

**PRELIMINARY
FOUNDATION INVESTIGATION AND DESIGN REPORT
SPITZIG ROAD UNDERPASS
HIGHWAY 7-NEW, KITCHENER TO GUELPH
G.W.P. 408-88-00**

Geocres Number: 40P8-170

Report to

**Ministry of Transportation Ontario
Southwestern Region**

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June 3, 2009
File: 15-64-17

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PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual findings obtained from a preliminary foundation investigation conducted at the site of the proposed underpass structure to carry Spitzig Road over Highway 7-New in the Regional Municipality of Waterloo, Ontario.

The purpose of the 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, a stratigraphic profile, laboratory test results and a written description of the subsurface conditions. A model of the subsurface conditions under the potential foundation footprint was developed from the data obtained in the course of the investigation.

The information collected in the course of the investigation and presented in this report is intended for preliminary design purposes only. Additional site investigation, field testing and engineering analysis will be required at the detail design stage. The extent of the additional investigation will depend, in part, on the final location and General Arrangement of the structure.

Thurber carried out the investigation for the Ministry of Transportation Ontario, Southwestern Region (MTO) under Purchase Order Number 3006-E-0123.

2 SITE DESCRIPTION

At the site, the Highway 7-New alignment runs approximately parallel to the existing Highway 7 alignment and 115 m to the north. The site lies approximately 5.5 km northeast of a developed area of the City of Kitchener.

Based on the Ontario Geological Survey Special Volume 2, The Physiography of Southern Ontario, Third Edition by Chapman and Putnam, the site lies within an area referred to as the Guelph Drumlin Field, an area of drumlinized till plain, also mapped as containing eskers. The till is described as stony and the occurrence of surface boulders is noted. Chapman and Putnam give a

typical gradation of the till as being 50% sand, 35% silt and 15% clay. Swampy valleys are reported to occur between the drumlins and associated gravel terraces.

The site lies within an area of farms and agricultural lands. There are farmsteads to the east of Spitzig Road, north of the existing Highway 7 alignment.

3 SITE INVESTIGATION AND FIELD TESTING

The site investigation and field testing at this site was carried out from January 13 to 21, 2009. Three boreholes, numbered 08-122, 08-123 and 08-124, were drilled approximately at the north abutment, pier and south abutment of a possible two-span structure arrangement. The depths of the boreholes ranged from 15.5 m to 20.3 m. The Record of Borehole sheets for the boreholes are included in Appendix A. The approximate locations of the three boreholes are shown on the attached Borehole Locations and Soil Strata Drawing in Appendix E.

Prior to commencing the site investigation, clearance was obtained from utility companies having plant in the area. Road occupancy permit was also obtained to complete site investigation.

The boreholes were drilled using solid stem auger equipment mounted on a track-mounted drill rig. Samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT) in the overburden soils.

Groundwater conditions in the open boreholes were observed throughout the drilling operations. In Borehole 08-123, drilled at the proposed pier location, a standpipe piezometer consisting of 19 mm diameter PVC pipe with a slotted screen was installed and enclosed in filter sand to permit longer term groundwater level monitoring. The location and completion details of the piezometer are shown in Table 3.1. Boreholes without piezometer installations were grouted with bentonite upon completion. The borehole completion details are also shown in Table 3.1.

The completion of the boreholes and the standpipe piezometer was carried out in accordance with the requirements of O. Reg. 903 (as amended by O. Reg. 372/07).

Table 3.1 – Borehole Completion Details

Foundation Unit	Borehole Location	Piezometer Tip Depth/ Elevation (m)	Completion Details
North Abutment	08-122	No Installation	Bentonite grout and cuttings from bottom of borehole to ground surface.
Pier	08-123	13.7/315.5	Piezometer with 1.5 m slotted screen installed with sand filter to 11.6 m, bentonite from 11.6 m to 9.4 m, bentonite mixed with auger cuttings from 9.4 to ground surface.
South Abutment	08-124	No Installation	Bentonite grout and cuttings from bottom of borehole to ground surface.

A member of Thurber's technical staff supervised the drilling and sampling operations on a full time basis. The supervisor logged the boreholes and processed the recovered soil samples for transport to Thurber's laboratory for further examination and testing.

4 LABORATORY TESTING

The recovered soil samples were subjected to Visual Identification (VI) and to natural moisture content determination. The results of this testing are shown on the Record of Borehole sheets in Appendix A. Selected samples were also subjected to gradation analysis (sieve and hydrometer) and Atterberg Limits testing where appropriate. The results of this testing program are shown on the Record of Borehole sheets in Appendix A and on the figures contained 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 stratigraphy along the proposed alignment are presented in this appendix and on the "Borehole Locations and Soil Strata" drawing in Appendix E. 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 overlying two distinct, glacial till deposits within the depth of exploration: sandy silt till and silty clay till. Layers of clayey silt and silty clay were also encountered below the topsoil.

5.1 Topsoil

Topsoil was identified at ground surface in the three boreholes. The topsoil thickness was 450 mm.

The topsoil thickness may vary between and beyond the borehole locations and the data is not intended for the purpose of estimating quantities.

5.2 Sand and Silt

A 900-mm thick layer of sand and silt containing trace gravel and occasional organics was contacted below the topsoil in Borehole 08-123. The depth to the base of the sand and silt layer was 1.4 m (Elevation 327.8).

An SPT 'N' value measured in the sand and silt layer was 27 blows per 0.3 m of penetration, indicating a compact relative density. The natural moisture content was 18%.

5.3 Clayey Silt and Silty Clay

Native brown to grey clayey silt containing trace gravel, some sand and occasional organics was encountered below the topsoil in Boreholes 08-122 and 08-124. In Borehole 08-123, a layer of brown silty clay was contacted at 1.4 m depth (Elevation 327.8) below

the sand and silt. Thickness of the clayey silt and silty clay layers ranged from 0.7 m to 1.8 m.

The depth to the base of the clayey silt and silty clay layers ranged from 1.5 m to 2.3 m (Elevations 325.2 to 329.1).

SPT 'N' values in the clayey silt and silty clay layers ranged from 5 to 34 blows per 0.3 m of penetration, indicating a firm to hard consistency. The natural moisture contents generally lay in the range of 18 to 40%.

Grain size distribution curve of silty clay sample tested are presented on the Record of Borehole sheets and on Figure B1 of Appendix B. Atterberg Limits test results are presented on Figure B7 of Appendix B. The results of the laboratory tests are summarized as follows:

Soil Particles	(%)
Gravel	0
Sand	3
Silt	71
Clay	26

Liquid Limit	38
Plastic Limit	17

The above results show that the silty clay is of medium plasticity with a group symbol of CI.

5.4 Sandy Silt Till

Brown to grey sandy silt till containing, trace gravel, trace clay, occasional cobbles and occasional shale fragments was encountered below the silty clay and clayey silt layers at depths and elevations indicated in Table 5.1.

Table 5.1 – Depths and Elevations of Native Sandy Silt Till

Borehole	Depth below existing ground surface (m)	Elevation (m)	Thickness (m)
08-122	1.5 to 16.3	329.1 to 314.3	14.8
08-123	2.1 to 13.7	327.1 to 315.5	11.6
08-124	2.3 to 12.5	325.2 to 315.0	10.2

Layers of sand, gravelly sand and silt were encountered within the sandy silt till deposit.

SPT 'N' values ranged from 16 to 100 blows per 0.3 m of penetration indicating a compact to very dense relative density. SPT 'N' values higher than 100 blows per 0.225 m of

penetration, indicating a very dense relative density were measured in Boreholes 08-122 and 08-124. The natural moisture contents generally lay in the range of 2% to 22%.

Grain size distribution curves of sandy silt till samples tested are presented on the Record of Borehole sheets and on Figures B2 to B5 of Appendix B. The results of the laboratory tests are summarized as follows:

Soil Particles	Sandy Silt Till (%)	Sand (%)	Gravelly Sand (%)	Silt (%)
Gravel	0 to 2	1	32	0
Sand	20 to 66	74	61	4 to 17
Silt	27 to 73	-	-	79 to 88
Clay	2 to 7	-	-	4 to 8
Silt & Clay	-	25	7	-

The sandy silt till deposit contains cobbles and possibly boulders which may account for some high SPT 'N' values.

5.5 Silty Clay Till

Grey silty clay till containing trace to some sand and trace gravel was contacted at 16.3 m, 13.7 m and 12.5 m depth (Elevations 314.3, 315.5 and 315.0) in Boreholes 08-122, 08-123 and 08-124, respectively. Boreholes were terminated within the silty clay till at 20.3 m, 17.2 m and 15.5 m depth (Elevations 310.3, 312.0 and 312.0) in Boreholes 08-122, 08-123 and 08-124, respectively.

SPT 'N' values in the silty clay till ranged from 100 blows per 0.3 m of penetration, to higher than 100 blows per 0.15 m of penetration, indicating a hard consistency. The natural moisture contents generally lay in the range of 8% to 20%.

Grain size distribution curves for silty clay till samples tested are presented on the Record of Borehole sheets and on Figure B6 of Appendix B. Atterberg Limits test results are presented on Figure B8 of Appendix B.

The results of laboratory tests carried out on silty clay till samples were as follows:

Soil Particles	(%)
Gravel	0
Sand	5 to 17
Silt	47 to 69
Clay	23 to 41

Liquid Limit	27 to 38
Plastic Limit	17 to 18

The above results show that the silty clay till is of low plasticity with a group symbol of CL.

Although not specifically identified in the boreholes, glacial tills are known to contain cobbles and boulders which may account for some high SPT 'N' values.

5.6 Groundwater Conditions

Water levels were observed in the boreholes during and upon completion of drilling. A standpipe piezometer was installed in Borehole 08-123 (at the proposed pier) to monitor water levels after completion of drilling. The water levels measured in the piezometer are summarized in Table 5.2, along with the measurements in the boreholes upon completion of drilling.

Table 5.2 – Water Level Measurements

Foundation Unit	Borehole	Date (2009)	Water Level (m)		Comment
			Depth	Elevation	
North Abutment	08-122	January 19	7.6	323.0	Open borehole
Pier	08-123	February 19	3.0	326.2	In piezometer
		April 23	4.3	324.9	In piezometer
South Abutment	08-124	January 21	4.3	323.2	Open borehole

The piezometric reading indicates that the groundwater level lies at Elevation 324.9.

The above values are short-term readings and seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level may be at a higher elevation after the spring snowmelt or after periods of heavy rainfall.

6 MISCELLANEOUS

DBW Drilling of Ajax, Ontario supplied a track-mounted drill rig and conducted the drilling, sampling and in-situ testing operations.

The drilling and sampling operations in the field were supervised on a full time basis by Mr. Ligang Hao of Thurber, under the direction of Mr. Alastair E. Gorman, P.Eng and Mr. Mark Farrant, P. Eng.

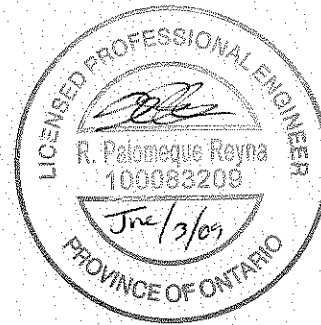
The coordinates for the boreholes and the ground surface Elevations were obtained by Thurber Engineering Ltd. using GPS equipment.

Overall supervision of the field program was conducted by Mr. Alastair E. Gorman, P.Eng. and Mr. M. Farrant, P. Eng. Interpretation of the data and preparation of the report were carried out by Mr. Alastair E. Gorman, P.Eng. and Ms. R. Palomeque Reyna, P.Eng.

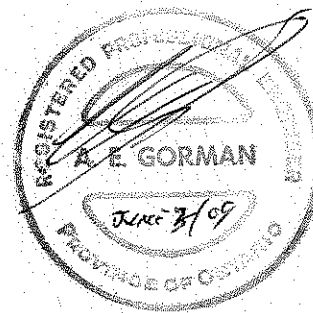
Dr. P.K. Chatterji, P.Eng. a Designated Principal Contact for MTO Foundations projects, reviewed the report.

Thurber Engineering Ltd

Rocio Palomeque Reyna, P.Eng.
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PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

7 GENERAL

This report presents interpretation of the geotechnical data in the factual report and presents preliminary geotechnical design recommendations to assist the design team to select and design a suitable foundation system for the new structure.

Based on the Plate 7 of the E.A:

- The mainline (proposed Highway 7) will be in a cut 3.0 m to 6.0 m deep with the base of the cut at approximate Elevation 324.5.
- Spitzig Road will be at Elevation 333.0 with approach embankments of 2.4 m to 5.5 m high

The discussion and recommendations presented in this report are based on our understanding of the project and on the factual data obtained in the course of this investigation.

8 STRUCTURE FOUNDATIONS

The stratigraphy identified in the preliminary investigation consisted primarily of topsoil and native silty clay and clayey silt overlying compact to very dense sandy silt till and hard silty clay till. The groundwater level measured in the piezometer is 4.3 m (Elevation 324.9) below the ground surface.

In the preparation of the preliminary geotechnical design recommendations, consideration was given to the following foundation types:

- Spread footings bearing on native soil
- Spread footings on engineered fill
- Steel H-piles driven into the hard glacial till soil

A comparison of the foundation alternatives based on advantages and disadvantages of each is included in Appendix C.

8.1 Spread Footings on Native Soil

Spread footings bearing on native soil generally are the least expensive form of construction.

The design of spread footings bearing on native hard clayey silt and compact to very dense sandy silt till must be in accordance with the elevations and bearing resistances given in Table 8.1.

Table 8.1 – Bearing Resistances for Spread Footings

Element	Depth (m)	Elev.	ULS _r (kPa)	SLS (kPa)
North Abutment (BH 08-122)	1.5	329.1	450	300
	3.1	327.5	600	400
	7.6	323.0	600	400
Pier (BH 08-123)	2.7	326.5	300	200
	7.7	321.5	600	400
South Abutment (BH 08-124)	2.5	325.0	450	300
	6.5	321.0	600	400

The bearing resistances in Table 8.1 are for vertical, concentric loading. In the case of eccentric or inclined loading, the bearing resistance must be adjusted as shown in the CHBDC (2006) Clause 6.7.3 and Clause 6.7.4.

The geotechnical SLS resistance values given above are based on an estimated total settlement not exceeding 25 mm. This settlement is expected to be substantially complete by the end of construction. Differential settlement is not expected to exceed 20 mm across the width of the structure or between foundation elements.

Founding elevations below the base of the cut presented in Table 8.1 are generally below the groundwater level of 324.9 measured in the piezometer.

If temporary excavations required to construct these footings extend in cohesionless soils below the water table, groundwater control will be required prior to excavation to construct the footings in the dry, to prevent sloughing of the sides and to prevent disturbance of the footing bases due to the inflow of groundwater.

8.2 Spread Footings on Engineered Fill

Spread footings can also be founded on Granular “A” engineered fill pads. These would probably be most useful in the case of perched abutments on footings.

If an engineered fill pad is used, all topsoil, or other deleterious materials must be stripped from the footprint of the foundation to expose competent native subgrade material. The

engineered fill should bear on stiff to very stiff clayey silt/silty clay and compact sand and silt and the highest permitted founding elevations at which engineered fill pads may be placed, are given in Table 8.2.

Table 8.2 – Founding Elevations for Engineered Fill Pads

North Abutment (BH 08-122)	Pier (BH 08-123)	South Abutment (BH 08-124)
330.0*	328.5*	326.6*

* Elevations are higher than proposed Highway 7 finish grade (324.5 m)

Typically, spread footings on pads of engineered granular fill at least 2 m thick may be designed for the following geotechnical resistances:

- Factored ULS 900 kPa
- SLS 350 kPa

These resistance values are for concentric, vertical loads only. In the case of eccentric or inclined loading, the geotechnical resistance must be calculated as illustrated in the CHBDC Clause 6.7.3 and Clause 6.7.4.

For footings designed on the basis of the geotechnical resistance values given above, total settlement under a footing is expected to not exceed 25 mm. Differential settlements are not expected to exceed 20 mm across the width of the structure or between foundation elements.

The Granular A pad must be compacted to 100% Standard proctor maximum dry density (SPMDD) at optimum moisture content $\pm 2\%$. The geometry of the fill pad must conform to the general requirements shown in Figure 1 in Appendix D.

8.3 Steel H-Piles

The soil stratigraphy encountered at this site is considered to be suitable for the support of foundations on driven steel piles.

It is recommended that the H-piles be driven to achieve resistance in the hard silty clay till encountered at this site.

The elevations at which the H-piles are expected to develop the required resistance are given in Table 8.3.

Table 8.3 – Estimated Pile Tip Elevation

Foundation Unit	Anticipated Pile length below original ground (m)	Highest Pile Tip Elevation
North Abutment (BH 08-122)	17.6	313.0
Pier (BH 08-123)	16.2	313.0
South Abutment (BH 08-124)	13.5	314.0

8.3.1 Axial Resistance

For preliminary design, the vertical, axial, factored geotechnical resistance at Ultimate Limit States (ULS) and geotechnical resistance at Serviceability Limit States (SLS) for a pile section when driven into the hard silty clay till are presented in Tables 8.4 .

Table 8.4 – Axial Resistance of Two Pile Sections Founded on Hard Soils

Pile Section	Geotechnical Resistance (kN)	
	Factored ULS	SLS
HP 310 X 110	1,600	1,400
HP 360 X 132	1,800	1,600

The structural resistance of the pile must be checked by the structural designer.

Installation of the piles must be in accordance with SP 903S01 and must be controlled using the Hiley Formula and an ultimate resistance of 3,200 kN for an HP 310 X 110 pile and 3,600 kN for the HP 360 X 132 pile.

These are preliminary recommendations and may change during detail design based on the final alignment, final bridge arrangement and the results of the site investigation and field testing to be completed at that time.

Due to the possible presence of cobbles and boulders in the glacial till layers through which the piles will be driven, the tips of all driven piles should be fitted with steel H-Pile driving shoes in accordance with OPSD 3000.100.

8.3.2 Downdrag

Downdrag on the piles is not an issue at this site.

8.4 Abutment Design Considerations

From a geotechnical perspective, the conditions at this site are considered to be suitable for the design of conventional, semi-integral or integral abutments.

8.5 Frost Cover

The design depth of frost penetration for this site is 1.4 m. All footing bases and undersides of pile caps/abutment stems must be provided with at least 1.4 m of soil cover.

8.6 Recommended Foundation

From a geotechnical perspective, and based on current information, the recommended abutment foundation consists of steel H-piles driven into the hard silty clay till, despite the higher cost noted in Appendix C. The recommended foundation at the pier is a spread footing on very dense sandy silt till.

9 BRIDGE APPROACHES AND EMBANKMENTS

Based on the three boreholes drilled at the site, the approach embankments will be constructed over native silty clay, clayey silt and compact to very dense sandy silt till.

Preliminary analysis indicates that at the abutments, settlement in the order of 10 to 15 mm is estimated in the foundation soils under the loading imposed by approximately 5.5 m of the approach fill. Due to the compact to very dense nature of the foundation soils, these settlements, as well as the settlements of the fill itself, will be essentially completed when construction of the fill is completed. Further settlement analysis should be conducted during the detail phase design.

No global stability issues are anticipated for approach embankments built at this site. The 2.4 m to 5.5 m high embankments likely to be constructed will be stable at side slopes of 2H:1V if constructed using SSM or granular fill.

The global, internal and surficial stability of the approach embankment fills should be further evaluated during the detail design phase.

10 PERMANENT CUT

Permanent earth cuts ranging from 3.0 to 6.1 m deep are required to construct the proposed Highway 7 grade at this site. The cut will be formed predominantly through the existing clayey silt, silty clay and sandy silt till.

All temporary excavations must be carried out in accordance with the requirements of the Occupational Health and Safety Act (OHSA). For the purposes of the OHSA, the soils within the likely depth of excavation at this site may be classed as Type 3.

The proposed base of cut at the Highway 7 grade will be at Elevation 324.5, approximately 0.4 m below the groundwater level measured in the piezometer. Perched water might be also observed during excavation within the sand and silt and till layers.

During detail design, when the grade has been finalized, permanent drainage and slope protection requirements must be addressed for the cut. Subject to depressing the groundwater level below the base of the cut and implementing permanent drainage, the cut slopes will be stable at slopes with a

maximum inclination of 2H: 1V. MTO policy requires a mid-height bench in cut slopes higher than 8.0 m.

The potential impact on the local groundwater table should be addressed by a hydrogeologist, who should also consider the need to apply for an MOE Permit to Take Water.

11 CONSTRUCTION CONCERNS

Potential construction concerns include, but are not necessarily limited to:

1. Pile refusal at higher elevation.

Although there was little direct evidence of their presence during drilling, glacial till deposits inherently contain boulders. It is possible that a pile will achieve refusal at a higher elevation than anticipated due to encountering a boulder. If it is suspected that this is happening, the QVE must immediately bring it to the attention of the CA. If the CA cannot resolve the issue, it must be referred to the design team for resolution.

2. Pile fails to develop specified resistance.

If a pile has not developed the specified resistance after being driven 2 m beyond the anticipated pile tip elevation, stop driving and check the Hiley calculation and all input values. If the calculation still shows that the pile has not reached the specified resistance, the following procedure should be implemented:

- a) Stop driving in that pile group for 48 hours (minimum)
- b) After 48 hours, warm up the hammer on another pile then commence re-driving the subject pile and measure the resistance.
- c) If the pile still does not reach the specified resistance, the QVE must immediately advise the CA who, in turn, should refer the issue to the design team.

3. Destabilization of excavations

If excavation is carried out in cohesionless soil without prior implementation of adequate measures to control groundwater and surface water, there is a risk that the sides and or base of the excavation will be destabilized. This could lead to a risk to personnel working on site, or to a loss of bearing resistance in the soil.

Accordingly, it must be emphasized to the contractor that proper groundwater and surface water control measures must be in place prior to commencing excavation.

12 INVESTIGATION FOR DETAIL DESIGN

During the detail design phase of the project, additional site investigation and field testing will be required. The following minimum program is recommended:

1. Boreholes for structure foundations.

Additional boreholes may be required for the structure foundations, especially if the structure is built off the current Spitzig Road alignment and thus removed from the alignment of the current investigation.

2. Boreholes for approaches.

A minimum of one borehole is recommended in each approach fill on Spitzig Road.

3. Cut stability

At least one borehole is required in the mainline cut to either side of the structure. The boreholes in the cut must include piezometers for groundwater monitoring. Stability of cuts must be investigated during detail design phase.

4. Groundwater impacts.

The potential impact of drainage of the cuts on the local groundwater table must be addressed by a hydrogeologist, who should also consider the need to apply for an MOE Permit to Take Water.

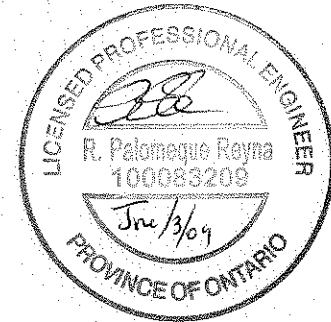
13 CLOSURE

Engineering analysis and preparation of the report were carried out by Mr. Alastair E. Gorman, P.Eng and Ms. R. Palomeque Reyna, P.Eng.

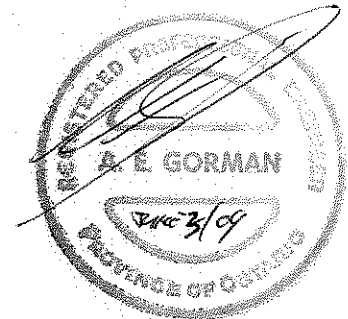
The report was reviewed by Dr. P.K. Chatterji, P.Eng., a Designated Principal Contact for MTO Foundations Projects.

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Alastair E. Gorman, P.Eng.,
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P. K. Chatterji, P.Eng.,
Review Principal



Appendix A

Record of Borehole Sheets

SYMBOLS, ABBREVIATIONS AND TERMS USED ON RECORDS OF BOREHOLES

1. TEXTURAL CLASSIFICATION OF SOILS

CLASSIFICATION	PARTICLE SIZE	VISUAL IDENTIFICATION
Boulders	Greater than 200mm	same
Cobbles	75 to 200mm	same
Gravel	4.75 to 75mm	5 to 75mm
Sand	0.075 to 4.75mm	Not visible particles to 5mm
Silt	0.002 to 0.075mm	Non-plastic particles, not visible to the naked eye
Clay	Less than 0.002mm	Plastic particles, not visible to the naked eye

2. COARSE GRAIN SOIL DESCRIPTION (50% greater than 0.075mm)

TERMINOLOGY	PROPORTION
Trace or Occasional	Less than 10%
Some	10 to 20%
Adjective (e.g. silty or sandy)	20 to 35%
And (e.g. sand and gravel)	35 to 50%

3. TERMS DESCRIBING CONSISTENCY (COHESIVE SOILS ONLY)

DESCRIPTIVE TERM	UNDRAINED SHEAR STRENGTH (kPa)	APPROXIMATE SPT ⁽¹⁾ 'N' VALUE
Very Soft	12 or less	Less than 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	Greater than 200	Greater than 30

NOTE: Hierarchy of Soil Strength Prediction

- 1) Laboratory Triaxial Testing
- 2) Field Insitu Vane Testing
- 3) Laboratory Vane Testing
- 4) SPT value
- 5) Pocket Penetrometer



4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

DESCRIPTIVE TERM	SPT "N" VALUE
Very Loose	Less than 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	Greater than 50

5. LEGEND FOR RECORDS OF BOREHOLES

SYMBOLS AND ABBREVIATIONS FOR SAMPLE TYPE	SS Split Spoon Sample	WS Wash Sample	AS Auger (Grab) Sample
	TW Thin Wall Shelby Tube Sample	TP Thin Wall Piston Sample	
	PH Sampler Advanced by Hydraulic Pressure	PM Sampler Advanced by Manual Pressure	
	WH Sampler Advanced by Self Static Weight	RC Rock Core	SC Soil Core

$$\text{Sensitivity} = \frac{\text{Undisturbed Shear Strength}}{\text{Remoulded Shear Strength}}$$






 Water Level
 Shear Strength Determination by Pocket Penetrometer

- (1) SPT 'N' Value Standard Penetration Test 'N' Value – refers to the number of blows from a 63.5kg hammer free falling a height of 0.76m to advance a standard 50 mm outside diameter split spoon sampler for 0.3 m depth into undisturbed ground.
- (2) DCPT Dynamic Cone Penetration Test – Continuous penetration of a 50 mm outside diameter, 60° conical steel point attached to "A" size rods driven by a 63.5 kg hammer free falling a height of 0.76 m. The resistance to cone penetration is the number of hammer blows required for each 0.3 m advance of the conical point into undisturbed ground.

UNIFIED SOILS CLASSIFICATION

MAJOR DIVISIONS		GROUP SYMBOL	TYPICAL DESCRIPTION
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	GW	Well-graded gravels or gravel-sand mixtures, little or no fines.
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines.
		GM	Silty gravels, gravel-sand-silt mixtures.
		GC	Clayey gravels, gravel-sand-clay mixtures.
	SAND AND SANDY SOILS	SW	Well-graded sands or gravelly sands, little or no fines.
		SP	Poorly-graded sands or gravelly sands, little or no fines.
		SM	Silty sands, sand-silt mixtures.
		SC	Clayey sands, sand-clay mixtures.
FINE GRAINED SOILS	SILTS AND CLAYS $W_L < 50\%$	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands or clayey silts with slight plasticity.
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays. ($W_L < 30\%$).
		CI	Inorganic clays of medium plasticity, silty clays. ($30\% < W_L < 50\%$).
		OL	Organic silts and organic silty-clays of low plasticity.
	SILTS AND CLAYS $W_L > 50\%$	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts.
		CH	Inorganic clays of high plasticity, fat clays.
		OH	Organic clays of medium to high plasticity, organic silts.
HIGHLY ORGANIC SOILS		Pt	Peat and other highly organic soils.
CLAY SHALE			
SANDSTONE			
SILTSTONE			
CLAYSTONE			
COAL			

EXPLANATION OF ROCK LOGGING TERMS

ROCK WEATHERING CLASSIFICATION		SYMBOLS	
Fresh (FR)	No visible signs of weathering.		CLAYSTONE
Fresh Jointed (FJ)	Weathering limited to the surface of major discontinuities.		SILTSTONE
Slightly Weathered (SW)	Penetrative weathering developed on open discontinuity surfaces, but only slight weathering of rock material.		SANDSTONE
Moderately Weathered (MW)	Weathering extends throughout the rock mass, but the rock material is not friable.		COAL
Highly Weathered (HW)	Weathering extends throughout the rock mass and the rock is partly friable.		Bedrock (general)
Completely Weathered (CW)	Rock is wholly decomposed and in a friable condition, but the rock texture and structure are preserved.		

DISCONTINUITY SPACING		STRENGTH CLASSIFICATION		
Bedding	Bedding Plane Spacing	Rock Strength	Approximate Uniaxial Compressive Strength (MPa)	Field Estimation of Hardness*
Very thickly bedded	Greater than 2m	Extremely Strong	Greater than 250	Specimen can only be chipped with a geological hammer
Thickly bedded	0.6 to 2m			
Medium bedded	0.2 to 0.6m	Very Strong	100-250	Requires many blows of geological hammer to break
Thinly bedded	60mm to 0.2m			
Very thinly bedded	20 to 60mm	Strong	50-100	Requires more than one blow of geological hammer to break
Laminated	6 to 20mm			
Thinly Laminated	Less than 6mm	Medium Strong	25.0 to 50.0	Breaks under single blow of geological hammer.
		Weak	5.0 to 25.0	Can be peeled by a pocket knife with difficulty
		Very Weak	1.0 to 5.0	Can be peeled by a pocket knife, crumbles under firm blows of geological pick.
		Extremely Weak (Rock)	0.25 to 1.0	Indented by thumbnail

TERMS	
Total Core Recovery: (TCR)	Core recovered as a percentage of total core run length.
Solid Core Recovery: (SCR)	Percent Ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run.
Rock Quality Designation: (RQD)	Total length of sound core recovered in pieces 0.1m in length or larger as a percentage of total core run length.
Uniaxial Compressive Strength (UCS)	Axial stress required to break the specimen
Fracture Index: (FI)	Frequency of natural fractures per 0.3m of core run.

RECORD OF BOREHOLE No 08-122

1 OF 3

METRIC

G.W.P. 408-88-00 LOCATION N 4 817 187.5 E 230 686.2 ORIGINATED BY LH
 HWY 7 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2009.01.16 - 2009.01.19 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				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					
330.6								20 40 60 80 100					
0.0	TOPSOIL (450mm)							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE					
330.1													
0.5	Clayey SILT, trace gravel, some sand, occasional organics and cobbles Very Stiff to Hard Brown		1	SS	17		330						
			2	SS	34								
329.1													
1.5	Sandy SILT, trace gravel, trace clay, oxidized staining Dense to Very Dense Brown Moist to Damp (TILL)		3	SS	38		329						
			4	SS	43		328						2 61 37 (SI+CL)
	Occasional shale fragments Layer of gravelly sand (600mm)		5	SS	59		327						
	Occasional cobbles		6	SS	100		326						
							325						
			7	SS	35		324						
	Wet												
							323						1 74 25 (SI+CL)
	Layer of sand		8	SS	63		322						
			9	SS	100/ 0.225		321						

Continued Next Page

+³ ×³: Numbers refer to Sensitivity

20
15 10 5
(%) STRAIN AT FAILURE

METRIC

Continued Next Page

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 08-122

3 OF 3

METRIC

G.W.P. 408-88-00 LOCATION N 4 817 187.5 E 230 686.2 ORIGINATED BY LH
 HWY 7 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2009.01.16 - 2009.01.19 CHECKED BY RPR

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					
310.3	Silty CLAY, some sand		16	SS	100								
20.3	Hard Grey (TILL)												
Continued From Previous Page END OF BOREHOLE AT 20.3m. WATER LEVEL AT 7.6m UPON COMPLETION OF DRILLING. BOREHOLE BACKFILLED WITH BENTONITE AND CUTTINGS TO SURFACE.													

RECORD OF BOREHOLE No 08-123

1 OF 2

METRIC

G.W.P. 408-88-00 LOCATION N 4 817 146.5 E 230 699.4 ORIGINATED BY LH
 HWY 7 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2009.01.20 - 2009.01.20 CHECKED BY RPR

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						
329.2								20 40 60 80 100						
0.0	TOPSOIL (450mm)						329							
328.7														
0.5	SAND and SILT, trace gravel, occasional organics, oxidized staining Compact Dark Brown to Brown Wet		1	SS	12									
			2	SS	27									
327.8							328							
1.4	Silty CLAY, trace sand Stiff Brown		3	SS	13									0 3 71 26
327.1														
2.1	Sandy SILT, trace clay, oxidized staining Compact to Very Dense Grey Wet (TILL)		4	SS	26		327							
			5	SS	30		326							0 20 73 7
							325							
			6	SS	16		324							
			7	SS	31		323							
							322							
			8	SS	70		321							
							320							1 59 38 2
			9	SS	66									

Continued Next Page

+ 3 X 3 Numbers refer to
Sensitivity 20 15 10 5 10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 08-123

2 OF 2

METRIC

G.W.P. 408-88-00 LOCATION N 4 817 146.5 E 230 699.4 ORIGINATED BY LH
 HWY 7 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2009.01.20 - 2009.01.20 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20	40	60	80	100		
	Continued From Previous Page							SHEAR STRENGTH kPa						
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE						
								WATER CONTENT (%)						
								40	80	120	160	200		
315.5	Sandy SILT, trace gravel, trace clay, oxidized staining Very Dense Grey Wet (TILL)		10	SS	39		319							
							318							
			11	SS	50		317							
							316							
312.0	Silty CLAY, trace sand Hard Grey (TILL)		12	SS	100/ 0.275		315							
							314							0 8 69 23
			13	SS	100/ 0.250		313							
17.2	END OF BOREHOLE AT 17.2m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 09/19/02 3.0 326.2 09/23/04 4.3 324.9													

RECORD OF BOREHOLE No 08-124

1 OF 2

METRIC

G.W.P. 408-88-00 LOCATION N 4 817 112.3 E 230 722.4 ORIGINATED BY LH
 HWY 7 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2009.01.13 - 2009.01.21 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
327.5								20	40	60	80	100		
0.0	TOPSOIL (450mm)													
327.0														
0.5	Clayey SILT, trace sand, occasional organics Firm to Hard Grey Layer of silty sand (500mm)		1	SS	5		327							
			2	SS	22									
			3	SS	33		326							
325.2														
2.3	Sandy SILT, trace gravel, trace clay, oxidized staining Compact to Very Dense Brown Wet (TILL)		4	SS	100/ 0.275		325							
			5	SS	76									
							324							1 66 27 6
			6	SS	23									
							323							
			7	SS	58									
	Grey						321							2 52 43 3
	Layer of gravelly sand		8	SS	52		320							
							319							
			9	SS	87									
							318							

Continued Next Page

+ 3 x 3 Numbers refer to
Sensitivity

20
15-5
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 08-124

2 OF 2

METRIC

G.W.P. 408-88-00 LOCATION N 4 817 112.3 E 230 722.4 ORIGINATED BY LH
 HWY 7 BOREHOLE TYPE Solid Stem Augers COMPILED BY AN
 DATUM Geodetic DATE 2009.01.13 - 2009.01.21 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT γ	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 (%)		
	Continued From Previous Page																			
	Sandy SILT, trace sand, trace clay Very Dense Grey Wet (TILL)																			
	Layer of silt		10	SS	59											0 4 88 8				
315.0			11	SS	100															
12.5	Silty CLAY, trace gravel, trace sand, occasional shale fragments Hard Grey (TILL)															0 5 54 41				
			12	SS	100/ 0.150															
312.0			13	SS	65/ 0.150															
15.5	Sandy silt layer																			
	END OF BOREHOLE AT 15.5m. WATER LEVEL AT 4.3m UPON COMPLETION OF DRILLING. BOREHOLE BACKFILLED WITH BENTONITE AND CUTTINGS TO SURFACE.																			

+ 3, x 3: Numbers refer to
Sensitivity

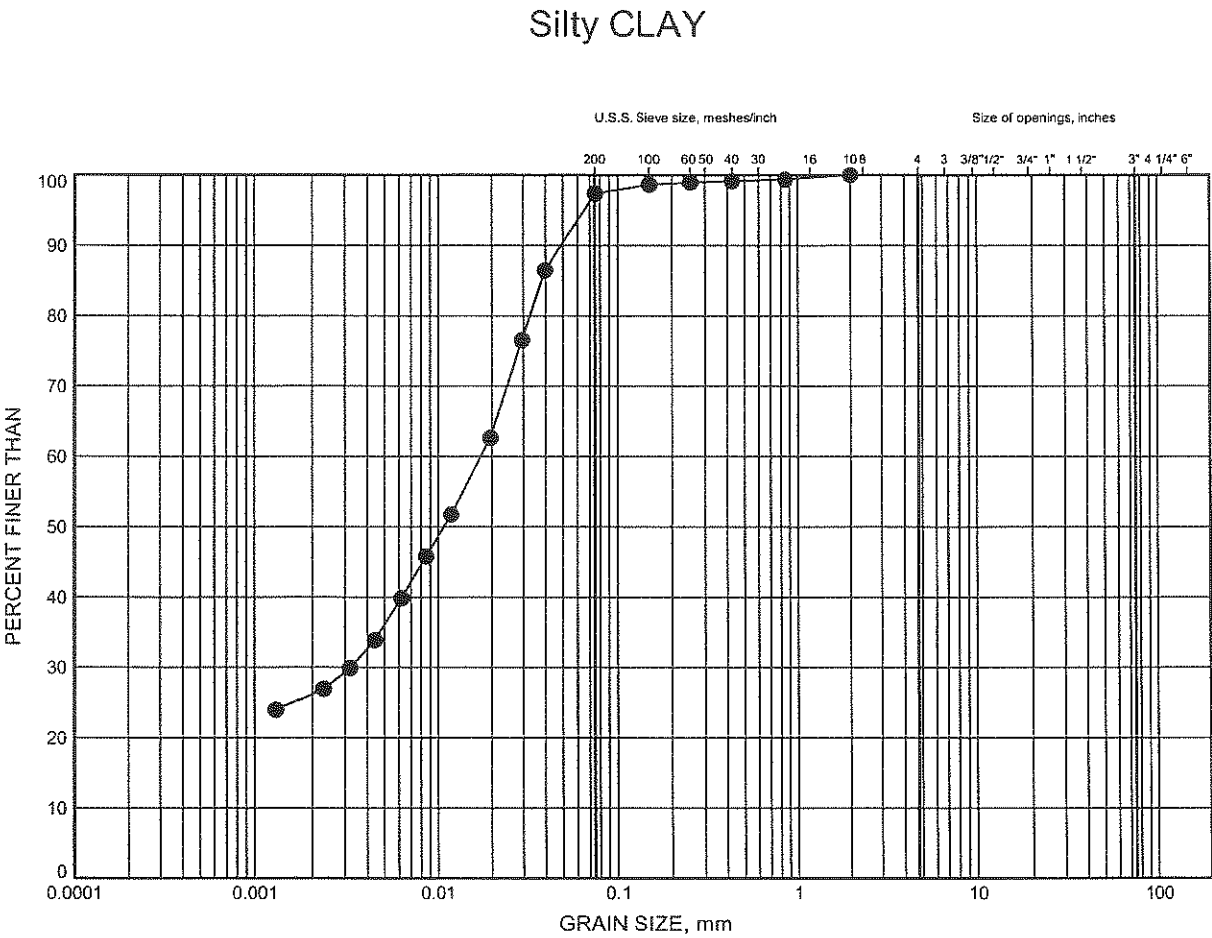
20
15 5
10 (%) STRAIN AT FAILURE

Appendix B

Laboratory Test Results

Highway 7 - New GRAIN SIZE DISTRIBUTION

FIGURE B1



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-123	1.83	327.37

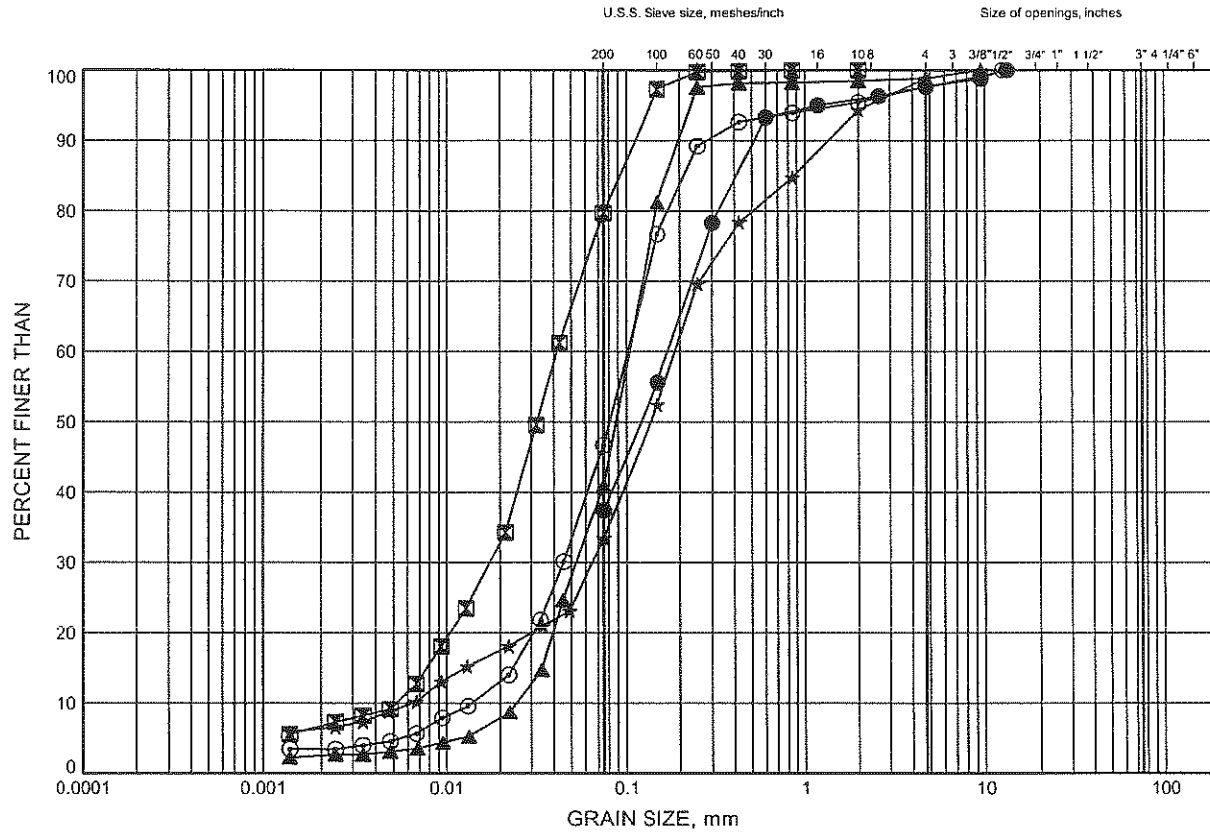


W.P.# 408-88-00
 Prepared By AN
 Checked By RPR

Highway 7 - New GRAIN SIZE DISTRIBUTION

FIGURE B2

Sandy SILT TILL



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

LEGEND

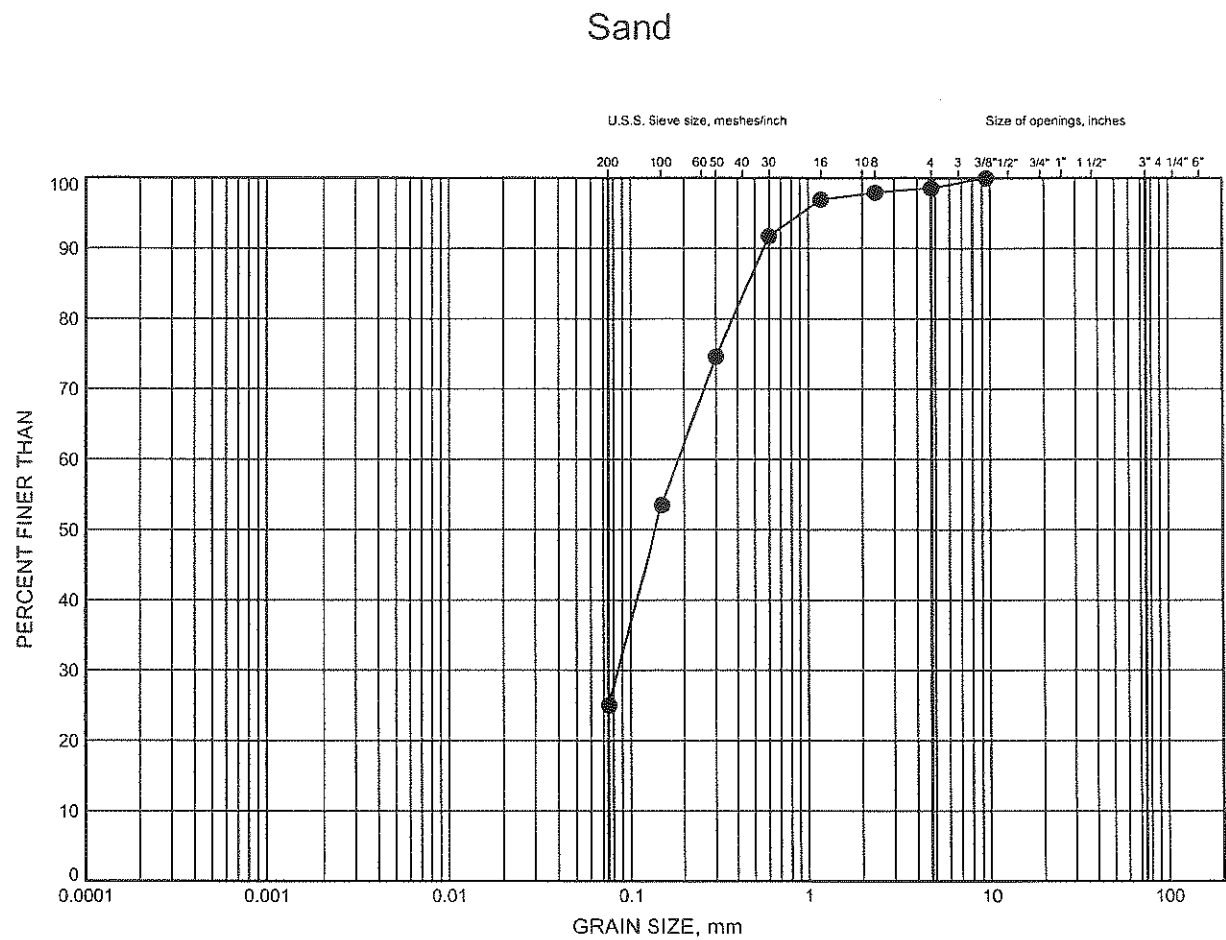
SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-122	2.59	328.01
⊠	08-123	3.35	325.85
▲	08-123	9.43	319.77
★	08-124	3.35	324.15
⊙	08-124	6.40	321.10



W.P.# 408-88-00.....
Prepared By AN.....
Checked By RPR.....

Highway 7 - New GRAIN SIZE DISTRIBUTION

FIGURE B3



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

LEGEND

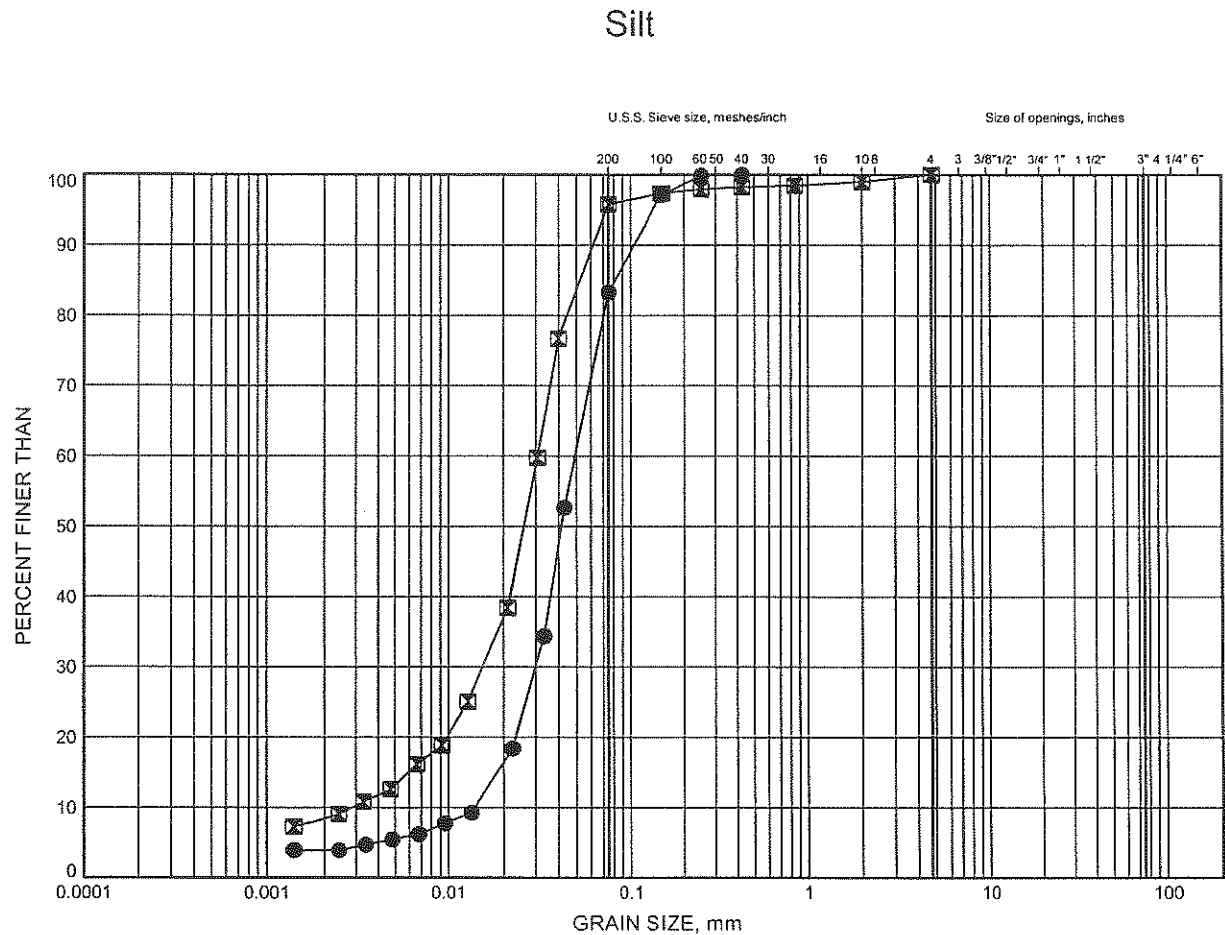
SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-122	7.92	322.68



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Prepared By AN
Checked By RPR

Highway 7 - New GRAIN SIZE DISTRIBUTION

FIGURE B4



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-122	15.54	315.06
⊠	08-124	10.97	316.53

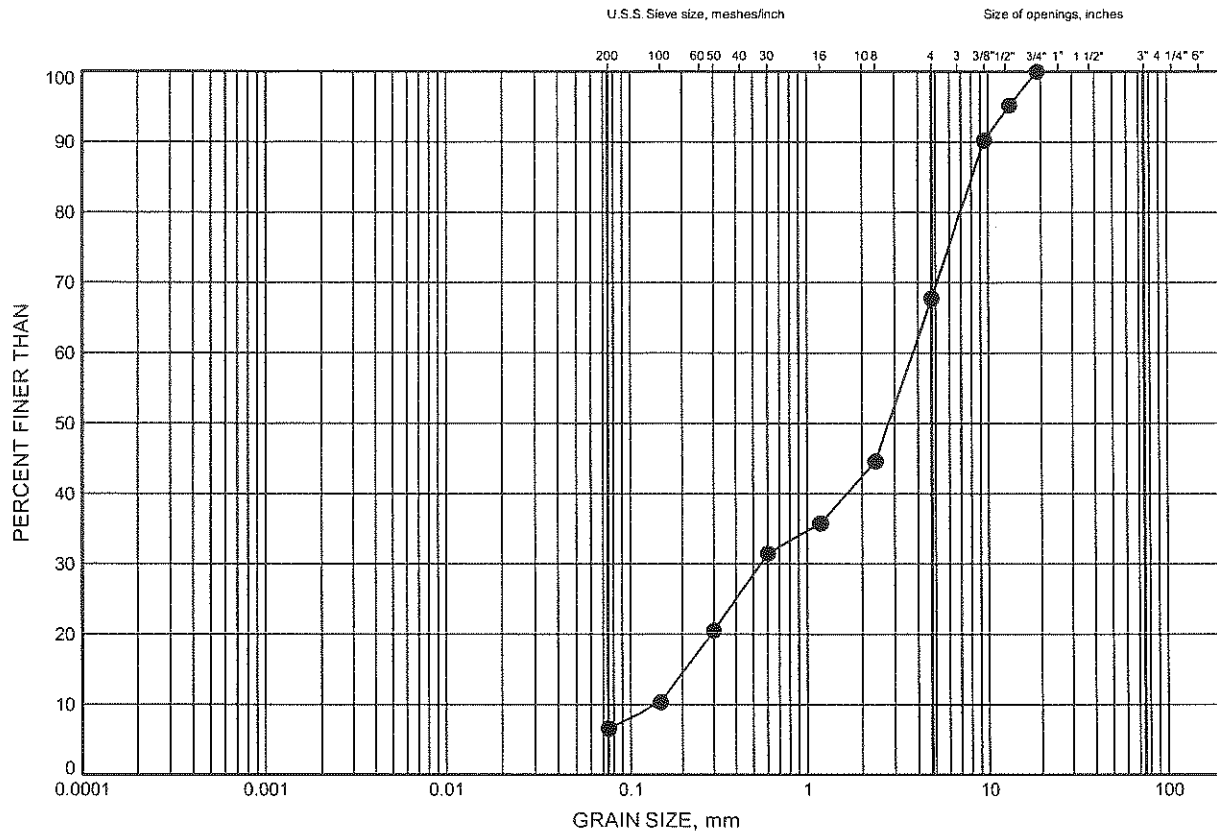


W.P.# 408-88-00.....
Prepared By .AN.....
Checked By .RPR.....

Highway 7 - New GRAIN SIZE DISTRIBUTION

FIGURE B5

Gravelly SAND



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-124	7.92	319.58

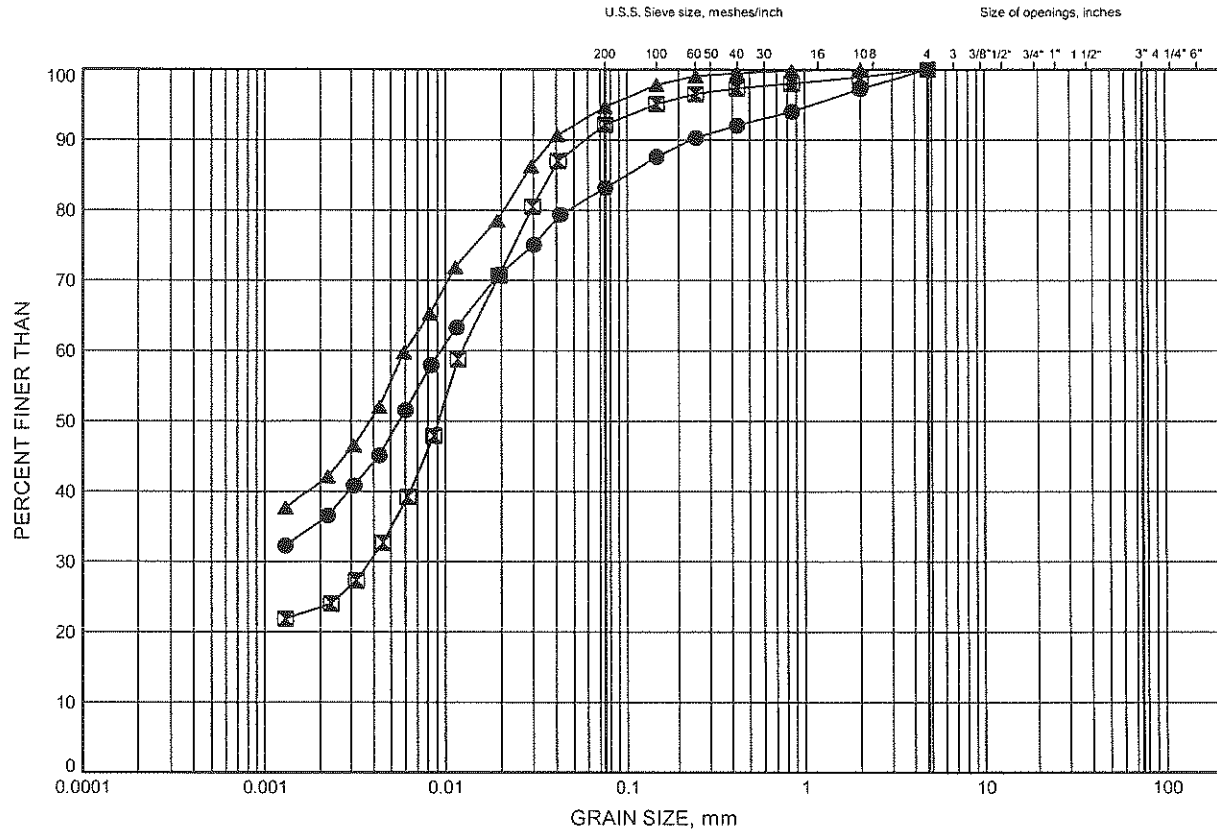


W.P.# 408-88-00
Prepared By AN
Checked By RPR

Highway 7 - New GRAIN SIZE DISTRIBUTION

FIGURE B6

Silty CLAY TILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-122	18.50	312.10
⊠	08-123	15.44	313.76
▲	08-124	12.80	314.70

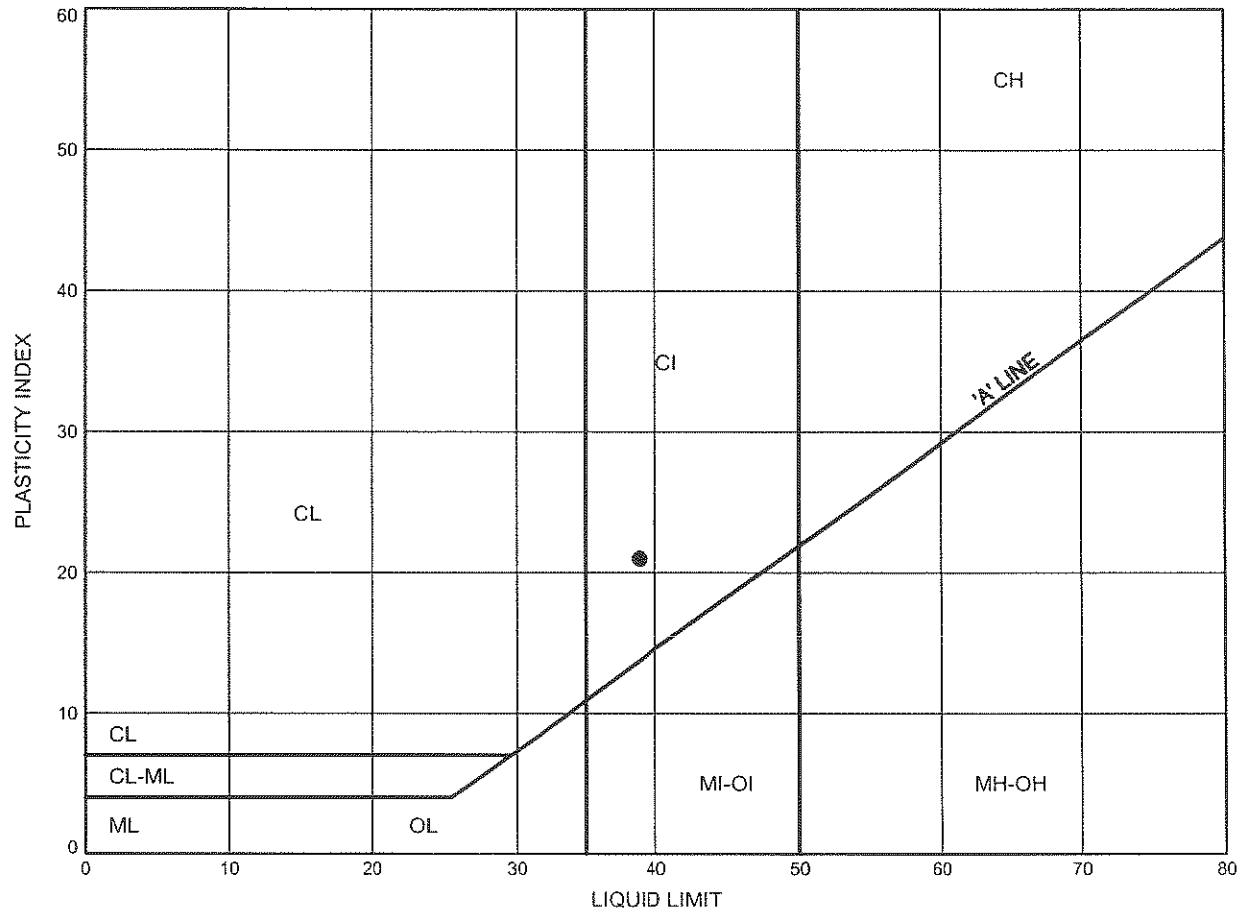


W.P.# 408-88-00
Prepared By AN
Checked By RPR

Highway 7 - New
ATTERBERG LIMITS TEST RESULTS

FIGURE B7

Silty CLAY



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	08-123	1.83	327.37

Date April 2009
 Project 408-88-00

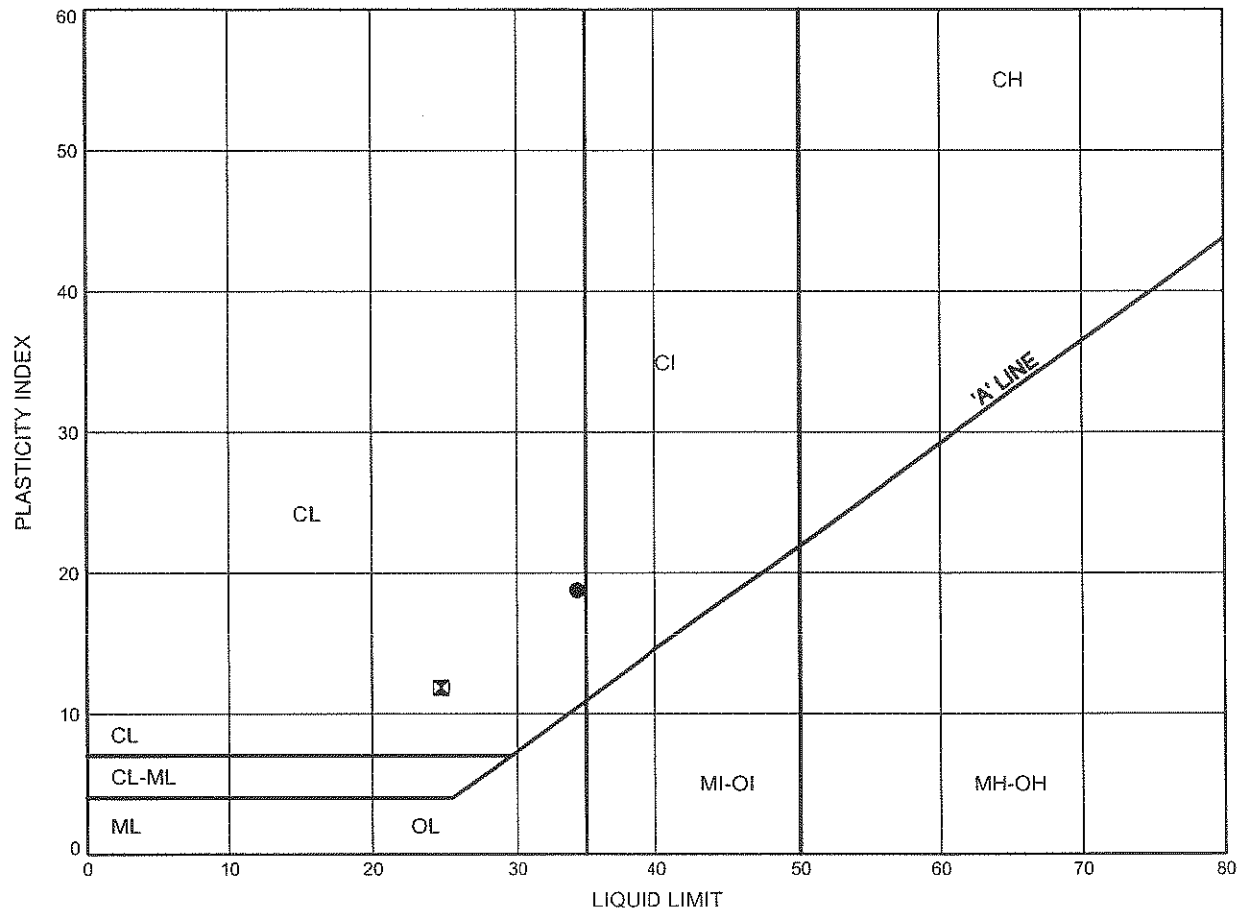


Prep'd AN
 Chkd. RPR

Highway 7 - New
ATTERBERG LIMITS TEST RESULTS

FIGURE B8

Silty CLAY TILL



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	08-122	18.50	312.10
⊗	08-123	15.44	313.76

Date April 2009
 Project 408-88-00



Prep'd AN
 Chkd. RPR

Appendix C

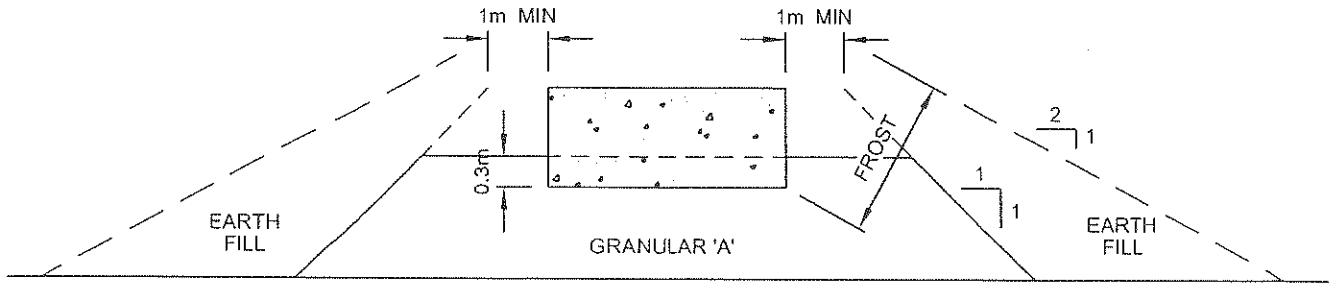
Foundation Comparison

COMPARISON OF FOUNDATION ALTERNATIVES FOR EACH FOUNDATION ELEMENT

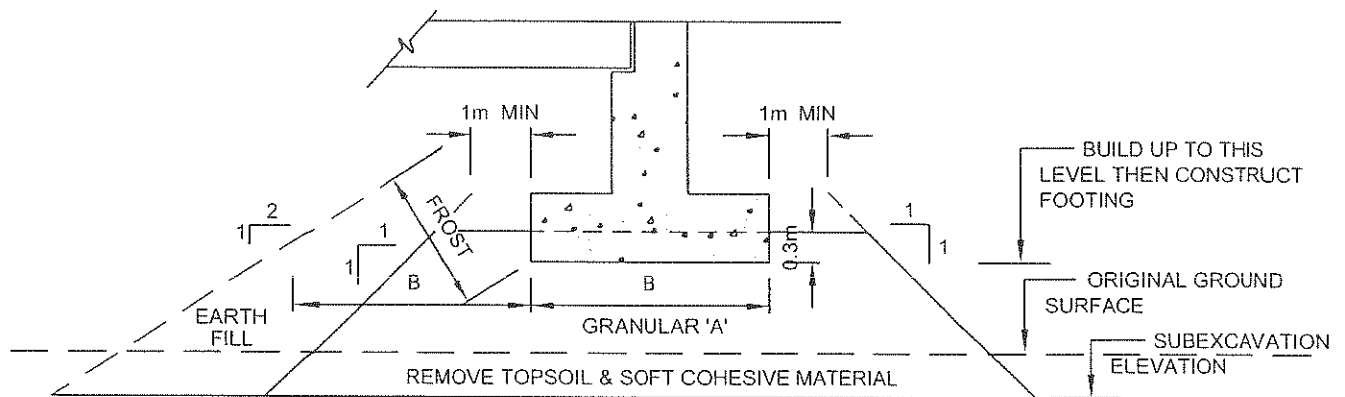
Foundation Element	Spread Footings	Spread Footings on Engineered Fill	Driven Piles
Abutments	<p>Advantages:</p> <ul style="list-style-type: none"> i. Generally less costly construction than deep foundation elements. <p>Disadvantages:</p> <ul style="list-style-type: none"> i. Lower geotechnical resistance available due to founding on compact soils near the surface. ii. Dewatering may be required, depending on depth of excavation. <p>NOT RECOMMENDED</p>	<p>Advantages:</p> <ul style="list-style-type: none"> i. Generally less costly construction than deep foundation elements. <p>Disadvantages:</p> <ul style="list-style-type: none"> i. Better geotechnical resistance than spread footings on native, but still influenced by the compact soils at the surface. ii. Dewatering may be required, depending on depth of excavation. <p>NOT RECOMMENDED</p>	<p>Advantages:</p> <ul style="list-style-type: none"> i. High geotechnical resistance may be developed by driving the piles into hard glacial tills. ii. Comparatively short abutment stem possible iii. Permits integral abutment design <p>Disadvantages:</p> <ul style="list-style-type: none"> i. Higher unit cost compared to footings. ii. Hard glacial tills at shallow depth will limit length of pile and geotechnical resistance that can be developed. <p>RECOMMENDED</p>
	<p>Advantages:</p> <ul style="list-style-type: none"> i. Generally less costly construction than deep foundation elements. <p>Disadvantages:</p> <ul style="list-style-type: none"> i. Dewatering may be required, depending on depth of excavation. <p>RECOMMENDED</p>	<p>Advantages:</p> <ul style="list-style-type: none"> i. Generally less costly construction than deep foundation elements. <p>Disadvantages:</p> <ul style="list-style-type: none"> i. Dewatering may be required, depending on depth of excavation. <p>NOT RECOMMENDED</p>	<p>Advantages:</p> <ul style="list-style-type: none"> i. High geotechnical resistance may be developed by driving the piles into hard glacial tills. <p>Disadvantages:</p> <ul style="list-style-type: none"> i. Higher unit cost compared to footings. ii. Hard glacial tills at shallow depth will limit length of pile and geotechnical resistance that can be developed. <p>NOT RECOMMENDED</p>

Appendix D

Figure



CROSS-SECTION



LONGITUDINAL SECTION

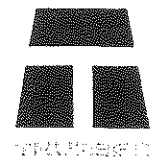
NOT TO SCALE

NOTES:

1. REMOVE TOPSOIL AND SOFT SILTY CLAY SUBSOIL UNDER FOOTPRINT OF COMPACTED GRANULAR 'A'.
2. PLACE GRANULAR 'A' AND EARTH FILL TO BOTTOM OF FOOTING LEVEL, COMPACTED ACCORDING TO O.P.S.S. 501.
3. CONSTRUCT CONCRETE FOOTING.
4. PLACE REMAINDER OF GRANULAR 'A' AND EARTH FILL AS REQUIRED.
5. SOURCE M.T.C. 1982.

ENGINEER	AEG
DRAWN	SS
DATE	April , 2004
APPROVED	PKC
SCALE	NTS

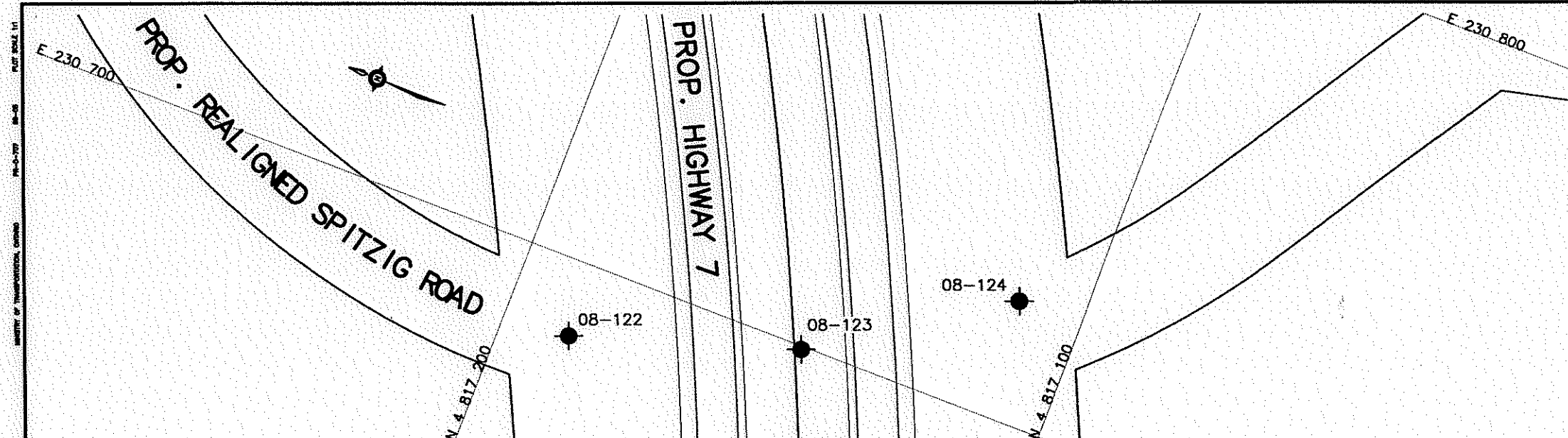
ABUTMENT ON COMPACTED FILL SHOWING
GRANULAR A CORE



DWG. NO.

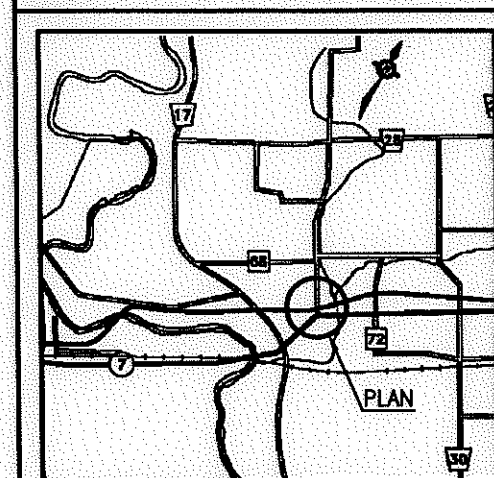
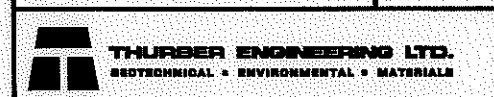
FIGURE 1

Appendix E
Drawing titled “Borehole Locations and Soil Strata”



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

CONT No GWP No 408-88-00		 SHEET
HIGHWAY 7 RECOMMENDED ROUTE REALIGNED SPITZIG ROAD BOREHOLE LOCATIONS AND SOIL STRATA		



KEYPLAN

LEGEND

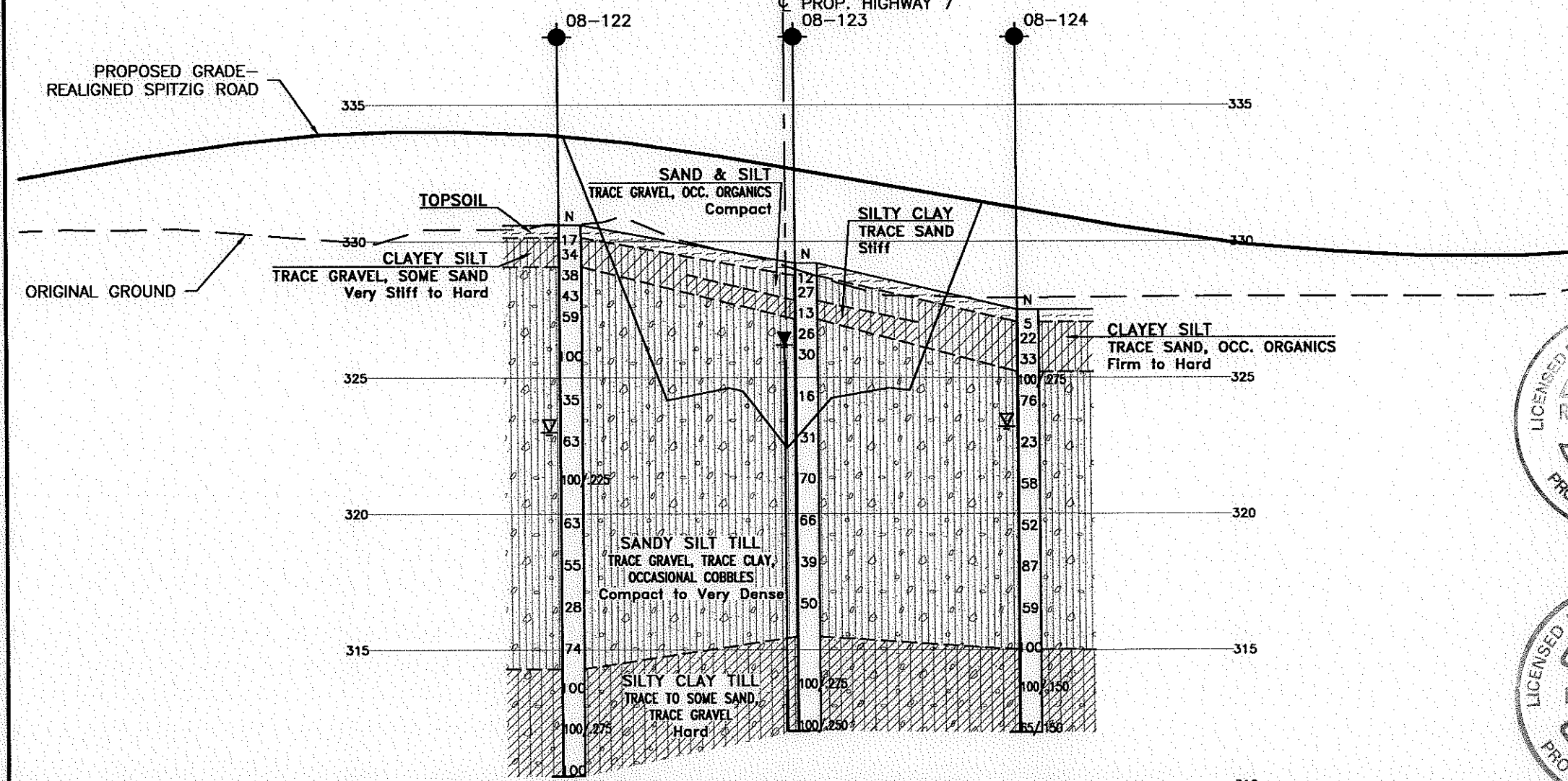
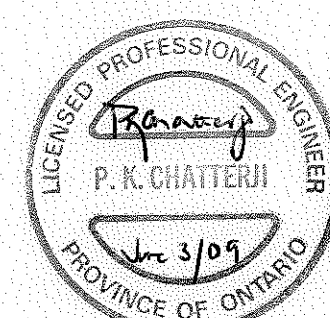
- ◆ Borehole
- ◆ Borehole and Cone
- N Blows /0.3m (Std Pen Test, 475J/blow)
- CONE Blows /0.3m (60' Cone, 475J/blow)
- PH Pressure, Hydraulic
- W Water Level
- HA Head Artesian Water
- PZ Piezometer
- 90% Rock Quality Designation (RQD)
- A/R Auger Refusal

NO	ELEVATION	NORTHING	EASTING
08-122	330.6	4 817 187.5	230 686.2
08-123	329.2	4 817 146.5	230 699.4
08-124	327.5	4 817 112.3	230 722.4

NOTES

- 1) The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- 2) This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
- 3) Proposed grades are from Plate 7 of the E.A. Study.

GEOCRES No. 40P8-170



PROFILE ALONG C OF PROP. REALIGNED SPITZIG ROAD



HOR 1:1000
VER 1:200

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

REVISIONS	DATE	BY	DESCRIPTION

FILE NAME: H:\Drawing\170\170-SubspRoad.dwg