PRELIMINARY

FOUNDATION INVESTIGATION AND DESIGN REPORT

SHANTZ STATION ROAD (RR 30) UNDERPASS

HIGHWAY 7-NEW, KITCHENER TO GUELPH

G.W.P. 408-88-00

Geocres Number: 40P9-47

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 Shantz Station 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 350 m to the north. The site lies approximately 7.5 km northeast of a developed area of the City of Kitchener and 6.5 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 is generally flat and lies within an area of active farms and agricultural lands. There are farmsteads to the east and west of Shantz Station Road, near the proposed Highway 7 alignment.

A photograph of the site, looking south along Shantz Station Road is 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 on May 22, 23, 30, June 2 and 3, 2008. Three boreholes, 08-157, 08-158 and 08-159, 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 20.0 to 21.4 m (Elevations 308.6 to 309.2).

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 advanced 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.

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.

Groundwater conditions in the open boreholes were observed throughout the drilling operations. In Borehole 08-158, drilled at the proposed pier location, 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 locations and completion details of the piezometer are shown in Table 3.1. Boreholes without piezometer installations were grouted with bentonite upon completion. The borehole completion details are also shown in Table 3.1.

The completion of the boreholes and the standpipe piezometer 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
North Abutment	08-157	No Installation	Bentonite benseal grout from bottom of borehole to 1.5 m, holeplug from 1.5 m to 0.6 m, then auger cuttings to ground surface.
Pier	08-158	21.4/308.6	Piezometer with 1.5 m slotted screen installed with sand filter to 19.1 m, holeplug from 19.1 m to 18.3 m, bentonite from 18.3 m to ground surface.
South Abutment	08-159	No Installation	Grout from 20.0 m to 15.0 m, holeplug from 15.0 m to 3.0 m and auger cuttings from 3.0 m to ground surface.

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/or granular fill overlying cohesive layers of very stiff to hard silty clay/silty clay till and clayey silt till and a lower deposit of sandy silt till. Layers of silt and silt till were also observed within the cohesive till deposits.

5.1 Topsoil

Topsoil was identified at the ground surface in Boreholes 08-157 and 08-159. The topsoil thickness ranged from 75 mm to 200 mm. The topsoil thickness may vary between and beyond the borehole locations and the data is not intended for the purpose of estimating quantities.

5.2 Fill

A layer of fill was encountered below the topsoil in Boreholes 08-157 and 08-159, and surficially in Borehole 08-158. The fill consists of dark brown sand, silty sand and silty clay with trace of gravel.

The depth to the base of the fill ranged from 1.4 m to 2.2 m (Elevations 327.4 to 327.8) at the abutments and 0.5 m (Elevation 329.5) at the pier.

The fill is classified as loose and firm to stiff, based on SPT values of 4, 6 and 11 blows for 0.3 m of penetration. The natural moisture content ranged from 5 to 20%.

5.3 Silty Clay Till and Silty Clay

Layers of native brown to grey silty clay and silty clay till containing some sand to sandy, trace gravel and occasional cobbles were encountered at various depths and elevations as indicated in Table 5.1.

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

Borehole	Depth below existing ground surface (m)	Elevation (m)	Thickness (m)
08-157	2.2 to 8.5	327.4 to 321.1	6.3
	8.5 to 10.3*	321.1to 319.3	1.8
	14.8 to 19.2	314.8 to 310.4	4.4
08-158	0.5 to 8.8	329.5 to 312.2	8.3
	13.3 to 17.7	316.7 to 312.3	4.4
08-159	1.4 to 4.1	327.8 to 325.1	2.7
	5.6 to10.2	323.6 to 319.0	4.6
	10.9 to 15.7	318.3 to 313.5	4.8

* Silty clay

SPT 'N" values in the silty clay and silty clay till generally ranged from 14 to 83 blows per 0.3 m of penetration, indicating a stiff to hard consistency. SPT-N value of 100 blows per 0.3 m of penetration was measured in Borehole 08-157 at 6.0 m depth. The natural moisture contents generally lay in the range of 10 to 22%.

Grain size distribution curves for samples tested are presented on the Record of Borehole sheets and on Figures B1 and B2 of Appendix B. Atterberg Limits test results are presented on Figures B6 and B7 of Appendix B.

The results of the laboratory tests carried out on samples of silty clay till are summarized as follows:

Soil Particles	(%)
Gravel	0 to 5
Sand	0 to 34
Silt	30 to 68
Clay	23 to 69

Liquid Limit	19 to 55
Plastic Limit	11 to 23

The above results show that the silty clay/silty clay till ranges from low to high plasticity with group symbols of CL, CI and CH.

Although not specifically identified in the boreholes, glacial tills are known to contain cobbles and boulders.

5.4 Upper Sandy Silt Till

An upper layer of grey sandy silt till was contacted at 4.1 m depth (Elevation 325.1) in Borehole 08-159. Thickness of the upper sandy silt till layer is 1.5 m.

SPT 'N' value measured in this layer was 100 blows per 0.15 m of penetration, indicating a very dense relative density. Moisture content was 8%.

Grain size distribution curves for an upper sandy silt till sample tested is presented on the Record of Borehole sheets and on Figure B5 of Appendix B.

The results of laboratory tests are summarized as follows:

Soil Particles	(%)
Gravel	4
Sand	41
Silt	40
Clay	15

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

5.5 Silt/Silt Till

Layers of grey silt/silt till with some sand and trace of clay were encountered in Boreholes 08-157, 05-158 and 08-159 at depths of 10.3 m, 8.8 m and 10.2 m, (Elevations 319.3, 321.2 and 319.0), respectively. The base of this layer ranged from elevations 317.7 to 320.7. The thickness of the layer ranges from 0.5 m to 1.6 m.

SPT 'N" values in the silt were 20 and 27 blows per 0.3 m of penetration indicating a compact relative density. SPT 'N' value in the silt till in Borehole 08-159 was 100 blows per 0.15 m of penetration indicating a very dense relative density. The natural moisture contents generally lay in the range of 20 to 22%.

Grain size distribution curves for 3 samples tested are presented on the Record of Borehole sheets and on Figure B3 of Appendix B.

The results of the laboratory tests carried out on the samples are summarized as follows:

Soil Particles	(%)
Gravel	0 to 1
Sand	8 to 16
Silt	77 to 81
Clay	4 to 10

Although not specifically identified in the boreholes, glacial tills are known to contain cobbles and boulders.

5.6 Clayey Silt Till

Native grey clayey silt till layers were observed intermixed with the cohesive silty clay till layers at depths and elevations shown in Table 5.2.

Table 5.2 – Depths and Elevations of Native Clayey Silt Till

Borehole	Depth below existing ground surface (m)	Elevation (m)	Thickness (m)
08-157	11.9 to 14.8	317.7 to 314.8	2.9
08-158	9.3 to 13.3	320.7 to 316.7	4.0

SPT 'N" values in the clayey silt till generally ranged from 20 to 87 blows per 0.3 m of penetration, indicating a very stiff to hard consistency. SPT-N value of 125 blows per 0.3 m of penetration was measured in Borehole 08-158 at 12.2 m depth. The natural moisture contents generally lay in the range of 10 to 20%.

Grain size distribution curves for 3 samples tested are presented on the Record of Borehole sheets and on Figure B4 of Appendix B. Atterberg Limits test results are presented on Figure B8 of Appendix B.

The results of the laboratory tests are summarized as follows:

Soil Particles	(%)
Gravel	0
Sand	5 to 9
Silt	70 to 77
Clay	16 to 21

Liquid Limit	19 to 20
Plastic Limit	13

Although not specifically identified in the boreholes, glacial tills are known to contain cobbles and boulders.

5.7 Lower Sandy Silt Till

Lower layers of grey sandy silt till containing trace to some clay and trace gravel were observed in all the boreholes at elevations and depths indicated in Table 5.3. The three boreholes were terminated within the lower sandy silt till, upon refusal to auger.

Table 5.3 – Depths and Elevations of Native Sandy Silt Till

Borehole	Depth below existing ground surface (m)	Elevation (m)	Thickness (m)
08-157	19.2 to 20.8	310.4 to 308.8	1.6
08-158	17.7 to 21.4	312.3 to 308.6	3.7
08-159	15.7 to 20.0	313.5 to 309.2	4.3

SPT 'N' values ranged from 65 blows per 0.3 m of penetration to higher than 100 blows per 0.05 m of penetration indicating a very dense density. The natural moisture contents generally lay in the range of 8 to 18%.

Grain size distribution curves for samples tested are presented on the Record of Borehole sheets and on Figure B5 of Appendix B. Atterberg Limits test results are presented on Figure B9 of Appendix B.

The results of the laboratory tests carried out on lower sandy silt till samples are summarized as follows:

Soil Particles	(%)
Gravel	4 to 16
Sand	40 to 43
Silt	33 to 42
Clay	8 to 15

Liquid Limit	16
Plastic Limit	10

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

5.8 Groundwater Conditions

Water levels were observed in the boreholes during and upon completion of drilling. A standpipe piezometer was installed in Borehole 08-158 (at the proposed pier) to monitor water levels after completion of drilling. The water levels measured in the piezometer are summarized in Table 5.4, along with the measurements in the boreholes upon completion of drilling.

Table 5.4 – Water Level Measurements

Foundation Unit	Borehole	Date (2008)	Water Level (m)		Comment
			Depth	Elevation	
North Abutment	08-157	May 30	Dry	-	Open borehole
Pier	08-158	May 28 June 2 July 15 August 14	6.8 8.8 9.0 8.4	323.2 321.2 321.0 321.6	In piezometer
South Abutment	08-159	June 3	Dry	-	Open borehole

The piezometric reading indicates that the groundwater level is near Elevation 321.6.

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 CME 75 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 Interpretation of the data and preparation of the report were carried out by Mr. Alastair E. Gorman, P.Eng and Ms. R. Palomeque Reyna, P.Eng.

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

Thurber Engineering Ltd

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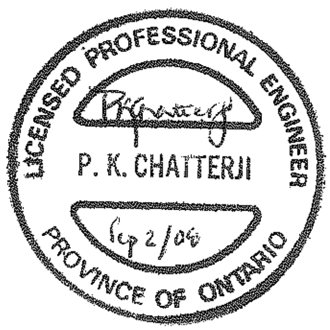

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Review Principal, Designated MTO Contact

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PART 2: ENGINEERING DISCUSSION AND RECOMMENDATIONS

7 GENERAL

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

Based on the Plate 11 of the E.A:

- The mainline will be in a cut 2.7 to 3.5 m deep at Elevation 326.5.
- Shantz Station Road will be at Elevation 333.8 with approach embankments 4.0 to 5.0 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 surficial topsoil and/or granular fill overlying cohesive layers of very stiff to hard silty clay/silty clay till and clayey silt till and a lower deposit of sandy silt till. The groundwater elevation measured in the piezometer was 321.6.

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 lower sandy silt till soil

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

8.1 Spread Footings on Native Soil

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

The 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 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)
North Abutment (BH 08-157)	2.4	327.2	300	200
	Below 6.0	Below 323.6	525	350
Pier (BH 08-158)	1.5	328.5*	600	400
	Below 2.4	327.6*	750	500
South Abutment (BH 08-159)	1.5	327.7	600	400

* Elevations are at or above the proposed Highway 7 grade (326.5).

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 generally above the 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

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, fill or other deleterious materials must be stripped from the footprint of the foundation to expose competent native subgrade material. Subexcavation of existing surficial topsoil, fill soils and native loose sands will be required. The engineered fill will bear on native very stiff to hard silty clay 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 08-157)	Pier (BH 08-158)	South Abutment (BH 08-159)
327.4*	328.5*	327.7*

* Elevations are higher than proposed Highway 7 finish grade (326.5 m)

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

- Factored ULS 900 kPa
- SLS 350 kPa

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

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

The Granular A pad must be compacted to 100% Standard proctor maximum dry density (SPMDD) at optimum moisture content ±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 glacial till 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 11 indicates that this depth of embedment should be achievable.

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	Anticipated Pile length below original ground (m)
North Abutment (BH 08-157)	308.7	20.9
Pier (BH 08-158)	311.0 *	19.0*
South Abutment (BH 08-159)	311.5	17.7

* Borehole termination elevation and depth

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 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 in very dense soil 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 very dense sandy silt till 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.

Higher geotechnical resistances may be achieved by installing the piles to greater depth. For piles extending below Elevation 308, 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 lower sandy silt till soil. The recommended foundation at the pier is a spread footing on hard native silty clay till soil.

9 BRIDGE APPROACHES AND EMBANKMENTS

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

No long term settlement or global stability issues are anticipated for approach embankments built at this site. The 4 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 11 may be at approximately 5.0 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.

10 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 Shantz Station 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. Boreholes for approaches.

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

3. Borehole termination depth for piles

   For piles extending below Elevation 308.0 (approximately) a greater depth of exploration is required.

11 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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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

THURBER

RECORD OF BOREHOLE No 08-157

METRIC

G.W.P. 408-88-00	LOCATION N 4 818 744.22 E 233 432.47		ORIGINATED BY SLL
HWY 7	BOREHOLE TYPE Hollow Stem Augers		COMPILED BY WM
DATUM Geodetic	DATE 2008.05.30 - 2008.06.02		CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
329.6 / 0.0	TOPSOIL: (75mm)				
0.1	Silty **SAND**, trace rootlets Loose Dark Brown Moist (FILL)	1	SS	6	
328.2 / 1.4	Silty, sandy **CLAY**, trace gravel Firm Brown (FILL)	2	SS	4	
327.4 / 2.2	Silty **CLAY**, some sand, trace gravel Very Stiff to Hard Brown to Grey (TILL)	3	SS	20	
		4	SS	30	1 11 39 49
		5	SS	28	
	occasional cobbles	6	SS	100	
		7	SS	54	
321.1 / 8.5	Silty **CLAY** Very Stiff Grey	8	SS	26	0 0 31 69

Column headings: SOIL PROFILE; STRAT PLOT; SAMPLES; GROUND WATER CONDITIONS; ELEVATION SCALE (329 to 320); 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

Continued Next Page

+ ³, × ³ : Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 08-157

METRIC

G.W.P. 408-88-00	LOCATION N 4 818 744.22 E 233 432.47		ORIGINATED BY SLL
HWY 7	BOREHOLE TYPE Hollow Stem Augers		COMPILED BY WM
DATUM Geodetic	DATE 2008.05.30 - 2008.06.02		CHECKED BY RPR

SOIL PROFILE; SAMPLES; GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20 40 60 80 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L, WATER CONTENT (%) (20 40 60); UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

Continued From Previous Page

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
	Silty **CLAY** Very Stiff Grey							
319.3 / 10.3	**SILT**, some fine sand, trace clay Compact Grey Wet	9	SS	27	0	16	80	4
317.7 / 11.9	Clayey **SILT**, trace to some sand Hard Grey (TILL)	10	SS	73				
		11	SS	87	0	9	70	21
314.8 / 14.8	Silty **CLAY**, trace sand, trace gravel, occasional cobbles Very Stiff Grey (TILL)	12	SS	22	0	5	30	65
		13	SS	22				
		14	SS	29				
310.4 / 19.2	Sandy **SILT**, some clay, trace gravel Very Dense Grey (TILL)							

Elevation scale: 319, 318, 317, 316, 315, 314, 313, 312, 311, 310

Continued Next Page

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

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

RECORD OF BOREHOLE No 08-157

METRIC

G.W.P. 408-88-00	LOCATION N 4 818 744.22 E 233 432.47		ORIGINATED BY SLL
HWY 7	BOREHOLE TYPE Hollow Stem Augers		COMPILED BY WM
DATUM Geodetic	DATE 2008.05.30 - 2008.06.02		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	GR	SA	SI	CL
	Continued From Previous Page													
	Sandy **SILT**, some clay, trace gravel Very Dense Grey (TILL)		15	SS	65		309				5	40	41	14
308.8 20.8	END OF BOREHOLE AT 20.8m. AUGER REFUSAL AT 20.8m ON PROBABLE BEDROCK OR BOULDER. BOREHOLE DRY UPON COMPLETION OF DRILLING. BOREHOLE BACKFILLED WITH BENTONITE BENSEAL TO 1.5m, HOLEPLUG FROM 1.5m TO 0.6m, THEN CUTTINGS TO SURFACE.													

Legend: O UNCONFINED; + FIELD VANE; ● QUICK TRIAXIAL; × LAB VANE. PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L. Scale: 20 40 60 80 100.

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

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

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No 08-158

METRIC

G.W.P. 408-88-00	LOCATION N 4 818 713.04 E 233 462.61	ORIGINATED BY SLL
HWY 7	BOREHOLE TYPE Hollow Stem Augers	COMPILED BY WM
DATUM Geodetic	DATE 2008.05.22 - 2008.05.23	CHECKED BY RPR

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
330.0 / 0.0	**SAND**, some gravel, mixed with clay, topsoil stained, Dark Brown (FILL)				330	
329.5 / 0.5	Silty **CLAY**, some sand to sandy, trace gravel, occasional cobbles, Stiff to Hard, Brown (TILL)	1	SS	14	329	
		2	SS	40	328	
		3	SS	67		
		4	SS	74	327	2 22 48 28
	becoming Grey				326	
		5	SS	46	325	
		6	SS	83	324	
	clay pockets	7	SS	61	323 / 322	1 18 47 34
321.2 / 8.8	**SILT**, some sand, trace gravel, trace clay, Compact, Grey, Wet				321	1 16 76 7
320.7 / 9.3	Clayey **SILT**, trace sand, trace gravel, Very Stiff, Grey: (TILL)	8	SS	20		

Groundwater level symbol shown at approx. elev. 321.7.

Chart headings: 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

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

THURBER

RECORD OF BOREHOLE No 08-158

METRIC

G.W.P. 408-88-00	LOCATION N 4 818 713.04 E 233 462.61	ORIGINATED BY SLL
HWY 7	BOREHOLE TYPE Hollow Stem Augers	COMPILED BY WM
DATUM Geodetic	DATE 2008.05.22 - 2008.05.23	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
	Clayey **SILT**, trace sand Hard Grey (TILL)				320	
		9	SS	51	319	0 5 75 20
					318	
		10	SS	125		0 7 78 15
316.7 / 13.3	Silty **CLAY**, trace sand, trace gravel Hard to Very Stiff Grey (TILL)				317	
		11	SS	55	316	
					315	
		12	SS	31		1 6 35 58
					314	
	Slow augering	13	SS	33	313	
312.3 / 17.7	Sandy **SILT**, some clay, trace gravel Very Dense Grey (TILL)				312	
		14	SS	100/ .175		4 42 39 15
					311	
		15	SS	100/		

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

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

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

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 08-158

METRIC

G.W.P. 408-88-00 | LOCATION N 4 818 713.04 E 233 462.61 | ORIGINATED BY SLL
HWY 7 | BOREHOLE TYPE Hollow Stem Augers | COMPILED BY WM
DATUM Geodetic | DATE 2008.05.22 - 2008.05.23 | 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**, some clay, trace gravel Very Dense Grey (TILL)				.125		310				
							309				
308.6			16	SS	100/				o		
21.4	END OF BOREHOLE AT 21.4m, AUGER REFUSAL ON PROBABLE BEDROCK OR BOULDER. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.				.100						

WATER LEVEL READINGS:

DATE	DEPTH(m)	ELEV.(m)
2008.05.28	6.8	323.2
2008.06.02	8.8	321.2
2008.07.15	9.0	321.0
2008.08.14	8.4	321.6

Legend: O UNCONFINED; + FIELD VANE; ● QUICK TRIAXIAL; × LAB VANE. PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L.

$+^3, \times^3$: Numbers refer to Sensitivity   20 / 15 ⊕ 5 / 10 (%) STRAIN AT FAILURE

ONTMT4S 6417R.GPJ 8/22/08

Ministry of Transportation Ontario

THURBER

RECORD OF BOREHOLE No 08-159

METRIC

G.W.P. 408-88-00 LOCATION N 4 818 685.97 E 233 461.96 ORIGINATED BY SLL

HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM

DATUM Geodetic DATE 2008.06.03 - 2008.06.03 CHECKED BY RPR

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
329.2					
0.0	**TOPSOIL:** (200 mm)				
0.2	Silty **CLAY**, trace gravel, occasional topsoil staining Stiff Brown (FILL)	1	SS	11	
327.8 / 1.4	Silty **CLAY**, some sand, trace gravel Hard Brown (TILL)	2	SS	63	
		3	SS	42	0 15 40 45
		4	SS	64	
325.1 / 4.1	Sandy **SILT**, some clay, trace to some gravel Very Dense Grey (TILL)	5	SS	100/150	4 41 40 15
323.6 / 5.6	Silty **CLAY**, trace sand Very Stiff to Hard Grey (TILL)	6	SS	47	0 6 39 55
		7	SS	29	
	occasional sand seams				
		8	SS	46	0 3 68 29

Column headings: SOIL PROFILE; STRAT PLOT; SAMPLES; GROUND WATER CONDITIONS; ELEVATION SCALE (329, 328, 327, 326, 325, 324, 323, 322, 321, 320); DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 20 40 60 80 100); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L, WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m[3].

Continued Next Page

+[3], ×[3]: Numbers refer to Sensitivity

15-⊕-5 (20/10) (%) STRAIN AT FAILURE

RECORD OF BOREHOLE No 08-159

METRIC

G.W.P. 408-88-00 LOCATION N 4 818 685.97 E 233 461.96 ORIGINATED BY SLL
HWY 7 BOREHOLE TYPE Hollow Stem Augers COMPILED BY WM
DATUM Geodetic DATE 2008.06.03 - 2008.06.03 CHECKED BY RPR

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page				
319.0					
10.2	**SILT**, trace sand, trace clay Very Dense Grey Wet (TILL)	9	SS	100/ .150	0 8 82 10
318.3 / 10.9	Silty **CLAY**, trace sand Very Stiff Grey (TILL)	10	SS	28	
		11	SS	23	0 1 35 64
	sandy, trace gravel	12	SS	50	5 34 38 23
313.5 / 15.7	Sandy **SILT**, some gravel, trace clay Very Dense Grey Wet (TILL)	13	SS	50/ .075	16 43 33 8
		14	SS	100/ .050	
309.2					

Elevation scale: 319, 318, 317, 316, 315, 314, 313, 312, 311, 310

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

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

15 20 5 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

THURBER

RECORD OF BOREHOLE No 08-159

METRIC

G.W.P. 408-88-00	LOCATION N 4 818 685.97 E 233 461.96	ORIGINATED BY SLL
HWY 7	BOREHOLE TYPE Hollow Stem Augers	COMPILED BY WM
DATUM Geodetic	DATE 2008.06.03 - 2008.06.03	CHECKED BY RPR

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
	Continued From Previous Page										
20.0	END OF BOREHOLE AT 20.0m. AUGER REFUSAL ON PROBABLE BEDROCK OR BOULDER. BOREHOLE DRY UPON COMPLETION OF DRILLING. BOREHOLE BACKFILLED WITH GROUT TO 15.0m, HOLEPLUG TO 3.0m, THEN AUGER CUTTINGS TO SURFACE.		15	SS	100/ .025						

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

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

Appendix B

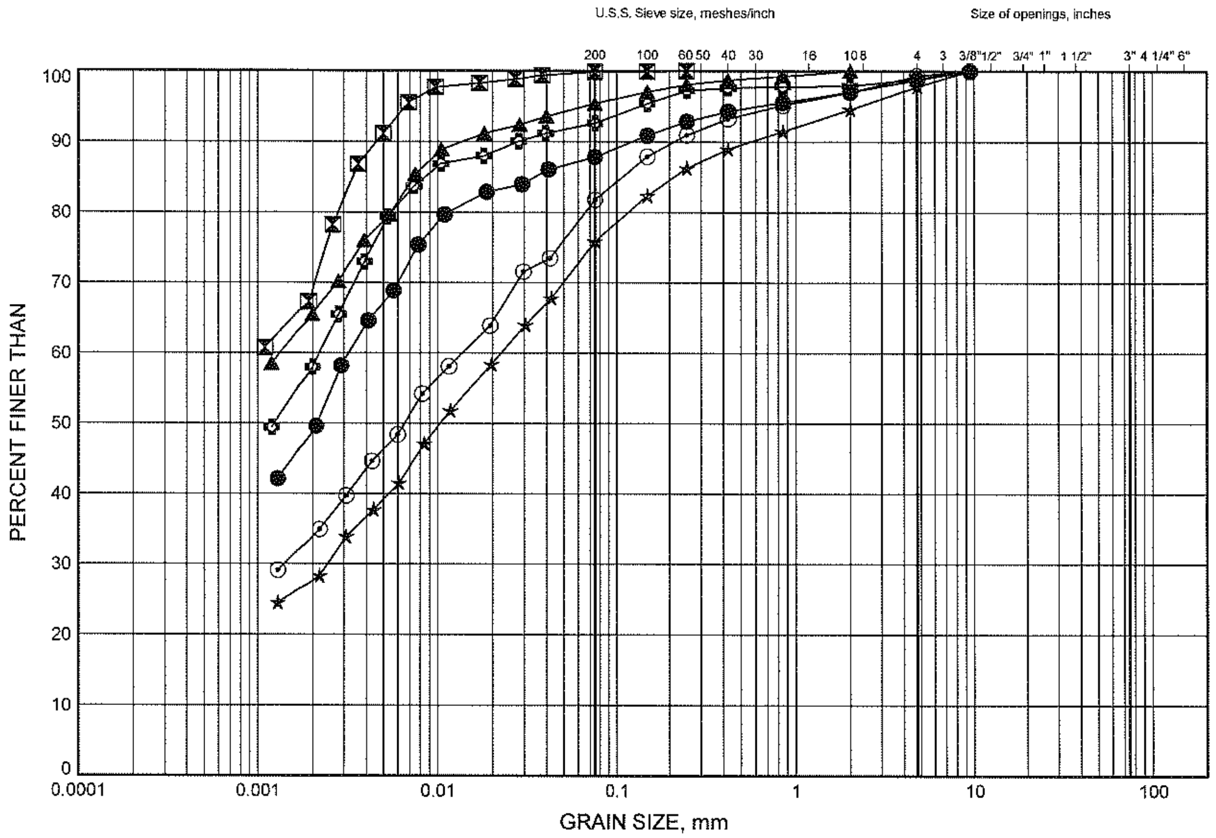
Laboratory Test Results

Highway 7 - New

GRAIN SIZE DISTRIBUTION

FIGURE B1

Silty Clay Till



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-157	3.35	326.25
⊠	08-157	9.45	320.15
▲	08-157	15.54	314.06
☆	08-158	3.35	326.65
⊙	08-158	7.92	322.08
✪	08-158	15.54	314.46

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

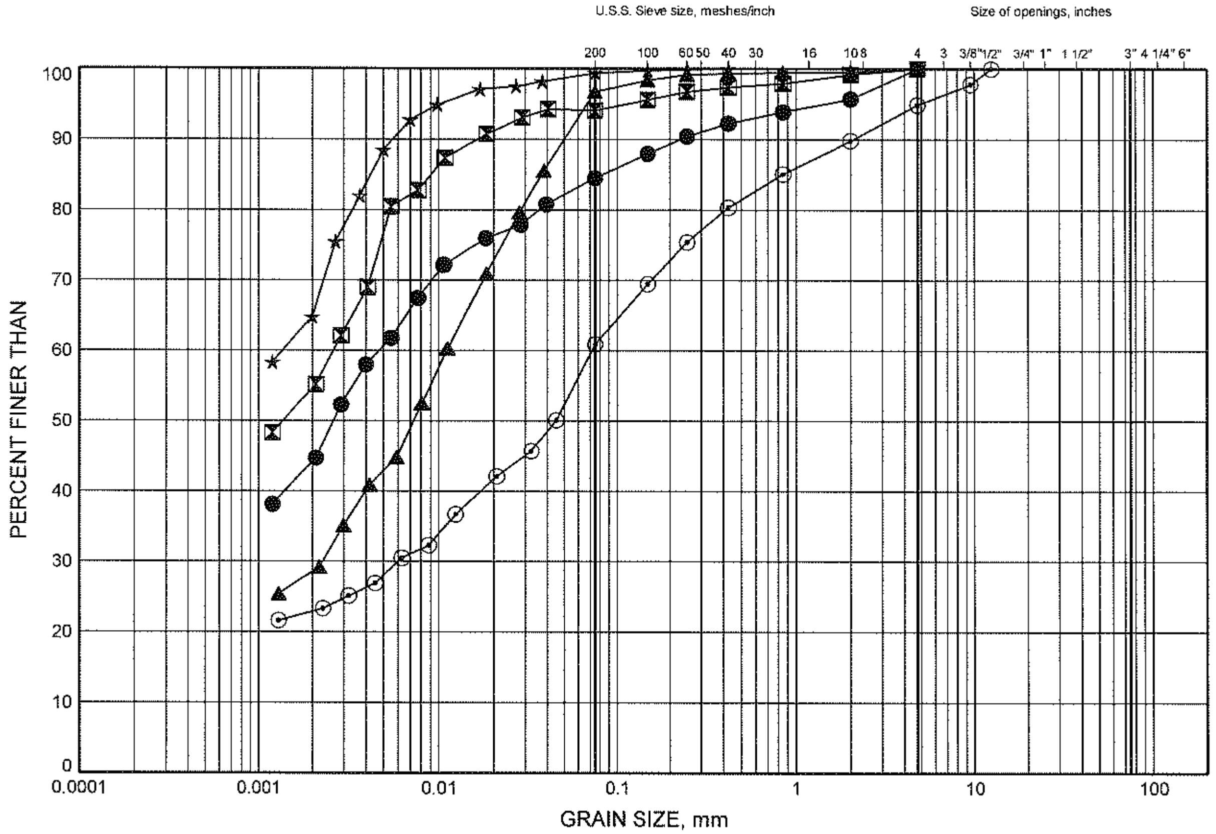
THURBER

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)
●	08-159	2.59	326.61
⊠	08-159	6.40	322.80
▲	08-159	9.37	319.83
☆	08-159	14.02	315.18
⊙	08-159	15.49	313.71

W.P.# 408-88-00

Prepared By MFA

Checked By RPR

THURBER

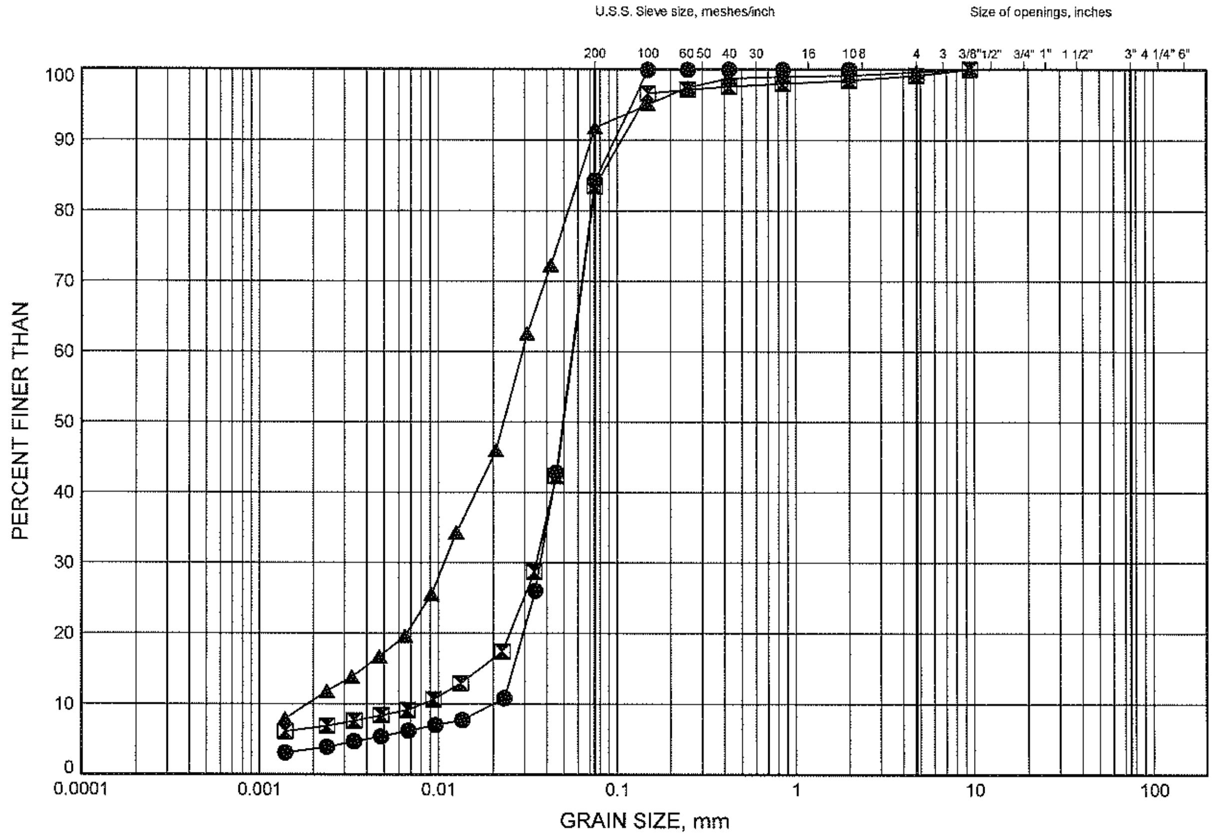
GRAIN SIZE DISTRIBUTION - THURBER 6417R.GPJ 8/19/08

Highway 7 - New

GRAIN SIZE DISTRIBUTION

FIGURE B3

Silt / Silt Till



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-157	10.97	318.63
⊠	08-158	9.24	320.76
▲	08-159	10.79	318.41

W.P.# 408-88-00

Prepared By MFA

Checked By RPR

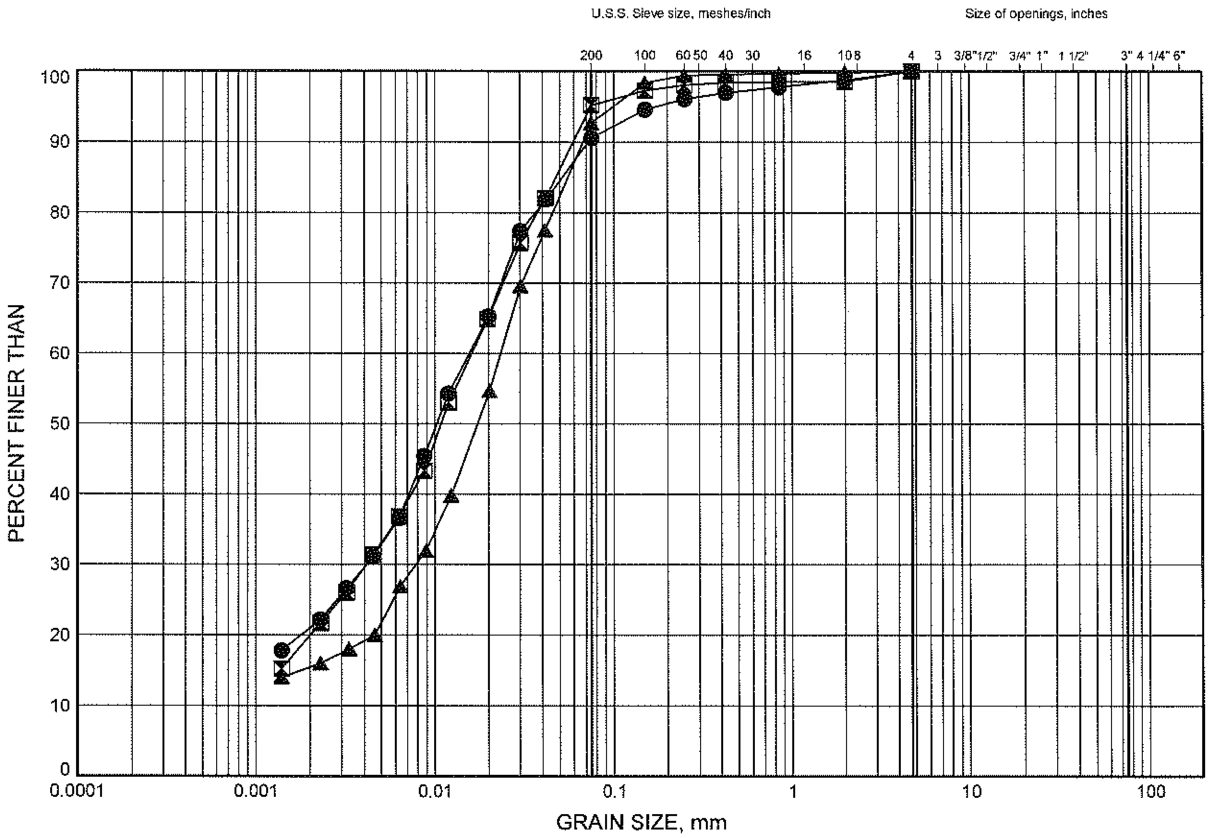
THURBER

Highway 7 - New

GRAIN SIZE DISTRIBUTION

FIGURE B4

Clayey Silt Till



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-157	14.02	315.58
⊠	08-158	10.97	319.03
▲	08-158	12.50	317.50

W.P.# 408-88-00

Prepared By MFA

Checked By RPR

THURBER

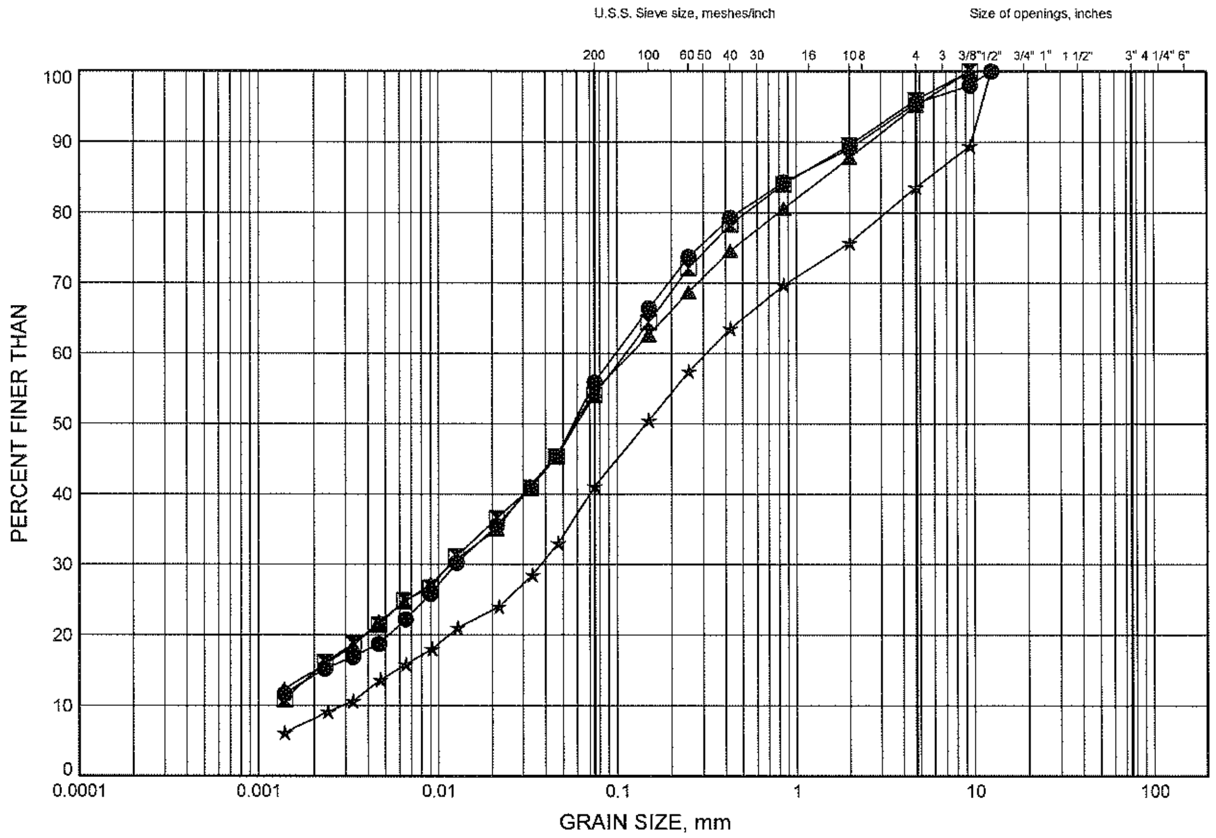
GRAIN SIZE DISTRIBUTION - THURBER 6417R.GPJ 8/19/08

Highway 7 - New

GRAIN SIZE DISTRIBUTION

FIGURE B5

Sandy Silt Till



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	08-157	20.04	309.56
⊠	08-158	18.30	311.70
▲	08-159	4.72	324.48
☆	08-159	16.89	312.31

W.P.# 408-88-00

Prepared By MFA

Checked By RPR

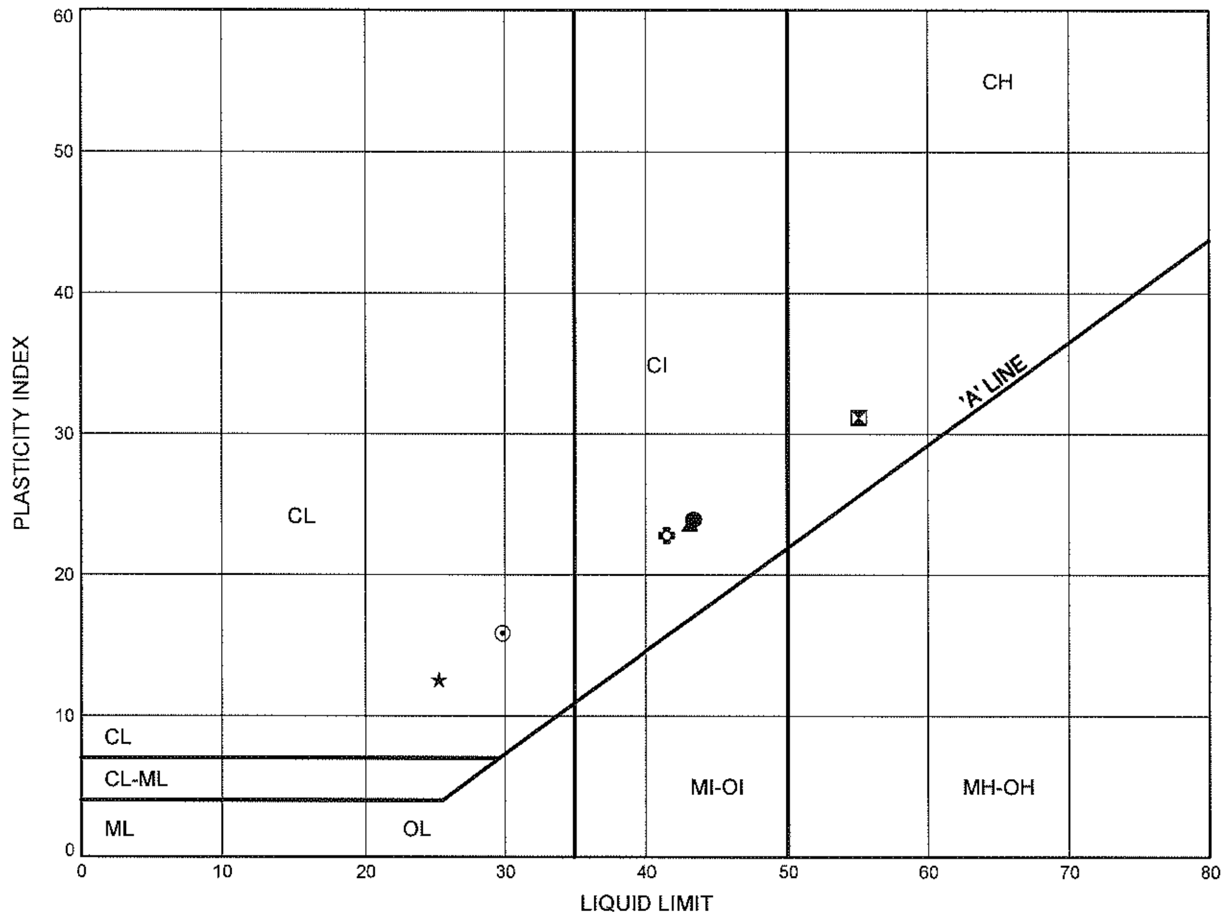
THURBER

Highway 7 - New

ATTERBERG LIMITS TEST RESULTS

FIGURE B6

Silty Clay Till



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	08-157	3.35	326.25
⧗	08-157	9.45	320.15
▲	08-157	15.54	314.06
★	08-158	3.35	326.65
⊙	08-158	7.92	322.08
✪	08-158	15.54	314.46

THURBALT 6417R.GPJ 8/19/08

Date August 2008

Project 408-88-00

THURBER

Prep'd MFA

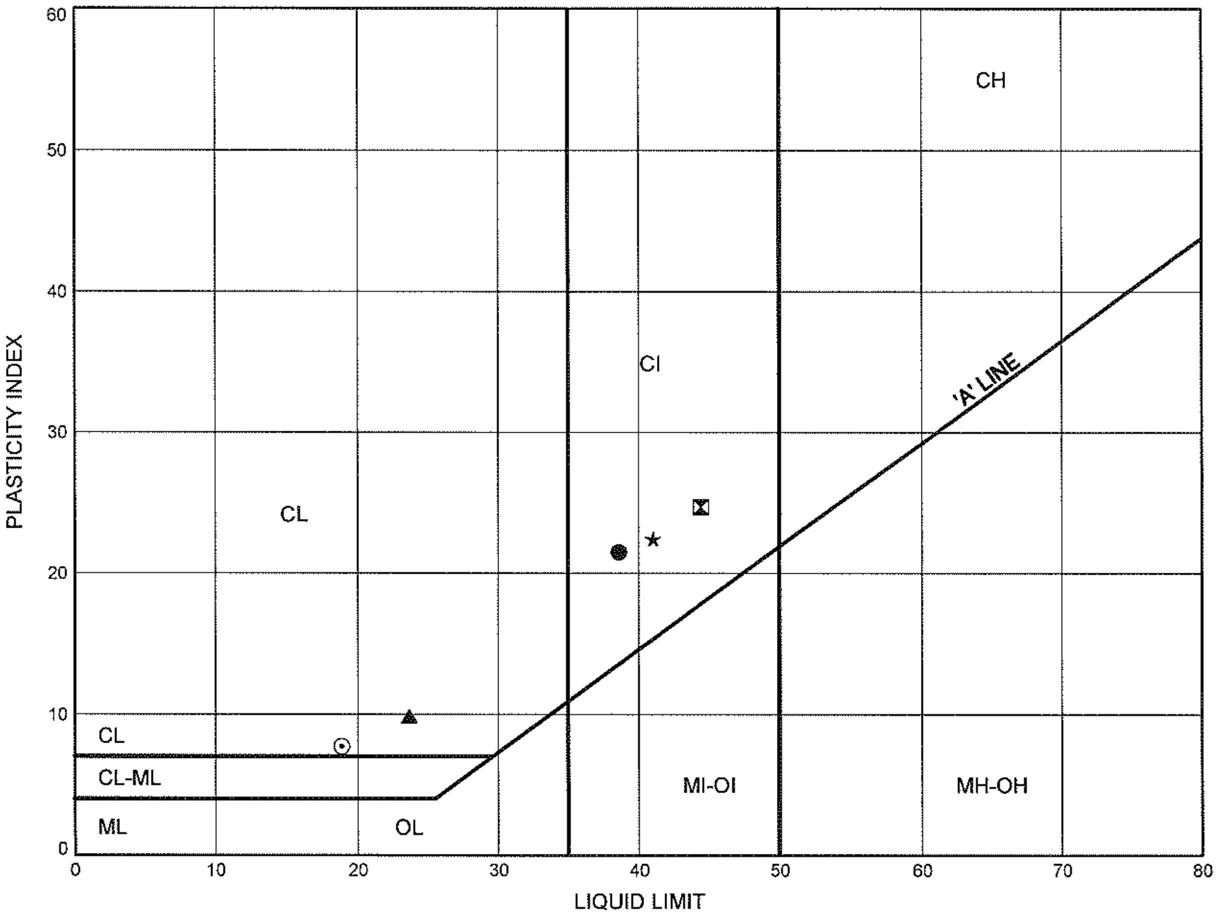
Chkd. RPR

Highway 7 - New

ATTERBERG LIMITS TEST RESULTS

FIGURE B7

Silty Clay Till



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	08-159	2.59	326.61
⧗	08-159	6.40	322.80
▲	08-159	9.37	319.83
★	08-159	14.02	315.18
⊙	08-159	15.49	313.71

Date August 2008
Project 408-88-00

THURBER

Prep'd MFA
Chkd. RPR

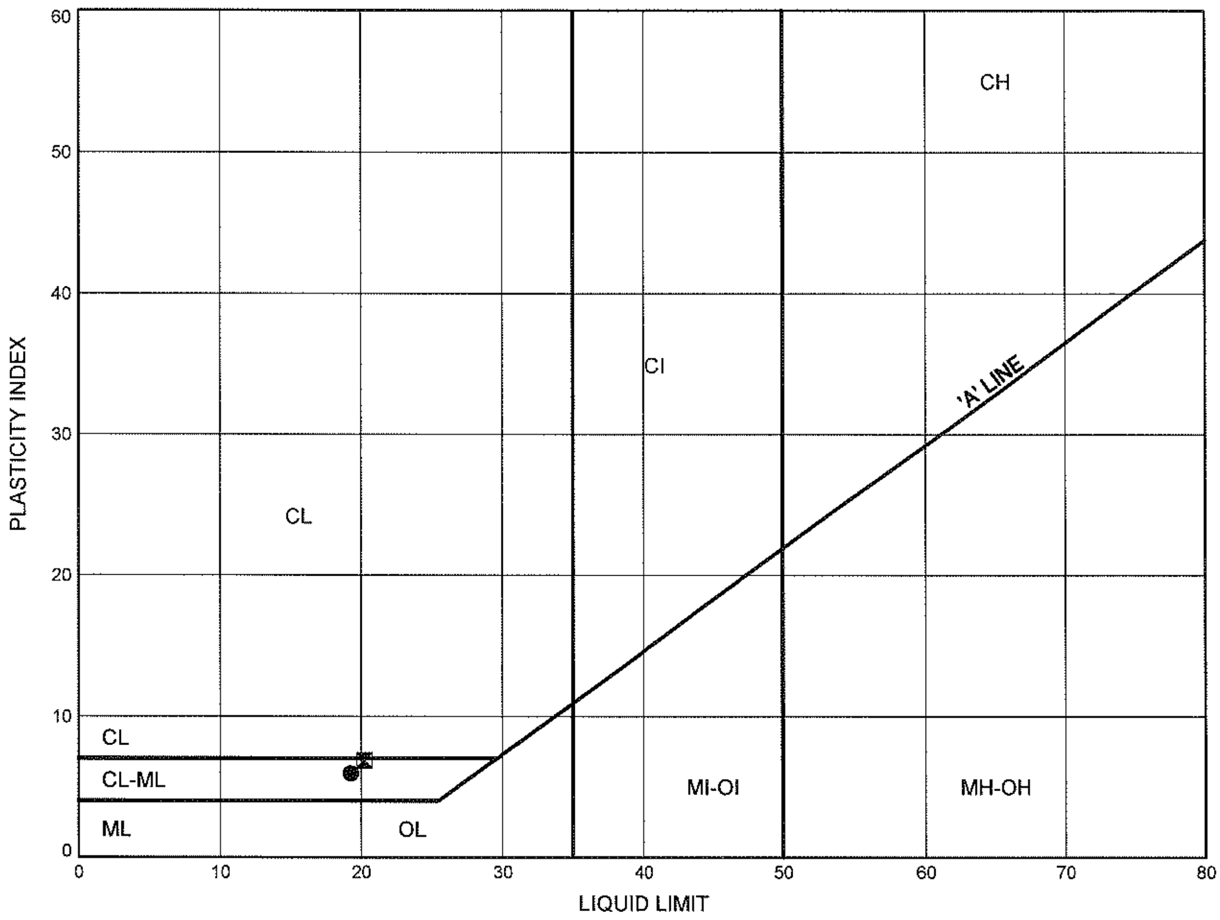
THURBALT 6417R.GPJ 8/19/08

Highway 7 - New

ATTERBERG LIMITS TEST RESULTS

FIGURE B8

Clayey Silt Till



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	08-157	14.02	315.58
⊠	08-158	10.97	319.03

THURBALT 6417R.GPJ 8/19/08

Date August 2008

Project 408-88-00

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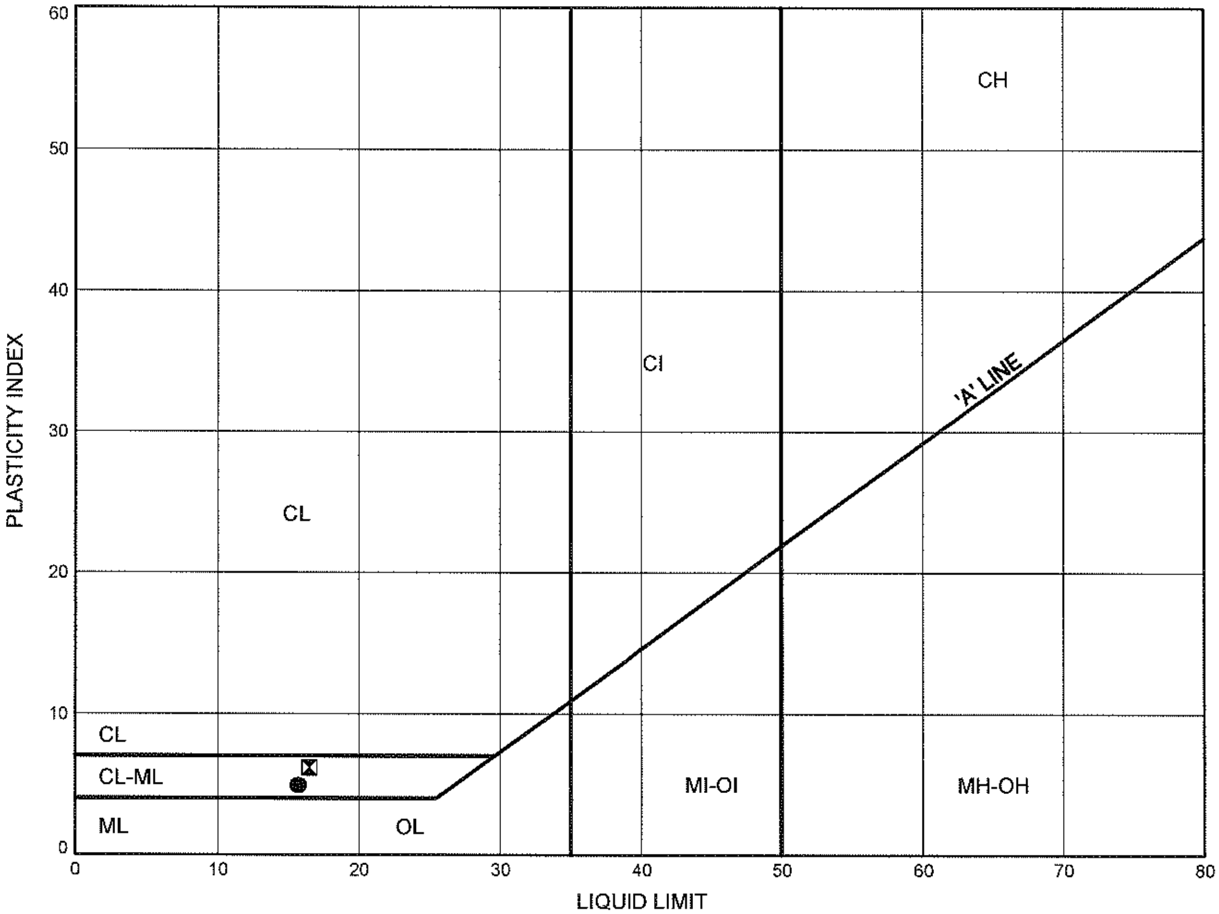
Chkd. RPR

Highway 7 - New

ATTERBERG LIMITS TEST RESULTS

FIGURE B9

Sandy Silt Till



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	08-157	20.04	309.56
⊠	08-158	18.44	311.56

Date August 2008

Project 408-88-00

THURBER

Prep'd MFA

Chkd. RPR

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Appendix C

Foundation Comparison

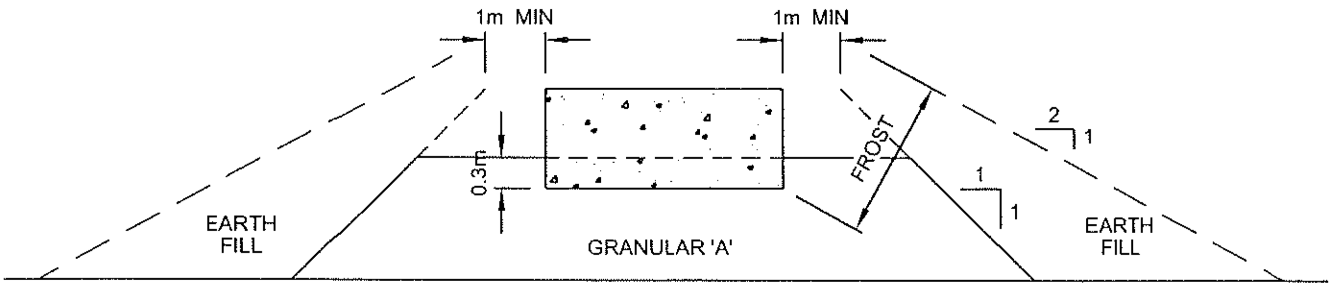
COMPARISON OF FOUNDATION ALTERNATIVES FOR EACH FOUNDATION ELEMENT

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**
Pier	***Advantages:*** i. Generally less costly construction than deep foundation elements. ***Disadvantages:*** i. Dewatering may be required, depending on depth of excavation. **RECOMMENDED**	***Advantages:*** i. Generally less costly construction than deep foundation elements. ***Disadvantages:*** i. 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. ***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. **NOT RECOMMENDED**

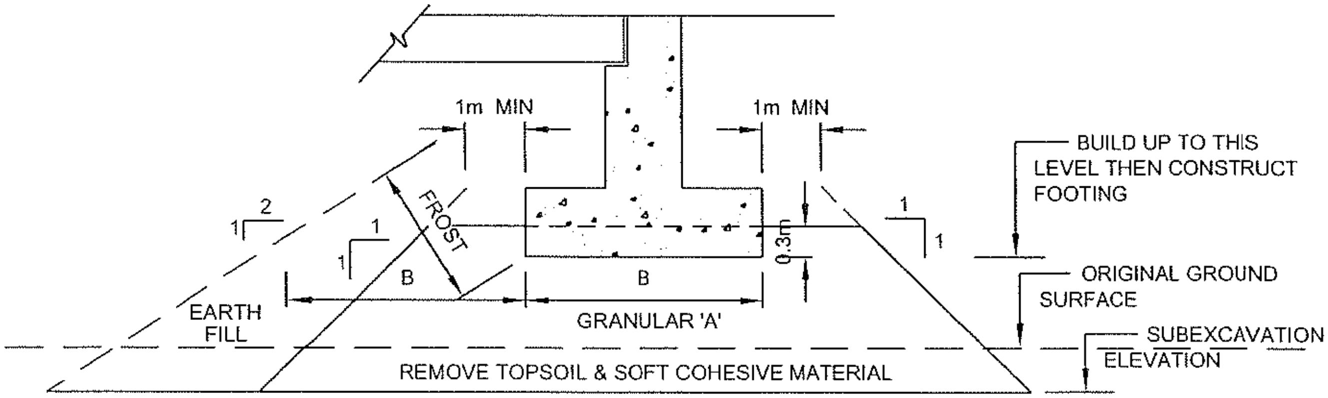
Appendix D

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

TE035146.DWG

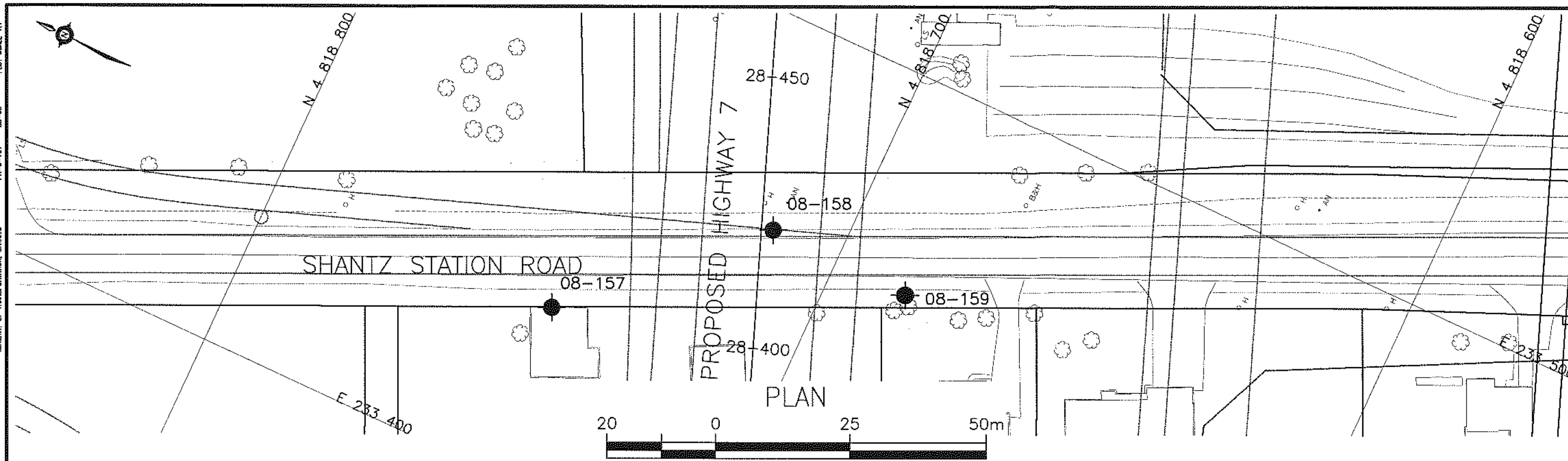
Appendix E

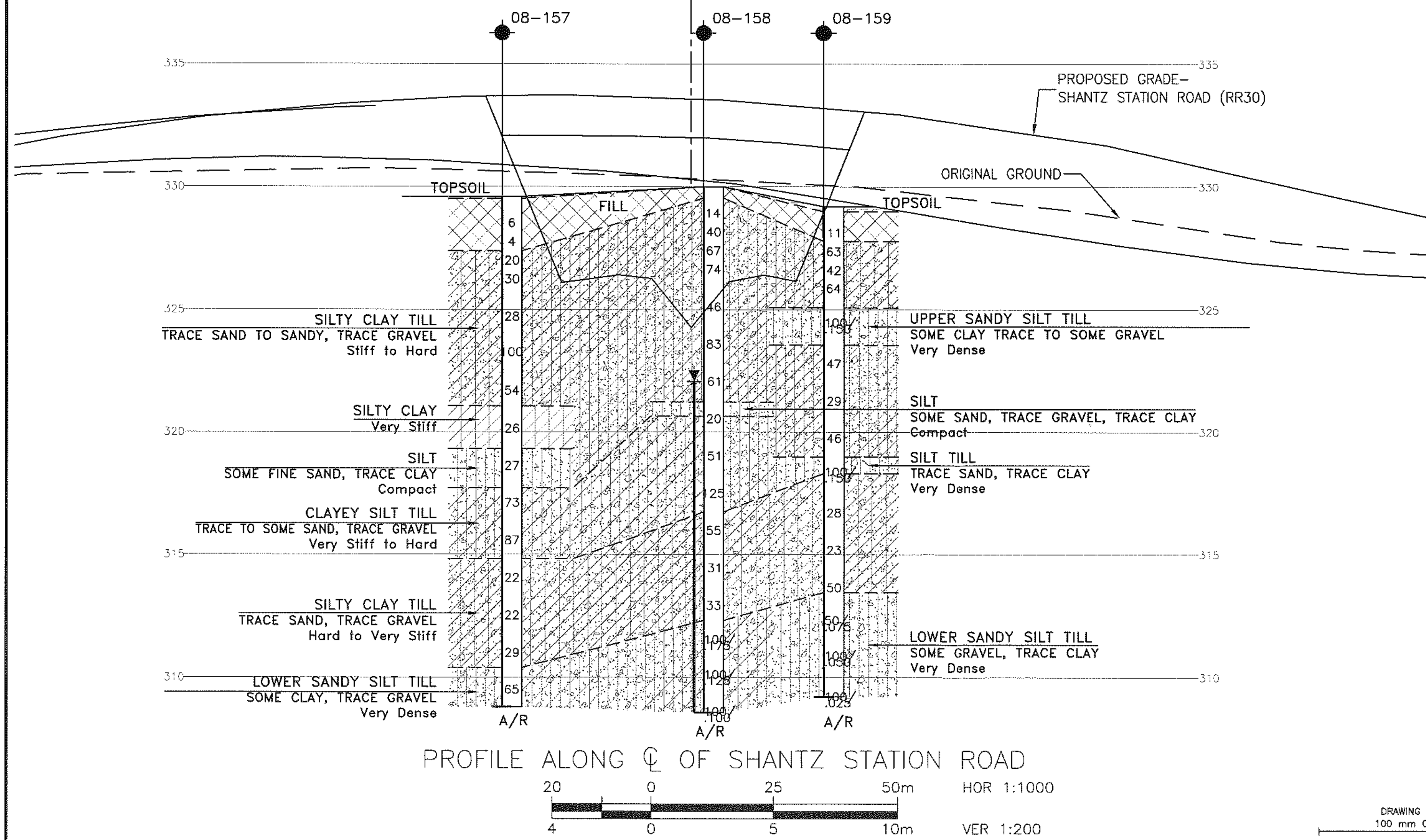
Site Photograph

Photo 1. Looking south along Shantz Station Road

Appendix F

Drawing titled "Borehole Locations and Soil Strata"





METRIC

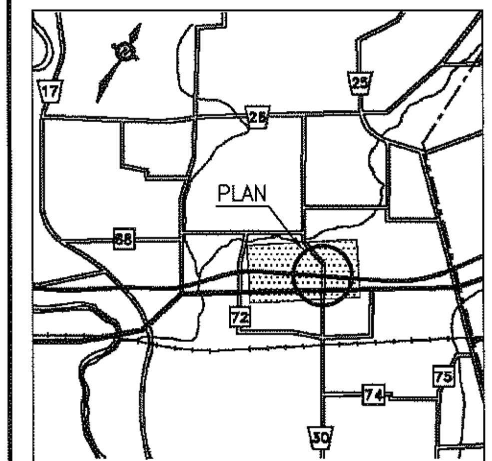
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

CONT No
GWP No 408–88–00

SHEET

HIGHWAY 7
RECOMMENDED ROUTE
SHANTZ STATION ROAD
BOREHOLE LOCATIONS AND SOIL STRATA

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
08–157	329.6	4 818 744.2	233 432.5
08–158	330.0	4 818 713.0	233 462.6
08–159	329.2	4 818 686.0	233 462.0

-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 13 of the E.A. Study.

GEOCRES No. 40P9-47

DRAWING NOT TO BE SCALED
100 mm ON ORIGINAL DRAWING

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