

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

Geocres Number: 40P9-44

Report to

**Ministry of Transportation Ontario
Southwestern Region**

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July 30, 2008
File: 15-64-17

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PART 1: FACTUAL INFORMATION

1 INTRODUCTION

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

The purpose of the investigation was to explore the subsurface conditions at the site and, based on the data obtained, to provide a borehole location plan, records of boreholes, a stratigraphic profile, laboratory test results and a written description of the subsurface conditions. A model of the subsurface conditions under the potential foundation footprint was developed from the data obtained in the course of the investigation.

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

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

2 SITE DESCRIPTION

At the site, the Highway 7-New alignment runs approximately parallel to the existing Highway 7 alignment and 450 m to the north. The site lies approximately 3.5 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. There are farmsteads to the east and west of Townline Road, north of the existing Highway 7 alignment.

Two photographs of the site, looking south along Townline Road 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 May 21 and May 22, 2008. Three boreholes, 08-172, 08-173 and 08-174, 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. 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 on 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 08-172, drilled at the proposed north abutment 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 was carried out in accordance with the requirements of O. Reg. 903 (as amended by O. Reg. 372/07).

Table 3.1 – Borehole Completion Details

Foundation Unit	Borehole Location	Piezometer Tip Depth/ Elevation (m)	Completion Details
North Abutment	08-172	8.1/329.2	Piezometer with 1.5 m slotted screen installed with sand filter to 5.7 m, holeplug from 5.7m to 5.4 m, holeplug mixed with auger cuttings from 5.4 m to 0.6 m, then quickcrete to surface.
Pier	08-173	No Installation	Bentonite grout from bottom of borehole to 3.0 m, bentonite mixed with auger cuttings to 0.6 m, then cuttings to ground surface.
South Abutment	08-174	No Installation	Bentonite grout from bottom of borehole to 2.7 m, bentonite/soil mixture to 0.5 m and sand to ground surface.

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

4 LABORATORY TESTING

The recovered soil samples were subjected to Visual Identification (VI) and to natural moisture content determination. The results of this testing are shown on the Record of Borehole sheets in Appendix A. Selected samples were also subjected to gradation analysis and 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 compact to very dense sandy silt till, very dense sand and gravel and a lower very dense 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 containing trace of gravel to gravelly and trace to some clay.

A layer of clayey silt fill was contacted in Borehole 08-173 below the sand fill.

A possible layer of cobbles and gravel fill overlying a layer of silty sand fill was also encountered in Borehole 08-172.

The depth to the base of fill ranges from 2.0 m to 2.2 m (Elevations 333.4 to 335.3) at the abutments. At the pier, the base of the fill was at 2.3 m depth (Elevation 334.4).

The cohesionless fill is classified as compact, based on SPT values ranging from 8 to 26 blows for 0.3 m of penetration. The natural moisture content ranged from 3 to 10%.

The cohesive fill layer is stiff to hard in consistency, based on SPT 'N' values ranging from 9 to 36 blows per 0.3 m of penetration. The moisture content varied from 17% to 19%.

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

Soil Particles	(%)
Gravel	9
Sand	47
Silt	34
Clay	10

5.2 Upper Sandy Silt Till

Native deposits of brown 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 5.1.

Table 5.1 – Depths and Elevations of Native Sandy Silt Till

Foundation Unit	Borehole	Depth below existing ground surface (m)	Elevation (m)	Thickness (m)
North Abutment	08-172	2.0 to 5.8	335.3 to 331.5	3.8
Pier	08-173	2.3 to 5.9	334.4 to 330.8	3.6
South Abutment	08-174	2.2 to 5.5	333.4 to 330.1	3.3

SPT values measured in the sandy silt till ranged from 23 blows per 0.3 m of penetration to higher than 100 blows per 0.1 m of penetration, indicating a compact to very dense relative density. The natural moisture contents generally lay in the range of 2 to 10%.

Grain size distribution curves for the samples tested are presented on the Record of Borehole sheets and on Figure B2 of Appendix B. The results of grain size distribution tests carried out on sandy silt till soil samples were as follows:

Soil Particles	(%)
Gravel	4 to 14
Sand	44 to 54
Silt	33 to 41
Clay	4 to 10

5.3 Sand and Gravel

The sandy silt till described above was underlain by a layer of sand and gravel. The soil colouration varies from brown to grey with depth.

Depths and elevations where native sand and gravel were encountered are indicated in Table 5.2.

Table 5.2 – Depths and Elevations of Sand and Gravel

Foundation Unit	Borehole	Depth below existing ground surface (m)	Elevation (m)	Thickness (m)
North Abutment	08-172	5.8 m to 8.1 (borehole termination depth)	331.5 to 329.2	>2.3
Pier	08-173	5.9 to 7.2	330.8 to 329.5	1.3
South Abutment	08-174	5.5 to 7.9	330.1 to 327.7	2.4

The sand and gravel layer is classified as very dense, based on SPT 'N' values ranging from 87 to higher than 100 blows per 0.125 m of penetration.

The natural moisture contents generally lay around 8 to 16%.

According to the results of the visual identification and the laboratory tests carried out on three samples, the soil particle gradation in this layer varies from sand to gravel but is generally described as sand and gravel.

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 sand and gravel samples were as follows:

Soil Particles	(%)
Gravel	13 to 47
Sand	40 to 68
Silt & Clay	9 to 19

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

5.4 Lower Sandy Silt Till

A lower deposit of brown sandy silt till containing some clay and trace of gravel was contacted in Boreholes 08-173 and 08-174 at 7.2 m and 7.9 m depth (Elevations 329.5 and 327.7), respectively. Both boreholes were terminated within the lower sandy silt till deposit.

SPT values measured in the lower sandy silt till were higher than 100 blows per 0.2 m of penetration, indicating a very dense relative density. The natural moisture contents generally lay in the range of 4 to 10%.

5.5 Groundwater Conditions

Water levels were observed in the boreholes during and upon completion of drilling. A standpipe piezometer was installed in Borehole 08-172 (at the proposed north abutment) 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 boreholes upon completion of drilling.

Table 5.3 – Water Level Measurements

Foundation Unit	Borehole	Date (2008)	Water Level (m)		Comment
			Depth	Elevation	
North Abutment	08-172	May 27	6.6	330.7	In piezometer
		June 18	6.9	330.4	
		June 19	6.7	330.6	
Pier	08-173	May 22	Dry	-	Open borehole
South Abutment	08-174	May 21	Dry	-	Open borehole

The piezometric reading indicates that the groundwater level is near Elevation 330.6 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 CME75 truck-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.

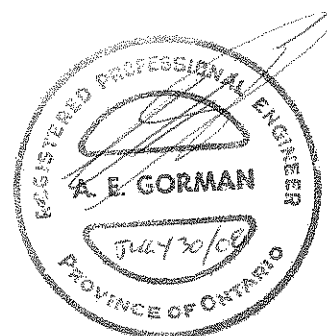
Overall supervision of the field program was conducted by Mr. Alastair E. Gorman, P.Eng. Interpretation of the data and preparation of the report were carried out by Mr. Alastair E. Gorman, P.Eng. and Ms. R. Palomeque Reyna, P.Eng.

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 15 of the E.A.:

- The mainline will be in a cut 3 to 4 m deep at Elevation 333.0
- Townline Road will be at Elevation 340.5 with approach embankments 3 to 5 m high

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

8 STRUCTURE FOUNDATIONS

The stratigraphy identified in the preliminary investigation consisted primarily of granular fill overlying upper sandy silt till, sand and gravel and sandy silt till. Groundwater level measured in the piezometer was 6.7 m (Elevation 330.6) 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 compact to very dense sandy silt till must be in accordance with the elevations and bearing resistances given in Table 8.1.

Table 8.1 – Bearing Resistances for Spread Footings

Element	Depth (m)	Elev.	ULS _f (kPa)	SLS (kPa)
North Abutment (BH 08-172)	2.3	335.0	750	500
	Below 3.3	Below 334.0	800	550
Pier (BH 08-173)	2.3	334.4	300	200
	Below 4.5	Below 332.2	800	550
South Abutment (BH 08-174)	2.3	333.3	300	200
	Below 4.6	Below 331.0	800	550

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 generally above the groundwater level observed during the investigation. However, if temporary excavations required to construct these footings extend in cohesionless soils 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 at the pier or 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 compact to dense sandy 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

North Abutment (BH 08-172)	Pier (BH 08-173)	South Abutment (BH 08-174)
335.3	334.4	333.4

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 glacial soils 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 15 indicates that this depth of embedment should be achieved at the abutments. At the pier, pile installation would probably 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 (6-m long pile)	Comments
North Abutment (BH 08-172)	331.3	A minimum pile length of 6 m must be achieved. Depending on final design, pre-augering may be required.
Pier (BH 08-173)	327.0*	A minimum pile length of 6 m must be maintained. At the pier this will most probably required pre-augering.
South Abutment (BH 08-174)	329.6	A minimum pile length of 6 m must be achieved. Depending on final design, pre-augering may be required.

* Elevation obtained based on proposed Highway 7 grade (elevation 333.0).

8.3.1 Axial Resistance

For preliminary design, the vertical, axial, factored geotechnical resistance at Ultimate Limit States (ULS) and geotechnical resistance at Serviceability Limit States (SLS) for two pile sections when driven into the very dense soil 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 328 (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 soil, 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 compact, non-cohesive sandy 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 3 to 5 m high embankments likely to be constructed will be stable at side slopes of 2H:1V if constructed using SSM or granular fill.

The mainline cut shown on EA Plate 15 may be at approximately 2.3 m above the groundwater table. During detail design, when the grade has been finalized, permanent drainage and slope protection requirements must be addressed. Subject to drainage control, the cut slopes will be stable at slopes with a maximum inclination of 2H: 1V.

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

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 Townline Road 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 328 (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 Townline Road. Similarly, 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.

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 ⁽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			

RECORD OF BOREHOLE No 08-172

1 OF 1

METRIC

G.W.P. 408-88-00 LOCATION N 4 819 919.66 E 235 600.33 ORIGINATED BY SLL/WB
 HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MFA
 DATUM Geodetic DATE 2008.05.22 - 2008.05.22 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
								20 40 60 80 100		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			
337.3													
0.0	SAND, some gravel, trace clay, topsoil stained Compact Brown Moist (FILL) COBBLES and GRAVEL		1	AS									
336.0			1	SS	18								
1.2	Silly SAND, trace to some clay, trace gravel Compact Brown Moist (FILL)												
335.3			2	SS	22								9 47 34 10
2.0	Sandy SILT, trace to some clay, trace gravel Very Dense Brown Moist (TILL)												
			3	SS	62								4 45 41 10
			4	SS	50/ .075								
	occasional cobbles		5	SS	100/ .100								
	Auger grinding at 5.2m												
331.5													
5.8	SAND and GRAVEL, trace to some silt and clay Very Dense Brown Moist to Wet		6	SS	87								13 68 19 (SI+CL)
329.2			7	SS	80/ 125								
8.1	END OF BOREHOLE AT 8.1m. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen. WATER LEVEL READINGS: DATE DEPTH(m) ELEV.(m) 2008.05.27 6.6 330.7 2008.06.18 6.9 330.4 2008.06.19 6.7 330.6												

ONTMT4S 6417R.GPJ 6/27/08

RECORD OF BOREHOLE No 08-173

1 OF 1

METRIC

G.W.P. 408-88-00 LOCATION N 4 819 885.30 E 235 620.82 ORIGINATED BY SLL/WB
 HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY MFA
 DATUM Geodetic DATE 2008.05.22 - 2008.05.22 CHECKED BY RPR

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE LIQUID CONTENT LIMIT			UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)					
336.7								20	40	60	80	100		W _P	W	W _L		
0.0	SAND, trace gravel, occasional topsoil Brown Moist (FILL)		1	AS										○				
335.8															○			
0.9	Clayey SILT, some sand, mixed with topsoil stains Hard to Stiff Dark Brown Moist (FILL)		1	SS	36									○				
															○			
			2	SS	9									○				
334.4																		
2.3	Sandy SILT, trace clay, trace gravel Compact to Dense Brown Moist (TILL)		3	SS	23									○				
															○			
	cobbles at 3.7m			4	SS	43									○			
	Very Dense			5	SS	100/ 275									○			
330.8																		
5.9	SAND and GRAVEL, trace silt and clay Very Dense Brown to Grey Moist		6	SS	100/ 200									○				
329.5																		
7.2	Sandy SILT, some clay, trace gravel Very Dense Brown Moist (TILL)													○				
328.9				7	SS	100/ 175									○			
7.8	END OF BOREHOLE AT 7.8m. BOREHOLE DRY UPON COMPLETION. BOREHOLE BACKFILLED WITH BENTONITE HOELPUG TO 3.0m, THEN MIXED WITH CUTTINGS TO 0.6m AND CUTTINGS TO SURFACE.																	

ONTMT4S 6417R.GPJ 6/27/08

METRIC

[illegible]

(%) STRAIN AT FAILURE

METRIC

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT W _P W W _L	UNIT WEIGHT γ kN/m ³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE 20 40 60 80 100	WATER CONTENT (%) 20 40 60			
Continued From Previous Page												

[illegible]

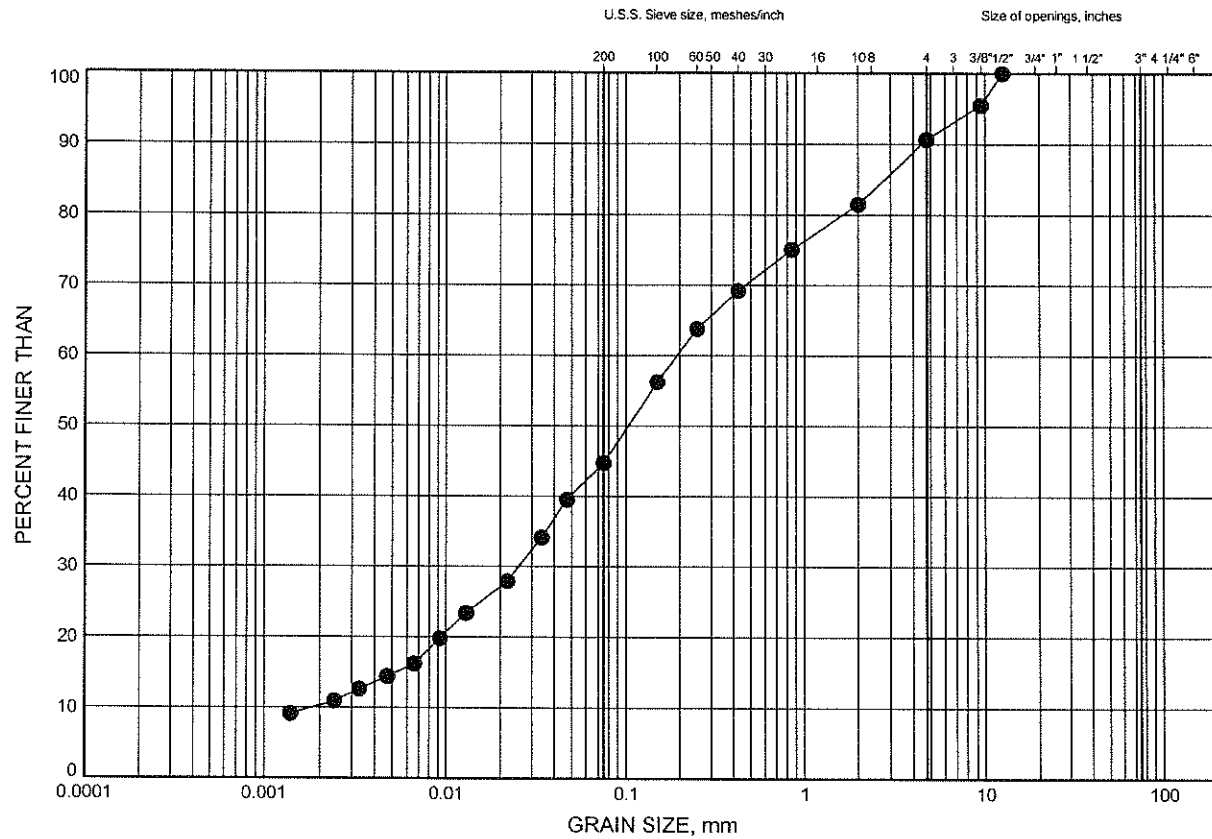
Appendix B

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)
●	08-172	1.83	335.43

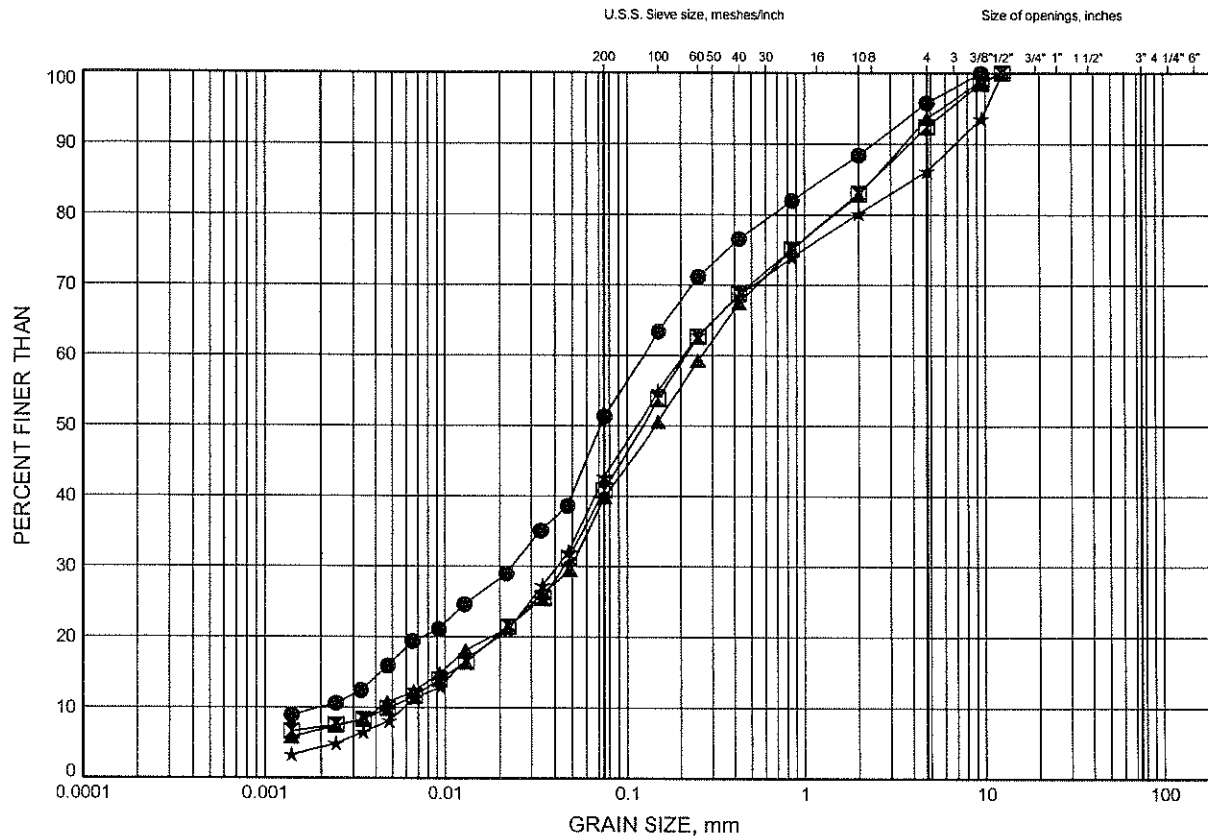


W.P.# 408-88-00
Prepared By MFA
Checked By RPR

Highway 7 - New GRAIN SIZE DISTRIBUTION

FIGURE B2

SANDY SILT TILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-172	2.59	334.67
⊠	08-173	2.59	334.12
▲	08-173	4.79	331.92
☆	08-174	2.59	333.05

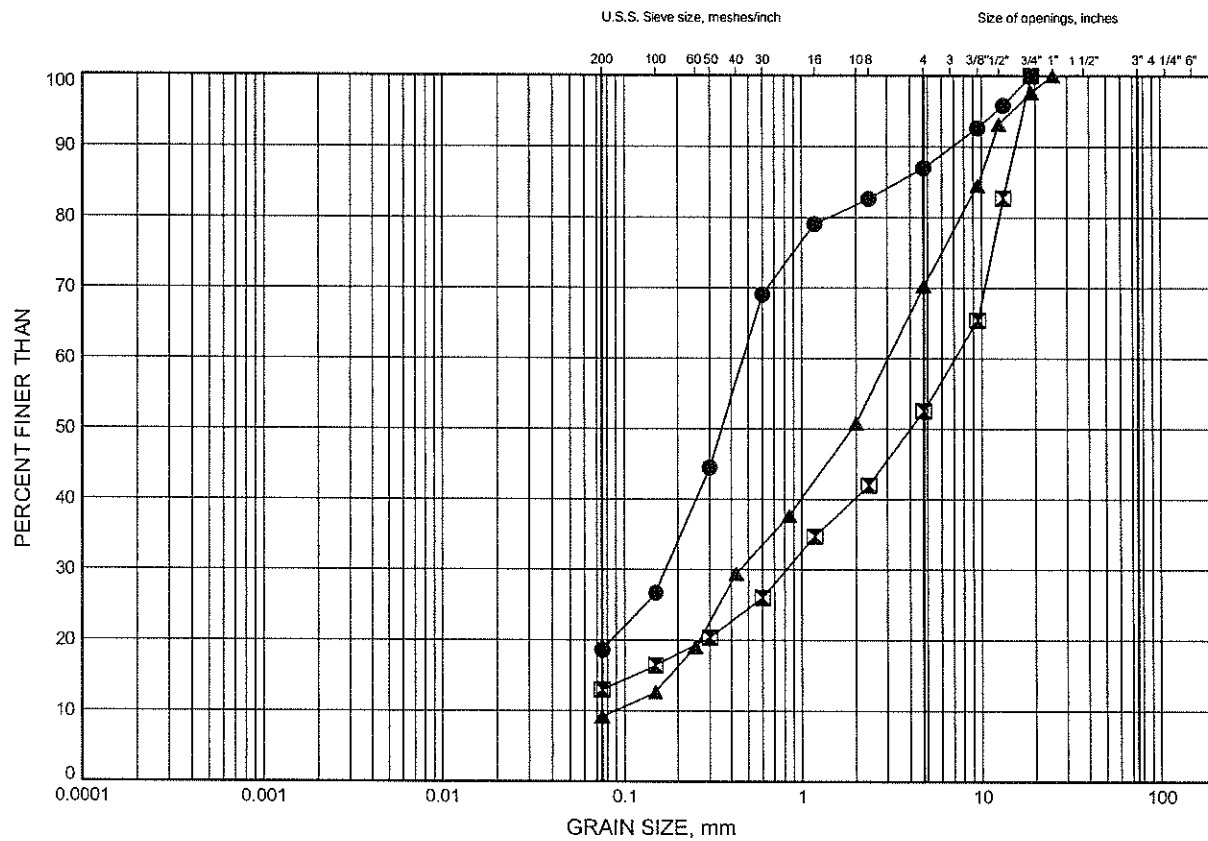


W.P.# 408-88-00
Prepared By MFA
Checked By RPR

Highway 7 - New GRAIN SIZE DISTRIBUTION

FIGURE B3

SAND AND GRAVEL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-172	6.38	330.88
⊠	08-173	6.20	330.51
▲	08-174	6.25	329.39



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

Appendix C

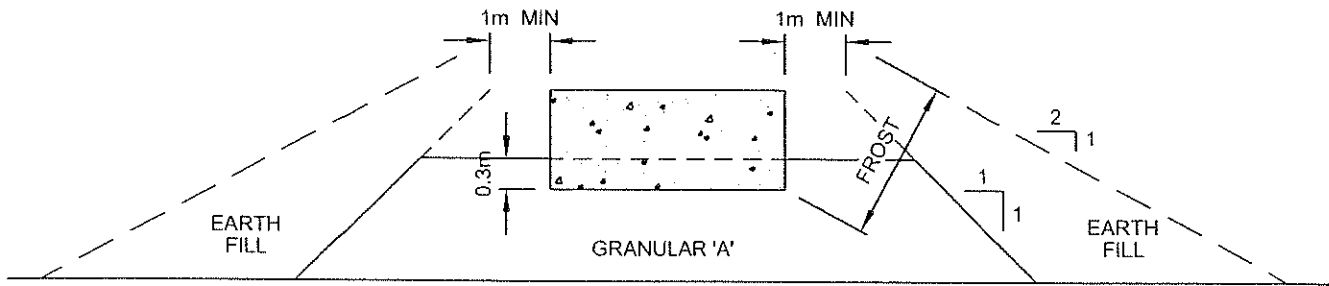
Foundation Comparison

COMPARISON OF FOUNDATION ALTERNATIVES FOR EACH FOUNDATION ELEMENT

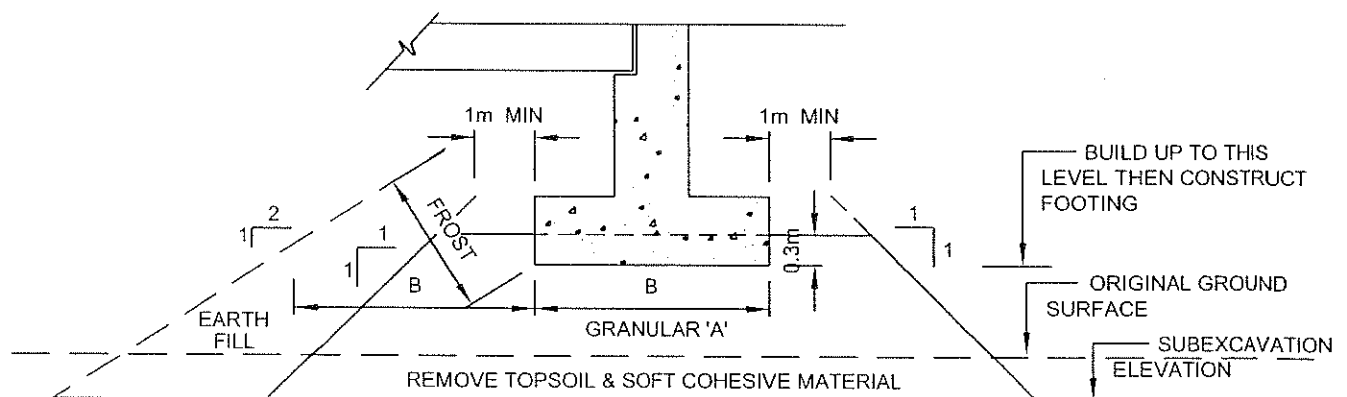
Foundation Element	Spread Footings	Spread Footings on Engineered Fill	Driven Piles
Abutments	<p>Advantages:</p> <ul style="list-style-type: none"> i. Generally less costly construction than deep foundation elements. <p>Disadvantages:</p> <ul style="list-style-type: none"> i. Lower geotechnical resistance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

Appendix D

Figure



CROSS-SECTION



LONGITUDINAL SECTION

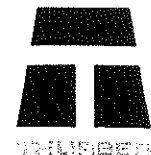
NOT TO SCALE

NOTES:

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

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

ABUTMENT ON COMPACTED FILL SHOWING
GRANULAR A CORE



DWG. NO.

FIGURE 1

Appendix E

Site Photographs

Townline Road Underpass
Highway 7-New, Kitchener to Guelph



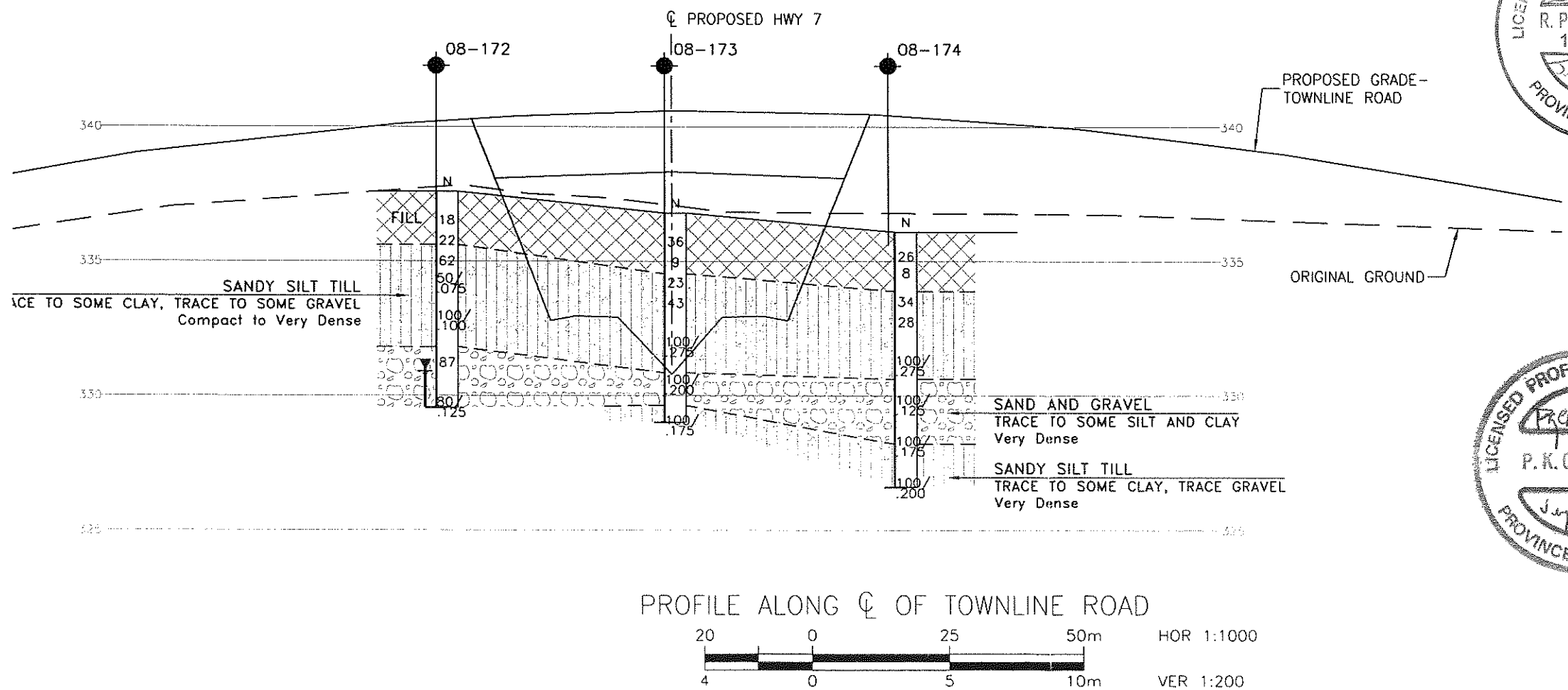
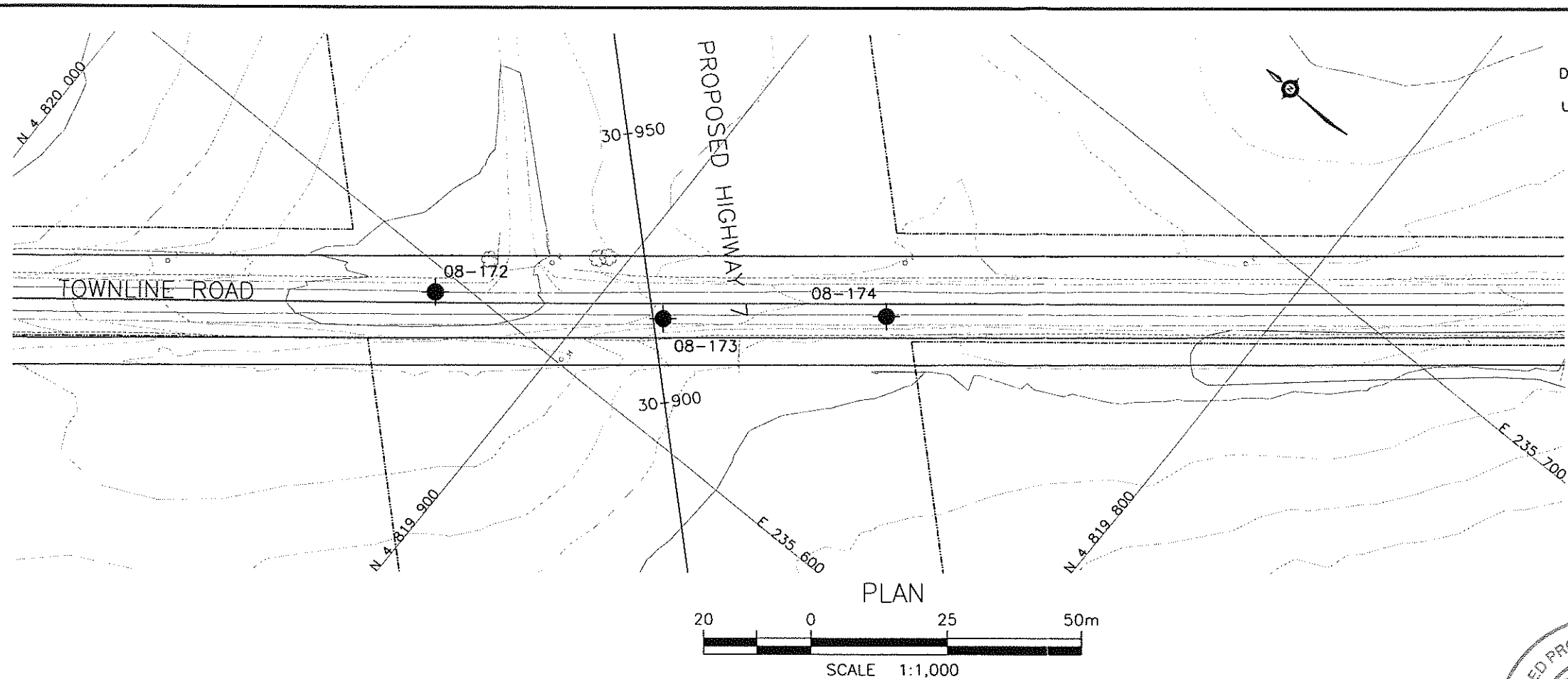
Photo 1. Looking south along Townline Road – Pier and North Abutment (Boreholes 08-173 and 08-174)



Photo 2. Looking south along Townline Road – South Abutment (Borehole 08-172)

Appendix F

Drawing titled “Borehole Locations and Soil Strata”

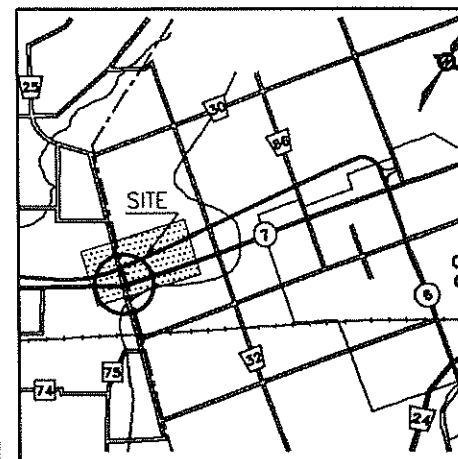


METRIC
DIMENSIONS ARE IN METRES
AND/OR MILLIMETRES
UNLESS OTHERWISE SHOWN

CONT No
GWP No 408-88-00






HIGHWAY 7
RECOMMENDED ROUTE
TOWNLINE ROAD
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET



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
08-172	337.6	4 819 924.0	235 595.9
08-173	336.8	4 819 888.4	235 618.6
08-174	336.1	4 819 856.5	235 644.9

-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 15 of the E.A. Study.

GEOCRES No. 40P9-44

REVISIONS								
	DATE	BY	DESCRIPTION					
DESIGN	AEG	CHK	PKC	ICODE			LOAD	DATE JULY 200
DRAWN	MFA	CHK	AEG	ISITE			STRUCT	IDWG

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

FILENAME: C:\JOB FILES\15\64\17\led5417-TownlineRoad.dwg