

**PRELIMINARY  
FOUNDATION INVESTIGATION AND DESIGN REPORT  
GUELPH ROAD 3 UNDERPASS  
HIGHWAY 7-NEW, KITCHENER TO GUELPH  
G.W.P. 408-88-00**

**Geocres Number: 40P9-45**

**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 underpass structure to carry Guelph Road 3 over Highway 7-New in the Wellington County, 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 350 m to the north. The site lies approximately 1.1 km northwest of a developed area of the City of Guelph.

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

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

The site lies within an area of active farms and agricultural lands. The site is generally flat. Ellis Creek is located approximately 150 m to the east of Guelph Road 3.

Two photographs of the site, looking north along Guelph Road 3 are included in Appendix E and show 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 between June 9 and June 10, 2008. Three boreholes, 08-184, 08-185 and 08-186, were drilled approximately at the north abutment, pier and south abutment of a possible two-span structure arrangement. The depths of the boreholes ranged from 7.8 m to 9.5 m (Elevations 328.3 to 331.1). The Record of Borehole sheets for the boreholes are included in Appendix A. The approximate locations of the three boreholes are shown on the attached Borehole Locations and Soil Strata Drawing in Appendix 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 operated by a CME75 truck-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 08-185, drilled at the proposed pier location, a standpipe piezometer consisting of 25 mm PVC pipe with a slotted screen was installed and enclosed in filter sand to permit longer term groundwater level monitoring. The location and completion details of the piezometer are shown in Table 3.1. Boreholes without piezometer installations were grouted with bentonite upon completion. The borehole completion details are shown in Table 3.1.

The completion of the boreholes 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**

<b>Foundation Unit</b>	<b>Borehole Location</b>	<b>Piezometer Tip Depth/ Elevation (m)</b>	<b>Completion Details</b>
North Abutment	08-184	No Installation	Holeplug to 5.5 m, bentonite benseal to 0.6 m, holeplug to 0.3 m, then auger cuttings to surface.
Pier	08-185	7.8/331.1	Piezometer with 1.5 m slotted screen installed with sand filter to 5.8 m, holeplug from 5.8 m to 3.0 m, auger cuttings from 3.0 m to 0.6 m, holeplug from 0.6 to 0.5 m, sand from 0.5 m to 0.3 m, then cement to surface.
South Abutment	08-186	No Installation	Holeplug to 8.5 m, then bentonite benseal mixed with auger cuttings 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 granular fill overlying native clayey silt till and sandy silt till.

##### **5.1 Fill**

A surficial layer of fill was encountered at all three exploration locations at this site. The fill consists of brown sand and gravel and sandy silt. Some asphalt fragments were encountered within the fill in Borehole 08-186.

The depth to the base of the fill ranges from 1.1 m to 1.5 m (Elevations 334.7 to 337.8).

The fill is classified as loose to compact, based on SPT values ranging from 8 to 17 blows for 0.3 m of penetration. The natural moisture content ranged from 5 to 19%.

Grain size distribution curve for a sample of sand and gravel fill tested, is presented on the Record of Borehole sheets and on Figure B1 of Appendix B. The result of laboratory test carried out on the sand and gravel fill was as follows:

Soil Particles	(%)
Gravel	50
Sand	40
Silt & Clay	10

## 5.2 Clayey Silt Till

Native brown to grey clayey silt till, sandy, trace gravel and occasional cobbles was contacted below the fill in all the boreholes. Thickness of this layer was 2.9 m and 3.1 m in Boreholes 08-184 and 08-185, respectively. In Borehole 08-186 the clayey silt till was contacted at 1.5 m depth (Elevation 337.1) and the thickness of this layer was 5.6 m.

In Boreholes 08-184 and 08-185, the depth to the base of the clayey silt till was 4.3 m and 4.2 m (Elevations 331.8 and 334.7). In Borehole 08-186, the base of the clayey silt till was 7.1 m (Elevation 331.5).

The cohesive layer is firm to hard in consistency, based on SPT 'N' values ranging from 4 to 86 blows per 0.3 m of penetration. SPT 'N' values higher than 100 blows per 0.25 m of penetration were measured in Borehole 08-186 below Elevation 332.5. The moisture content varied from 10% to 17%.

Grain size distribution curves for the samples 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 laboratory tests carried out on cohesive soil samples were as follows:

Soil Particles	(%)
Gravel	1 to 4
Sand	30 to 35
Silt	48 to 49
Clay	15 to 18

Liquid Limit	17 to 18
Plastic Limit	11 to 12

The above results show that the clayey silt till is of low plasticity with a group symbol of CL-ML. It should be noted that glacial tills are known to contain cobbles and boulders.

### 5.3 Sandy Silt Till

Native deposits of grey sandy silt till containing trace gravel, trace to some clay and occasional cobbles were observed below the clayey silt till in all the boreholes. Boreholes 08-184 and 08-185 were terminated within the sandy silt till at 7.8 m depth (Elevations 328.3 and 331.1). Borehole 08-186 was also terminated in the sandy silt till at 9.5 m depth (Elevation 329.1).

SPT 'N' values measured in the sandy silt till were higher than 100 blows per 0.15 m of penetration, indicating a very dense relative density. The natural moisture contents generally lay in the range of 8 to 19%.

Grain size distribution curves for the samples tested are presented on the Record of Borehole sheets and on Figure B3 of Appendix B. The results of laboratory tests carried out on sandy silt till soil samples were as follows:

Soil Particles	(%)
Gravel	2 to 9
Sand	35 to 46
Silt	38 to 47
Clay	12 to 15

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

### 5.4 Groundwater Conditions

Water levels were observed in the boreholes during and upon completion of drilling. A standpipe piezometer was installed in Borehole 08-185 (at the proposed pier) to monitor water levels after completion of drilling. The water levels measured in the piezometer 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	
North Abutment	08-184	June 9	6.2	329.9	Open borehole
Pier	08-185	July 15	2.1	336.8	In piezometer
South Abutment	08-186	June 9	Dry	-	Open borehole

The piezometric readings indicate that the groundwater level is near Elevation 336.8 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 truck-mounted CME75 drill rig and conducted the drilling, sampling and in-situ testing operations.

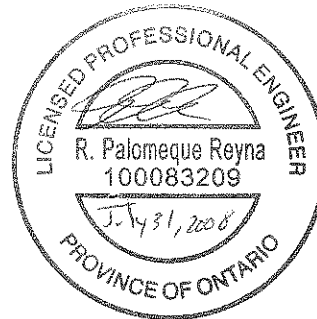
The drilling and sampling operations in the field were supervised on a full time basis by Mr. Stephane Loranger, C.E.T. of Thurber, under the direction of Mr. Alastair E. Gorman, P.Eng.

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

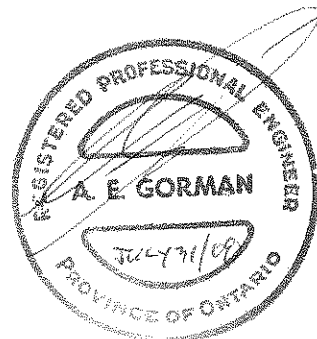
Overall supervision of the field program was conducted by Mr. Alastair E. Gorman, P.Eng. and Mr. M. Farrant, P. Eng. Interpretation of the data and preparation of the report were carried out by Mr. Alastair E. Gorman, P.Eng and Ms. R. Palomeque Reyna, P.Eng.

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

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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 19 of the E.A:

- The mainline will be in a cut 6.0 to 8.8 m deep at Elevation 330.0.
- Guelph Road 3 will be at Elevation 339.0 with approach embankments 0.5 to 3 m high

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

**8 STRUCTURE FOUNDATIONS**

The stratigraphy identified in the preliminary investigation consisted primarily of granular fill overlying native clayey silt till and sandy silt till. The groundwater level measured in the piezometer was 2.1 m (Elevation 336.8) 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 very stiff to hard clayey silt till or very dense sandy silt till must be in accordance with the elevations and bearing resistances given in Table 8.1.

**Table 8.1 – Bearing Resistances for Spread Footings**

Element	Depth (m)	Elev.	ULS <sub>r</sub> (kPa)	SLS (kPa)
<b>North Abutment</b> (BH 08-184)	Below 4.7	Below 331.4	750	500
<b>Pier</b> (BH 08-185)	2.4	336.5	450	300
	Below 4.4	Below 334.5	750	500
<b>South Abutment</b> (BH 08-186)	3.0	335.6	300	200
	Below 4.6	Below 334.0	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.

Founding elevations presented in Table 8.1 are below groundwater level observed during the investigation. If temporary excavations required to construct these footings extend below the water table, local groundwater control will be required to construct the footing in the dry and to prevent disturbance of the footing base.

## 8.2 Spread Footings on Engineered Fill

Consideration was also given to placing spread footings on an engineered fill pad if higher founding levels are required.

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 and native loose sands will be required. The

engineered fill will bear on native stiff to hard clayey silt till and the highest permitted founding/base elevations at which engineered fill pads may be founded, are given in Table 8.2.

**Table 8.2 – Founding Elevations for Engineered Fill Pads**

<b>North Abutment (BH 08-184)</b>	<b>Pier (BH 08-185)</b>	<b>South Abutment (BH 08-186)</b>
334.0	337.5	336.5

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.

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

### **8.3 Steel H-Piles**

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

It is recommended that the H-piles be driven to achieve resistance in the very dense sandy silt till 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 Plate 19 indicates that this depth of embedment can be achieved at the abutments. At the pier, pile installation would require pre-augering to achieve sufficient embedment.

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	Highest Pile Tip Elevation	Comments
North Abutment (BH 08-184)	330.0	A minimum pile length of 6 m must be achieved. Depending on final design, pre-augering may be required.
Pier (BH 08-185)	324.0 <sup>1,2</sup>	A minimum pile length of 6 m must be maintained. At the pier this will most probably require pre-augering.
South Abutment (BH 08-186)	331.0	Pile length from ground surface to top of very dense sandy silt till is 7.1 m.

1 Elevation based on proposed Highway 7 grade (Elevation 330.0).

2 Below depth of exploration

### 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 till are presented in Tables 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 and 3,600 kN for the HP 360 X 132.

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 expected founding layer, the tips of all driven piles should be fitted/protected with steel H-Pile driving shoes in accordance with OPSD 3000.100.

Higher geotechnical resistances may be achieved by installing the piles to greater depth but this will require pre-augering. For piles extending below Elevation 330 (approximately) a greater depth of exploration is required and must be addressed during the detail design phase. This analysis must also address the drivability of the piles.

### **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 native sandy silt till, despite the higher cost noted in Appendix C. The recommended foundation at the pier is a spread footing on very dense soil.

## **9 BRIDGE APPROACHES AND EMBANKMENTS**

Based on the three boreholes drilled at the site, the approach embankments will be constructed over stiff to hard, cohesive clayey silt till and may incorporate the sand and gravel fill of the existing embankment.

No long term settlement or global stability issues are anticipated for approach embankments built at this site. The 0.5 to 3 m high embankments likely to be constructed will be stable at side slopes of 2H:1V if constructed using SSM or granular fill.

The mainline cut shown on EA Plate 19 may be at approximately 6.8 m below the groundwater table. During detail design, when the grade has been finalized, permanent drainage and slope protection requirements must be addressed. Subject to depressing the groundwater level below the

base of the cut and implementing permanent drainage, the cut slopes will be stable at slopes with a maximum inclination of 2H: 1V. MTO policy requires a mid-height bench in cut slopes higher than 6.0 m.

## **10 CONSTRUCTION CONCERNS**

Based on the Recommended Alignment and the preliminary geotechnical information, potential construction concerns include, but are not necessarily limited to:

### **1. Pile Installation**

The presence of very dense soil at comparatively shallow depth will limit the length of pile that can be driven. If design requires longer piles, pre-augering will be required.

### **2. Excavation**

Hydraulic equipment is expected to be capable of excavating to the required depths at this site. If excavations advance below the existing groundwater level, groundwater control measures may have to be implemented in order to maintain stable sides and base in the excavation.

## **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 Guelph Road 3 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 Elevation 330.0 (approximately) 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 on Guelph Road 3.

### **4. Cut stability**

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

5. Groundwater impacts.

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

## 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.

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## **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 <sup>(1)</sup> '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<sub>pen</sub>



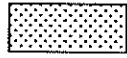


Shear Strength Determination by Pocket Penetrometer

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

# UNIFIED SOILS CLASSIFICATION

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

## EXPLANATION OF ROCK LOGGING TERMS

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

DISCONTINUITY SPACING		STRENGTH CLASSIFICATION			
Bedding	Bedding Plane Spacing	Rock Strength	Approximate Uniaxial Compressive Strength		Field Estimation of Hardness*
			(MPa)	(psi)	
Very thickly bedded	Greater than 2m	Extremely Strong	Greater than 250	Greater than 36,000	Specimen can only be chipped with a geological hammer
Thickly bedded	0.6 to 2m				
Medium bedded	0.2 to 0.6m	Very Strong	100-250	15,000 to 36,000	Requires many blows of geological hammer to break
Thinly bedded	60mm to 0.2m				
Very thinly bedded	20 to 60mm	Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
Laminated	6 to 20mm				
Thinly Laminated	Less than 6mm	Medium Strong	25.0 to 50.0	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

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

RECORD OF BOREHOLE No 08-184

1 OF 1

METRIC

G.W.P. 408-88-00 LOCATION N 4 821 443.32 E 236 975.38 ORIGINATED BY SLL  
HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM  
DATUM Geodetic DATE 2008.06.09 - 2008.06.09 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
336.1								20 40 60 80 100						
0.0	SAND, trace silt Brown Moist (FILL)		1	AS			336							
335.4														
0.7	Sandy SILT, trace gravel, occasional topsoil staining Loose Brown Moist (FILL)		1	SS	8		335							
334.7														
1.4	Clayey SILT, sandy, trace gravel Stiff Brown (TILL)		2	SS	8		334							
			3	SS	12									1 35 49 15
			4	SS	9		333							
331.8							332							
4.3	Sandy SILT, trace to some clay, trace gravel, occasional cobbles Very Dense Grey Moist (TILL)		5	SS	100/ .250		331							2 41 44 13
			6	SS	100/ .150		330							4 39 45 12
							329							
328.3			7	SS	100/ .150									
7.8	END OF BOREHOLE AT 7.77 m. BOREHOLE OPEN TO 7.62 m AND WATER LEVEL AT 6.25 m ON COMPLETION. BOREHOLE BACKFILLED WITH HOLEPLUG TO 5.5m, BENTONITE BENSEAL AND AUGER CUTTINGS TO 0.6m, HOLEPLUG TO 0.3m AND AUGER CUTTING TO SURFACE													

ONTMT4S 6417R.GPJ 7/21/08

# RECORD OF BOREHOLE No 08-185

1 OF 1

METRIC

G.W.P. 408-88-00 LOCATION N 4 821 405 33 E 235 994.69 ORIGINATED BY SLL  
 HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM  
 DATUM Geodetic DATE 2008.06.10 - 2008.06.10 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100	20 40 60 80 100		
338.9 0.0	SAND and GRAVEL, trace silt Compact Brown Moist (FILL)		1	AS										
337.8	Occasional topsoil		2	SS	17		338							
1.1	Clayey SILT, sandy, trace gravel Stiff to Hard Brown (TILL) Occasional cobbles		3	SS	11		337							
			4	SS	31		336							
	Brown to grey		5	SS	47		335							2 32 48 18
334.7							334							
4.2	Sandy SILT, trace to some clay, trace gravel, occasional cobbles Very Dense Grey Moist (TILL)		6	SS	100/ .200		333							9 39 40 12
			7	SS	100/ .125		332							3 39 44 14
331.1			8	SS	100/ .225									2 39 46 13
7.8	END OF BOREHOLE AT 7.85 m. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.													
	WATER LEVEL READINGS: DATE DEPTH(m) ELEV.(m) 2008.07.15 2.1 336.8													

ONTM14S 6417R.GPJ 7/24/08

+ 3 X 3 : Numbers refer to  
Sensitivity

20  
15 10 5  
10 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 08-186

1 OF 2

METRIC

G.W.P. 408-88-00 LOCATION N 4 821 386.48 E 237 031.74 ORIGINATED BY SLL  
 HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM  
 DATUM Geodetic DATE 2008.06.09 - 2008.06.09 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT  $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa											
								WATER CONTENT (%)											
338.6							20	40	60	80	100	PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	GR	SA	SI	CL	
0.0	SAND and GRAVEL, some asphalt fragments, trace silt Compact Brown Moist (FILL)		1	AS												50	40	10	(SI+CL)
			2	SS	12														
337.1																			
1.5	Clayey SILT, sandy, trace gravel Firm to Very Stiff Brown (TILL)		3	SS	4														
			4	SS	13														
			5	SS	17														
	Hard Grey Moist		6	SS	86														
			7	SS	100/ 250														
331.5																			
7.1	Sandy SILT, some clay Very Dense Grey (TILL)		8	SS	100/ 125														
																		</	

Continued Next Page

+<sup>3</sup>, x<sup>3</sup>: Numbers refer to  
Sensitivity 20  
15 5  
10 (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 08-186

2 OF 2

METRIC

G.W.P. 408-88-00 LOCATION N 4 821 386.48 E 237 031.74 ORIGINATED BY SLL  
HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM  
DATUM Geodetic DATE 2008.06.09 - 2008.06.09 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE LIMIT CONTENT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	W <sub>P</sub> W W <sub>L</sub>				
	Continued From Previous Page													
	BOREHOLE BACKFILLED WITH HOLE PLUG TO 8.5m, THEN BENTONITE BENSEAL MIXED WITH AUGER CUTTING TO SURFACE.													



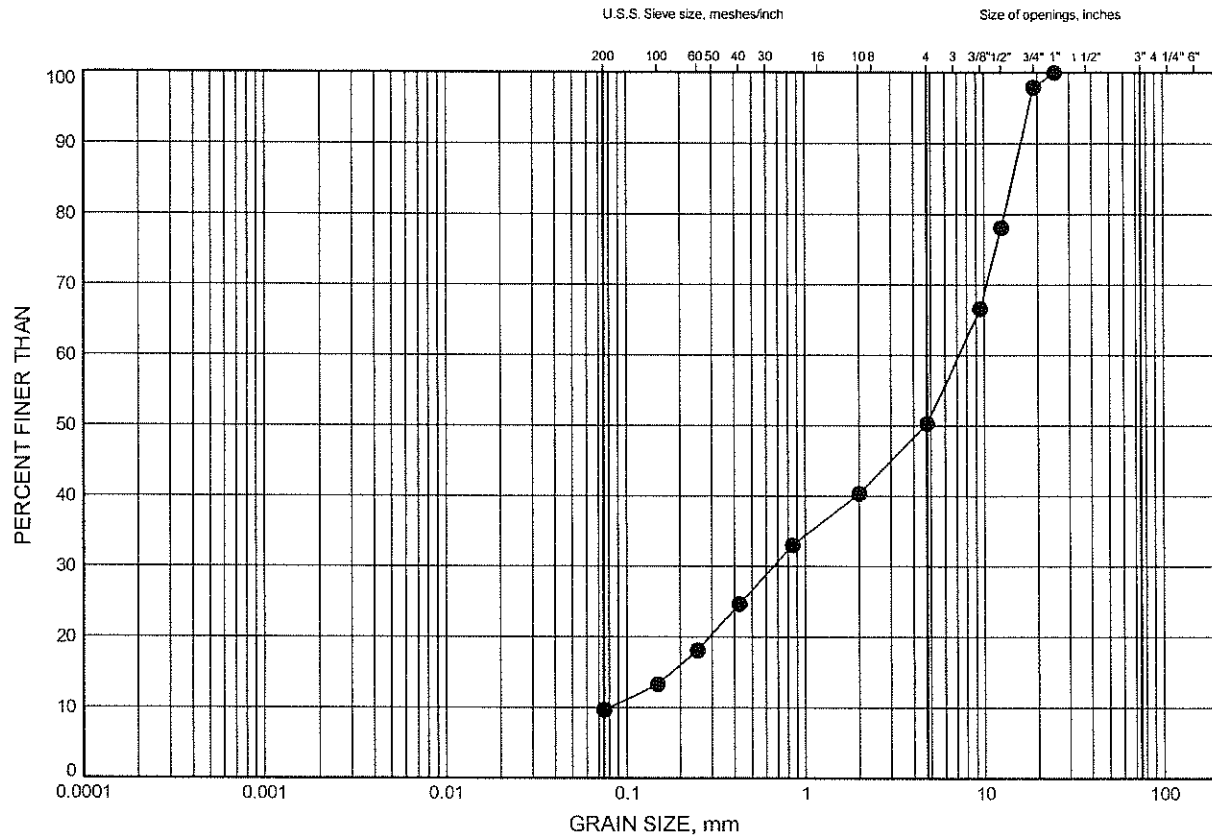
## **Appendix B**

### **Laboratory Test Results**

# Highway 7 - New GRAIN SIZE DISTRIBUTION

FIGURE B1

## Sand and Gravel Fill



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-186	0.15	338.45

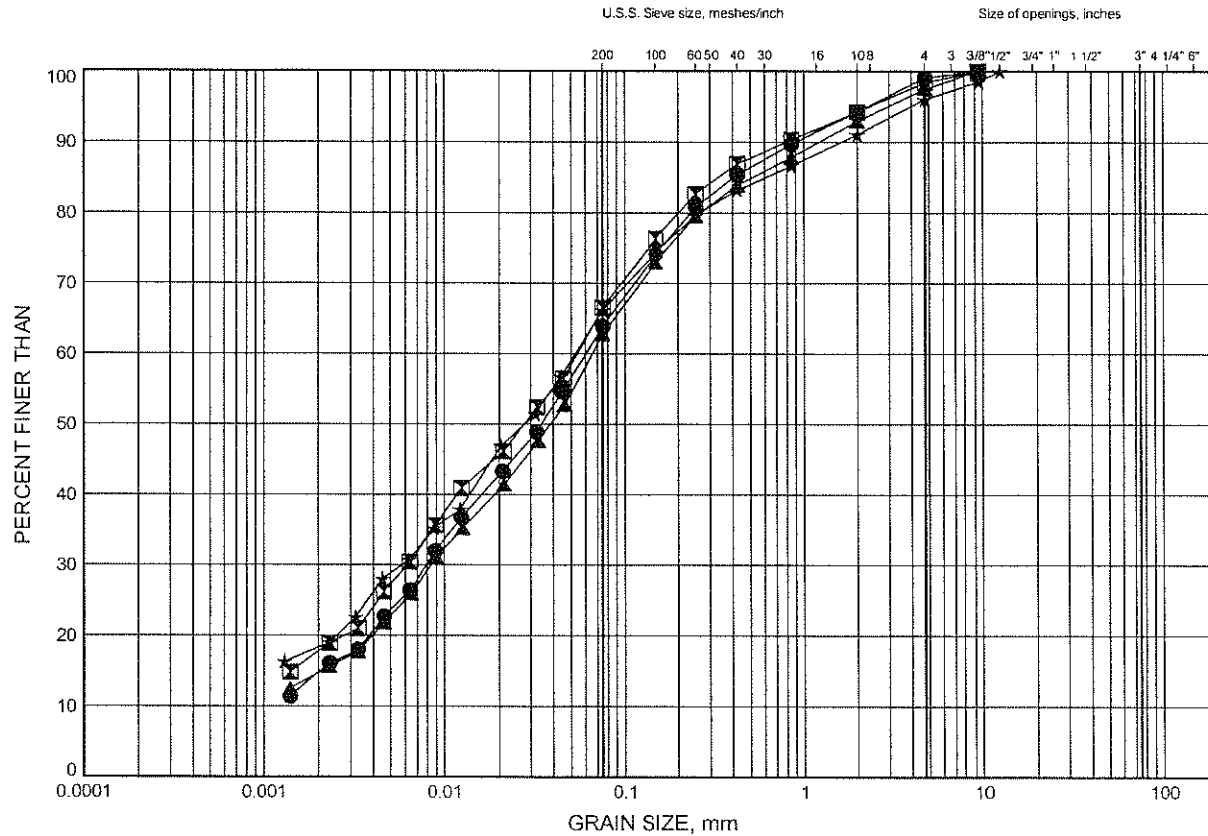


W.P.# 408-88-00.....  
Prepared By MFA.....  
Checked By RPR.....

# Highway 7 - New GRAIN SIZE DISTRIBUTION

FIGURE B2

## Clayey Silt Till



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-184	2.59	333.51
■	08-185	3.35	335.55
▲	08-186	2.59	336.01
☆	08-186	6.32	332.28

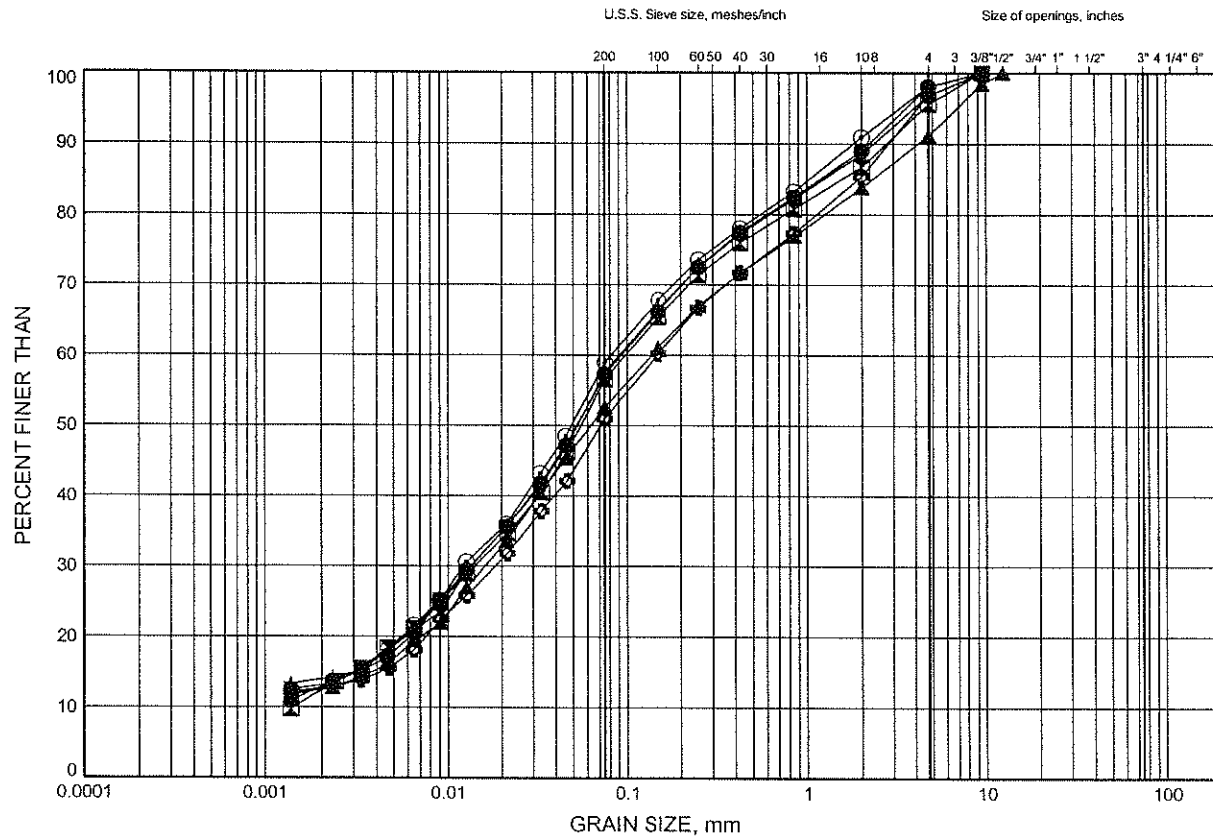


W.P.# 408-88-00.....  
Prepared By MFA.....  
Checked By RPR.....

# 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)
●	08-184	4.79	331.31
⊠	08-184	6.25	329.85
▲	08-185	4.75	334.15
☆	08-185	6.24	332.66
⊙	08-185	7.73	331.17
⊕	08-186	7.76	330.84

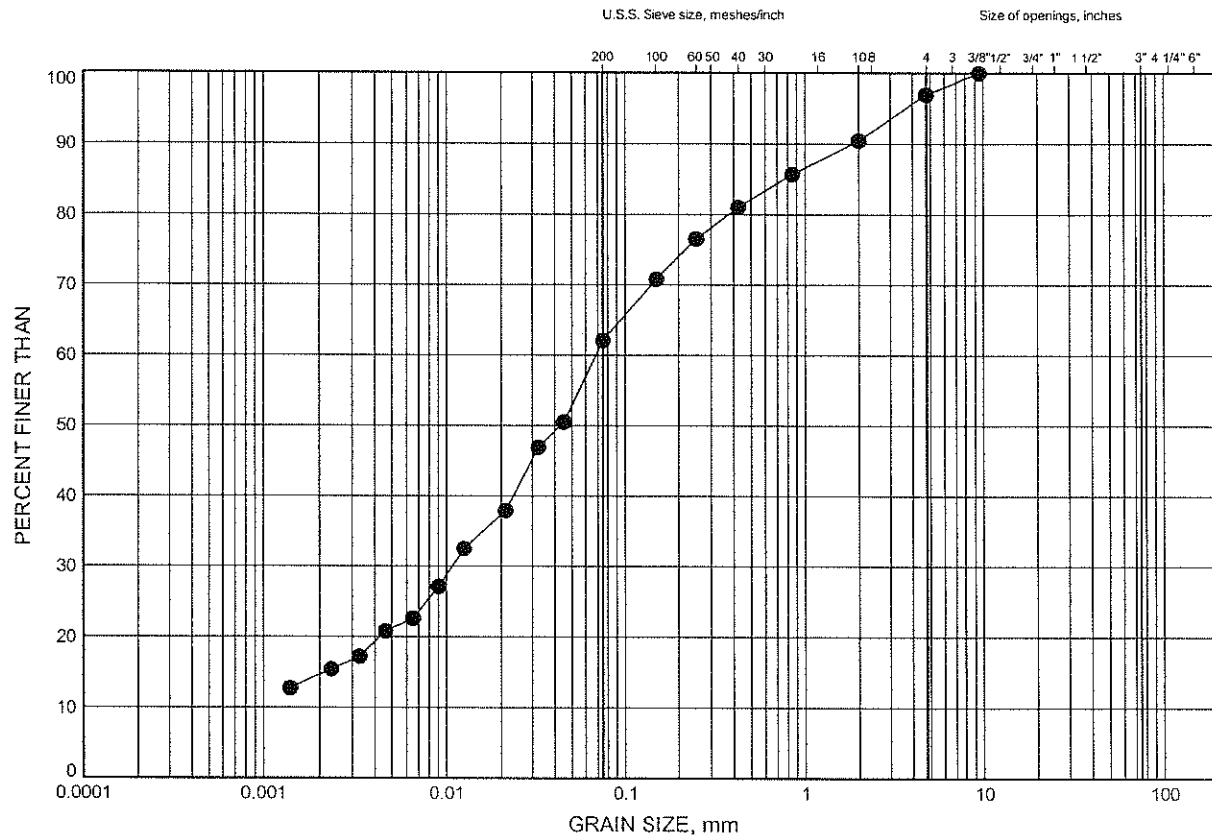


W.P.# 408-88-00  
Prepared By MFA  
Checked By RPR

# Highway 7 - New GRAIN SIZE DISTRIBUTION

FIGURE B4

## Sandy Silt Till



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-186	9.36	329.24

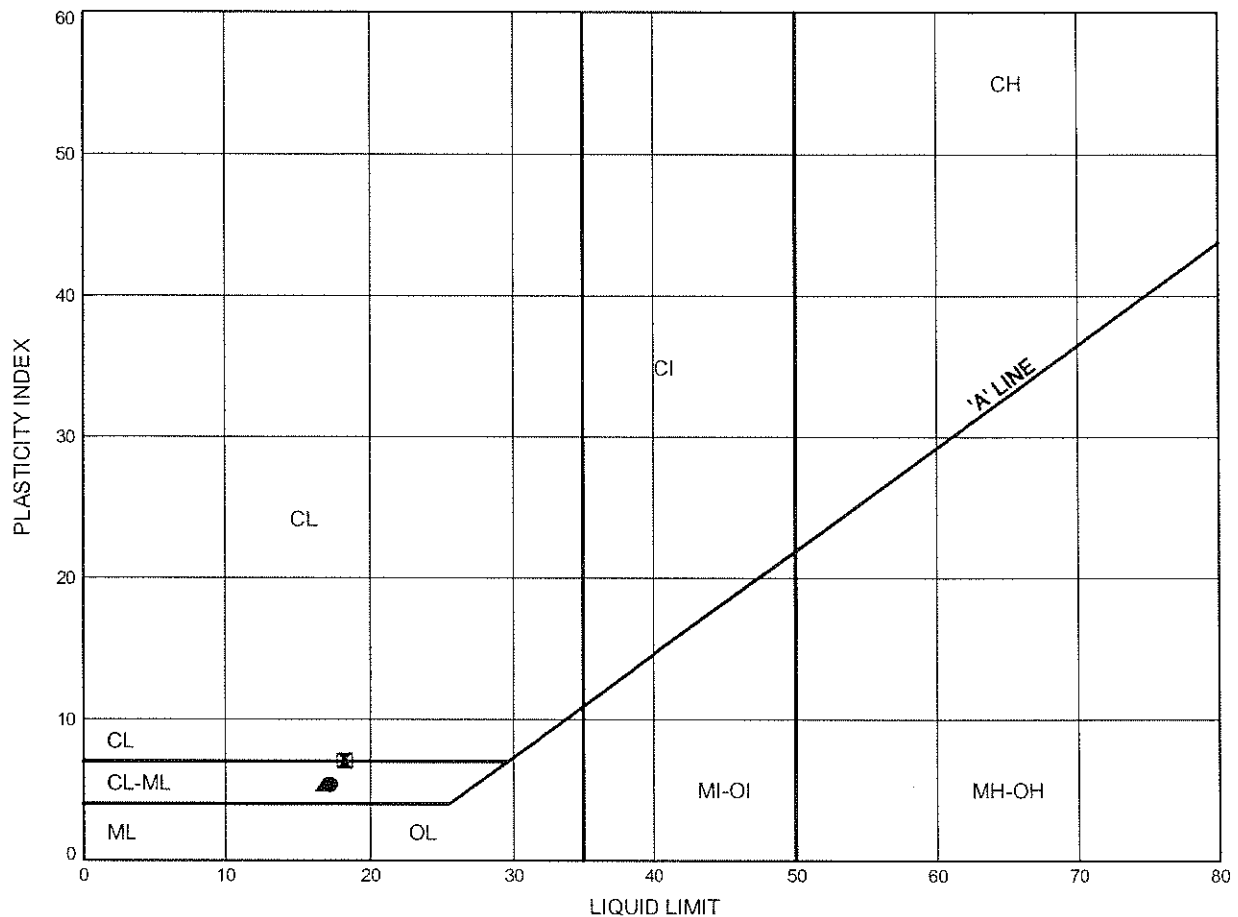


W.P.# 408-88-00  
Prepared By MFA  
Checked By RPR

# Highway 7 - New ATTERBERG LIMITS TEST RESULTS

FIGURE B5

Clayey Silt Till



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	08-184	2.59	333.51
⊠	08-185	3.35	335.55
▲	08-186	2.59	336.01

Date July, 2008  
Project 408-88-00



Prep'd MFA  
Chkd. RPR

## **Appendix C**

### **Foundation Comparison**

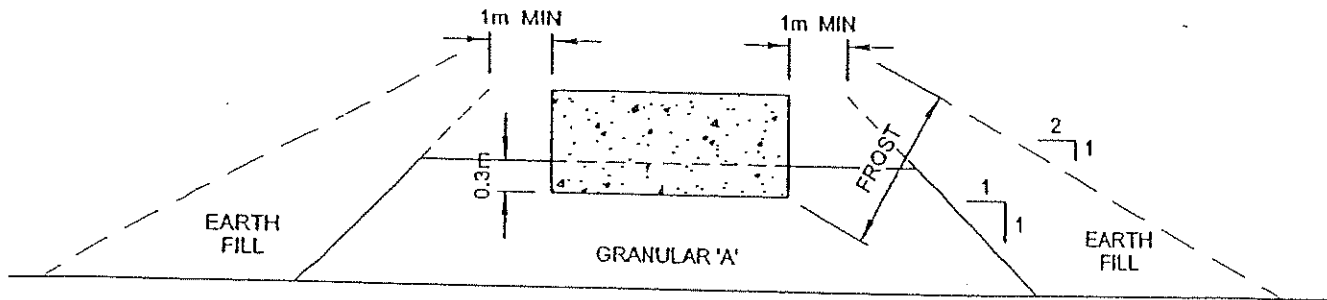
**COMPARISON OF FOUNDATION ALTERNATIVES FOR EACH FOUNDATION ELEMENT**

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

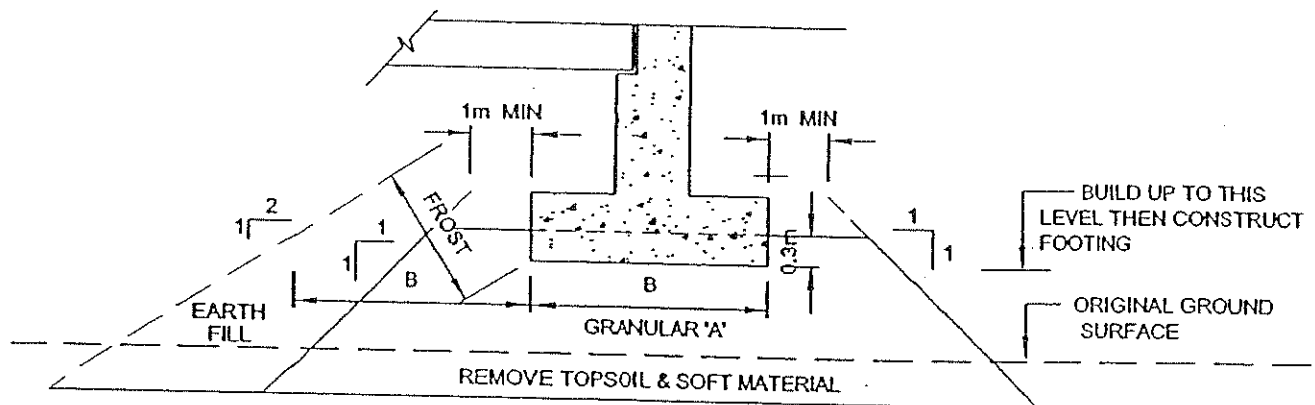


## Appendix D

### Figure



CROSS-SECTION




LONGITUDINAL SECTION

NOT TO SCALE

NOTES:

1. REMOVE TOPSOIL AND OR SOFT SUBSOIL UNDER AREA OF COMPACTED GRANULAR 'A' AND EARTH FILL.
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	 THURBER
DRAWN	SS		
DATE	April , 2004		
APPROVED	PKC		
SCALE	NTS		
			DWG. NO.
			FIGURE 1

## **Appendix E**

### **Site Photographs**

Guelph Road 3 Underpass  
Highway 7-New, Kitchener to Guelph

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**Photo 1.** Looking north along Guelph Road 3—Pier and North Abutment (Boreholes 08-184 and 08-185)

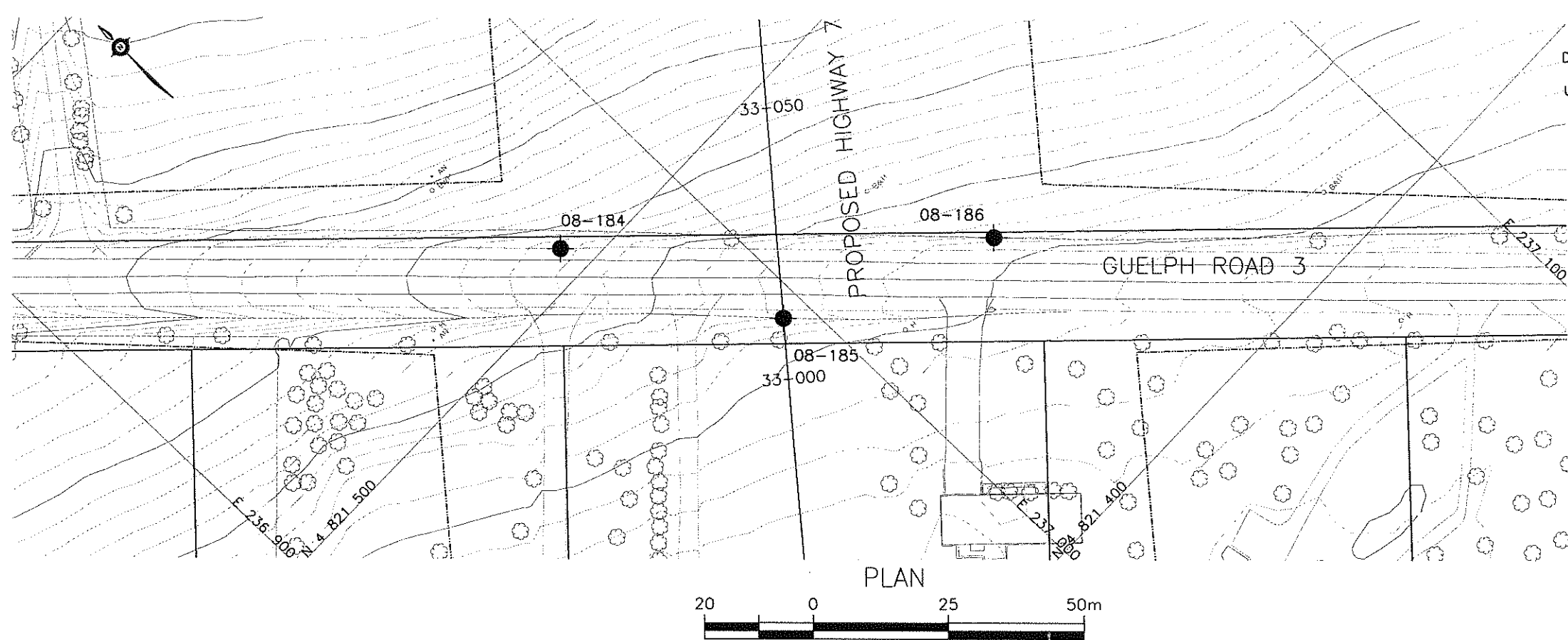


**Photo 2.** Looking north along Guelph Road 3 – South Abutment (Boreholes 08-186)

## **Appendix F**

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





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

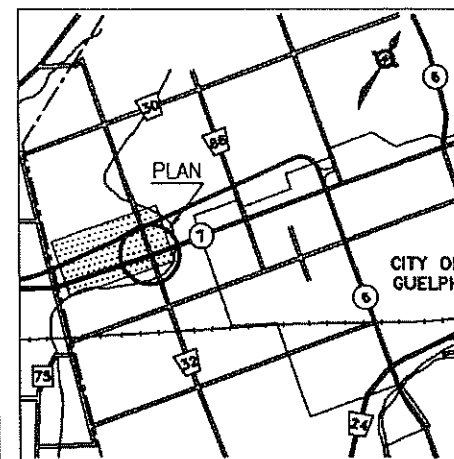
CONT No  
GWP No 408-88-00

HIGHWAY 7  
RECOMMENDED ROUTE  
GUELPH ROAD 3  
BOREHOLE LOCATIONS AND SOIL STRATA



SHEET

**THURBER ENGINEERING LTD.**  
GEOTECHNICAL • ENVIRONMENTAL • MATERIALS



KEYPLAN

LEGEND

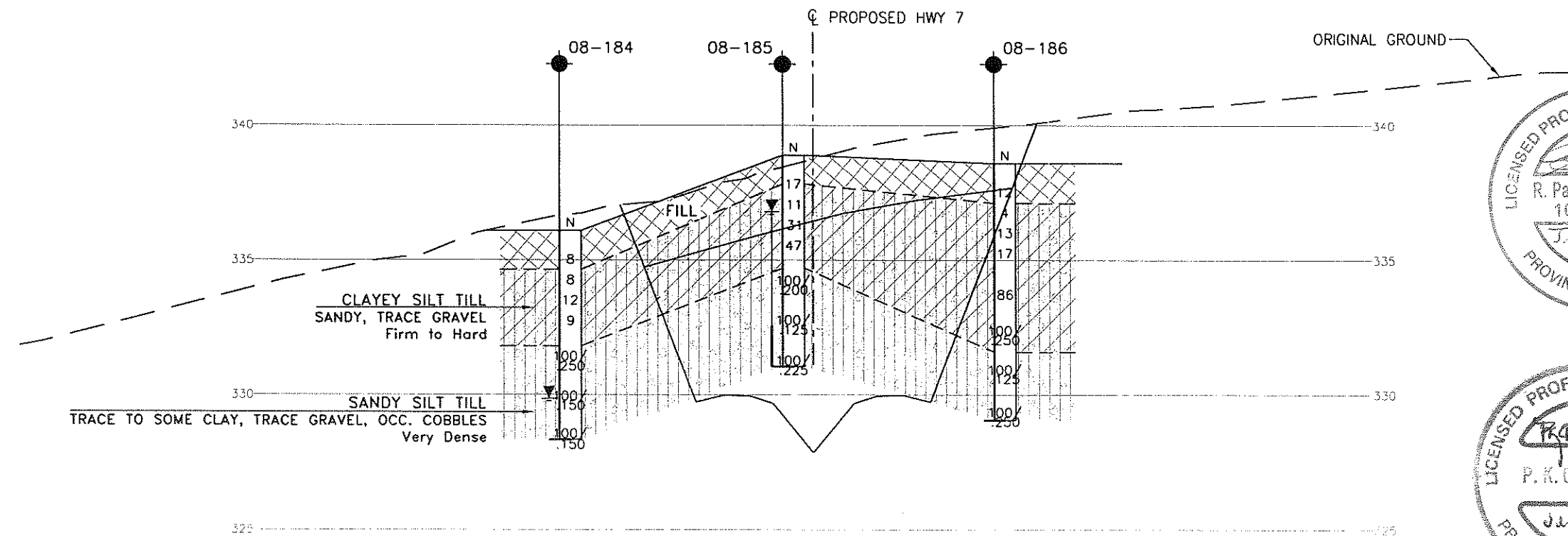
- ◆ Borehole
- ◆ Borehole and Cone
- N Blows /0.3m (Std Pen Test, 475J/blow)
- CONE Blows /0.3m (60' Cone, 475J/blow)
- PH Pressure, Hydraulic
- Water Level
- Head Artesian Water
- Piezometer
- 90% Rock Quality Designation (RQD)
- A/R Auger Refusal

NO	ELEVATION	NORTHING	EASTING
08-184	336.1	4 821 443.3	236 975.4
08-185	338.9	4 821 405.3	236 994.7
08-186	338.6	4 821 386.5	237 031.7

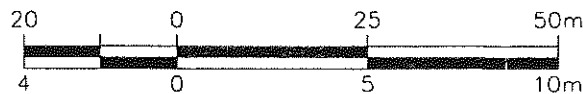
-NOTES-

- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
- This drawing is for subsurface information only. Surface details and features are for conceptual illustration.
- Proposed grades are from Plate 17 of the E.A. Study.

GEOCREs No. 40P9-45



PROFILE ALONG CL OF GUELPH ROAD 3



HOR 1:1000

VER 1:200



DRAWING NOT TO BE SCALED  
100 mm ON ORIGINAL DRAWING

REVISIONS	DATE	BY	DESCRIPTION
DESIGN	AEG	CHK PKC	CODE
DRAWN	MFA	CHK AEG	SITE
			LOAD
			STRUCT
			DWG
			DATE JULY 2008