PRELIMINARY
FOUNDATION INVESTIGATION AND DESIGN REPORT
PROPOSED HIGHWAY 7 BRIDGE OVER RIVERBEND DRIVE CONNECTOR
HIGHWAY 7-NEW, KITCHENER TO GUELPH
G.W.P. 408-88-00

Geocres Number: 40P8-178

Report to

Ministry of Transportation Ontario
Southwestern Region

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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 overpass structure to carry the eastbound lanes (EBL) and westbound lanes (WBL) of proposed Highway 7 over Riverbend Drive connector in the City of Kitchener, 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 400 m to the north. The site lies 700 m to the east of the existing Kitchener-Waterloo Expressway and 250 m to the east of existing Riverbend Drive.

Based on the Ontario Geological Survey Special Volume 2, The Physiography of Southern Ontario, Third Edition by Chapman and Putnam, the site lies within the physiographic region known as Waterloo Hills, characterized by ridges of sandy till and kames or kame moraines, with outwash sands occupying the intervening hollows.

The site lies within undeveloped/vacant land. Lands to the south of the site are generally industrial and/or commercial. Lands to the north of the site are also vacant or undeveloped. Vegetation consists mainly of tall grass and mature trees. Currently the topography of the site slopes gently towards the east.

A photograph of the site, looking at Borehole 08-033 (WBL west abutment) before drilling is included in Appendix F and shows the general nature of the surrounding land.

3 SITE INVESTIGATION AND FIELD TESTING

The site investigation and field testing at this site was carried out from June 11 to 20, 2008. Four boreholes, numbered 08-033 to 08-036, were drilled for the proposed WBL and EBL bridges. One borehole was drilled at each bridge abutment of possible one-span structure arrangements. The depths of the three boreholes ranged from 20.0 m to 21.5 m. Borehole 08-035 drilled at the EBL West abutment was terminated at 9.6 m depth. The Record of Borehole sheets for the boreholes are included in Appendix A. The approximate locations of the four boreholes are shown on the attached Borehole Locations and Soil Strata Drawing in Appendix G.

Prior to commencing the site investigation, clearance was obtained from utility companies having plant in the area.

The boreholes were drilled using hollow stem auger equipment mounted on a CME75 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. Standpipe piezometers were installed in Boreholes 08-034 (WBL east abutment) and 08-035 (EBL, West abutment). The standpipe piezometers consist of 25 mm diameter PVC pipe with a slotted screen enclosed in filter sand to permit longer term groundwater level monitoring. The locations and completion details of the piezometers 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
WBL	West Abutment	08-033	No Installation	Borehole backfilled with bentonite to 0.6 m, then holeplug to surface.
	East Abutment	08-034	18.8/293.4	Piezometer with 1.5 m slotted screen installed with sand filter to 16.8 m, holeplug from 16.8 m to 16.2 m, bentonite seal from 16.2 m to 1.8 m, holeplug from 1.8 m to 0.6 m, then auger cuttings to ground surface.
EBL	West Abutment	08-035	9.0/306.3	Piezometer with 1.5 m slotted screen installed with sand filter to 7.0 m, holeplug from 7.0 m to 6.6 m, bentonite seal from 6.6 m to 0.3 m, then holeplug to ground surface.
	East Abutment	08-036	No Installation	Borehole backfilled with bentonite to 0.9 m, then holeplug to 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 G. 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 native sand, stiff to very stiff silty clay and silty clay till and very dense sandy silt till. Layers of very dense sand were encountered within the till deposits.

5.1 Topsoil

Topsoil was identified at ground surface in all the boreholes. The topsoil thickness ranged from 150 mm to 200 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

Layers of native brown sand containing trace gravel and some silt were encountered below the topsoil in Boreholes 08-033 and 08-034. A 500-mm thick layer of silt was contacted within the sand in Borehole 08-033. The thickness of these upper sand layers range form 1.2 m to 1.3 m with the base of the layers at Elevation 310.7 to 311.7.

Layers of grey sand were also contacted within the glacial till deposits at lower depths, 6.6 m and 16.2 m (Elevations 306.6 and 296.0) in Boreholes 08-033 and 08-034, respectively. The thickness of these layers range from 2.4 m to 3.8 m with the base of the layers at Elevations 293.6 to 302.8.

The upper layers of sand and silt have a compact relative density with SPT 'N' values of 13 and 14 blows per 0.3 m of penetration. SPT 'N' values measured in the lower layers of sand within the till deposit ranged from 93 blows per 0.3 m of penetration to higher than 100 blows per 0.15 m of penetration, indicating a very dense relative density. Moisture content ranged from 15% to 20%.

Grain size distribution curves for two samples of the lower sand layers are presented on the Record of Borehole sheets and on Figure B1 of Appendix B. The results of grain size distribution tests carried out on sand samples were as follows:

Soil Particles	(%)
Gravel	2 to 13
Sand	76 to 91
Silt & Clay	7 to 11

5.3 Silty Clay and Silty Clay Till

Native brown to grey silty clay and silty clay till containing trace gravel and trace sand were observed in all the boreholes at depths and elevations indicated in Table 5.1.

Table 5.1 – Depths and Elevations of Native Silty Clay and Silty Clay Till

Foundation Unit		Borehole	Depth below existing ground surface (m)	Elevation (m)	Thickness (m)
WBL	West Abutment	08-033	1.5 to 4.1 12.2 to 17.4	311.7 to 309.1 301.0 to 295.8	2.6 5.2
	East Abutment	08-034	1.4 to 6.1 10.0 to 16.2	310.7 to 306.1 302.2 to 296.0	4.6 6.2
EBL	West Abutment	08-035	0.2 to 4.4 8.8 to 9.6* (Borehole termination depth)	315.1 to 310.9 306.5 to 305.7	4.2 0.8
	East Abutment	08-036	2.1 to 13.3* 13.3 to 18.1	312.6 to 301.4 301.4 to 296.6	11.2 4.8

* Silty clay till

The base of the silty clay and silty clay till layers is at elevation ranging from 295.8 to 296.6.

Within the upper 4.0 to 8.0 m, the silty clay and silty clay till layers are generally stiff to hard in consistency with SPT 'N' values ranging from 10 to 45 blows per 0.3 m of penetration. Below 8.0 m depth, SPT 'N' values were higher, generally ranging from 29 to 85, indicating a very stiff to hard consistency. SPT 'N' values higher than 100 blows per 0.1 m of penetration were also measured at and below elevation 306 in Boreholes 08-035 and 08-036, both boreholes drilled at the proposed Highway 7 EBL.

The natural moisture contents generally lay in the range of 18 to 25%.

Grain size distribution curves for the silty clay and silty clay till samples are presented on the Record of Borehole sheets and on Figures B2 and B3 of Appendix B. Atterberg Limits test results are presented on Figures B7 and B8 of Appendix B. The results of grain size distribution tests are summarized as follows:

Soil Particles	(%)
Gravel	0 to 1
Sand	0 to 15
Silt	22 to 48
Clay	39 to 77

Liquid Limit	39 to 59
Plastic Limit	17 to 22

The above results show that the silty clay and silty clay till is of medium to high plasticity with a group symbol of CI-CH.

It should be noted that glacial tills are know to contain cobbles and boulders.

5.4 Sandy Silt and Sandy Silt Till

Native deposits of brown to grey sandy silt and sandy silt till containing trace of gravel, trace to some clay and occasional cobbles were observed in the boreholes at depths and elevations indicated in Table 5.2.

Table 5.2 – Depths and Elevations of Native Sandy Silt/Sandy Silt Till

Foundation Unit		Borehole	Depth below existing ground surface (m)	Elevation (m)	Thickness (m)
WBL	West Abutment	08-033	4.1 to 6.6 10.4 to 12.2 17.4 to 21.1 ** (borehole termination depth)	309.1 to 306.6 302.8 to 301.0 295.8 to 292.1	2.5 1.8 3.7
	East Abutment	08-034	6.1 to 10.0 18.6 to 20.0 ** (borehole termination depth)	306.1 to 302.2 293.6 to 292.2	3.9 1.4
EBL	West Abutment	08-035	4.4 to 8.8	310.9 to 306.5	4.4
	East Abutment	08-036	0.2 to 2.1 * 18.1 to 21.5 ** (borehole termination depth)	314.4 to 312.6 296.6 to 293.2	1.9 3.4

* Sandy silt
** Lower sandy silt till layer

SPT values measured in the sandy silt and sandy silt till generally ranged from 15 to 39 blows per 0.3 m of penetration, indicating a compact to dense relative density. SPT 'N' values of 90 blows per 0.3 m of penetration to higher than 100 blows per 0.1 m of penetration were measured below 6.0 m depth in Boreholes 08-033 and 08-035 (west abutments) and below 18.0 m depth in Boreholes 08-034 and 08-036 (east abutments). The high SPT 'N" values were generally measured in the lower sandy silt till layers.

The natural moisture contents generally lay in the range of 7 to 30%.

Grain size distribution curves for the sandy silt and sandy silt till samples tested are presented on the Record of Borehole sheets and on Figures B4 to B6 of Appendix B. Atterberg Limits test results are presented on Figure B9 of Appendix B. The results of grain size distribution tests were as follows:

Soil Particles	(%)
Gravel	0 to 5
Sand	6 to 55
Silt	20 to 82
Clay	3 to 25

Liquid Limit	10 -20
Plastic Limit	10- 16

Although not specifically identified in the boreholes, this layer may contain cobbles and boulders which may account for some high SPT 'N' values and resistance to augering.

5.5 Groundwater Conditions

Water levels were observed in the boreholes during and upon completion of drilling. Standpipe piezometers were installed in two boreholes to monitor water levels after completion of drilling. The water levels measured in the piezometers are summarized in Table 5.3, along with the measurements in the open boreholes upon completion of drilling.

Table 5.3 – Water Level Measurements

Foundation Unit		Borehole	Date (2008)	Water Level (m)		Comment
				Depth	Elevation	
WBL	West Abutment	08-033	June 19	Dry	-	During drilling
	East Abutment	08-034	August 20 August 27	12.5 12.4	299.7 299.8	In piezometer
EBL	West Abutment	08-035	June 13 July 2 August 20 August 27	0.5* 0.6* 0.7* 0.7*	315.8 315.9 316.0 316.0	In piezometer
	East Abutment	08-036	June 12	Dry	-	During drilling

*Above ground surface (artesian conditions)

Piezometric readings indicate the presence of artesian conditions on the site. Groundwater level was 0.7 m above ground surface (Elevations 316.0) in Borehole 08-035.

Groundwater level was 12.4 m (Elevation 299.8) below ground surface in Borehole 08-034.

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

All-Terrain Drilling of Waterloo, Ontario supplied a CME75 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. Stephane Loranger, C.E.T. of Thurber, under the direction of Mr. Alastair E. Gorman, 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.

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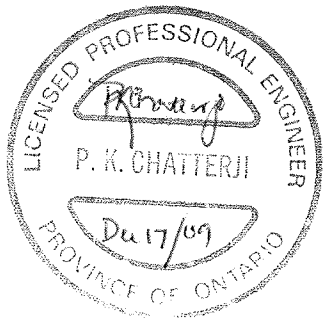

P.K. Chatterji, P.Eng.,
Review Principal, Designated MTO Contact

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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 2B of the E.A:

- The proposed Highway 7 grade at Elevation 327.0 will be in fill 11 m to 15 m high (relative to the surrounding ground surface).
- Riverbend Drive Connector will also be in a fill at Elevation 319.0 on an embankment 6 m to 7 m high under the WBL and 4 m to 5 m high under the EBL.

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 overlying native layers of compact to very dense sand, stiff to hard silty clay and silty clay till and compact to very dense sandy silt till. The groundwater levels measured in the piezometer indicate localized artesian conditions on site with groundwater levels 0.7 m (Elevation 316.0) above ground surface at the west abutment of the eastbound structure.

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 very dense 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. This option can be considered. However, it does not seem feasible at this site, based on the grades currently shown.

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

Table 8.1 – Bearing Resistances for Spread Footings

Foundation Unit		Borehole	Depth (m)	Elev.	ULS_f (kPa)	SLS (kPa)
WBL	West Abutment	08-033	1.6	311.6	300	200
			6.2	307.0	750	500
	East Abutment	08-034	2.3	309.8	300	200
			7.6	304.6	600	400
EBL	West Abutment	08-035	1.5	313.8	300	200
			6.3	309.0	750	500
	East Abutment	08-036	2.1	312.6	300	200
			6.0	308.6	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.

Artesian conditions were observed at this site and consequently, founding elevations presented in Table 8.1 are generally 2.2 m to 6.8 m below the groundwater level. 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.

Elevations and depths provided in Table 8.1 were determined based on existing ground surface. Plate 2B indicates that approximately 11 m to 15 m of fill will be placed on site to

raise Highway 7 and Riverbed Drive connector to their proposed grades. Therefore, elevations and depths on Table 8.1 will be 12 m to 20 m below proposed Highway 7 grade.

For these reasons, footings on native soils are not recommended.

8.2 Spread Footings on Engineered Fill

Spread footings can also be founded on Granular "A" engineered fill pads.

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. Subexcavation of existing topsoil, deleterious materials and native loose sands will be required. The engineered fill must bear on native compact sand/sandy silt or very stiff silty clay. The highest permitted founding/base elevations at which engineered fill pads may be placed, are given in Table 8.2.

Table 8.2 – Founding Elevations for Engineered Fill Pads

Foundation Unit		Borehole	Founding Depth (m)	Founding Elevation
WBL	West Abutment	08-033	0.4	312.8
	East Abutment	08-034	0.4	311.8
EBL	West Abutment	08-035	0.3	315.0
	East Abutment	08-036	0.4	314.2

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% of Standard proctor maximum dry density (SPMDD) at optimum moisture content ±2%. The minimum extent of the fill pad must conform to the general requirements shown in Figure 1 in Appendix D. In practical terms, at this site this may involve placing one continuous pad on engineered fill under the structure footprint.

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 very dense and hard soils underlying the site.

Based on an HP 310 X 110 pile, a minimum embedment depth of 6 m is required. The preliminary information in EA Plate 2B indicates that this depth of embedment should be achievable at the abutments.

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		Borehole	Anticipated Pile Length* (m)	Highest Pile Tip Elevation
WBL	West Abutment	08-033	≈ 10	303.2
	East Abutment	08-034	18	294.2
EBL	West Abutment	08-035	≈ 8	307.5
	East Abutment	08-036	≈ 10	304.6

* Measured from existing grade. Must be adjusted after the underside of the abutment has been set.

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 two pile sections when driven into the very dense sand and silty sand till are presented in Table 8.4.

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

Pile Section	Geotechnical Resistance (kPa)	
	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 sand and silty sand till layer and the expected founding layer, 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, as frost protection.

8.6 Recommended Foundation

From the prespective of geotechnical conditions and cost effectiveness, spread footings on engineered fill are the recommended foundation for this site.

If an integral abutment design is selected, driven steel H-piles may be used.

9 BRIDGE APPROACHES AND EMBANKMENTS

Based on the four boreholes drilled at the site, the approach embankments will be constructed over compact, non-cohesive sand and sandy silt and very stiff silty clay.

Preliminary analysis indicates that at the abutments, settlement in the order of 35 to 45 mm is estimated in the foundation soils under the loading imposed by approximately 15 m of the approach fill. Due to the density and consistency 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. A more detailed settlement analysis should be conducted during the detail phase design.

The 11 to15 m high embankments likely to be constructed will be stable at side slopes of 2H:1V if constructed using SSM or granular fill. Where earth fill embankments are higher than 8 m, mid-height berms should be incorporated in the design. The berms should:

- extend for the length through which the embankment height exceeds 8 m
- be at least 2 m wide
- have 2% positive grade to shed run-off water.

For the purpose of preliminary embankment stability analyses, the commercially available slope stability program GSLOPE developed by Mitre Software Inc. was used. The Bishop's simplified method for stability analysis was employed.

Global stability analyses were conducted for a 15 m high, 2H:1V SSM or earth fill embankment. The stability of the embankment was also checked under seismic loading assuming an acceleration of 0.08g. The computed factors of safety are as shown in Table 9.1. Slope stability computation outputs are included in Appendix E.

Table 9.1 Computed Factors of Safety

Location / Material	Condition	Factor of Safety	Figure (Appendix E)
15 m High –EBL West Approach			
Earth Fill	Normal	1.3	1
Earth Fill	Seismic = 0.08g	1.1	2

These factors of safety are considered to be acceptable for the proposed embankment bearing on the foundation soils present at this site.

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

During detail design, when the grade has been finalized, permanent drainage and slope protection requirements must be addressed.

10 GROUNDWATER

A small artesian head was noted in the groundwater at the west abutment of the eastbound structure. Since embankment fill will be placed to much higher elevations, this small artesian heads is not considered to be a concern.

11 CONSTRUCTION CONCERNS

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

1. Variability in Pile Lengths.

The subsurface information obtained to date suggests that there might be significant variability in the lengths of driven pile required to develop the specified resistance, particularly from foundation element to foundation element.

This situation could lead to uncertainty in the field during construction and a need for an increased percentage of re-driving of piles.

The variability of the soils should be addressed during the detail design phase to attempt to resolve the stratigraphic details.

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 Riverbend Drive connector 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 Riverbend Drive connector.

3. Artesian conditions

   Further investigation of artesian conditions will be required during the detail design phase of the project. The boreholes must include piezometers for groundwater monitoring.

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.

Thurber Engineering Ltd.

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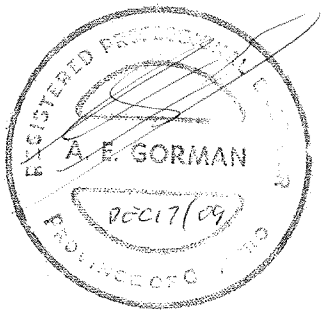
Geotechnical Engineer



Alastair E. Gorman, P.Eng.,
Senior Foundations Engineer

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

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

$\blacktriangledown$ Water Level

C_{pen} 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

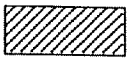
MAJOR DIVISIONS		GROUP SYMBOL	TYPICAL DESCRIPTION
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	GW	Well-graded gravels or gravel-sand mixtures, little or no fines.
		GP	Poorly-graded gravels or gravel-sand mixtures, little or no fines.
		GM	Silty gravels, gravel-sand-silt mixtures.
		GC	Clayey gravels, 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			

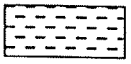
EXPLANATION OF ROCK LOGGING TERMS

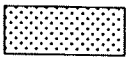
ROCK WEATHERING CLASSIFICATION

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

SYMBOLS


CLAYSTONE


SILTSTONE


SANDSTONE


COAL


Bedrock (general)

DISCONTINUITY SPACING

Bedding	Bedding Plane Spacing
Very thickly bedded	Greater than 2m
Thickly bedded	0.6 to 2m
Medium bedded	0.2 to 0.6m
Thinly bedded	60mm to 0.2m
Very thinly bedded	20 to 60mm
Laminated	6 to 20mm
Thinly Laminated	Less than 6mm

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.

STRENGTH CLASSIFICATION

Rock Strength	Approximate Uniaxial Compressive Strength (MPa)	(psi)	Field Estimation of Hardness*
Extremely Strong	Greater than 250	Greater than 36,000	Specimen can only be chipped with a geological hammer
Very Strong	100-250	15,000 to 36,000	Requires many blows of geological hammer to break
Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
Medium Strong	25.0 to 50.0	3,500 to 7,500	Breaks under single blow of geological hammer.
Weak	5.0 to 25.0	750 to 3,500	Can be peeled by a pocket knife with difficulty
Very Weak	1.0 to 5.0	150 to 750	Can be peeled by a pocket knife, crumbles under firm blows of geological pick.
Extremely Weak (Rock)	0.25 to 1.0	35 to 150	Indented by thumbnail

THURBER

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RECORD OF BOREHOLE No 08-033 1 OF 3 METRIC

G.W.P. 408-88-00 LOCATION N 4 814 712.66 E 226 708.59 ORIGINATED BY SLL
HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY ES
DATUM Geodetic DATE 2008.06.19 - 2008.06.20 CHECKED BY RPR

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 (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
313.2											
0.0	**TOPSOIL**, occasional roots and rootlets: (150mm)										
0.2	**SAND**, some silt Compact Brown Moist						313				
	Layer of silt, some clay (500mm)		1	SS	14						
311.7							312				
1.5	Silty **CLAY**, trace sand Stiff to Very Stiff Brown to Grey		2	SS	22						
			3	SS	26		311				0 2 48 50
			4	SS	14		310				
309.1											
4.1	Sandy **SILT**, trace gravel, trace to some clay Compact to Very Dense Grey Moist (TILL)		5	SS	18		309				1 55 20 24
			6	SS	90		308				
306.6							307				5 45 40 10
6.6	**SAND**, trace silt, trace gravel, trace clay Very Dense Grey Wet		7	SS	93		306				2 91 7 (SI+CL)
							305				
			8	SS	100/250		304				

Continued Next Page

+ ^{3}, × ^{3}: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

ONTMT4S 6417R.GPJ 8/6/08

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RECORD OF BOREHOLE No 08-033 2 OF 3 METRIC

G.W.P. 408-88-00 LOCATION N 4 814 712.66 E 226 708.59 ORIGINATED BY SLL
HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY ES
DATUM Geodetic DATE 2008.06.19 - 2008.06.20 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (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 (%) (20 40 60)	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
302.8	**SAND**, trace silt, trace gravel, trace clay						303				
10.4	Very Dense Grey Wet										
	Sandy **SILT**, trace clay Very Dense Grey Moist to Wet (TILL)		9	SS	100/.150		302		o		0 48 49 3
301.0											
12.2	Silty **CLAY**, trace sand, trace gravel Hard Grey		10	SS	35		301		o		
			11	SS	79		300		o		
			12	SS	85		299		o		1 4 40 55
			13	SS	53		298		o		
295.8							297				
17.4	Sandy **SILT**, trace to some clay, trace gravel Very Dense Grey Moist (TILL) Slow augering at 17.4m.		14	SS	100/.175		296		o		2 27 47 24
			15	SS	100/.075		295		o		2 44 42 12
							294				

Continued Next Page

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

20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

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RECORD OF BOREHOLE No 08-033 3 OF 3 METRIC

G.W.P. 408-88-00 LOCATION N 4 814 712.66 E 226 708.59 ORIGINATED BY SLL

HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY ES

DATUM Geodetic DATE 2008.06.19 - 2008.06.20 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: O 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 (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	Continued From Previous Page										
	Sandy **SILT**, trace to some clay, trace gravel Very Dense Grey Moist (TILL)						293		o		
292.1			16	SS	100/						
21.1	END OF BOREHOLE AT 21.1m. BOREHOLE DRY UPON COMPLETION OF DRILLING. BOREHOLE BACKFILLED WITH BENTONITE TO 0.61m THEN HOLEPLUG TO SURFACE.				.075						

+ 3 . × 3 . Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

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RECORD OF BOREHOLE No 08-034 1 OF 3 METRIC

G.W.P. 408-88-00 LOCATION N 4 814 735.77 E 226 754.73 ORIGINATED BY SLL

HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY ES

DATUM Geodetic DATE 2008.06.17 - 2008.06.18 CHECKED BY RPR

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: O 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 (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
312.2											
0.0	**TOPSOIL**, peaty, occasional roots and rootlets: (200mm) Black Moist						312				
0.2	**SAND**, some silt Compact Brown Wet		1	SS	13				c		
310.7							311				
1.4	Silty **CLAY**, trace gravel Stiff to Very Stiff Brown to Grey		2	SS	12				c		
			3	SS	18		310		o		0 0 47 53
			4	SS	14		309		o		
			5	SS	10		308		o		
306.1							307				
6.1	Sandy **SILT**, trace gravel, some clay Compact to Dense Grey Moist (TILL)		6	SS	16		306		H o		1 30 55 14
	occasional silt pockets		7	SS	37		305		o		3 40 41 16
							304		o		
			8	SS	39		303		o		
302.2											

Continued Next Page

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

20 / 15 5 / 10 (%) STRAIN AT FAILURE

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RECORD OF BOREHOLE No 08-034 2 OF 3 METRIC

G.W.P. 408-88-00 LOCATION N 4 814 735.77 E 226 754.73 ORIGINATED BY SLL
HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY ES
DATUM Geodetic DATE 2008.06.17 - 2008.06.18 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: ○ UNCONFINED + 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 (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
10.0	Continued From Previous Page Silty **CLAY**, trace gravel, occasional silt pockets Very Stiff to Hard Grey						302				
			9	SS	29		301				0 1 22 77
			10	SS	34	▼	300				
			11	SS	45		299				
			12	SS	38		298				
296.0							297				
16.2	**SAND**, some gravel, trace silt, trace clay, occasional cobbles Very Dense Grey Wet		13	SS	100/ 150		296				13 76 11 (SI+CL)
293.6			14	SS	100/ 175		295				
18.6	Sandy **SILT**, some clay, trace gravel Very Dense Grey (TILL)						294				
292.2			15	SS	100/		293				2 32 47 19

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$+^{3}$, $\times^{3}$ Numbers refer to Sensitivity

(%) STRAIN AT FAILURE

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RECORD OF BOREHOLE No 08-034 3 OF 3 METRIC

G.W.P. 408-88-00 LOCATION N 4 814 735.77 E 226 754.73 ORIGINATED BY SLL
HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY ES
DATUM Geodetic DATE 2008.06.17 - 2008.06.18 CHECKED BY RPR

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 (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						
	Continued From Previous Page										
20.0	END OF BOREHOLE AT 20.0m. Piezometer installation consists of 25mm diameter schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2008.08.20 12.5m 299.7 2008.08.27 12.4m 299.8				150						

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

$\frac{20}{15 \oplus 5}$ (%) STRAIN AT FAILURE
10

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THURBER

RECORD OF BOREHOLE No 08-035 1 OF 2 METRIC

G.W.P. 408-88-00 LOCATION N 4 814 668.41 E 226 725.11 ORIGINATED BY SLL
HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM
DATUM Geodetic DATE 2008.06.11 - 2008.06.11 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE 20 40 60 80 100	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L WATER CONTENT (%) 20 40 60	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
315.3											
0.0	**TOPSOIL**, trace sand and gravel, occasional roots and rootlets: (150mm)										
0.2	Silty **CLAY**, trace sand Very Stiff Brown		1	SS	16		315	○			
			2	SS	25		314	○			
			3	SS	30		313	⊖			0 4 45 51
			4	SS	25		312	○			
310.9											
4.4	Sandy **SILT**, trace clay, trace gravel Compact Brown Moist to Wet (TILL)		5	SS	22		311	○			1 45 46 8
	Very Dense Grey		6	SS	100/.250		310				
	trace sand, some clay		7	SS	100/.200		309	○			2 49 39 10
306.5							308	○			0 6 82 12
8.8	Silty **CLAY**, trace sand Hard Grey (TILL)		8	SS	64/100		307				
305.7							306	⊖			0 4 39 57
9.6	END OF BOREHOLE AT 9.6m. Piezometer installation consists of 25mm diameter schedule 40 PVC pipe										

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

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RECORD OF BOREHOLE No 08-035 2 OF 2 METRIC

G.W.P. 408-88-00 LOCATION N 4 814 668.41 E 226 725.11 ORIGINATED BY SLL
HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM
DATUM Geodetic DATE 2008.06.11 - 2008.06.11 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100 / SHEAR STRENGTH kPa: O 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 (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
	Continued From Previous Page										
	with a 1.52m slotted screen.										
	WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2008.02.07 0.5* 315.8 2008.06.13 0.5* 315.8 2008.07.02 0.6* 315.9 2008.08.20 0.7* 316.0 2008.08.27 0.7* 316.0 *Above ground level										

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

$\frac{20}{15 \oplus 5}$ (%) STRAIN AT FAILURE
10

ONTMT4S 6417R.GPJ 9/11/08

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 08-036 1 OF 3 METRIC

G.W.P. 408-88-00 LOCATION N 4 814 685.09 E 226 764.24 ORIGINATED BY SLL
HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM
DATUM Geodetic DATE 2008.06.12 - 2008.06.12 CHECKED BY RPR

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: 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 (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
314.6											
0.0	**TOPSOIL**, with roots and rootlets: (175mm)										
0.2	Sandy **SILT**, trace clay Compact Brown Wet		1	SS	15		314		o		
			2	SS	17		313		o		0 23 73 4
312.6											
2.1	Silty **CLAY**, trace sand Very Stiff Grey (TILL)		3	SS	19		312		o		
			4	SS	19		311		o		0 5 45 50
			5	SS	8		310		o		
	Hard Grey		6	SS	45		309		o		
			7	SS	17		308		o		
	Wet silty sand seam (150mm)						307		o		0 15 46 39
			8	SS	100/275		306		o		
304.6							305				

Continued Next Page

+ ^{3}, × ^{3}: Numbers refer to Sensitivity

20 / 15 5 / 10 (%) STRAIN AT FAILURE

ONTMT4S 6417R.GPJ 8/6/08

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 08-036 2 OF 3 METRIC

G.W.P. 408-88-00 LOCATION N 4 814 685.09 E 226 764.24 ORIGINATED BY SLL
HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM
DATUM Geodetic DATE 2008.06.12 - 2008.06.12 CHECKED BY RPR

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 (%) (20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
10.0	Silty **CLAY**, trace sand Hard Grey (TILL)										
			9	SS	80/ .275		304				
							303				
			10	SS	73						0 6 42 52
301.4							302				
13.3	Silty **CLAY**, occasional silt pockets Hard Grey										
			11	SS	60		301				0 4 30 66
							300				
			12	SS	72		299				
							298				
			13	SS	63						0 4 31 65
296.6							297				
18.1	Sandy **SILT**, some clay, trace, gravel Very Dense Grey Moist (TILL)						296				
			14	SS	100/ .150						
							295				
			15	SS	100/						3 26 46 25

Continued Next Page

+ ³ , × ³ : Numbers refer to Sensitivity

15 (20 / 10) 5 (%) STRAIN AT FAILURE

ONTMT4S 6417R.GPJ 8/6/08

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 08-036 3 OF 3 METRIC

G.W.P. 408-88-00 LOCATION N 4 814 685.09 E 226 764.24 ORIGINATED BY SLL
HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM
DATUM Geodetic DATE 2008.06.12 - 2008.06.12 CHECKED BY RPR

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 (%) 20 40 60	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
	Continued From Previous Page										
	Sandy **SILT**, some clay, trace, gravel Very Dense Grey Moist (TILL)				.125		294				
293.2			16	SS	100/				○		1 15 71 13
21.5	END OF BOREHOLE AT 21.5m. BOREHOLE DRY UPON COMPLETION OF DRILLING. BOREHOLE BACKFILLED WITH BENTONITE TO 0.90m THEN HOLEPLUG TO SURFACE.				.125						

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

$15 \overset{20}{\underset{10}{\oplus}} 5$ (%) STRAIN AT FAILURE

ONTMT4S 6417R.GPJ 8/6/08

Appendix B

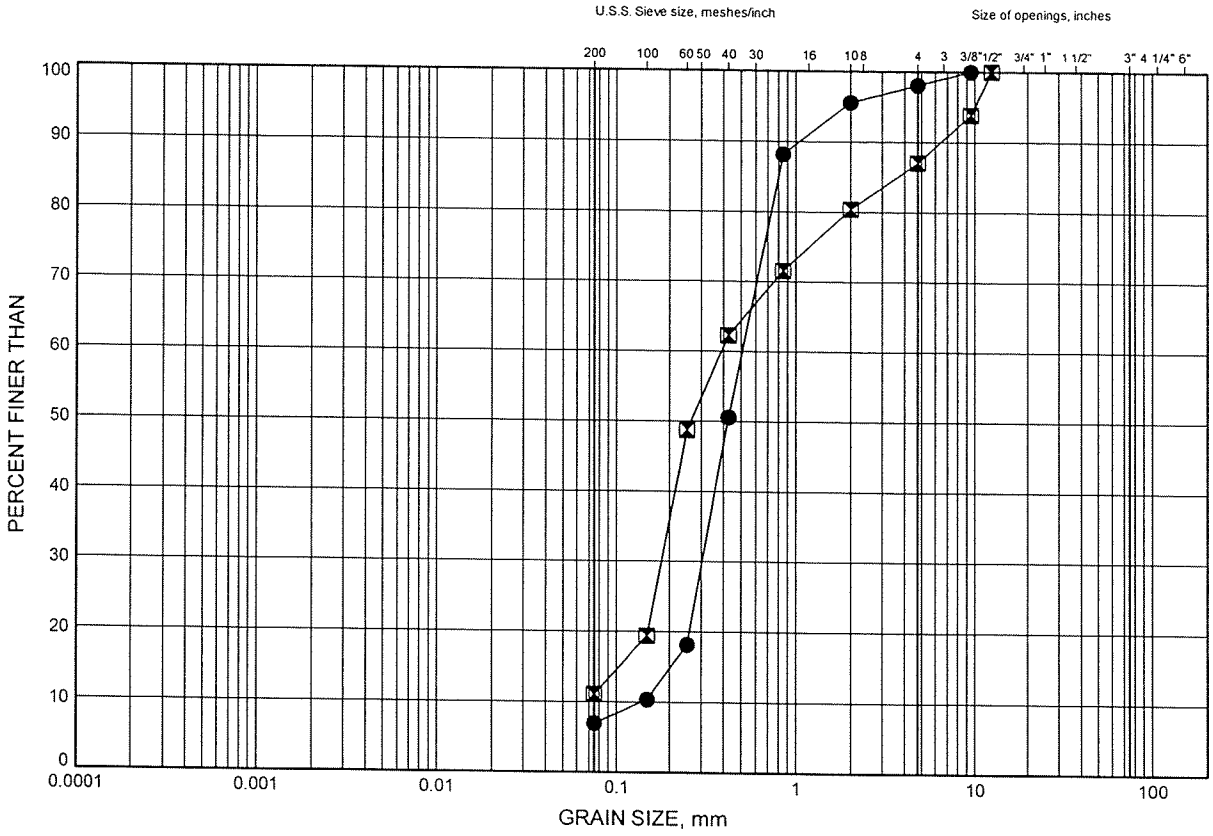
Laboratory Test Results

Highway 7 - New

GRAIN SIZE DISTRIBUTION

FIGURE B1

Sand



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-033	7.85	305.36
⊠	08-034	16.92	295.28

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

THURBER

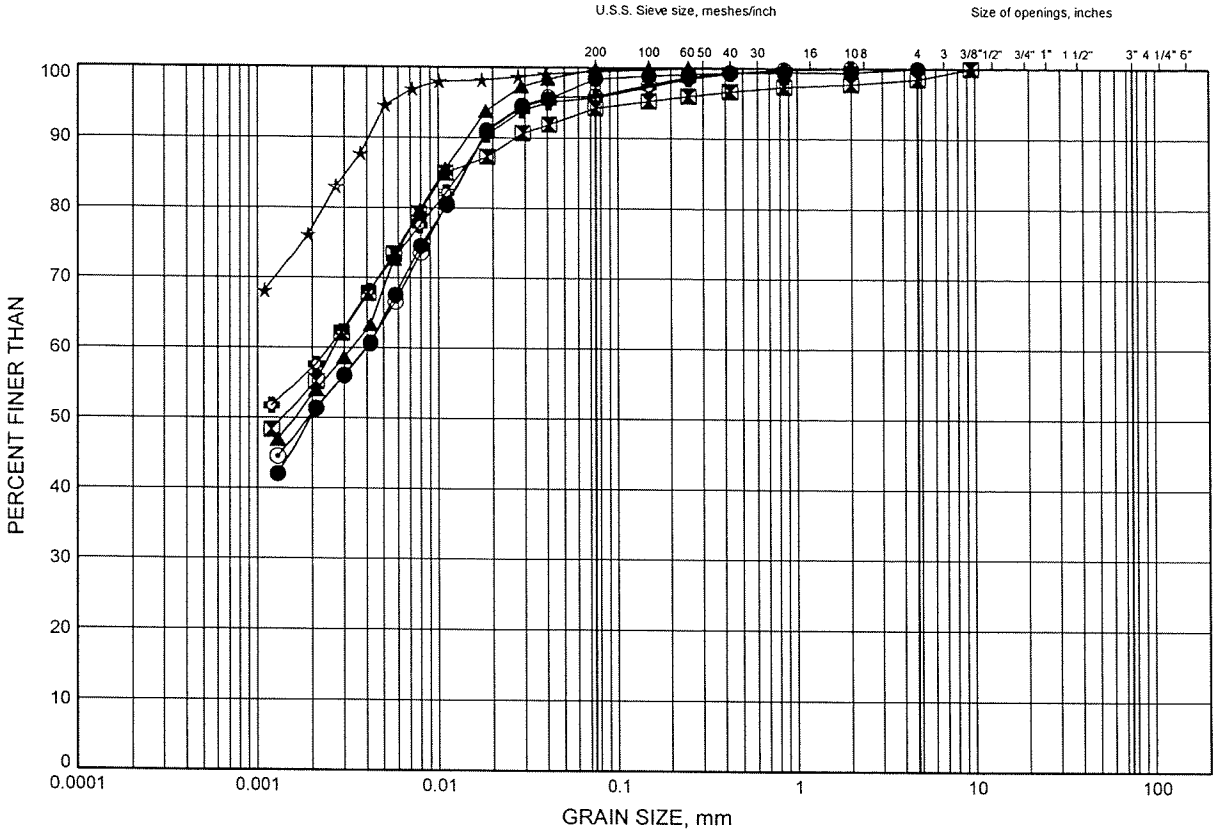
GRAIN SIZE DISTRIBUTION - THURBER 6417R.GPJ 7/29/08

Highway 7 - New

GRAIN SIZE DISTRIBUTION

FIGURE B2

Silty Clay and Silty Clay Till



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-033	2.59	310.61
⊠	08-033	15.24	297.96
▲	08-034	2.59	309.60
☆	08-034	10.97	301.22
⊙	08-035	2.59	312.70
✿	08-035	9.36	305.93

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

THURBER

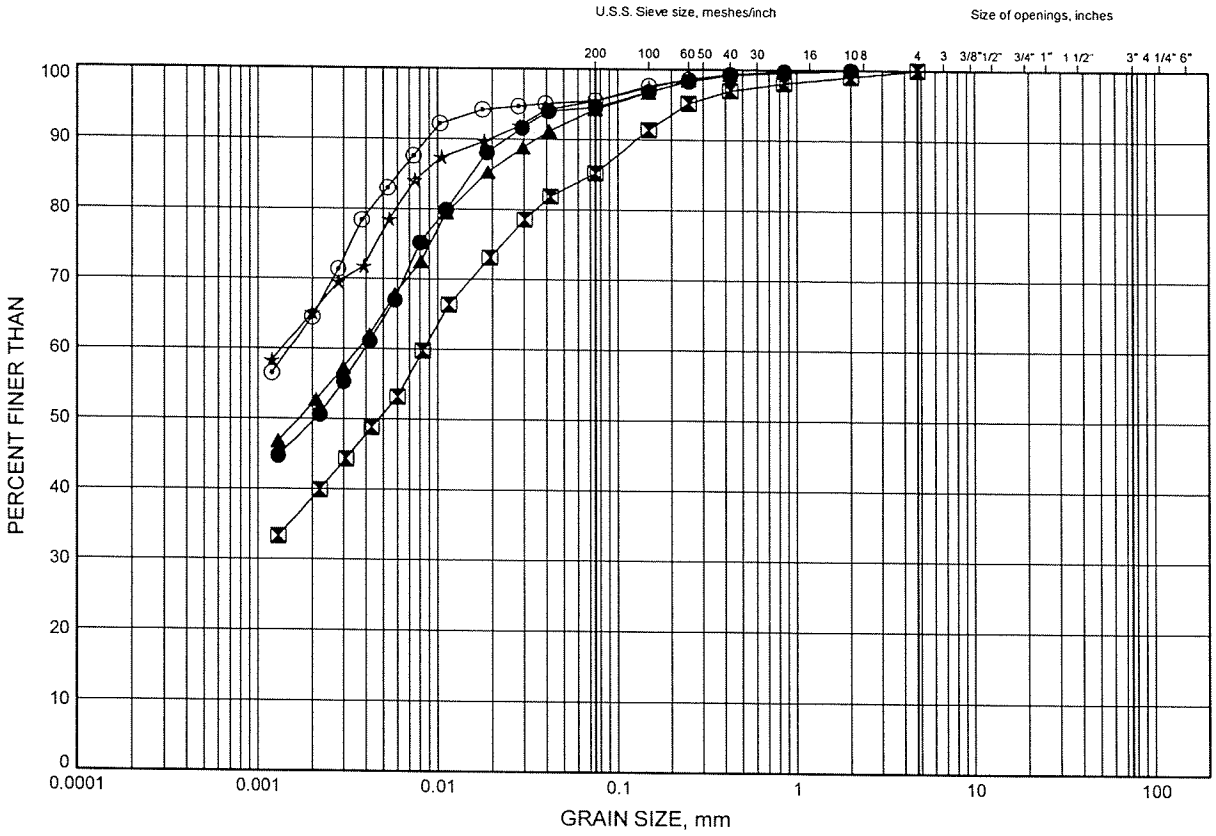
GRAIN SIZE DISTRIBUTION - THURBER 6417R.GPJ 7/29/08

Highway 7 - New

GRAIN SIZE DISTRIBUTION

FIGURE B3

Silty Clay and Silty Clay Till



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-036	3.35	311.28
⊠	08-036	7.92	306.71
▲	08-036	12.48	302.15
☆	08-036	14.02	300.61
⊙	08-036	17.07	297.56

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

THURBER

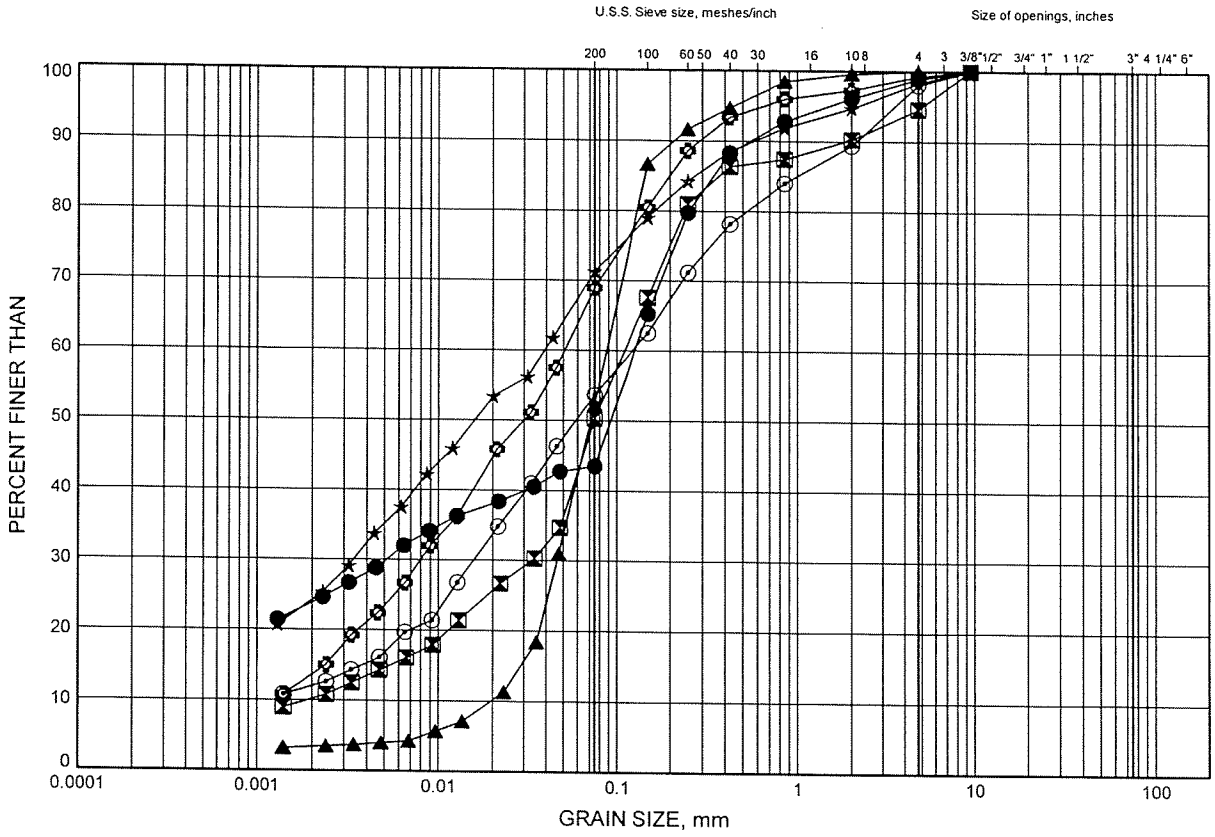
GRAIN SIZE DISTRIBUTION - THURBER 6417R.GPJ 7/29/08

Highway 7 - New

GRAIN SIZE DISTRIBUTION

FIGURE B4

Sandy Silt and Sandy Silt Till



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-033	4.88	308.33
⊠	08-033	6.38	306.83
▲	08-033	10.82	302.38
☆	08-033	18.07	295.13
⊙	08-033	19.54	293.66
✿	08-034	6.40	305.79

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

THURBER

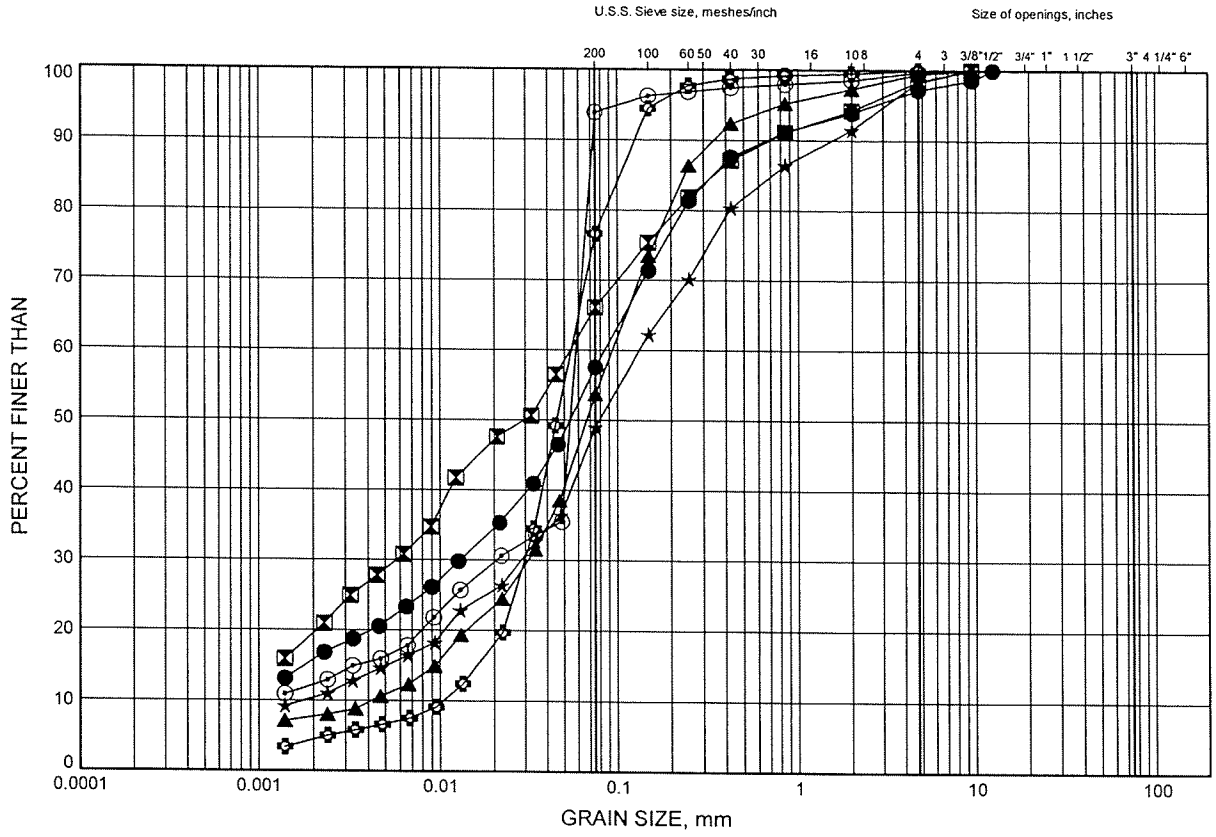
GRAIN SIZE DISTRIBUTION - THURBER 6417R.GPJ 7/29/08

Highway 7 - New

GRAIN SIZE DISTRIBUTION

FIGURE B5

Sandy Silt and Sandy Silt Till



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-034	7.89	304.31
⊠	08-034	19.89	292.30
▲	08-035	4.88	310.41
☆	08-035	6.22	309.07
⊙	08-035	7.72	307.57
✿	08-036	1.83	312.80

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

THURBER

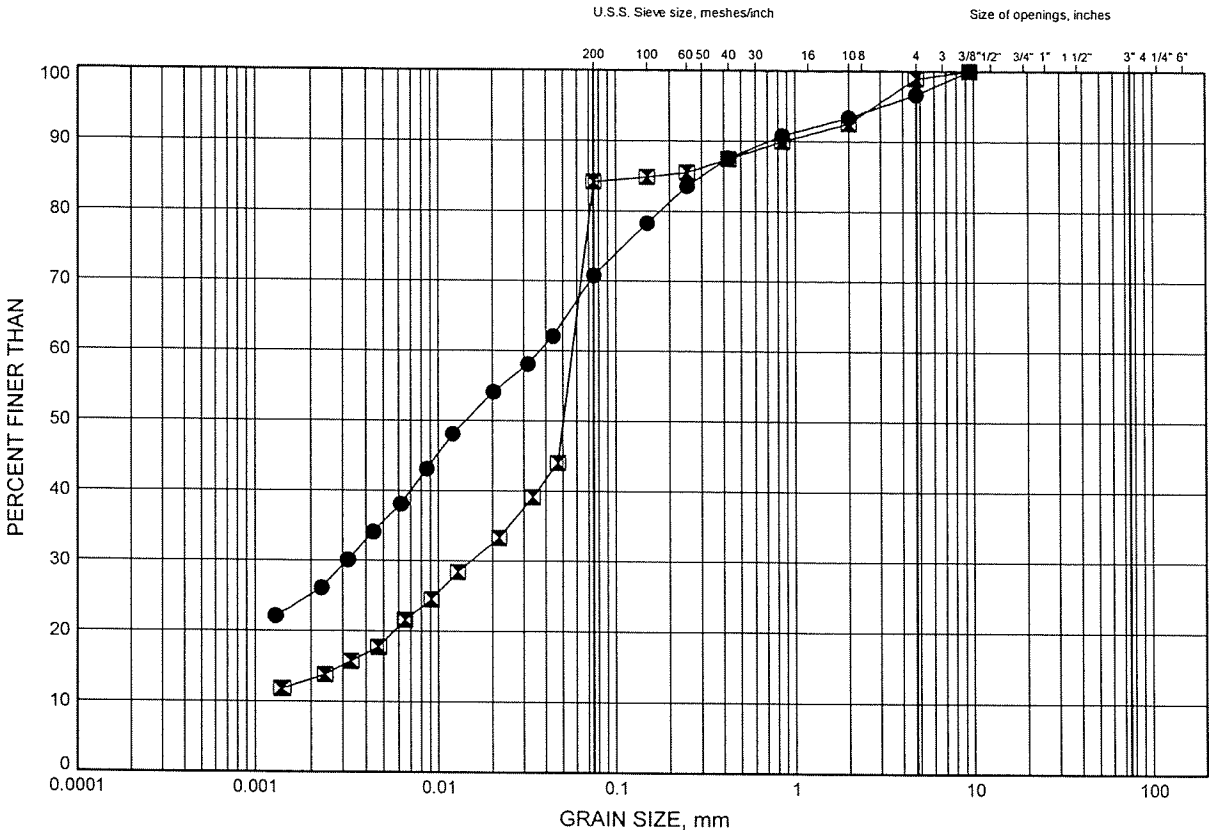
GRAIN SIZE DISTRIBUTION - THURBER 6417R.GPJ 7/29/08

Highway 7 - New

GRAIN SIZE DISTRIBUTION

FIGURE B6

Sandy Silt and Sandy Silt Till



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-036	19.87	294.76
⊠	08-036	21.40	293.23

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

THURBER

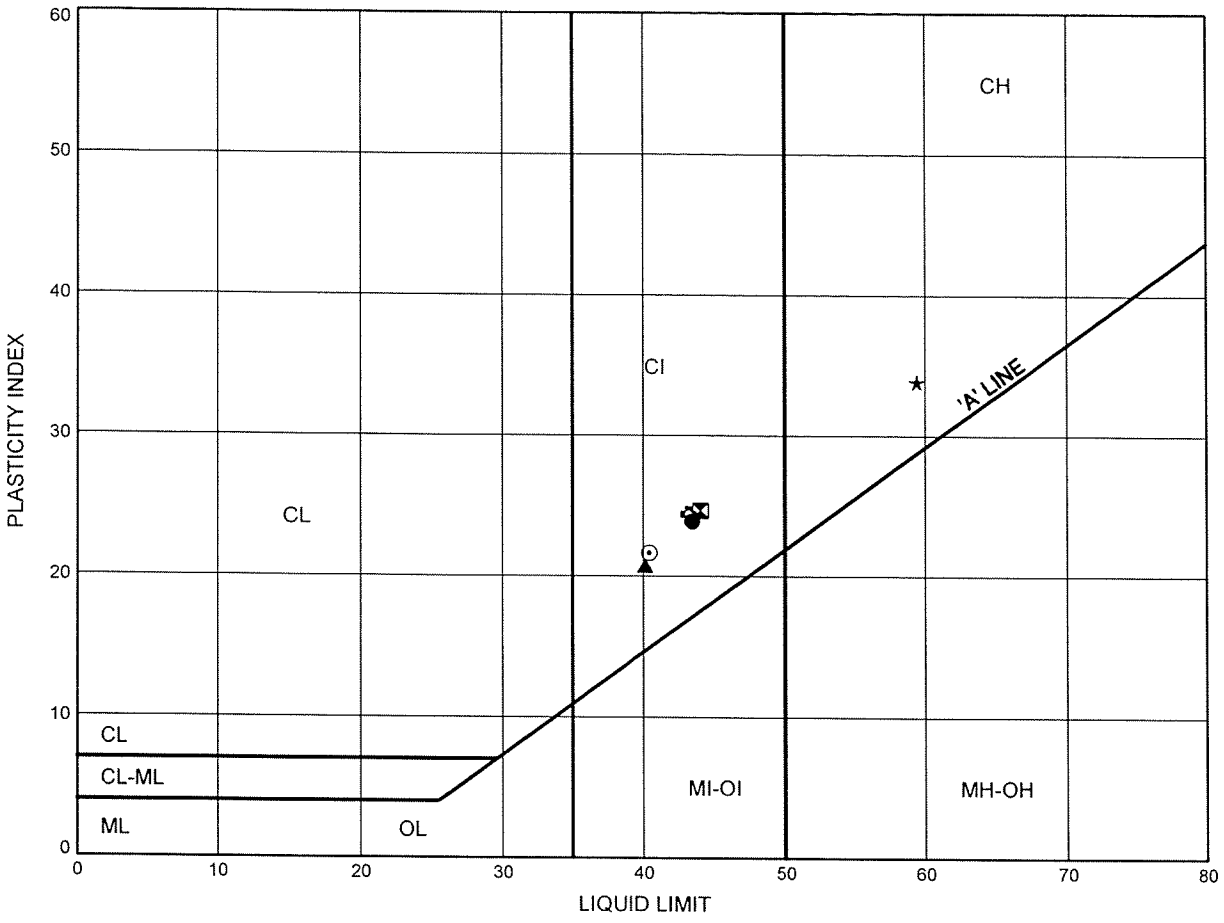
GRAIN SIZE DISTRIBUTION - THURBER 6417R.GPJ 7/29/08

Highway 7 - New

ATTERBERG LIMITS TEST RESULTS

FIGURE B7

Silty Clay and Silty Clay Till



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	08-033	2.59	310.61
⊠	08-033	15.24	297.96
▲	08-034	2.59	309.60
★	08-034	10.97	301.22
⊙	08-035	2.59	312.70
✪	08-035	9.36	305.93

Date July 2008

Project 408-88-00

THURBER

Prep'd SA

Chkd. RPR

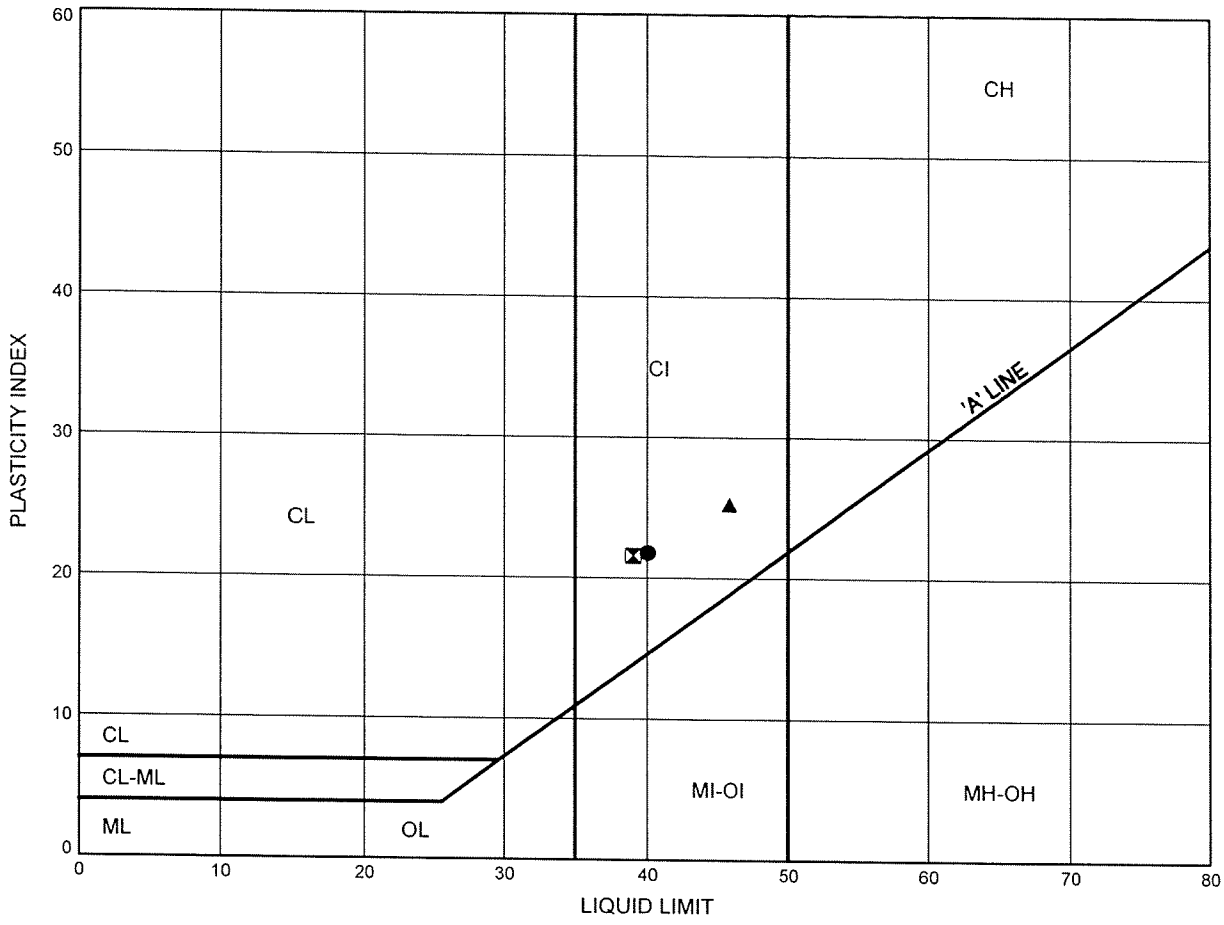
THURBALT 6417R.GPJ 7/29/08

Highway 7 - New

ATTERBERG LIMITS TEST RESULTS

FIGURE B8

Silty Clay and Silty Clay Till



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	08-036	3.35	311.28
⊠	08-036	12.48	302.15
▲	08-036	17.07	297.56

Date July 2008

Project 408-88-00

THURBER

Prep'd SA

Chkd. RPR

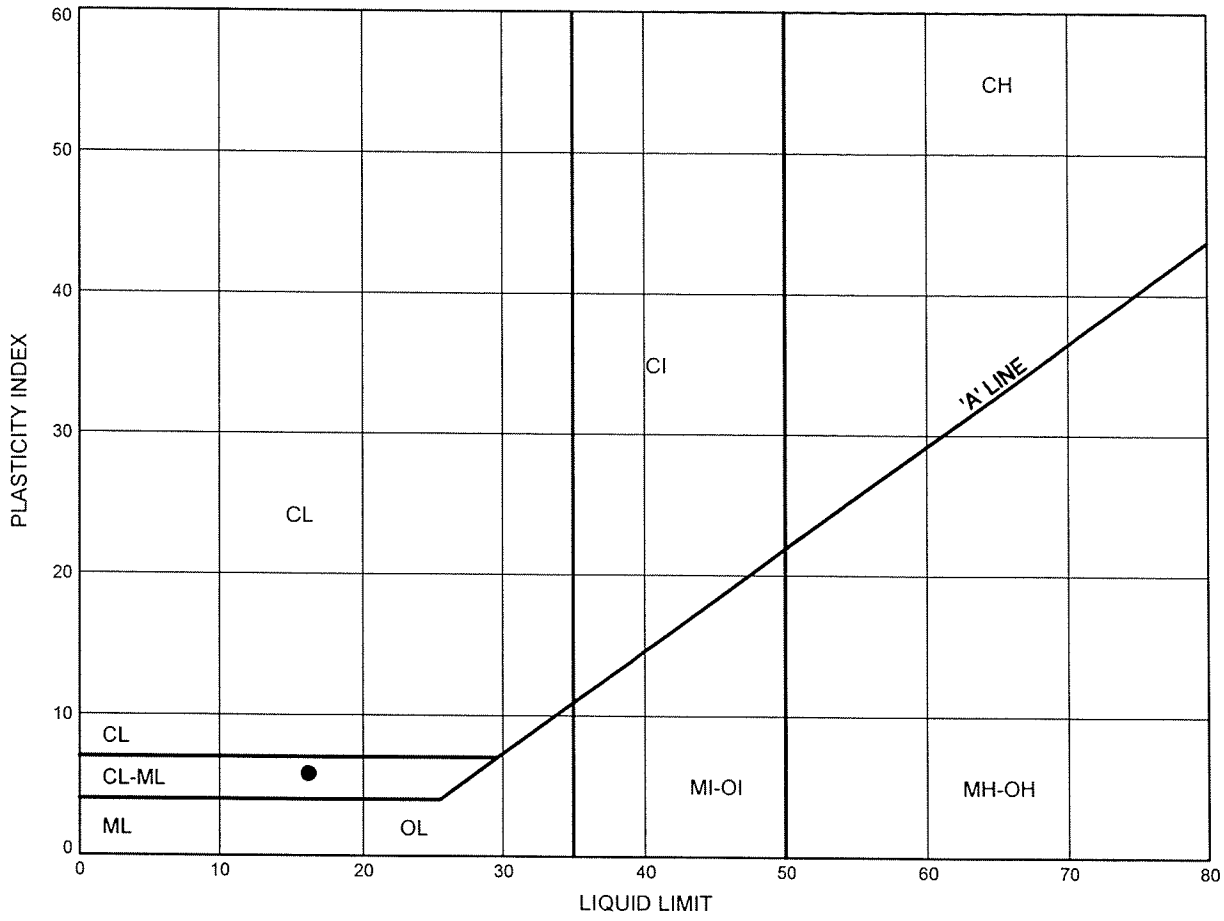
THURBALT 6417R.GPJ 7/29/08

Highway 7 - New

ATTERBERG LIMITS TEST RESULTS

FIGURE B9

Sandy Silt and Sandy Silt Till



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	08-034	6.40	305.79

Date July 2008

Project 408-88-00

THURBER

Prep'd SA

Chkd. RPR

THURBALT 6417R.GPJ 7/29/08

Appendix C

Foundation Comparison

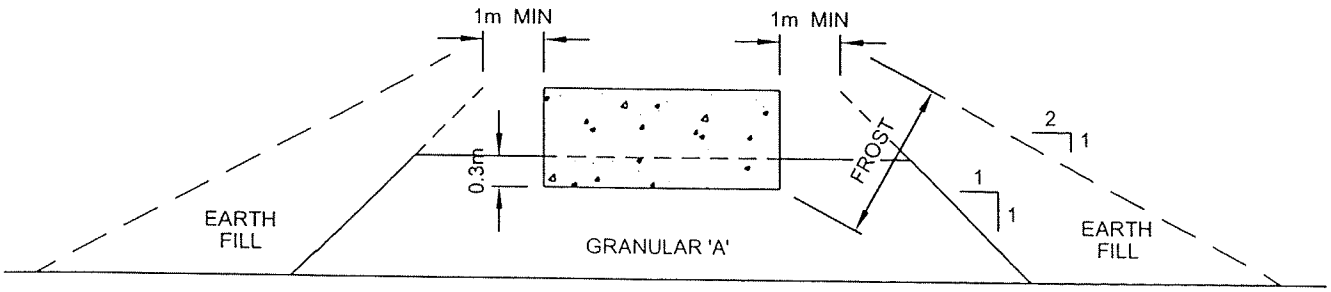
COMPARISON OF FOUNDATION ALTERNATIVES FOR EACH FOUNDATION ELEMENT

Foundation Element	Spread Footings	Spread Footings on Engineered Fill	Driven Piles
Abutments	*Advantages:* i. Generally less costly construction than deep foundation elements. *Disadvantages:* i. Lower geotechnical resistance available due to founding on compact soils near the surface. ii. Dewatering may be required, depending on depth of excavation. **NOT RECOMMENDED**	*Advantages:* i. Generally less costly construction than deep foundation elements. *Disadvantages:* 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. **FEASIBLE**	*Advantages:* i. High geotechnical resistance may be developed by driving the piles into very dense soils. ii. Comparatively short abutment stem possible iii. Permits integral abutment design *Disadvantages:* i. Higher unit cost compared to footings. ii. Very dense/hard soils at shallow depth will limit length of pile and geotechnical resistance that can be developed. **FEASIBLE**

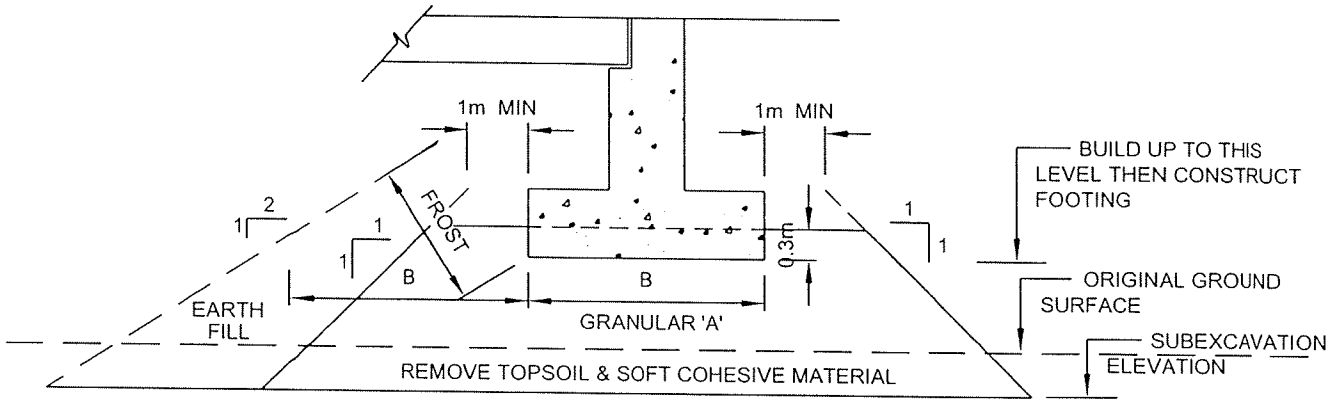
Appendix D

Figure

March , 2004



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	ABUTMENT ON COMPACTED FILL SHOWING GRANULAR A CORE	THURBER
DATE: April , 2004		DWG. NO. FIGURE 1
APPROVED: PKC		
SCALE: NTS		

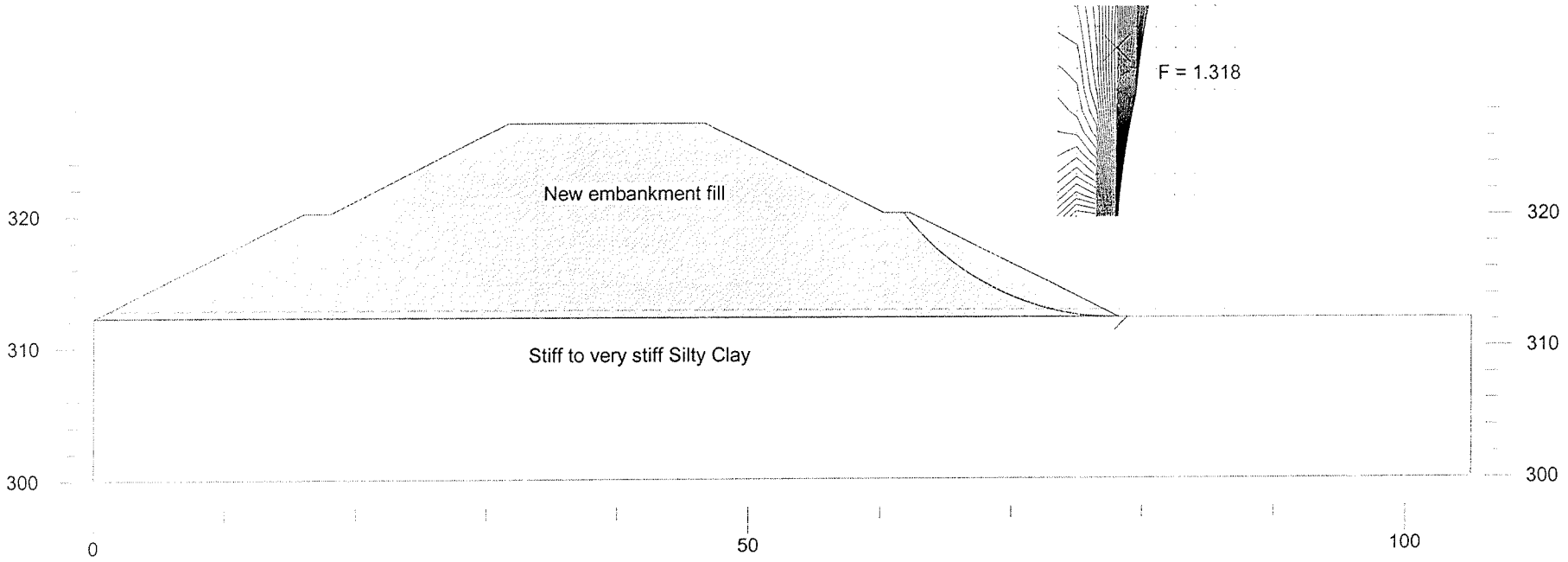
TED35146.DWG

Appendix E

Slope Stability Output

	Gamma kN/m3	C kPa	Phi deg	Piezo Surf.
Earth Fill	21	0	30	1
Silty Clay	18	80	0	1

Thurber Engineering Ltd. - Toronto
15-64-17 Highway 7 - New
Riverbend Drive
July 25, 2008
WBL
East Approach Earth Fill



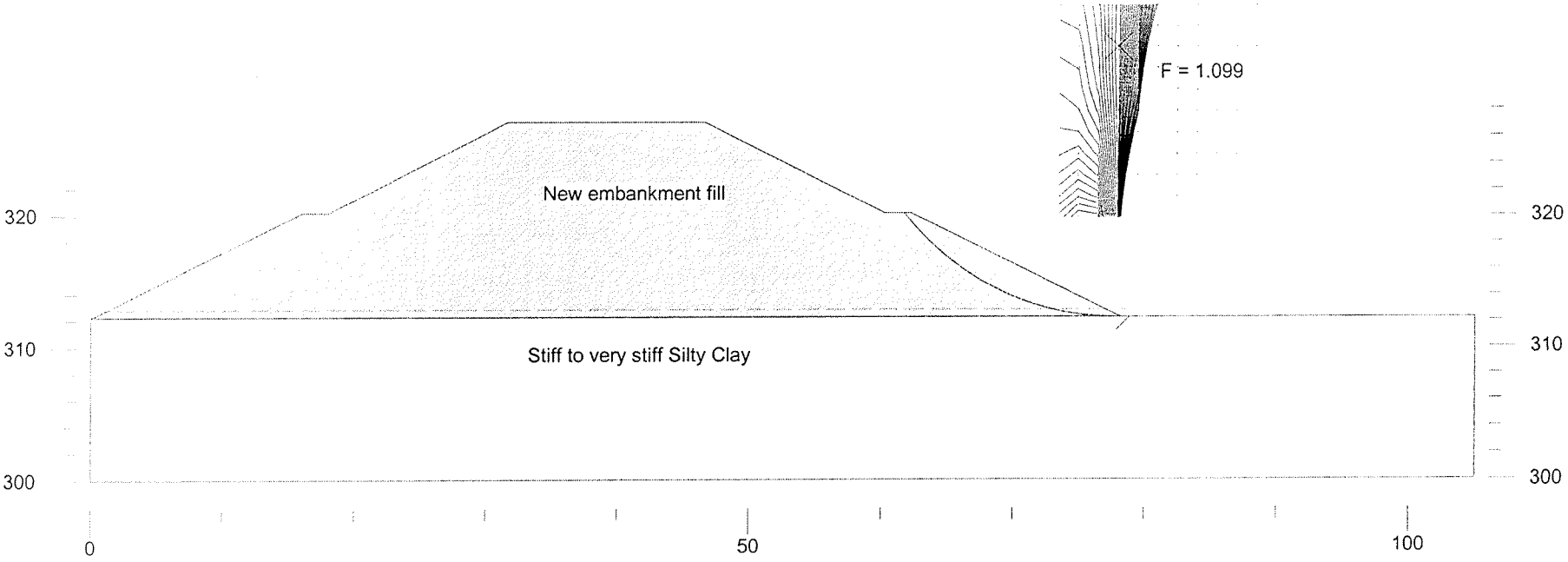
7/25/2008 4:41:35 PM \\Torserver1\Projects\15\64\17HWY7~1\STRUCT~1\RIVERB~1\WBLEA2.GSL Thurber Engineering Ltd. - Toronto F = 1.318

FIGURE 1

	Gamma kN/m3	C kPa	Phi deg	Min c/p	Piezo Surf.
Earth Fill	21	0	30	0	1
Silty Clay	18.5	80	0	0	1

Seismic coefficient = 0.08

Thurber Engineering Ltd. - Toronto
15-64-17 Highway 7 - New Riverbend Drive
July 25, 2008
WBL
East Approach Earth Fill



7/28/2008 3:18:49 PM H:\15\64\17HWY7~1\STRUCT~1\RIVERB~1\WBLEA2S.GSL Thurber Engineering Ltd. - Toronto F = 1.099

FIGURE 2

Appendix F

Site Photograph

Photo 1. Looking at Borehole 08-033 (WBL-West abutment) before drilling

Appendix G

Drawing titled "Borehole Locations and Soil Strata"

METRIC

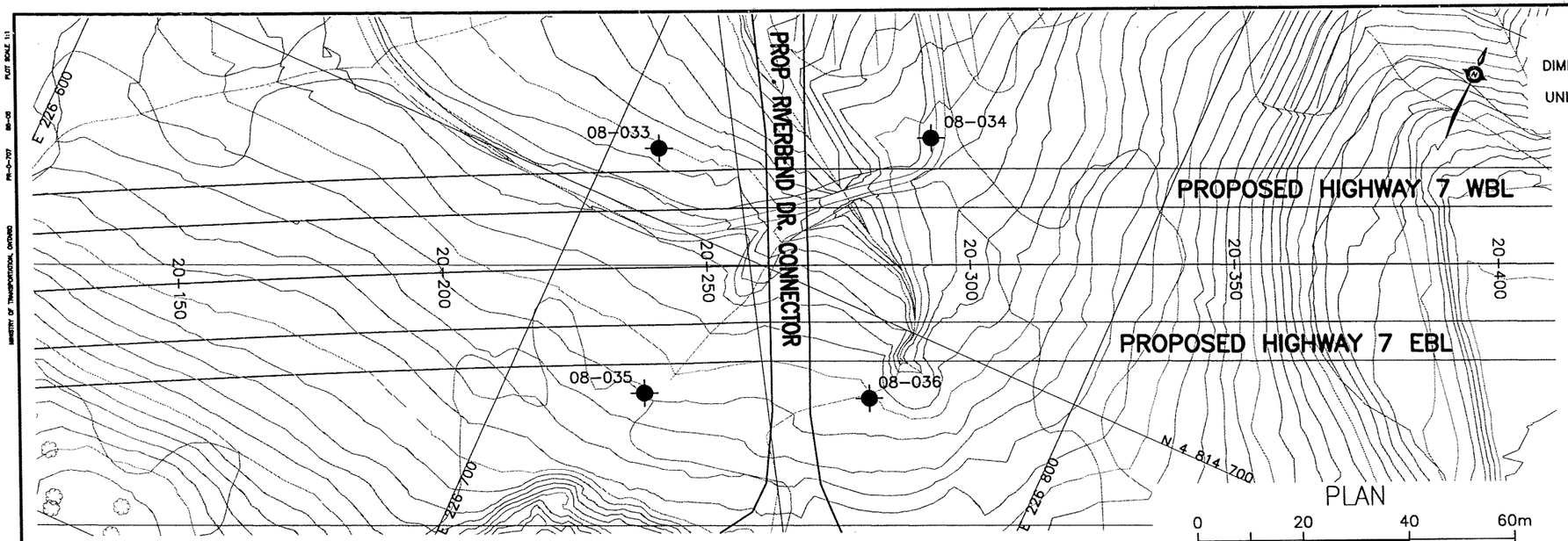
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

CONT No
GWP No 408-88-00

HIGHWAY 7
RECOMMENDED ROUTE
RIVERBEND DRIVE CONNECTOR
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

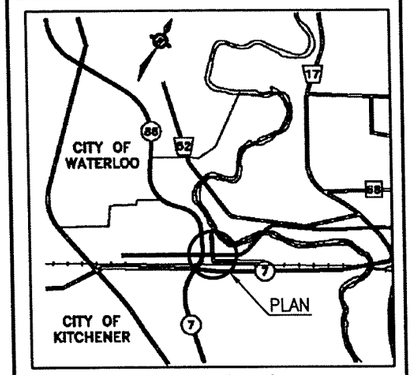
THURBER ENGINEERING LTD.
GEOTECHNICAL • ENVIRONMENTAL • MATERIALS



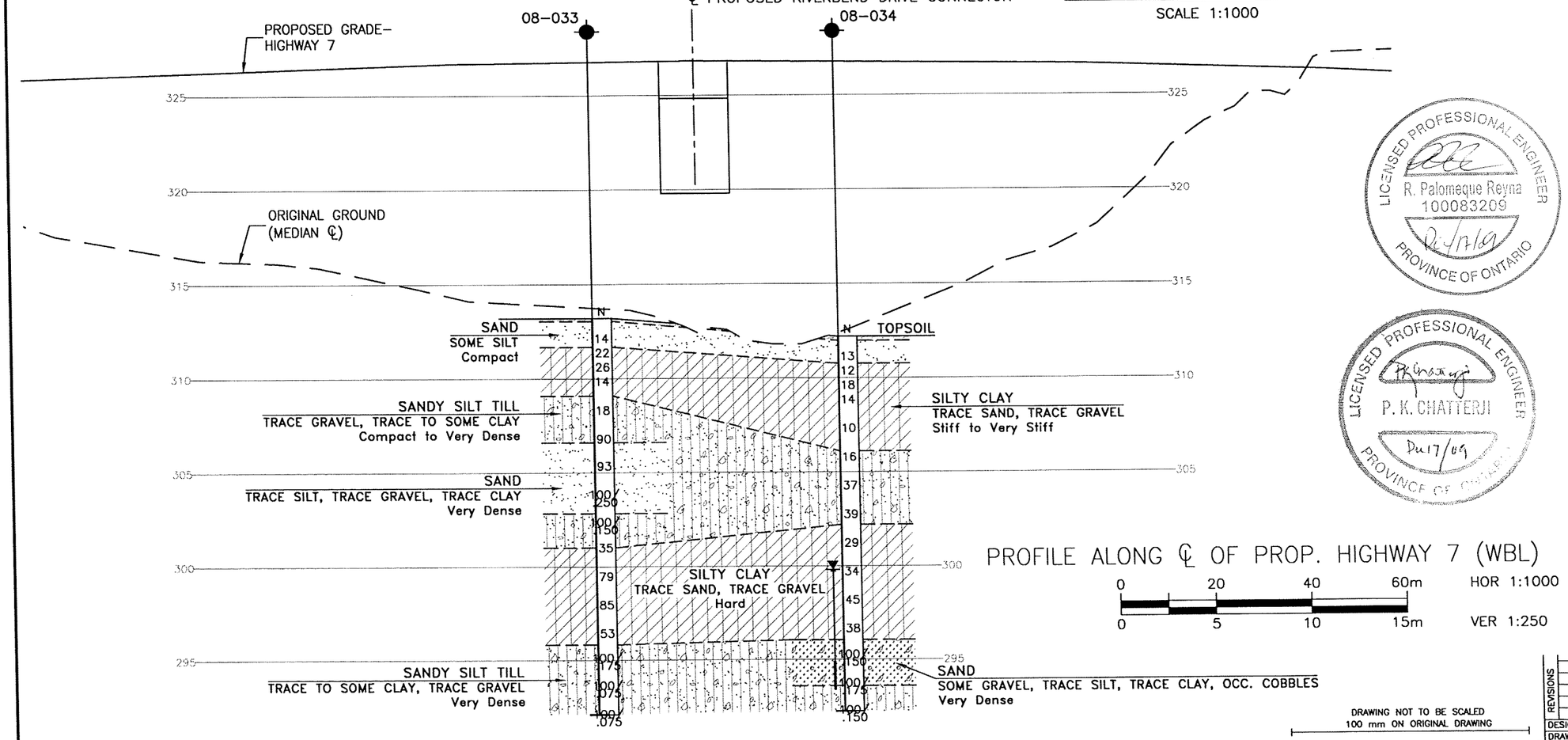
PLAN

0 20 40 60m

SCALE 1:1000



KEYPLAN



PROFILE ALONG ℄ OF PROP. HIGHWAY 7 (WBL)

0 20 40 60m HOR 1:1000

0 5 10 15m VER 1:250

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

LICENSED PROFESSIONAL ENGINEER
R. Palomeque Reyna
100083209
PROVINCE OF ONTARIO
Dec 17/09

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
Dec 17/09
PROVINCE OF ONTARIO

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
▽	Water Level
▼	Head Artesian Water
	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
08-033	313.2	4 814 712.7	226 708.6
08-034	312.2	4 814 735.8	226 754.7
08-035	315.3	4 814 668.4	226 725.1
08-036	314.6	4 814 685.1	226 764.2

-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 2B of the E.A. Study.

GEOCRES No. 40P8-178

REVISIONS		
DATE	BY	DESCRIPTION

DESIGN	AEG	CHK	PKC	CODE	LOAD	DATE	DEC. 2009
DRAWN	MFA	CHK	AEG	SITE	STRUCT	DWG	

METRIC

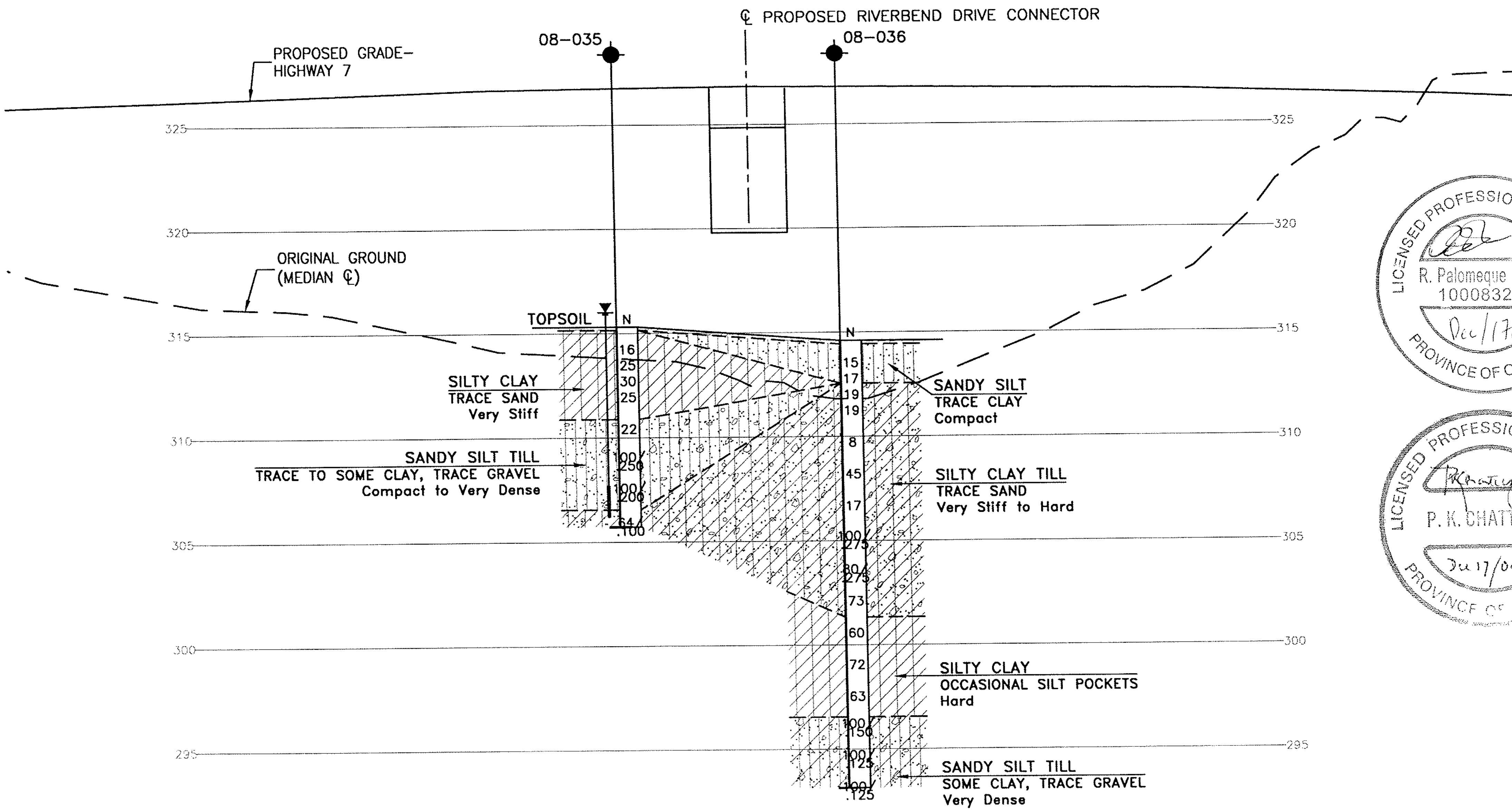
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

CONT No
GWP No 408-88-00

HIGHWAY 7
RECOMMENDED ROUTE
RIVERBEND DRIVE CONNECTOR
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

THURBER ENGINEERING LTD.
GEOTECHNICAL • ENVIRONMENTAL • MATERIALS



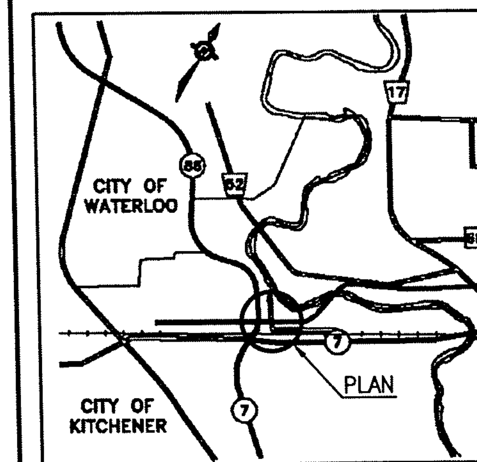
PROFILE ALONG ℄ OF PROPOSED HIGHWAY 7 (EBL)

0 20 40 60m HOR 1:1000

0 5 10 15m VER 1:250

LICENSED PROFESSIONAL ENGINEER
R. Palomeque Reyna
100083209
Dec/17/09
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
Dec 17/09
PROVINCE OF ONTARIO



KEYPLAN

LEGEND

Symbol	Description
◆	Borehole
◈	Borehole and Cone
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
▽	Water Level
▼	Head Artesian Water
┬	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
08-033	313.2	4 814 712.7	226 708.6
08-034	312.2	4 814 735.8	226 754.7
08-035	315.3	4 814 668.4	226 725.1
08-036	314.6	4 814 685.1	226 764.2

-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 2B of the E.A. Study.

GEOCRES No. 40P8-178

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

REVISIONS	DATE	BY	DESCRIPTION		
DESIGN AEG	CHK PKC	CODE	LOAD	DATE DEC. 2009	
DRAWN MFA	CHK AEG	SITE	STRUCT	DWG	