



GRAIN SIZE DISTRIBUTION

FIGURE B1

FILL - Silty Clay



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

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	1	1.0	176.2
⊠	4	0.3	179.8

Date November 2010

Project 1-09-4135

Prep'd DB

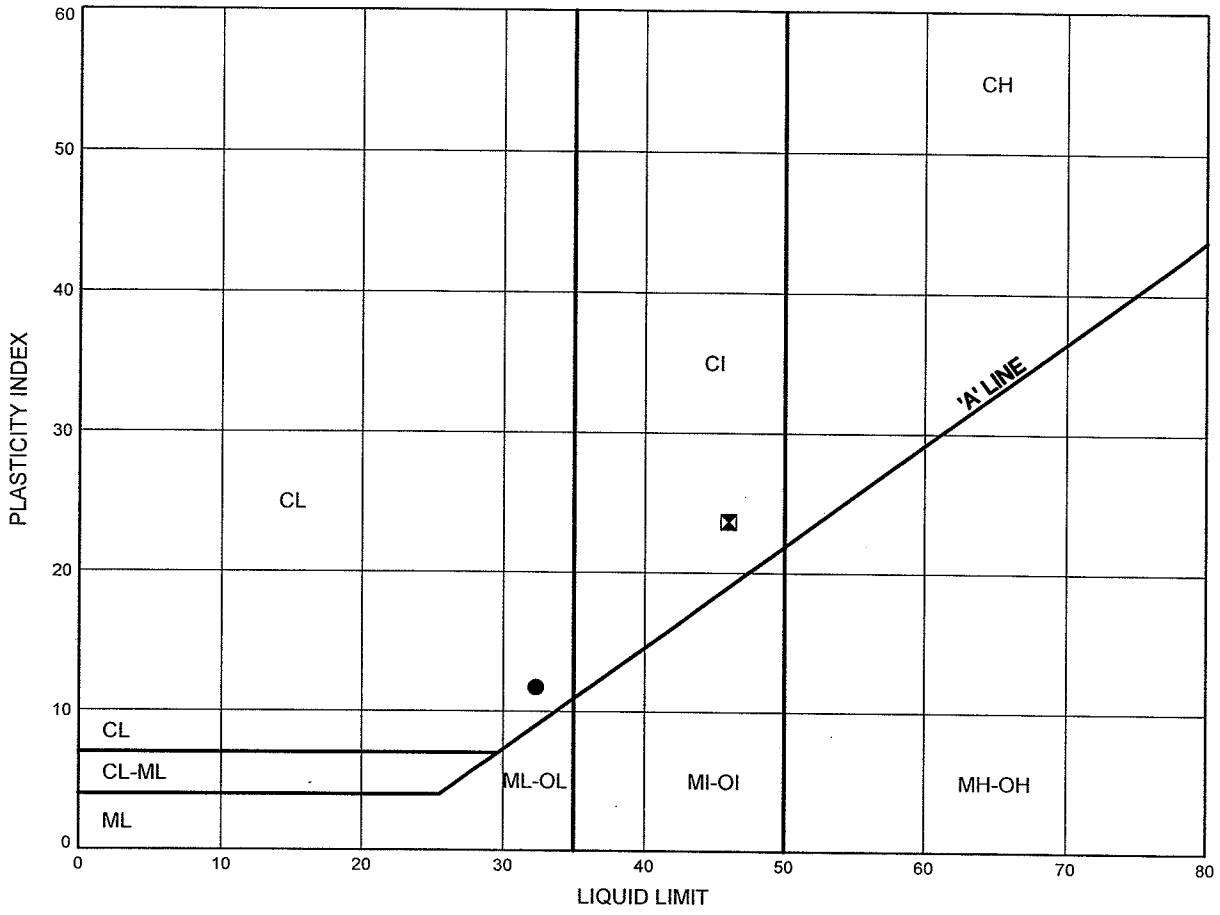
Chkd. HA

GSD 1-09-4135 SOUND BERM.GPJ 11/02/10

ATTERBERG LIMITS TEST RESULTS

FIGURE B2

FILL - Silty Clay



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	1	1.0	176.2
⊠	4	0.3	179.8

Date November 2010

Project 1-09-4135

Prep'd DB

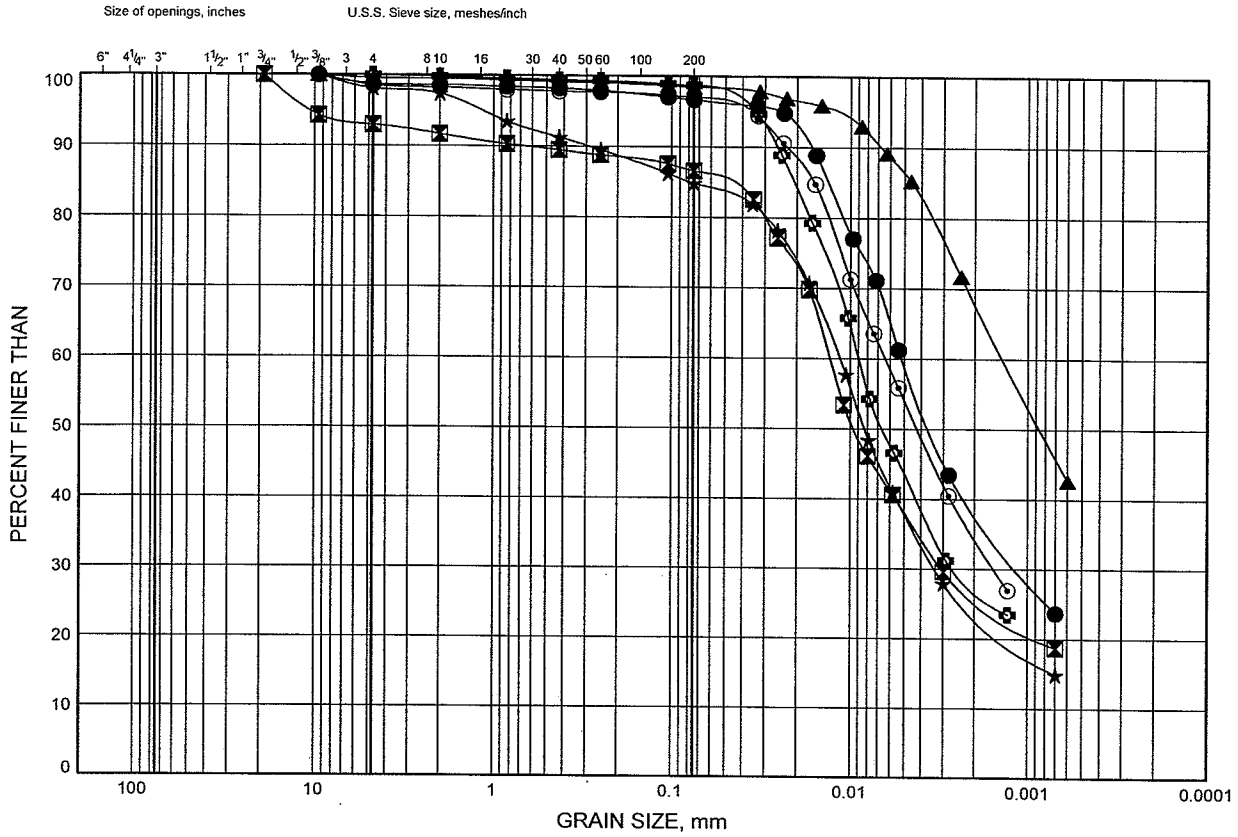
Chkd. HA

ALTR 1-09-4135 SOUND BERM.GPJ 11/02/10

GRAIN SIZE DISTRIBUTION

FIGURE B3

SILTY CLAY



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

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	1	2.5	174.7
⊠	1	6.3	170.9
▲	2	1.7	175.7
★	2	4.7	172.7
⊙	2	6.3	171.1
✿	2	10.9	166.5

Date November 2010

Project 1-09-4135

Prep'd DB

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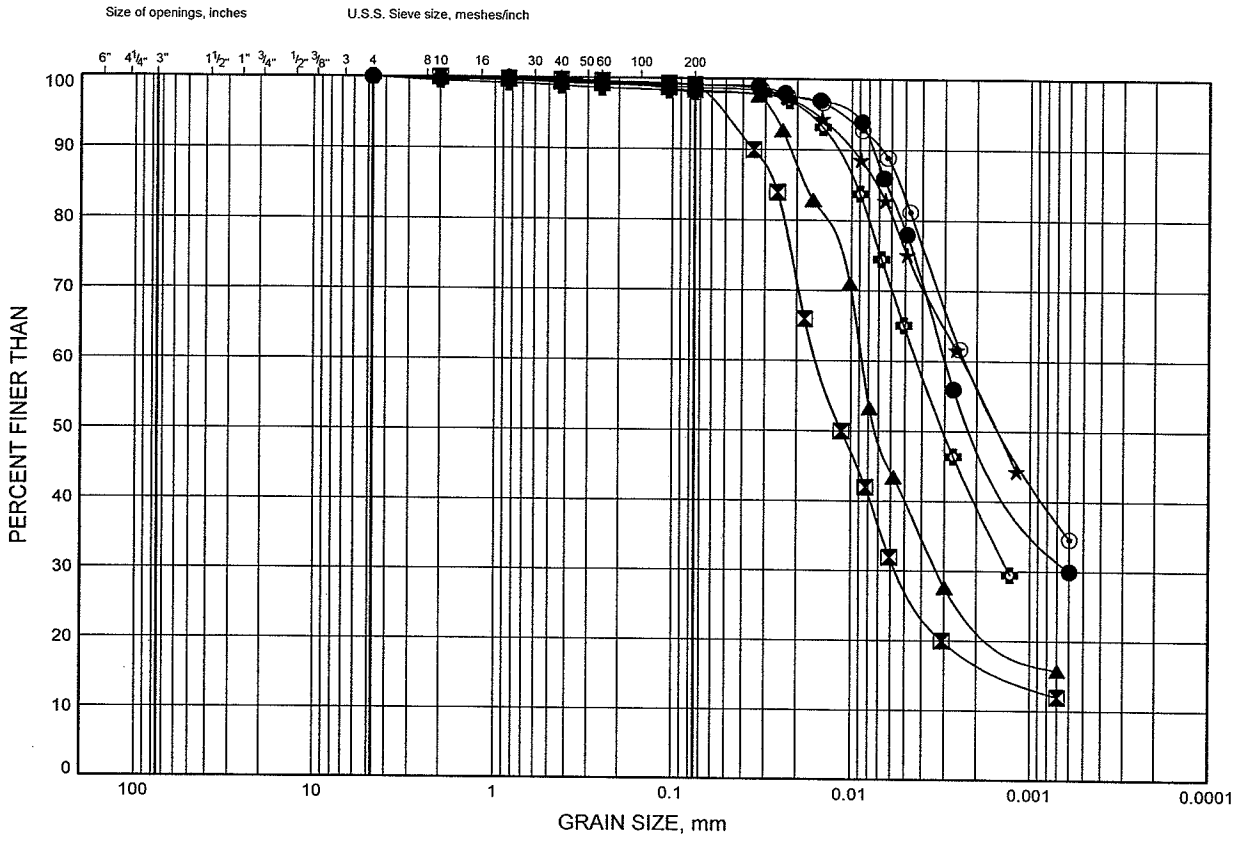
GSD 1-09-4135 SOUND BERM.GPJ 11/02/10

GRAIN SIZE DISTRIBUTION

FIGURE B4

SILTY CLAY



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

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	3	2.5	174.8
⊠	3	4.7	172.6
▲	3	9.3	168.0
★	4	2.5	177.6
⊙	4	6.3	173.8
✿	4	7.8	172.3

Date November 2010

Project 1-09-4135

Prep'd DB

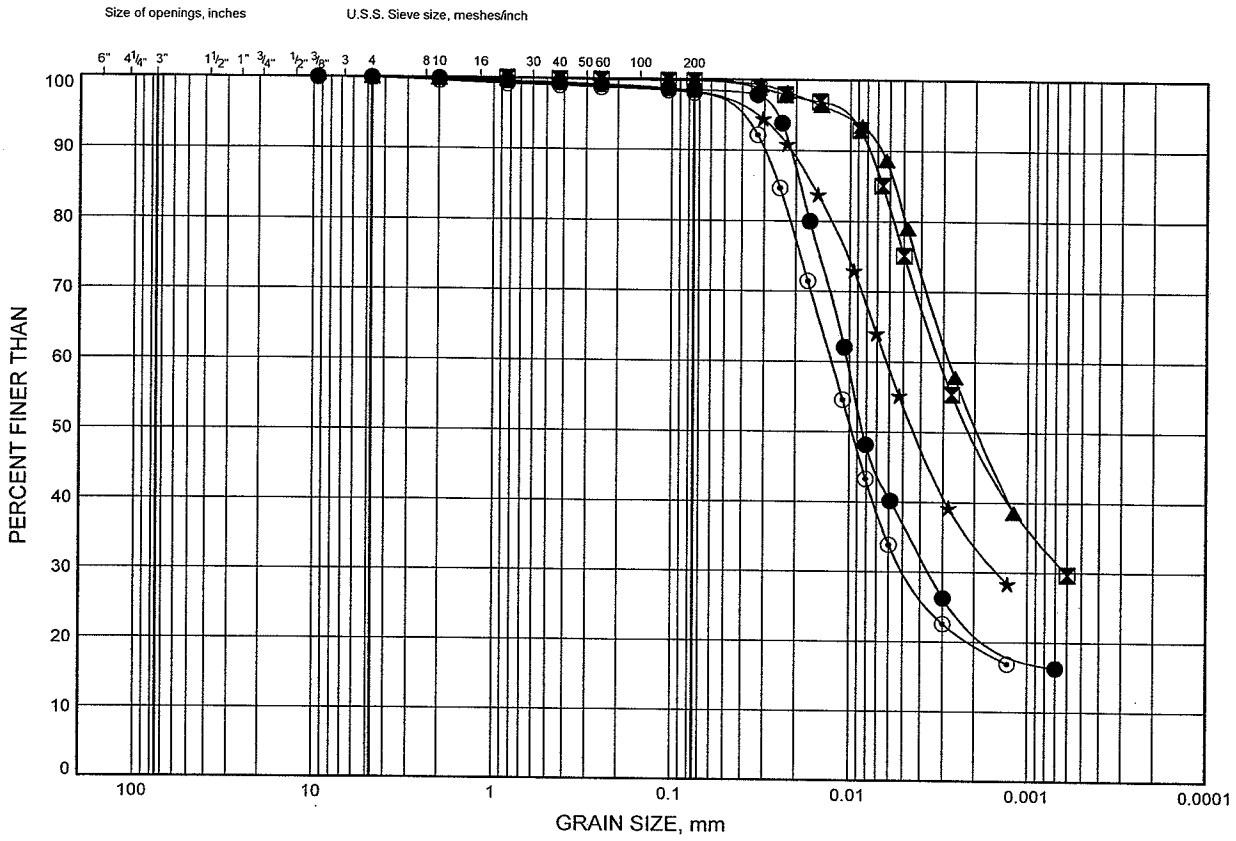
Chkd. HA

GSD 1-09-4135 SOUND BERM.GPJ 11/02/10

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)
●	4	12.4	167.7
⊠	5	3.2	177.4
▲	5	6.3	174.3
★	5	9.3	171.3
⊙	5	10.9	169.7

Date November 2010

Project 1-09-4135

Prep'd DB

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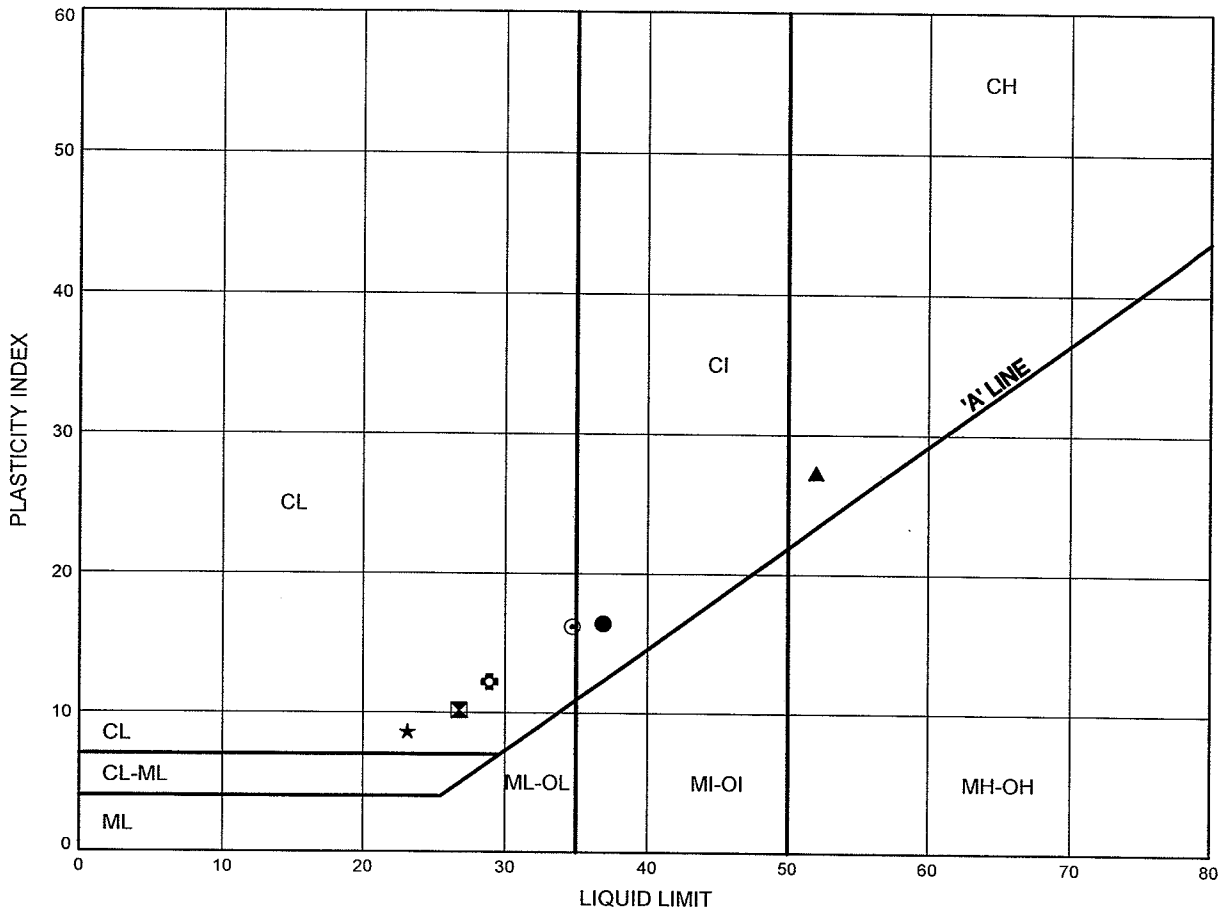
GSD 1-09-4135 SOUND BERM.GPJ 11/02/10

ATTERBERG LIMITS TEST RESULTS

FIGURE B6

SILTY CLAY



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	1	2.5	174.7
⊠	1	6.3	170.9
▲	2	1.7	175.7
★	2	4.7	172.7
⊙	2	6.3	171.1
✿	2	10.9	166.5

Date November 2010

Project 1-09-4135

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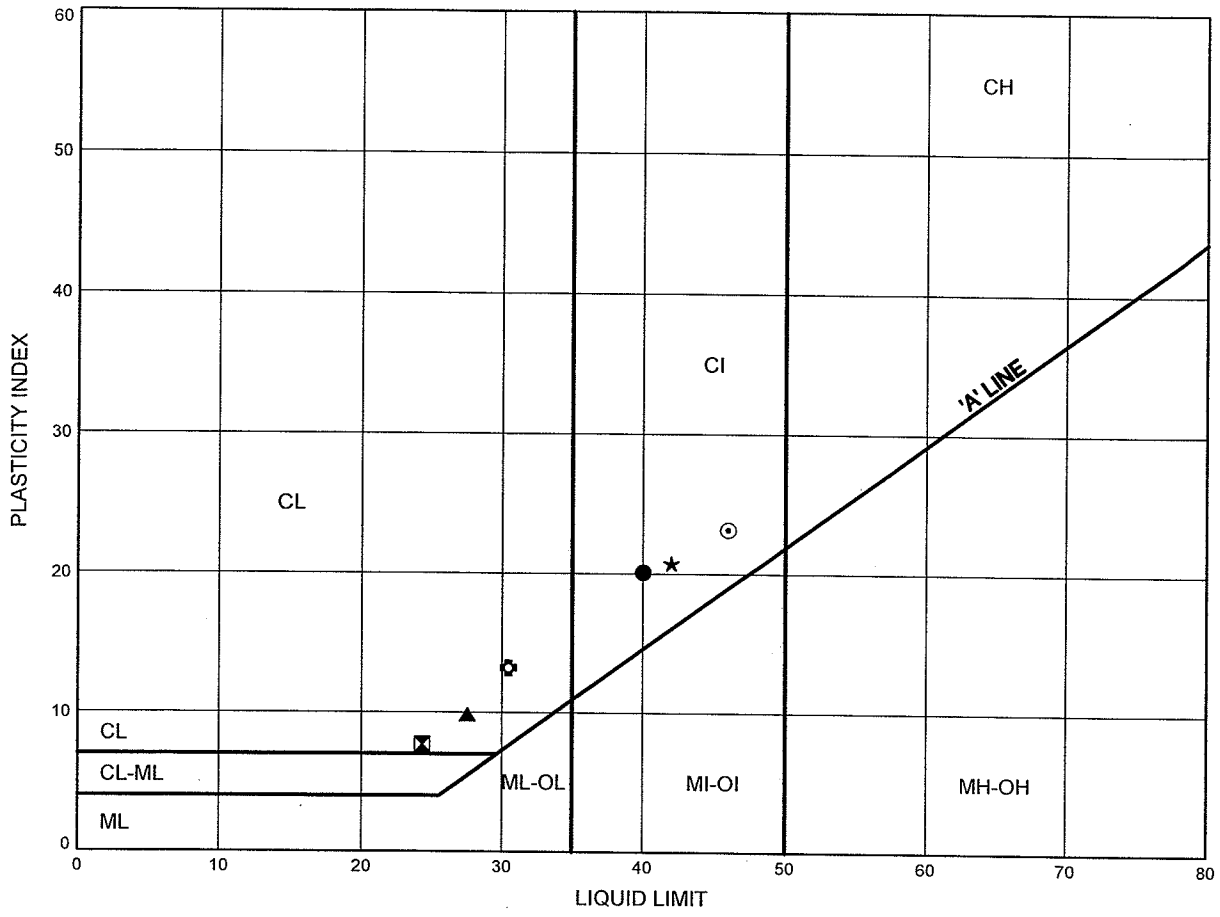
ALTR 1-09-4135 SOUND BERM.GPJ 11/02/10

ATTERBERG LIMITS TEST RESULTS

FIGURE B7

SILTY CLAY



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	3	2.5	174.8
⊠	3	4.7	172.6
▲	3	9.3	168.0
★	4	2.5	177.6
⊙	4	6.3	173.8
✿	4	7.8	172.3

Date November 2010

Project 1-09-4135

Prep'd DB

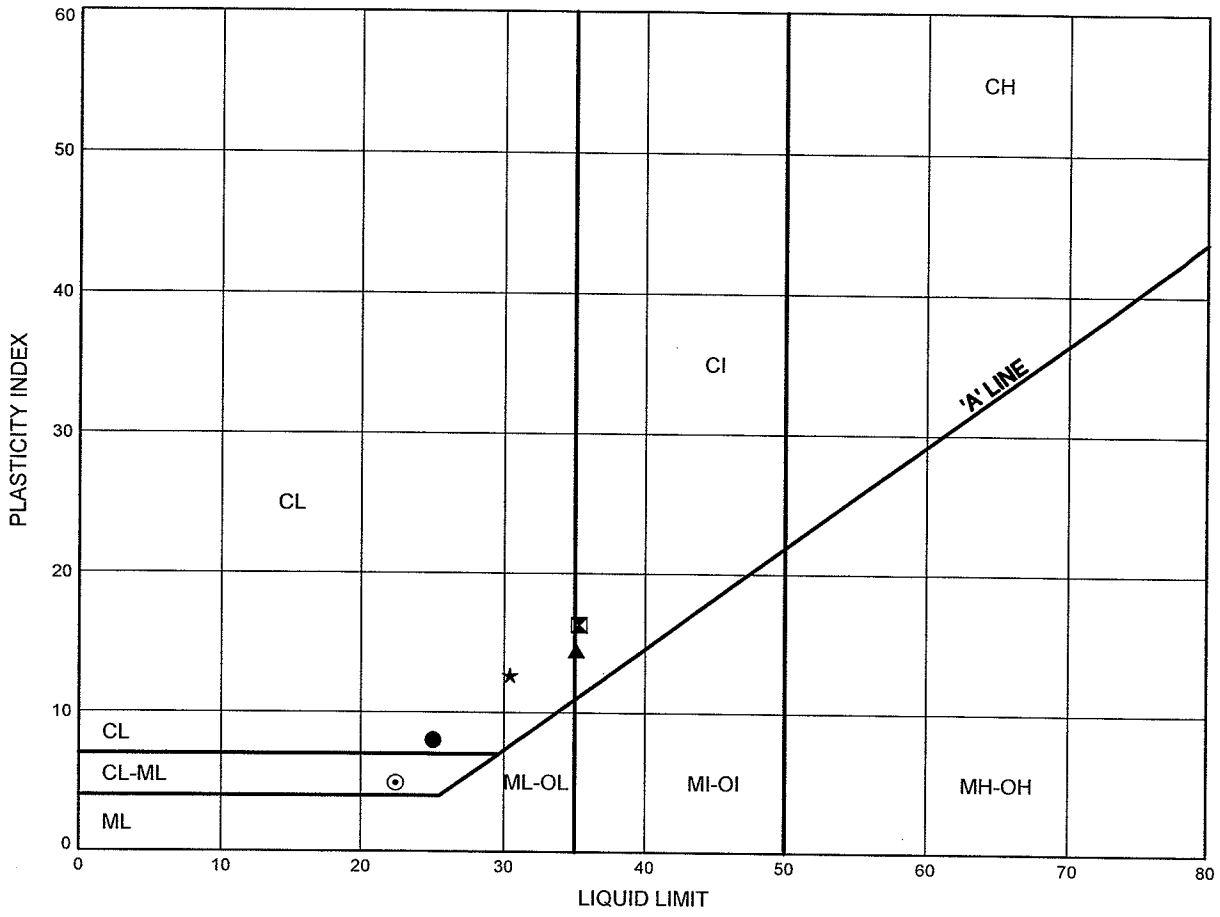
Chkd. HA

ALTR 1-09-4135 SOUND BERM.GPJ 11/02/10

ATTERBERG LIMITS TEST RESULTS

FIGURE B8

SILTY CLAY



SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	4	12.4	167.7
⊠	5	3.2	177.4
▲	5	6.3	174.3
★	5	9.3	171.3
⊙	5	10.9	169.7

Date November 2010

Project 1-09-4135

Prep'd DB

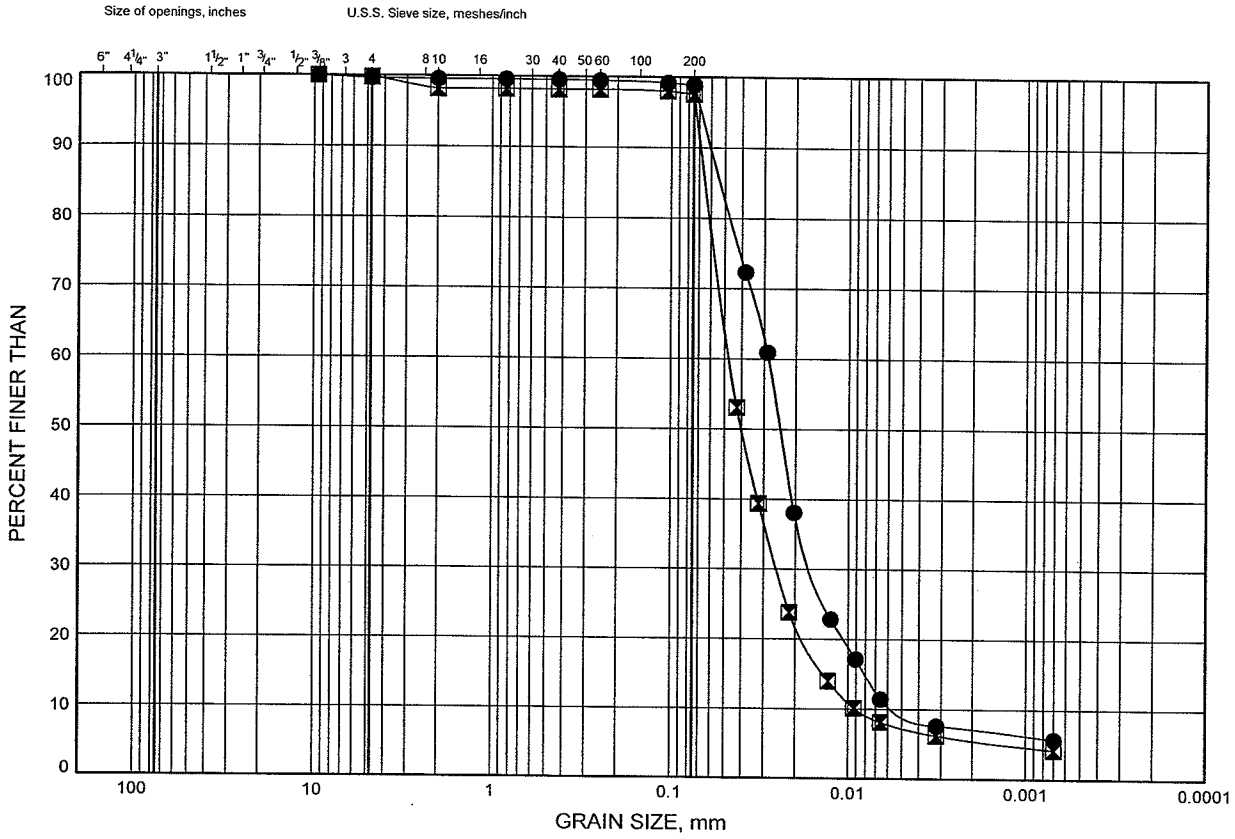
Chkd. HA

ALTR 1-09-4135 SOUND BERM.GPJ 11/02/10

GRAIN SIZE DISTRIBUTION

FIGURE B9

SILT



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

SYMBOL	BOREHOLE	DEPTH (m)	ELEVATION (m)
●	1	4.7	172.5
⊠	4	9.3	170.8

Date November 2010

Project 1-09-4135

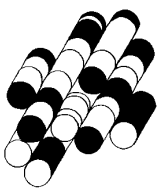
Prep'd DB

Chkd. HA

GSD 1-09-4135 SOUND BERM.GPJ 11/02/10

APPENDIX C

TERRAPROBE INC.



Test Pit 6A (Sta. 10+070 406 S-Merritt E/W, 29.0 m Rt C/L)

Test Pit 6A (Sta. 10+070 406 S-Merritt E/W, 29.0 m Rt C/L)

Test Pit 6A (Sta. 10+070 406 S-Merritt E/W, 29.0 m Rt C/L)

Test Pit 6B (Sta. 10+025 406 S-Merritt E/W, 23.0 m Rt C/L)

Test Pit 6B (Sta. 10+025 406 S-Merritt E/W, 23.0 m Rt C/L)

Test Pit 6B (Sta. 10+025 406 S-Merritt E/W, 23.0 m Rt C/L)

Test Pit 6C (Sta. 14+413 Hwy 406, 44.8 m Rt C/L)

Test Pit 6C (Sta. 14+413 Hwy 406, 44.8 m Rt C/L)

Test Pit 6D (Sta. 14+372 Hwy 406, 45.9 m Rt C/L)

Test Pit 6D (Sta. 14+372 Hwy 406, 45.9 m Rt C/L)

Test Pit 6E (Sta. 14+331 Hwy 406, 46.3 m Rt C/L)

Test Pit 6F (Sta. 14+284 Hwy 406, 46.8 m Rt C/L)

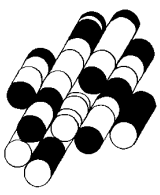
Test Pit 6F (Sta. 14+284 Hwy 406, 46.8 m Rt C/L)

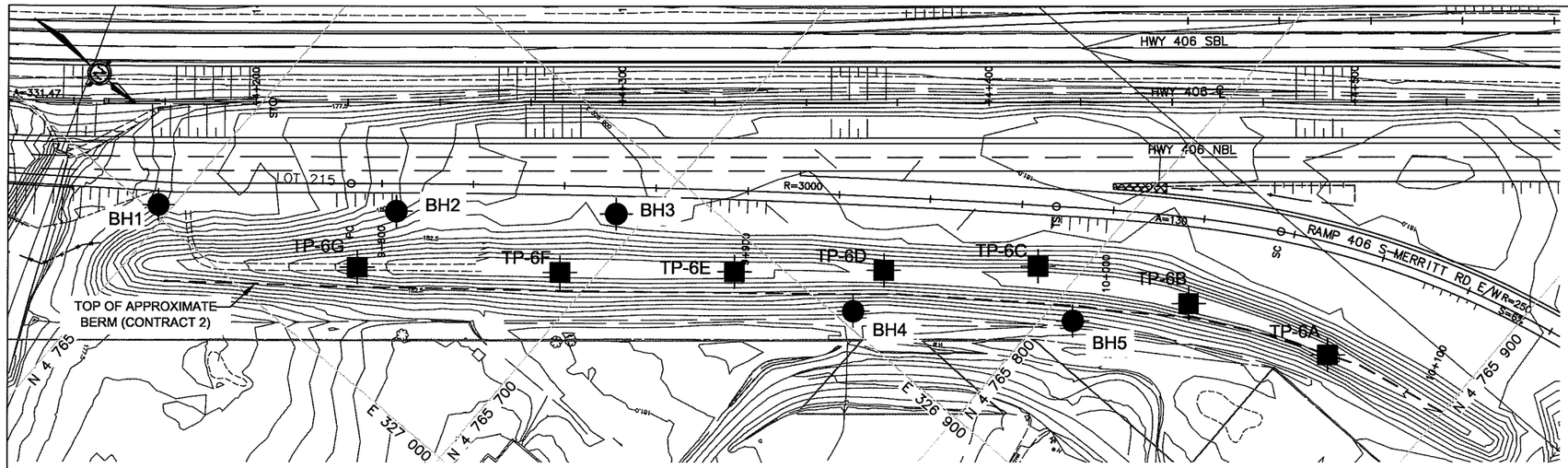
Test Pit 6G (Sta. 14+228 Hwy 406, 45.1 m Rt C/L)

Test Pit 6G (Sta. 14+228 Hwy 406, 45.1 m Rt C/L)

APPENDIX D

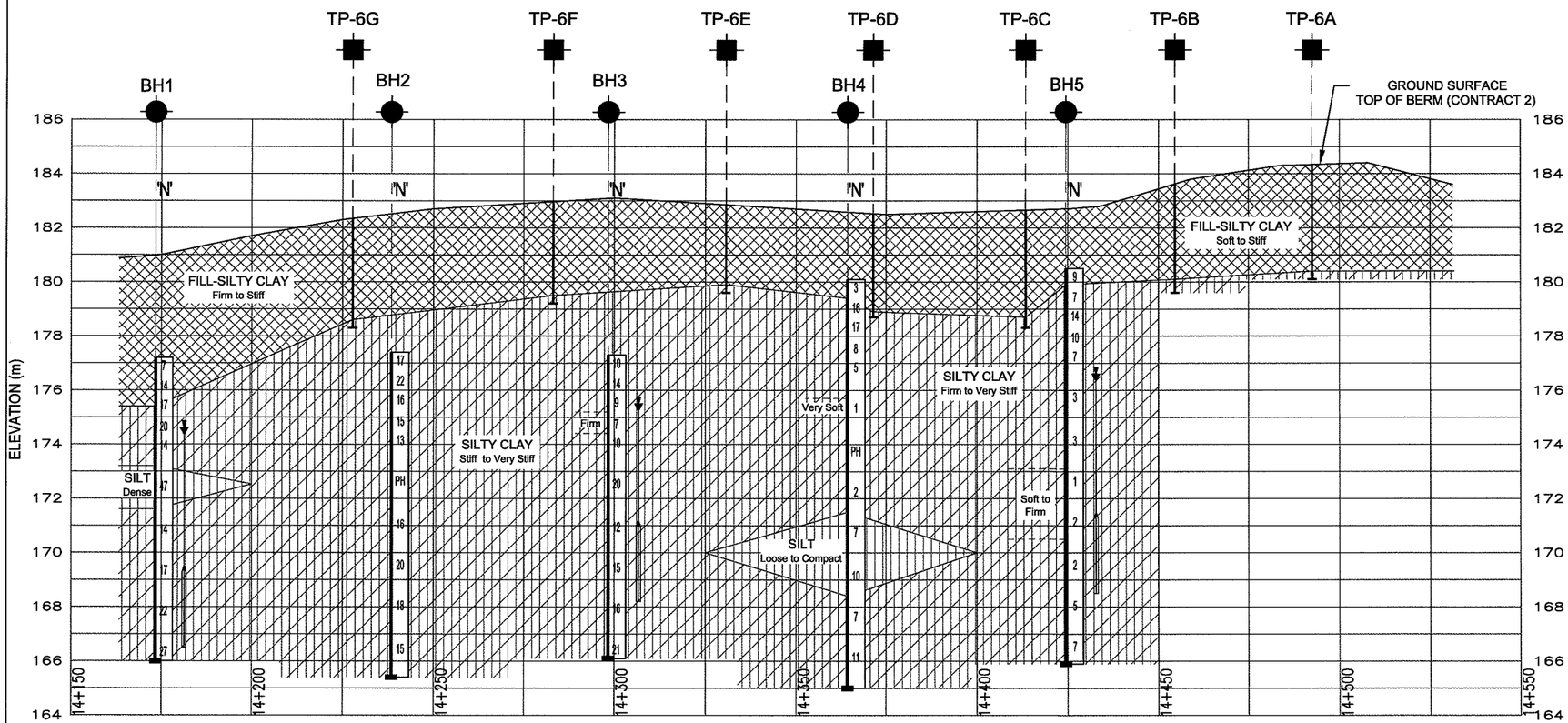
TERRAPROBE INC.





PLAN

SCALE 0 10 20 30 40m



PROFILE ℄ - TOP OF BERM (CONTRACT 2)

VERTICAL SCALE 0 1 2 3 4 5m

HORIZONTAL SCALE 0 10 20 30 40m

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

CONT No

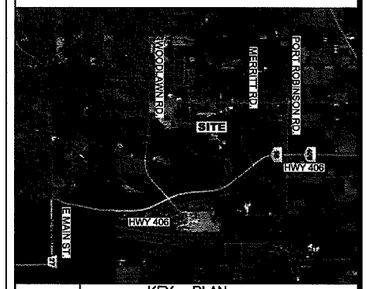
WP No 280-99-00

HIGHWAY 406
NOISE MITIGATION UPGRADE
BOREHOLE LOCATIONS AND SOIL 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) 796-2650



KEY PLAN

LEGEND

●	Bore Hole
⊕	Dynamic Cone Penetration Test
⊕	Bore Hole And Cone
■	Test Pit
'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 (OCT. 2010)
	Piezometer
90%	Rock Quality Designation
A/R	Auger Refusal

No	ELEV.	COORDINATES	
		NORTHING	EASTING
BH1	177.2	4 765 596.7	326 997.4
BH2	177.4	4 765 647.1	326 956.5
BH3	177.3	4 765 693.3	326 917.9
BH4	180.1	4 765 759.7	326 896.0
BH5	180.6	4 765 807.0	326 859.2
TP6A	184.5	4 765 865.9	326 820.9
TP6B	184.5	4 765 828.0	326 835.0
TP6C	183.5	4 765 790.0	326 854.0
TP6D	184.0	4 765 758.8	326 882.1
TP6E	184.5	4 765 728.0	326 909.0
TP6F	184.5	4 765 692.0	326 940.0
TP6G	184.0	4 765 649.0	326 975.0

Ground Surface elevation prior to Contract 2.

NOTE

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

This drawing is for subsurface information only. Surface details and features are for conceptual illustration. Existing berm regraded in Contract 2. Base mapping illustrates ground conditions prior to Contract 2.

REVISIONS	DATE	BY	DESCRIPTION

DESIGN R.A	CODE CHBDC2006	LOAD	DATE NOV. 2010	
DRAWN K.C	CHK R.A	STRUCT	GEOCRES 30M3-267	

REGISTERED PROFESSIONAL ENGINEER M. TANOS 25'01'2011 PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER R.A. ABDUL Jan 25/2011 PROVINCE OF ONTARIO

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