PRELIMINARY
FOUNDATION INVESTIGATION AND DESIGN REPORT
E-S EXIT RAMP/CONNECTOR FROM HIGHWAY 7 OVER E-N AND S-W WELLINGTON STREET RAMPS
HIGHWAY 7-NEW, KITCHENER TO GUELPH
G.W.P. 408-88-00

Geocres Number: 40P8-164

Report to

Ministry of Transportation Ontario
Southwestern Region

Thurber Engineering Ltd.
2010 Winston Park Drive, Suite 103
Oakville, Ontario
L6H 5R7
Phone: (905) 829 8666
Fax: (905) 829 1166

June 1, 2009
File: 15-64-17

\\Torserver1\Projects\15\64\17 Hwy 7 New\Reports & Memos\Structures\E-S Ramp-Connector over Wellington N&S- 17&18\15-64-17 ES RampConnector over Wellingthon NS ramp FIDR-final.doc

TABLE OF CONTENTS

Appendices

PRELIMINARY
FOUNDATION INVESTIGATION AND DESIGN REPORT
E-S EXIT RAMP/CONNECTOR FROM HIGHWAY 7 OVER
E-N AND S-W WELLINGTON STREET RAMPS
HIGHWAY 7-NEW, KITCHENER TO GUELPH
G.W.P. 408-88-00

Geocres Number: 40P8-164

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 E-S exit ramp/connector from Highway 7 over E-N and S-W Wellington Street ramps in the Regional Municipality of Waterloo. The proposed N-E exit ramp is part of the Highway 7-New project.

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

The site lies in the northeast quadrant of existing Kitchener Waterloo Expressway and Wellington Street interchange in Waterloo, Ontario. At this location, the proposed E-S exit ramp will cross over the proposed E-N and S-W Wellington Street ramps.

The lands surrounding the site are generally industrial and commercial. The site is generally flat.

Four photographs of the site are included in Appendix E and show the general nature of the surrounding land.

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 the Waterloo Hills, characterized by ridges of sandy till and kames or kame moraines, with outwash sands occupying the intervening hollows.

3 SITE INVESTIGATION AND FIELD TESTING

The site investigation and field testing at this site was carried out on June 25 and July 21, 2008. Two boreholes, numbered 08-017 and 08-018, were drilled approximately at the west and east abutments of a possible single-span structure arrangement. The termination depths of Boreholes 08-017 and 08-018 were 18.4 m and 11.1 m (Elevations 302.0 and 311.9), respectively. The Record of Borehole sheets for the boreholes are included in Appendix A. The approximate locations of the two boreholes are shown on the attached Borehole Locations and Soil Strata Drawing in Appendix F.

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. In Borehole 08-018, drilled at the proposed east abutment, a standpipe piezometer consisting of 25 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. Borehole 08-017 was grouted upon completion. The borehole completion details are shown in Table 3.1.

The completion of the borehole and the standpipe piezometer were 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
West abutment	08-017	No Installation	Borehole backfilled with grout to surface.
East abutment	08-018	10.7/312.4	Piezometer with 1.5 m slotted screen installed with sand filter to 8.5 m, holeplug from 8.5 m to 8.2 m, bentonite from 8.2 m to 0.9 m, holeplug from 0.9 m to 0.3 m, then sand and concrete 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 F. 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 and granular fill overlying native silty sand, silty clay, silty clay till and sandy silt till.

5.1 Topsoil

Topsoil was encountered surficially in both boreholes. Thickness of the topsoil was 150 mm and 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 Fill

Fill was encountered below the topsoil in Borehole 08-018. The fill consists of brown sand and gravel and silty sand containing trace silt and occasional cobbles. Thickness of the fill was 2.3 m.

The depth to the base of the fill was 2.4 m (Elevation 320.6).

SPT 'N' values measured in the fill ranged from 25 to 59 blows per 0.3 m of penetration, indicating a compact to very dense relative density. Moisture content ranged from 4% to 18%.

Grain size distribution curve for a silty sand fill sample is presented on the Record of Borehole sheets and on Figure B1 of Appendix B. The results of the laboratory test are summarized as follows:

Soil Particles	(%)
Gravel	2
Sand	54
Silt	41
Clay	3

5.3 Silty Sand

Native light brown silty sand was contacted in Borehole 08-017 at 2.4 m depth (Elevation 318.0). Thickness of the silty sand was 2.3 m .

The depth to the base of the silty sand was at 4.7 m (Elevation 315.8).

SPT 'N' values measured in the silty sand were higher than 100 blows per 0.225 m of penetration, indicating a very dense relative density. Moisture content ranged from 4% to 5%.

5.4 Silty Clay and Silty Clay Till

Native brown to grey silty clay and silty clay till containing trace to some sand, trace gravel and occasional cobbles were contacted in both boreholes at depths and elevations as 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)
West abutment	08-017	0.2 to 2.4 4.7 to 14.9	320.3 to 318.0 315.8 to 305.5	2.2 10.2
East abutment	08-018	2.4 to 6.2 *	320.6 to 316.9	3.8

* Silty Clay Till

The cohesive layer is hard in consistency, based on SPT 'N' values ranging from 38 blows per 0.3 m of penetration to higher than 107 blows per 0.175 m of penetration. The moisture content varied from 10% to 21%.

Grain size distribution curves for the silty clay and silty clay till tested are presented on the Record of Borehole sheets and on Figure B2 Appendix B. Atterberg Limits test results are presented on Figure B5 of Appendix B.

The results of the laboratory tests are summarized as follows:

Soil Particles	(%)
Gravel	0 to 5
Sand	1 to 19
Silt	44 to 53
Clay	23 to 55

Liquid Limit	25 to 41
Plastic Limit	15 to 19

The above results show that the silty clay/silty clay till is of low to medium plasticity with group symbols of CI-CL. It should be noted that glacial tills are known to contain cobbles and boulders.

5.5 Sandy Silt Till

Native sandy silt till was contacted below the silty clay and silty clay till at 14.9 m and 6.2 m depth (Elevations 305.5 and 316.9) in Boreholes 08-017 and 08-018, respectively.

A layer of sand was contacted within the sandy silt till layer at 10.8 m (Elevation 312.3) depth in Borehole 08-018.

Both boreholes were terminated within the sandy silt till at 18.4 m and 11.1 m depth (Elevations 302.0 and 311.9).

The sandy silt till is classified as very dense, based on SPT values ranging from 96 blows for 0.3 m of penetration to higher than 100 blows per 0.15 m of penetration. The natural moisture content ranged from 8 to 18%.

Grain size distribution curves for two sandy silt till samples are presented on the Record of Borehole sheets and on Figure B3 of Appendix B. Grain size distribution curve for a sand sample is presented on the Record of Borehole sheets and on Figure B4 of Appendix B. The results of laboratory tests are summarized as follows:

Soil Particles	Sandy silt till (%)	Sand (%)
Gravel	1 to 3	1
Sand	39 to 40	84
Silt	41 to 56	-
Clay	4 to 16	-
Silt & Clay	-	15

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

5.6 Groundwater Conditions

Water levels were observed in the boreholes during and upon completion of drilling. A standpipe piezometer was installed in Borehole 08-018 (east abutment) to monitor water levels after completion of drilling. The water levels measured in the piezometer are summarized in Table 5.2.

Table 5.2 – Water Level Measurements

Foundation Unit	Borehole	Date (2008)	Water Level (m)		Comment
			Depth	Elevation	
East abutment	08-018	July 7	4.6	318.5	In piezometer
		July 15	6.6	316.5	
		August 20	6.6	316.5	

The piezometric reading indicates that the groundwater level is near Elevations 316.5 m.

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 track-mounted CME75 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 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

Rocío Palomeque Reyna, P.Eng.
Geotechnical Engineer

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

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

PRELIMINARY
FOUNDATION INVESTIGATION AND DESIGN REPORT
E-S EXIT RAMP/CONNECTOR FROM HIGHWAY 7 OVER
E-N AND S-W WELLINGTON STREET RAMPS
HIGHWAY 7-NEW, KITCHENER TO GUELPH
G.W.P. 408-88-00

Geocres Number: 40P8-164

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 ramp structure.

Based on the Plates 2A and 2B of the E.A:

- The E-S exit ramp/connector will cross over the proposed E-N and S-W Wellington Street ramps. The proposed finished grade of the E-S ramp will be 332.0. The existing ground surface within the proposed E-S ramp structure varies from Elevation 320.5 to 323.1, from west to east. Hence, the E-S ramp embankments will be about 10.0 m to 11.5 m high relative to the surrounding grade.
- The grade of S-W ramp will be at Elevation 322.0, resulting in a 1.0 m cut at the east abutment and a 1.5 m high fill at the west abutment.

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 fill overlying native layers of very dense silty sand, hard silty clay/silty clay till and very dense sandy silt till. The groundwater level measured in the piezometer was at 6.6 m (Elevations 316.5) 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 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.

The existing fill is not considered to be suitable for the support of spread footings and the footings must be placed on the underlying native soils.

The design of spread footings bearing on native undisturbed hard silty clay and silty clay 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_f (kPa)	SLS (kPa)
West abutment (BH 08-017)	0.8	319.7	600	400
	Below 1.6	318.9	750	500
East abutment (BH 08-018)	Below 2.6	320.5	750	500

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 presented in Table 8.1 are above groundwater level measured in the piezometer. However, 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 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. Subexcavation of existing surficial fill soils will be required. The engineered fill must bear on native hard silty clay and silty clay till 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

West abutment (BH 08-017)	East abutment (BH 08-018)
320.0	320.6

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 settlement is 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 of ±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 very dense sandy silt till layer encountered at this site. Based on an HP 310 X 110 pile, a minimum embedment depth of 6 m is required. The preliminary information in EA Plates 2A and 2B indicates that this depth of embedment can be achieved at the abutments. The depths and 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	Pile Tip Depth (m)	Highest Pile Tip Elevation	Comments
West abutment (BH 08-017)	16.0	304.5	-
East abutment (BH 08-018)	6.1	317.0	A minimum pile length of 6 m must be achieved. Depending on final design, pre-augering may be required.

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 sandy silt till layer are presented in Table 8.4.

Table 8.4 – Axial Resistance of Two Pile Sections Founded on Very Dense 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 sandy silt till layer at 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. Depending on final grades, integral abutment design may require pre-augering to install the piles and achieve the flexibility required in the upper 3 m.

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, or an equivalent combination of soil cover and extruded polystyrene (EPS) insulation. A 25 mm thickness of EPS is equivalent to 600 mm 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 very dense sandy silt till, despite the higher cost noted in Appendix C.

9 BRIDGE APPROACHES AND EMBANKMENTS

Based on the two boreholes drilled at the site, the approach embankments will be constructed over hard silty clay till and silty clay and may incorporate the sand fill of the existing embankment.

Preliminary analysis indicates that at the abutments, settlement in the order of 25 to 35 mm is estimated in the foundation soils under the loading imposed by approximately 11.0 m of the approach fill. Due to the stiff to hard 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.

The 11.0 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.

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.

At the east abutment, cut slopes for the S-W ramp will be stable at slopes with a maximum inclination of 2H: 1V.

10 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 redriving 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.

11 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 E-S exit ramp/connector from Highway 7 over E-N and S-W Wellington Street ramps alignment and thus removed from the alignment of the current investigation. Particular attention should be paid to groundwater levels and exploration off the existing road embankment is recommended.

2. Pile Design

   For piles extending below Elevations 302.0 and 312.0 at the west and east abutments, respectively, a greater depth of exploration is required and must be addressed during the detail design phase.

3. Boreholes for approaches.

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

12 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.

Rocío Palomeque Reyna, P.Eng., M.Eng.
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

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

▼ 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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No 08-017

METRIC

G.W.P. 408-88-00	LOCATION N 4 814 534.75 E 226 282.11		ORIGINATED BY LG
HWY 7	BOREHOLE TYPE Hollow Stem Augers		COMPILED BY SA
DATUM Geodetic	DATE 2008.07.21 - 2008.07.21		CHECKED BY RPR

Column headings: SOIL PROFILE (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, + 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	NUMBER	TYPE	"N" VALUES	REMARKS GR SA SI CL
320.5 / 0.0	**TOPSOIL:** (150mm), roots, rootlets				
0.2	Silty **CLAY**, trace to some gravel, trace rootlets Hard Light Brown to Brown	1	SS	47	
	Hard	2	SS	87	
318.0 / 2.4	Silty **SAND**, some gravel Very Dense Light Brown Moist	3	SS	100/ 150	
		4	SS	100/ 225	
315.8 / 4.7	Silty **CLAY**, trace sand Hard Brown	5	SS	75	
		6	SS	59	0 1 44 55
	Mottled Grey to Brown	7	SS	58	
		8	SS	50	

Elevation scale: 320, 319, 318, 317, 316, 315, 314, 313, 312, 311

Continued Next Page

+³, ×³: Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 08-017

METRIC

G.W.P. 408-88-00 LOCATION N 4 814 534.75 E 226 282.11 ORIGINATED BY LG

HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY SA

DATUM Geodetic DATE 2008.07.21 - 2008.07.21 CHECKED BY RPR

Continued From Previous Page

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Silty CLAY Hard Mottled Grey to Brown				310	
		9	SS	38	309	
		10	SS	52	308	0 2 49 49
		11	SS	50	307, 306	
305.5 / 14.9	Sandy SILT, some clay, trace gravel Very Dense Brown Moist to wet (TILL)	12	SS	100/.225	305, 304	3 40 41 16
		13	SS	100/.200	303	
302.0 / 18.4	END OF BOREHOLE AT 18.4m. BOREHOLE BACKFILLED WITH GROUT TO SURFACE.	14	SS	100/.150		

Column headings: SOIL PROFILE (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

+ ³, × ³: Numbers refer to Sensitivity   20 / 15 ⌖ 5 / 10 (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No 08-018

METRIC

G.W.P. 408-88-00 LOCATION N 4 814 548.71 E 226 330.85 ORIGINATED BY SA

HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY SA

DATUM Geodetic DATE 2008.06.25 - 2008.06.25 CHECKED BY RPR

ELEV / DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
323.1					
0.0	TOPSOIL: (200mm), occasional roots				
0.2	Dark Brown, Moist	1	SS	25	
322.4 / 0.6	SAND AND GRAVEL, trace silt, occasional cobbles, Compact, Brown, Moist (FILL)	2	SS	59	
	Silty SAND, some gravel, trace silt, occasional cobbles, Dense to Very Dense, Brown, Moist (FILL)	3	SS	41	2 54 41 3
320.6 / 2.4	Silty CLAY, trace to some sand, trace gravel, occasional cobbles, Hard, Brown to Grey (TILL)	4	SS	70	
		5	SS	110	5 19 53 23
		6	SS	107/ 175	
316.9 / 6.2	Sandy SILT, trace gravel, trace clay, Very Dense, Grey, Moist (TILL)	7	SS	105/ 200	
	Wet	8	SS	96	1 39 56 4
		9	SS	138/ 225	

ELEVATION SCALE: 323, 322, 321, 320, 319, 318, 317, 316, 315, 314

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

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

15-⊕-5 (20, 10) (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 08-018

METRIC

G.W.P. 408-88-00 | LOCATION N 4 814 548.71 E 226 330.85 | ORIGINATED BY SA

HWY 7 | BOREHOLE TYPE Hollow Stem Augers | COMPILED BY SA

DATUM Geodetic | DATE 2008.06.25 - 2008.06.25 | CHECKED BY RPR

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT / SHEAR STRENGTH kPa	WATER CONTENT (%)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page										
	Sandy SILT, trace gravel, trace clay Very Dense Grey Moist (TILL)						313				
311.9	Layer of sand		10	SS	129				o		1 84 15 (SI+CL)
11.1	END OF BOREHOLE AT 11.1m. Piezometer installation consists of 25mm diameter schedule 40 PVC pipe with a 1.52m slotted screen.										

WATER LEVEL READINGS:

DATE	DEPTH (m)	ELEV. (m)
2008.07.07	4.6	318.5
2008.06.15	6.6	316.5
2008.08.20	6.6	316.5

Legend: O UNCONFINED; + FIELD VANE; ● QUICK TRIAXIAL; × LAB VANE. Plastic limit w_P, natural moisture content w, liquid limit w_L.

+³, ×³: Numbers refer to Sensitivity

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

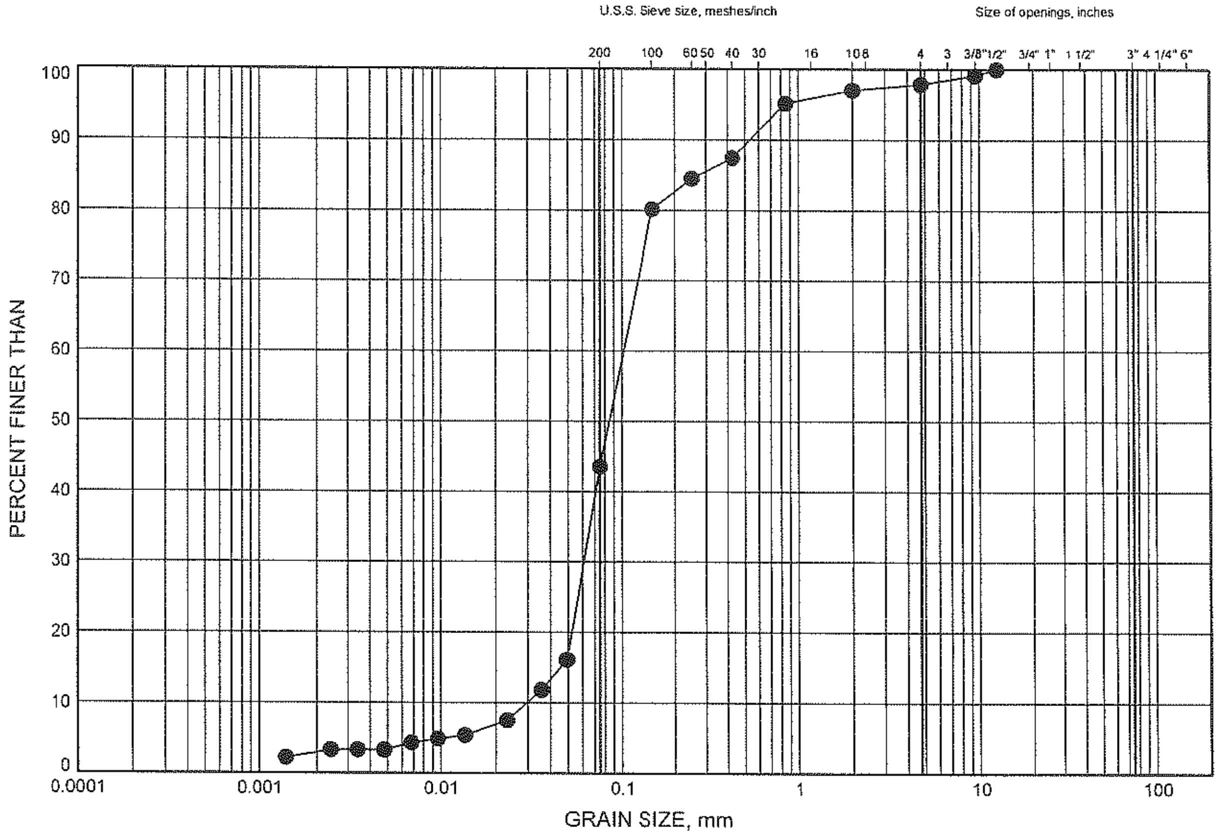
Appendix B

Laboratory Test Results

Highway 7 - New
GRAIN SIZE DISTRIBUTION

FIGURE B1

Silty Sand Fill



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-018	2.06	321.00

W.P.# 408-88-00

Prepared By MFA

Checked By RPR

THURBER

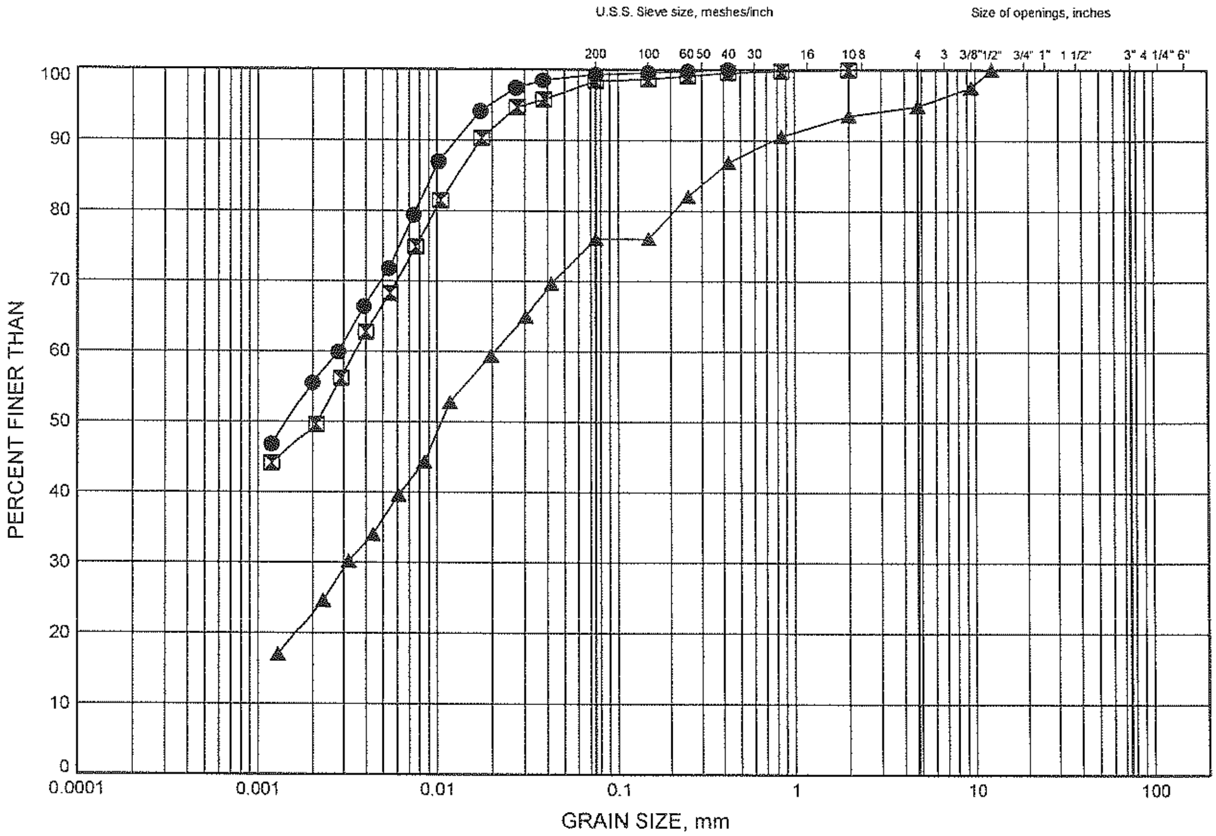
GRAIN SIZE DISTRIBUTION - THURBER 6417R.GPJ 9/4/08

Highway 7 - New

GRAIN SIZE DISTRIBUTION

FIGURE B2

Silty Clay Till



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-017	6.40	314.06
⊠	08-017	12.50	307.96
▲	08-018	3.28	319.78

GRAIN SIZE DISTRIBUTION - THURBER 6417R.GPJ 9/4/08

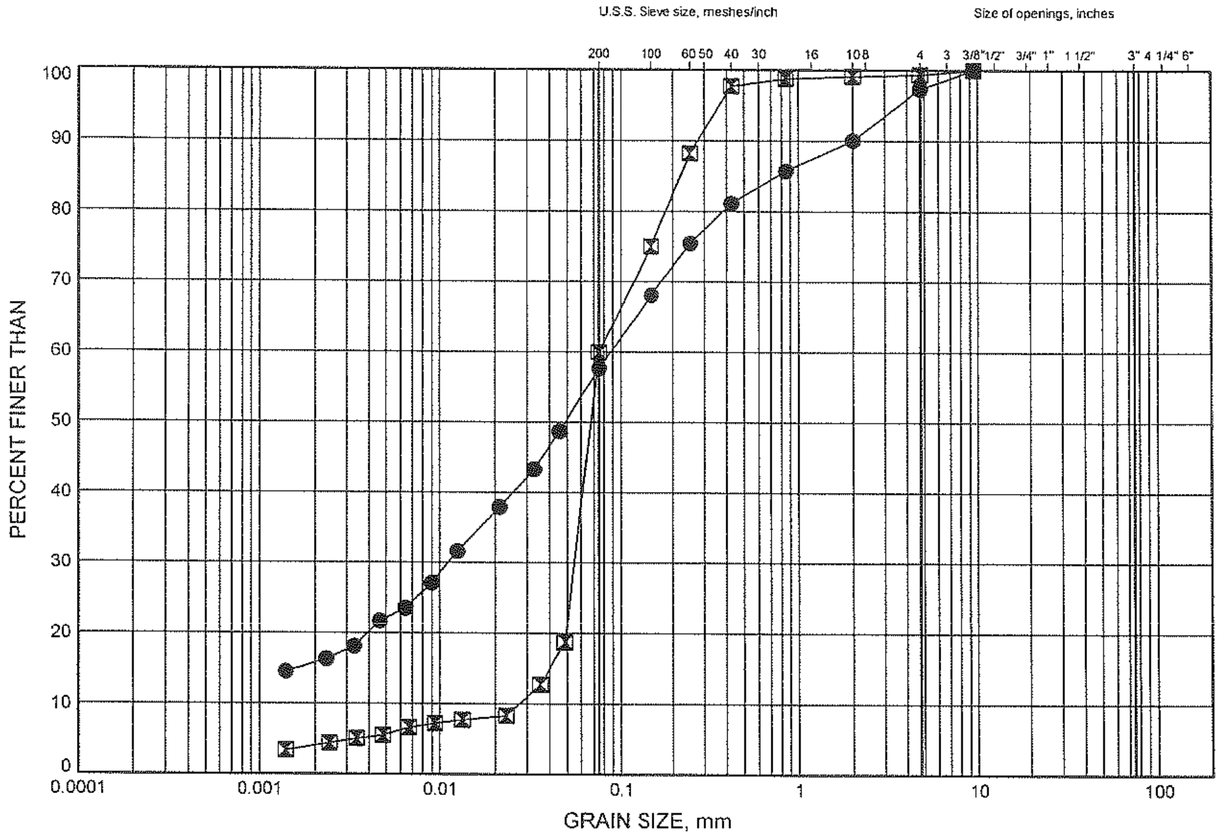
W.P.# 408-88-00
Prepared By MFA
Checked By RPR

THURBER

Highway 7 - New
GRAIN SIZE DISTRIBUTION

FIGURE B3

Sandy Silt Till



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-017	15.35	305.11
⊠	08-018	7.81	315.25

W.P.# 408-88-00

Prepared By MFA

Checked By RPR

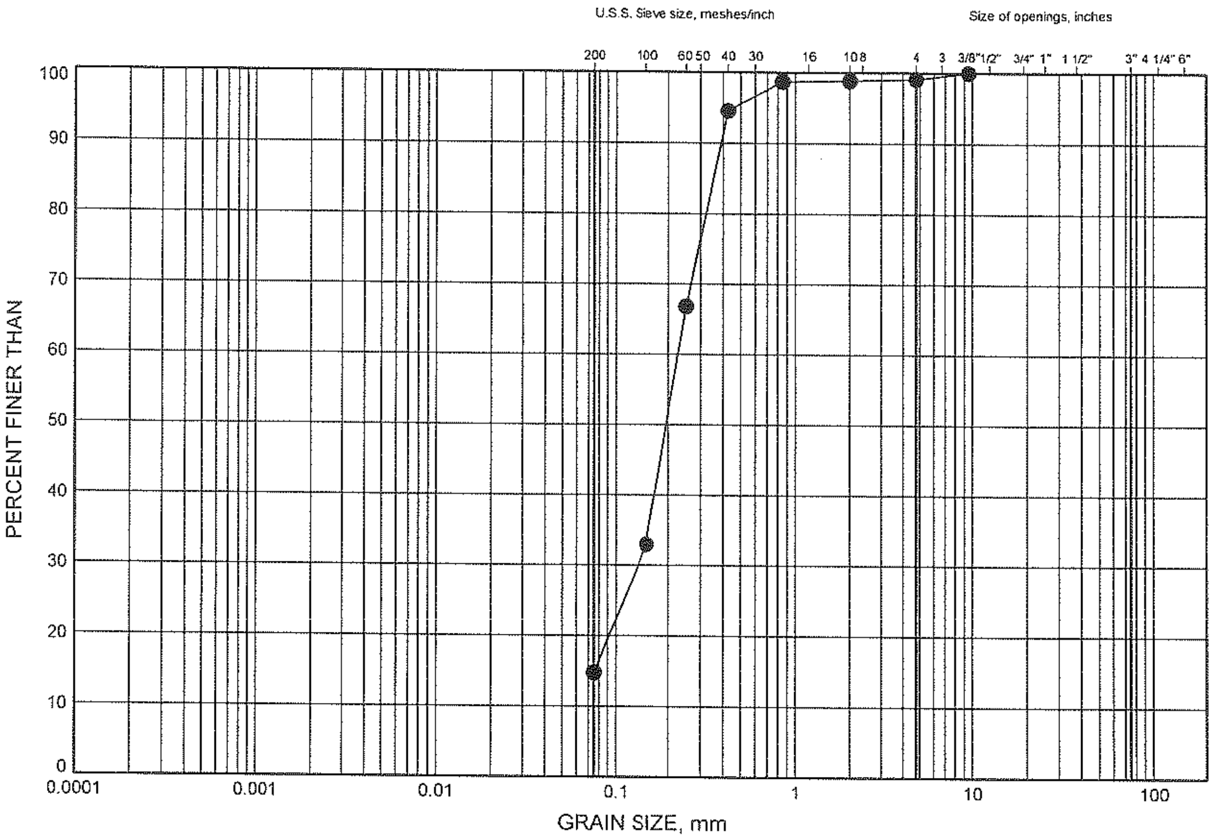
THURBER

Highway 7 - New

GRAIN SIZE DISTRIBUTION

FIGURE B4

Sand



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-018	10.90	312.16

W.P.# 408-88-00

Prepared By MFA

Checked By RPR

THURBER

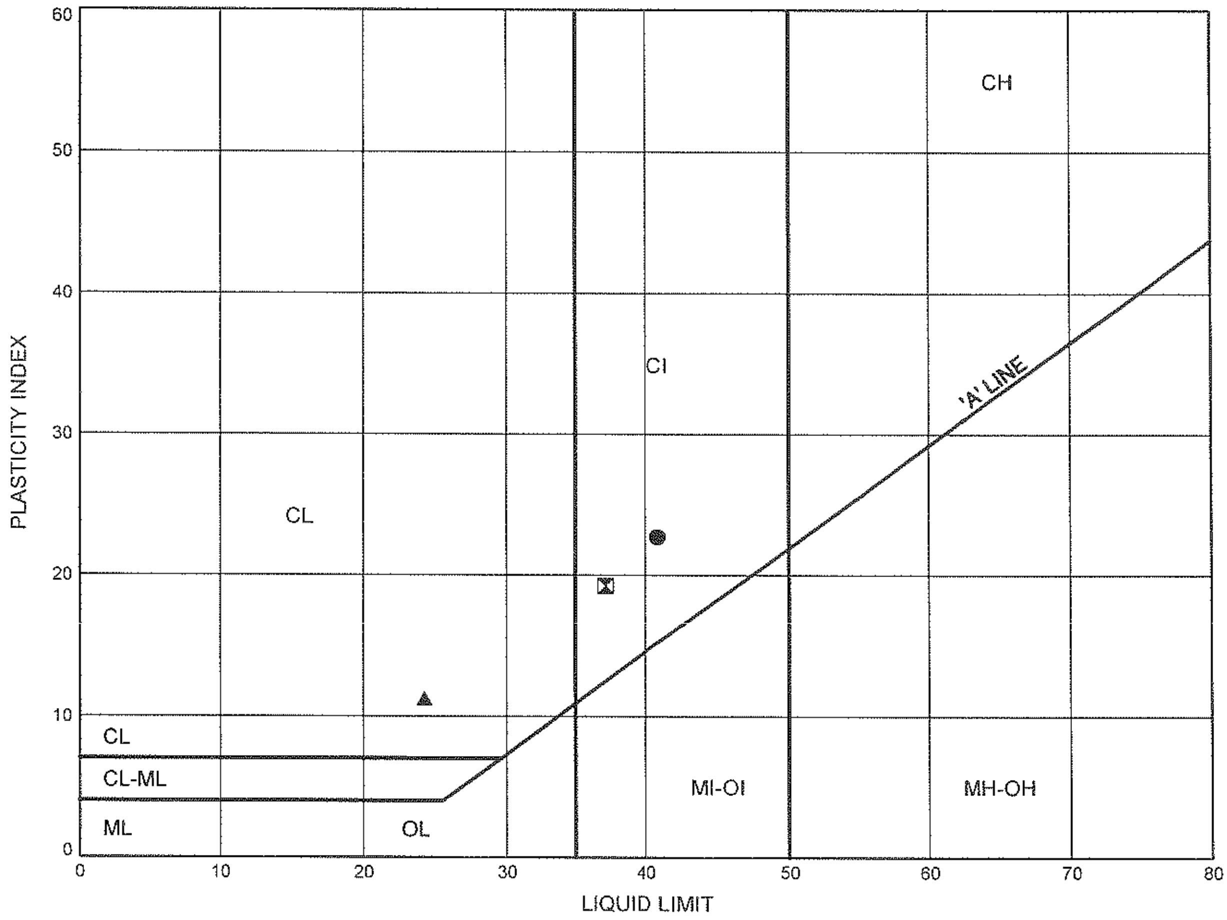
GRAIN SIZE DISTRIBUTION - THURBER 6417R.GPJ 9/4/08

Highway 7 - New

ATTERBERG LIMITS TEST RESULTS

FIGURE B5

Silty Clay Till



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	08-017	6.40	314.06
⌧	08-017	12.50	307.96
▲	08-018	3.28	319.78

THURBALT 6417R.GPJ 9/4/08

Date September 2008

Project 408-88-00

THURBER

Prep'd MFA

Chkd. RPR

Appendix C

Foundation Comparison

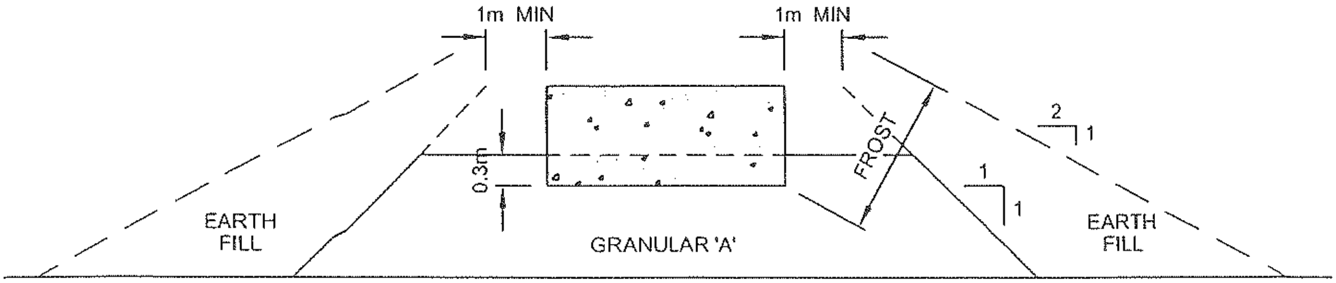
COMPARISON OF FOUNDATION ALTERNATIVES FOR EACH FOUNDATION ELEMENT

Foundation Element	Spread Footings	Spread Footings on Engineered Fill	Driven Piles
Abutments	*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. NOT RECOMMENDED	*Advantages:* i. High geotechnical resistance may be developed by driving the piles into very dense/hard 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. RECOMMENDED

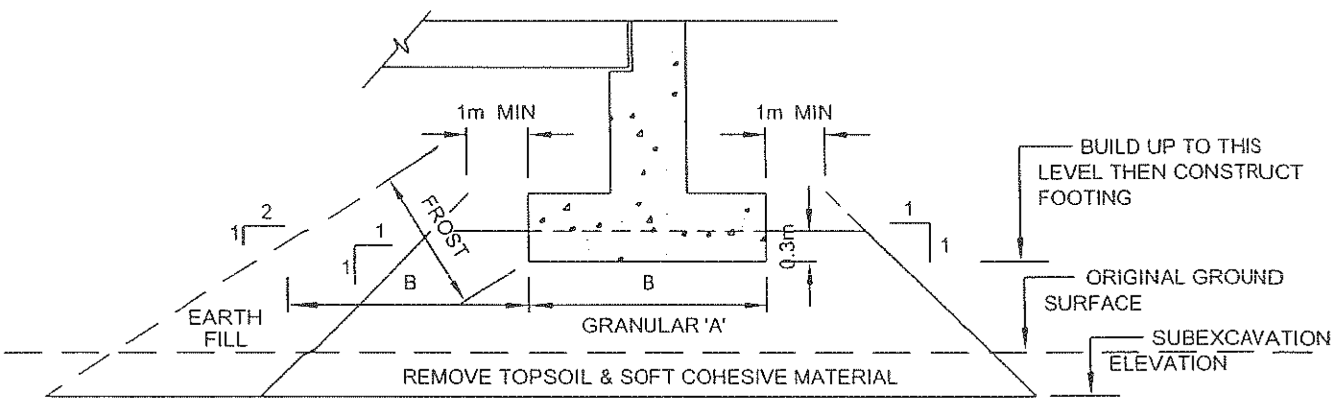
Appendix D

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

TED35146.DWG

Appendix E

Site Photographs

KWE NBL

Existing ramp

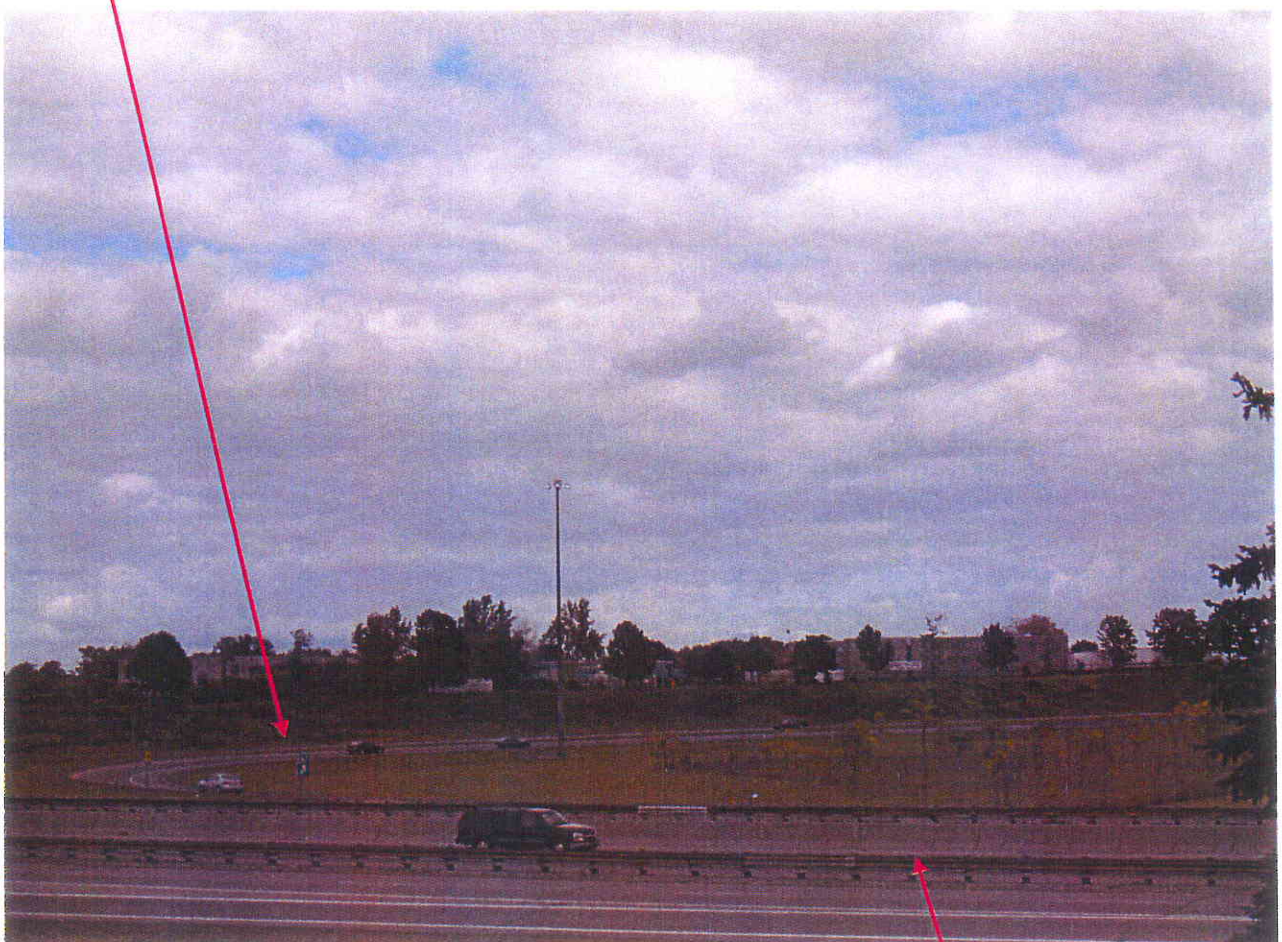
Photo 1. Looking at the northeast quadrant of Wellington Street and KWE interchange. Existing exit ramp from KWE NBL to Wellington Street West

Existing ramp

Wellington Street WBL

Photo 2. Looking at the northeast quadrant of Wellington Street and KWE interchange.
Existing exit ramp from KWE NBL to Wellington Street West

Existing ramp



KWE

Photo 3. Looking at the northeast quadrant of Wellington Street and KWE interchange. Existing exit ramp from KWE NBL to Wellington Street West

KWE

Photo 4. Looking at the northeast quadrant of Wellington Street and KWE interchange.
Existing exit ramp from KWE NBL to Wellington Street West

Appendix F

Drawing titled "Borehole Locations and Soil Strata"

METRIC

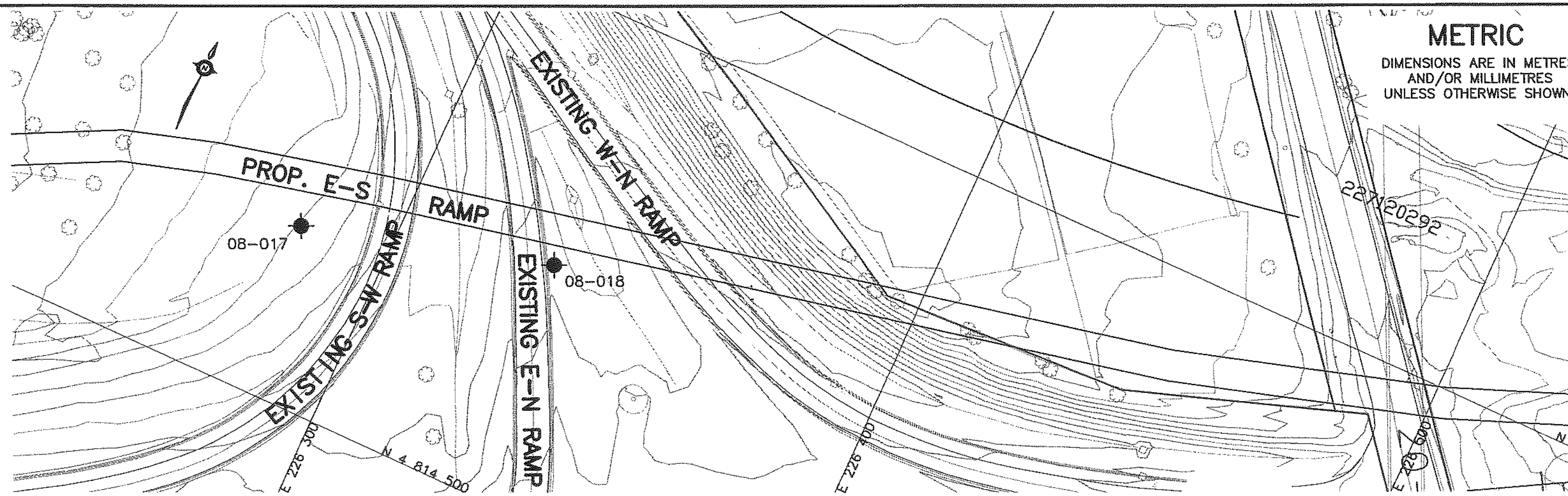
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

CONT No
GWP No 408-88-00

HIGHWAY 7
RECOMMENDED ROUTE
E-S RAMP/CONNECTOR OVER E-N & S-W WELLINGTON ST RAMPS
BOREHOLE LOCATIONS AND SOIL STRATA

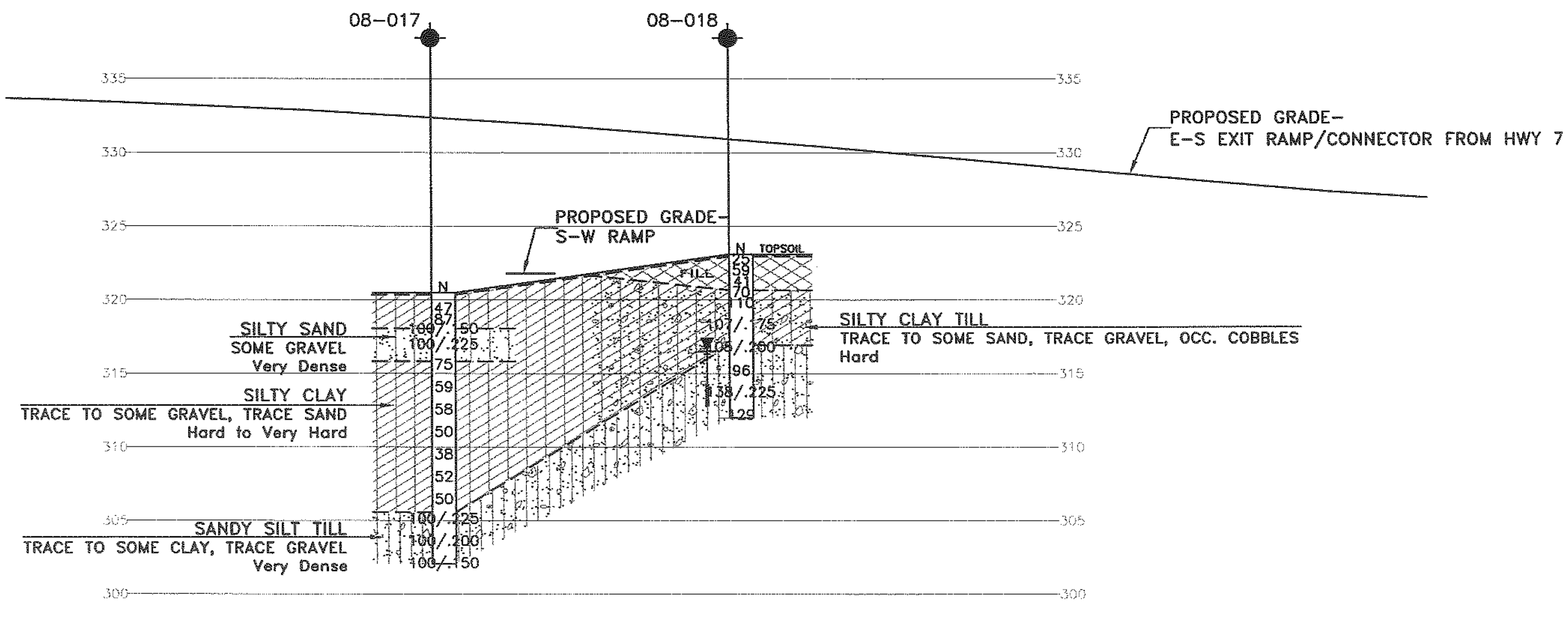
SHEET

THURBER ENGINEERING LTD.
GEOTECHNICAL • ENVIRONMENTAL • MATERIALS



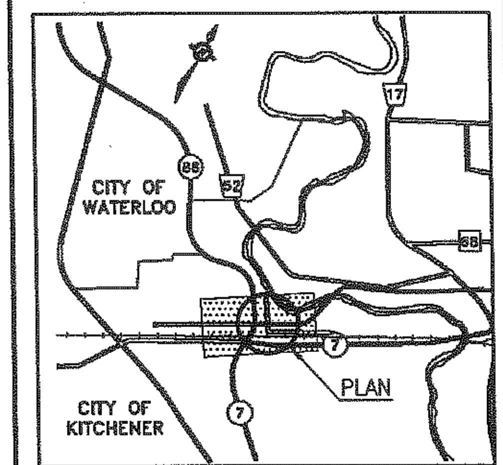
PLAN

SCALE 1:1000



PROFILE ALONG ℄ OF PROP. E-S EXIT RAMP/CONNECTOR FROM HWY 7

HOR 1:1000
VER 1:400



KEYPLAN

LICENSED PROFESSIONAL ENGINEER
R. Palomeque Rojas
100053209
June 1/09
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
June 1/09
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
08-017	320.5	4 814 534.8	226 282.1
08-018	323.1	4 814 548.7	226 330.9

-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. 40P8-164

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

REVISIONS	DATE	BY	DESCRIPTION

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

FILENAME: H:\Drafting\15\64\17\td8417-Ramps(017,018).dwg

MINISTRY OF TRANSPORTATION, ONTARIO