FOUNDATION INVESTIGATION AND DESIGN REPORT
HIGHWAY 427 WIDENING
FROM FASKEN DRIVE TO STEELES AVENUE
CN HALTON SUBDIVSION OVERHEAD
TORONTO, ONTARIO
G.W.P. 202-95-00

Geocres Number: 30M12-288

Report to

SNC-Lavalin

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November 26, 2009
File: 19-92-70

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PART 1: FACTUAL INFORMATION

1 INTRODUCTION

This report presents the factual findings obtained from a foundation investigation conducted for the design and construction of the proposed widening of the existing mainline bridge structures at the Highway 427 overhead crossing at the CN Halton Subdivision in Toronto, Ontario.

The purpose of the investigation was to explore the subsurface conditions at the site and, based on the data obtained, provide a borehole location plan, borehole logs, stratigraphic profile and cross-sections and a written description of the subsurface conditions. A model of the subsurface conditions was developed to describe the geotechnical conditions influencing design and construction of the foundations and approach embankments for the structures.

Thurber carried out the investigation as a sub-consultant to SNC-Lavalin under the Ministry of Transportation Ontario (MTO) Agreement Number 2004-E-0071.

During the preparation of this report and in addition to the boreholes drilled for the proposed structure widening, reference has been made to available information on subsurface conditions from a previous investigation documented in the report below.

- MTO report titled "Foundation Investigation and Design Report, Hwy 427 C.N.R. Overhead (Halton Subdivision), W.P. 153-80-02, Site No. 37-1109, Central Region, Toronto", GEOCRES No.30M12-235, 1981 (Reference 1).

2 SITE DESCRIPTION

The site is located approximately 300 m south of Albion Road and 1.6 km west of Highway 27 in Toronto, Ontario. The site is generally flat except for the embankment fills, and the vegetation is moderate consisting mainly of tall grass and shrubs.

Lands surrounding the site have been developed for commercial and industrial uses.

The existing structure consists of the northbound and southbound (NBL and SBL) bridges of Highway 427 over the existing CN tracks which run in an east-west orientation.

Photographs of the site are included in Appendix G and show the general layout of the adjacent lands.

The site is situated within the South Slope physiographic region. The geology generally comprises a till plain consisting of clayey silt to silty clay (Halton Till) overlying bedrock at relatively shallow depth. The bedrock consists of grey shale with hard siltstone and limestone interlayers of the Georgian Bay Formation.

3 SITE INVESTIGATION AND FIELD TESTING

The present site investigation was carried out from December 1 to 18, 2008. The field program consisted of drilling and sampling ten boreholes (numbered CNH-01 to CNH-10) at the site. Boreholes were drilled at locations of the structure abutments, piers and approaches parallel to the alignments of, and between, the existing Highway 427 bridges.

Boreholes CNH-02 to CNH-04 and CNH-06 to CNH-08 drilled for the proposed piers and abutments were terminated upon refusal in silty sand and silty clay till at depths ranging from 13.9 m to 23.2 m (Elevations 152.4 to 165.7 m). Boreholes CNH-09 and CNH-10 drilled at the south and north approaches, respectively, were terminated in silty clay fill and silty clay till at 6.7 m depth (Elevations 173.1 and 174.6 m).

Boreholes CNH-01 and CNH-05, drilled near the south abutment, were terminated upon refusal in bedrock at 25.0 m and 26.1 m depths (Elevations 155.3 and 154.1 m). Borehole CNH-01 was further advanced into shale bedrock by coring to a depth of 30.9 m (Elevation 149.4 m).

The approximate borehole locations are shown on the Borehole Locations and Soil Strata Drawing in Appendix H. The coordinates and elevations of the boreholes are given on these drawings and on the individual Record of Borehole Sheets in Appendix A. Records of boreholes (numbered 1 to 8) drilled during the previous investigation (1981) are enclosed in Appendix C.

Prior to commencement of drilling, utility clearances were obtained for all borehole locations. A CN permit was obtained and flagging from CN Rail was used while drilling within the CN right of way.

Solid stem augers were used to advance the boreholes in the overburden and into the shale. Samples were obtained at selected intervals using a split spoon sampler in conjunction with Standard Penetration Testing (SPT). NQ rock coring equipment was used to recover core samples of the bedrock in Borehole CNH-01. Core samples of the shale bedrock were carefully protected to prevent drying during transport to the laboratory

A member of Thurber's engineering staff supervised the drilling and sampling operations on a full time basis. The supervisor logged the boreholes, visually examined the recovered samples, and transported them to Thurber's laboratory for further examination and testing.

All rock cores were logged, and the Total Core Recovery (TCR), Rock Quality Designation (RQD) and the Fracture Indices (FI) were determined.

Groundwater conditions in the open boreholes were observed throughout the drilling operations. Three standpipe piezometers consisting of 19 mm PVC pipes with screens were installed in selected boreholes to permit monitoring of groundwater levels. Details of the piezometer installations and other borehole completion details are as shown in Table 3.1.

Table 3.1 – Borehole Completion Details

Foundation Unit		Borehole	Piezometer Tip Depth/ Elevation (m)	Completion Details
South Approach		CNH-09	None installed	Bentonite holeplug to surface.
South Abutment	Median	CNH-01	None installed	Borehole grouted with bentonite to surface.
South Abutment	Median	CNH-05	25.0/155.2	Piezometer with 1.5 m slotted screen installed with sand filter to 21.3 m, bentonite holeplug from 21.3 m to 19.8 m, bentonite grout from 19.8 m to 2.4 m, then bentonite holeplug to ground surface.
South Pier	CNR grade	CNH-02	None installed	Bentonite grout to 2.1 m, then bentonite holeplug to surface.
South Pier	CNR grade	CNH-06	15.2/156.1	Piezometer with 1.5 m slotted screen installed with sand filter to 13.4 m, bentonite holeplug from 13.4 m to 12.5 m, bentonite grout from 12.5 m to 1.5 m, then bentonite holeplug to ground surface.
North Pier	CNR grade	CNH-03	12.7/158.9	Piezometer with 1.5 m slotted screen installed with sand filter to 7.6 m, bentonite holeplug from 7.6 m to 7.0 m, bentonite grout from 7.0m to 1.5 m, then bentonite holeplug to ground surface.
North Pier	CNR grade	CNH-07	None installed	Bentonite grout to 1.5 m, then holeplug to surface.
North Abutment	Median	CNH-04	None installed	Bentonite holeplug and auger cuttings to 0.075m, then asphalt to surface.
North Abutment	Median	CNH-08	None installed	Bentonite holeplug and auger cuttings to 0.075m, then asphalt to surface.
North Approach		CNH-10	None installed	Bentonite holeplug and auger cuttings to 0.075m, then asphalt to surface.

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4 LABORATORY TESTING

All recovered soil samples were subjected to Visual Identification (VI) and rock samples to geological logging. At least 25% of the recovered samples of soil were also subjected to grain size distribution analyses (sieve and hydrometer) and Atterberg Limits testing where appropriate. Moisture content determinations were carried out on all soil samples. 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. Laboratory testing results from the 1981 investigation (Reference 1) are also included in Appendix C.

5 DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Records of Borehole sheets in Appendix A. Details of the encountered soil and rock stratigraphy are presented in this appendix and on the Borehole Locations and Soil Strata Drawing in Appendix H. 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 terms, the soil stratigraphy encountered at this site outside of the railway tracks comprises surficial topsoil or pavement structure overlying fill underlain by native silty clay till and silty sand. Weathered shale bedrock was contacted below the silty sand at the south abutment of the Highway 427 SBL. More detailed descriptions of the individual strata are presented below.

5.1.1 Topsoil

Topsoil was identified surficially in Boreholes CNH-01, CNH-05 and CNH-09. The topsoil thickness generally ranged from 50 mm to 75 mm. The topsoil thickness may vary between and beyond the borehole locations and the data is not intended for the purpose of estimating quantities.

5.1.2 Pavement Structure

Pavement structure consisting of approximately 75 mm of asphalt overlying granular (gravelly sand to silt and sand fill) road base was encountered in Boreholes CNH-04, CNH-08 and CNH-10 drilled at the Highway 427 median shoulder. The road base granular fill was 1.0 m thick in Borehole CNH-08 and the fill is in a dense to very dense state with SPT 'N' values ranging from 47 to 60 blows per 0.3 m of penetration. The moisture content of the granular fill is in the order of 5% to 7%.

5.1.3 Sub-ballast

A 200-mm thick layer of rail sub-ballast was encountered surficially in Borehole CNH-03 drilled near the existing north pier of Highway 427 SBL.

5.1.4 Fill

Fill was contacted below the topsoil and the asphalt in boreholes drilled at the existing approaches and embankments (Boreholes CNH-01, CNH-04, CNH-05 and CNH-08 to CNH-10). It is understood that the fill was placed during construction of the existing bridges. The fill generally consists of layers of various types of soils:

- Brown silty clay with sand and trace gravel
- Brown silt and sand containing trace to some gravel and trace clay
- Brown gravelly sand

The thickness of the fill ranged from 6.7 m to 9.1 m at the south abutment and south approach and from 3.9 m to 4.5 m at the north abutment and north approach.

The depths to the base of the fill ranged from 4.0 m to 9.1 m (Elevations 171.1 to 177.3 m).

Borehole CNH-09 was terminated within the silty clay fill at 6.7 m depth (Elevation 173.1m).

Based on SPT 'N' values ranging from 8 to 30 blows per 0.3 m of penetration, the cohesive fill is described as stiff to hard in consistency. The cohesionless fill (silt and sand, and gravelly sand) is described as loose to very dense, based on SPT 'N' values of 7 to 60 blows per 0.3 m of penetration.

The natural moisture contents of the fill samples ranged from 8% to 21%.

Grain size distribution curves for fill samples tested are presented on the Record of Borehole sheets and on Figures B1 and B2 of Appendix B. Atterberg Limit test results are presented on Figure B10 of Appendix B.

The results of laboratory tests are summarized as follows:

Soil Particles	Silty Clay Fill (%)	Silty Sand Fill (%)
Gravel	3 to 8	0
Sand	24 to 31	45 to 55
Silt	34 to 41	39 to 51
Clay	25 to 34	4 to 6

Liquid Limit	36 to 38	-
Plasticity Index	20	-

The above results show that the silty clay fill is typically of medium plasticity with a group symbol of CI.

5.1.5 Silty Clay Till

Native brown to grey silty clay till with sand and trace gravel was contacted below the asphalt, topsoil, sub-ballast and fill at depths ranging from 8.5 m to 9.1 m at the south abutment, 4.0 m to 4.6 m at the north abutment and at 0.2 m at the north pier.

During the present investigation, silty clay till was also contacted suficially in two boreholes drilled at the south pier (Boreholes CNH-02 and CNH-06) and in one borehole drilled at the north pier (Borehole CNH-07). Silty clay till was also encountered surficially in the eight boreholes drilled during the previous investigation.

Thickness of the silty clay till ranged from 7.4 m to 13.8 m.

Layers of clayey silt were encountered within the silty clay till deposit.

A 1.6 m thick layer of silty clay till was also contacted at 9.1 m depth (Elevation 162.5 m) in Borehole CNH-03.

The depth to the base of the silty clay till ranged from 10.7 m to 21.3 m (Elevations 158.9 to 163.4 m).

Boreholes CNH-08 and CNH-10 were terminated within the silty clay till at 15.6 m and 6.7 m depth (Elevations 165.7 and 174.6 m).

Based on SPT 'N' values ranging from 8 to 92 blows for 0.3 m of penetration, the silty clay till is described as firm to hard in consistency. SPT 'N' values higher than 100 blows per 0.225 m of penetration were observed at or below Elevation 169.0 m in Boreholes CNH-04 and CNH-08, and near Elevations 166.0 to 163.0 m in Boreholes 6 and 7.

The natural moisture contents of the samples recovered from the silty clay till layer ranged from 8% to 30%.

Grain size distribution curves for the silty clay till samples tested are presented on the Record of Borehole sheets and on Figures B3 to B5 of Appendix B. Grain size distribution curves for clayey silt samples are presented on Figure B6 of Appendix B Atterberg Limit test results are presented on Figures B11 to B13 of Appendix B.

Laboratory test results of previous investigation are presented in Appendix C.

The results of laboratory tests are summarized as follows:

Soil Particles	Silty Clay Till (%)	Clayey Silt (%)
Gravel	0 to 23	0
Sand	3 to 46	1 to 4
Silt	27 to 82	74 to 83
Clay	4 to 40	16 to 25

Liquid Limit	18 to 48	-
Plasticity Index	8 to 27	-

The above results show that the silty clay till is typically of low to medium plasticity with a group symbol of CL-CI.

Cobbles and boulders were noted in the silty clay till in Boreholes 3, 5, 6 and 7 drilled during the previous investigation. Glacial tills inherently contain cobbles and boulders which may occur for some high blow counts and resistance to augering.

5.1.6 Silty Sand

Native grey silty sand was contacted below the silty clay till in Boreholes CNH-01 to CNH-03 and CNH-05 to CNH-07, and 1 to 8, drilled for the present and previous investigations, respectively. The silty sand contains trace gravel, trace clay and occasional cobbles, boulders throughout the deposit and shale fragments.

The silty sand layer was fully penetrated in Borehole CNH-01 located at the south abutment, with a thickness of 5.2 m.

A layer of sand was encountered within the silty sand in Borehole CNH-01 near Elevation 157.0 m.

A layer of silt and sand was contacted below the silty clay till at 17.8 m depth in Borehole CNH-04. Borehole CNH-04 was terminated within the silt and sand layer at 23.2 m (Elevation 158.0 m).

Layers of sand and gravel and layers of cobbles and boulders were encountered within the silty sand layer in boreholes drilled during the previous investigation.

Boreholes were terminated within the silty sand layer at depths ranging from 13.9 m to 26.1 m (Elevations 147.7 to 158.0 m). Borehole 3, drilled at the south pier of the Highway 427 NBL, was terminated at 33.4 m depth (Elevation 138.1 m).

SPT 'N' values measured in the silty sand layer generally ranged from 100 to 128 blows per 0.3 m of penetration, indicating a very dense relative density. An SPT 'N' value of 20 blows per 0.3 m of penetration, indicating compact relative density, was measured in Borehole CNH-01 near Elevation 157.0. SPT 'N" values higher than 100 blows per 0.1 m of penetration were measured near borehole termination depths.

The natural moisture contents of the samples recovered from the silty sand layer ranged from 10% to 19%.

Grain size distribution curves for the silty sand samples tested are presented on the Record of Borehole sheets and on Figures B7 and B8 of Appendix B.

Laboratory test results of the previous investigation are presented in Appendix C.

The results of laboratory tests are summarized as follows:

Soil Particles	Sand (%)	Silt and Sand (%)	Silty Sand (%)
Gravel	4	5	0 to 25
Sand	80	37	28 to 85
Silt	-	42	11 to 64
Clay	-	16	1 to 15
Silt & Clay	16	-	-

Occasional cobbles and boulders are reported throughout the silty sand layer, and the lower part of this deposit (just above bedrock) may contain pieces and slabs of bedrock which may account for some high blow counts and resistance to augering.

5.1.7 Sandy Silt

Native grey sandy silt containing trace clay was contacted within the silty clay till in Boreholes CNH-03 and CNH-07 drilled for the present investigation. The thickness of the sandy silt was 1.5 m and 1.0 m in Boreholes CNH-03 and CNH-07, respectively.

The depths to the base of the sandy silt were 9.1 m and 6.9 m (Elevations 162.5 and 164.7 m).

Based on SPT 'N' values of 15 and 60 blows for 0.3 m of penetration, the sandy silt is described as compact to very dense.

The natural moisture contents of the samples recovered from the sandy silt layer were 20%.

Grain size distribution curves for two sandy silt samples tested are presented on the Record of Borehole sheets and on Figure B9 of Appendix B.

The results of laboratory tests are summarized as follows:

Soil Particles	Sandy Silt (%)
Gravel	0
Sand	29 to 46
Silt	50 to 68
Clay	3 to 4

5.1.8 Bedrock

Bedrock was contacted below the silty sand at 25.0 m depth (Elevation 155.3 m) in Borehole CNH-01. The shale encountered in the borehole is described as thinly bedded and contains frequent hard interbedded siltstone and limestone layers, typical of the Georgian Bay Formation. The shale bedrock is highly to moderately weathered within the upper 2 m below which the degree of weathering decreases with depth and the rock strength increases with depth. An SPT 'N' value obtained in the upper part of the shale bedrock was higher than 100 blows per 0.1 m penetration. A moisture content of 11% was measured.

Bedrock cores were collected using NQ sized coring equipment. Total core recovery (TCR) in the bedrock were 80% and 100% in the two core runs.

RQD values recorded in the core runs were 7%, indicating a very poor rock quality.

The shale bedrock typically contains layers of siltstone and limestone that can be significantly harder than the shale itself. The distribution, thickness and strength of these layers vary from location to location, and these layers typically exhibit less pronounced weathering than the shale.

5.1.9 Water Levels

Water levels were observed in the boreholes during and upon completion of drilling. Standpipe piezometers were installed in three selected boreholes to monitor water levels after completion of drilling. The water levels measured in the piezometers are summarized in Table 5.1, along with the measurements in the boreholes upon completion of drilling.

Table 5.1 – Measured Groundwater Levels

Foundation Element		Borehole	Date	Water Level (m)		Comment
				Depth (m)	Elevation (m)	
South Abutment	SBL	1	December 11, 1981	0.5	171.4	Perched water
	Median	CNH-05	January 21, 2009 May 5, 2009 June 8, 2009	14.5 14.2 14.2	165.7 166.0 166.0	In piezometer
	NBL	2	December 14, 1981	0.5	171.1	Perched water
South Pier	SBL	4	December 21, 1981	1.4	170.0	Perched water
	CNR grade	CNH-02	December 9, 2008	8.2	162.9	In open borehole
	CNR grade	CNH-06	January 21, 2009 May 5, 2009 June 8, 2009	6.1 4.9 4.9	165.3 166.5 166.5	In piezometer
	NBL	3	December 17, 1981	0.9	170.6	Perched water
North Pier	SBL	6	December 21, 1981	0.0	170.6	Perched water
	CNR grade	CNH-03	January 21, 2009 May 5, 2009 June 8, 2009	6.1 5.6 5.5	165.5 166.0 166.1	In piezometer
	CNR grade	CNH-07	December 12, 2008	0.5	171.1	In open borehole
North Abutment	Median	CNH-04	December 15, 2008	11.6	169.7	In open borehole
	NBL	5	December 18, 1981	5.7	165.8	In open borehole

Groundwater levels measured in the piezometers ranged from Elevations 166.0 to 166.5 m. A higher perched water level was noted at elevations ranging from 170.0 to 171.4 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. Further, perched water may be encountered at higher levels in pockets or zones of more permeable sands and silts within the heterogeneous tills, or within the fill.

6 MISCELLANEOUS

Co-ordinates and ground surface elevations for boreholes of the present investigation were supplied to Thurber by SNC-Lavalin.

The drilling and sampling equipment was supplied and operated by DBW Drilling of Ajax, Ontario and Groundwork Drilling Inc. of Etobicoke, Ontario. The field work was supervised on a full time basis by Mr. George Azzopardi and Mr. William Ball of Thurber Engineering Ltd. under the direction of Dr. Sydney Pang, P. Eng.

Laboratory testing was carried out at Thurber's Laboratory in Oakville, Ontario.

Overall supervision of the field program was conducted by Dr. Sydney Pang, P. Eng. Interpretation of the data and preparation of the report were carried out by Dr. Sydney Pang, 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 DISCUSSIONS AND RECOMMENDATIONS

7 INTRODUCTION

This report presents interpretation of the geotechnical data in the factual report and presents geotechnical design recommendations to assist the design team to select and design a suitable foundation system and approach fills for the proposed inside widening of the NBL and SBL bridges at the Highway 427 and CN overhead crossing in Toronto, Ontario. The widening will be carried out in the air gap between the existing bridges

Based on the General Arrangement (GA) drawings provided by SNC-Lavalin, the existing structures are three-span, precast prestressed concrete girder twin bridges carrying the Highway 427 southbound lanes (SBL) and northbound lanes (NBL) over the CN tracks of the Halton Subdivision. Each of the SBL and NBL bridges measures approximately 57 m in total span length. The NBL bridge which also includes exit ramps to Highway 407 is approximately 26 m wide and the SBL bridge is approximately 18 m wide. Each bridge is supported by two conventional abutments and two piers. The abutments (north and south) are supported on driven steel H-piles arranged in two rows, one vertical and one battered. Both piers are supported on spread footings. The approach embankments are up to about 10 m high with a design inclination of 2H : 1V for the side and forward slopes.

The GA drawings for the existing structures indicate that buried CPCN telecommunications cables are located in close proximity to the south piers and adjacent to the CN south track. Preliminary GA drawings, dated January 12, 2009, provided by SNC-Lavalin indicate that the proposed structure widenings will be located within the air gap between the two existing structures, and that the new abutments and piers will be aligned with the existing ones.

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

8 FOUNDATION DESIGN

Consideration was given to various alternate foundation systems, taking account of the site stratigraphy and the structure General Arrangement.

In general terms, the stratigraphy encountered at the site consists of topsoil or asphalt overlying approach embankment fill consisting of variable soils (stiff to very stiff silty clay, loose to very dense silty sand and gravelly sand). Native stiff to hard silty clay till was encountered surficially or below the fill. Compact to very dense silty sand was contacted below the silty clay till. Weathered shale bedrock was contacted at elevation 155.3 m below the silty sand in Borehole CNH-01 drilled at the south abutment. Piezometers installed in selected boreholes revealed that groundwater level is anticipated to be between 14 and 14.5 m depths (from the top of approach fill) and about 5 m depth below CN track level, at elevations ranging from 166.0 to 166.5 m. Perched water may be encountered at higher levels within the fill.

Initial consideration was given to the following foundation types:

- Spread footings on native silty clay till
- Spread footings on engineered fill
- Augered Caissons (drilled shafts)
- Driven steel H-piles

A comparison of these foundation alternatives based on advantages and disadvantages of each is included in Appendix D. In order to avoid undermining the existing bridge foundations during construction of the bridge widening and to achieve consistency with the existing structures, it is recommended that the proposed foundation layouts of the abutments and piers for the widening structure be similar to the existing ones, i.e. abutments founded on driven H-piles and piers supported on spread footings.

From a foundations technical, constructability and cost-effectiveness perspective, the recommended foundations at this site are:

- Abutments - steel H-piles driven to achieve resistance in the very dense silty sand or hard native silty clay till soils.
- Piers - spread footings on very stiff to hard native silty clay till.

8.1 Spread Footings on Native Silty Clay Till

It is recommended that spread footings be used as foundation support for the north and south piers of the bridge widening.

Spread footings are not recommended at the abutments due to the presence of an extensive thickness of embankment fill. Deep excavations ranging from 4.5 m to 9.0 m depth would be required to penetrate the fill for constructing spread footings on native very stiff to hard silty clay till.

It is understood that the existing pier footings were designed to be founded on very stiff to hard native silty clay till at approximate Elevation 169.5 m for the SBL and NBL. Based on the GA drawings, it is assumed that existing footings are in the order of 0.8 m in thickness.

It is recommended that all new footings be founded at similar elevations as the existing footings, where possible, such that the latter will not be undermined. It is critical for the designer to have accurate information on footing base elevations and outlines of existing footing footprints to avoid interference between new and existing footings.

Spread footings should be founded on the very stiff to hard silty clay till. Provided a minimum footing width of 2 m is maintained, footings founded on the above recommended stratum may be designed in accordance with the elevations and geotechnical resistances given in Table 8.1.

Table 8.1 – Geotechnical Resistances for Spread Footings

Foundation Element		Borehole	Depth below existing ground surface (m)	Founding Elevation (m)	ULS_f (kPa)	SLS (kPa)	Soil
South Pier	CNR grade	CNH-02	1.6	169.5	450	300	Very stiff silty clay till
		CNH-06	1.9	169.5	450	300	Very stiff silty clay till
North Pier	CNR grade	CNH-03	3.1	168.5*	450	300	Very stiff silty clay till
		CNH-07	3.1	168.5*	450	300	Very stiff silty clay till

* Elevation 168.5 is approximately 1.0 m below existing footing base elevation.

At the location of the north pier (Boreholes CNH-03 and CNH-07), low SPT 'N" values (8 and 9 blows per 0.3 m of penetration) were measured in the upper 3.0 m of the native silty clay till and therefore founding elevations of spread footings presented in Table 8.1 are approximately 1.0 m below the existing bridge footing base. Further construction recommendations are provided in Section 8.1.1 of this report to prevent undermining, settlement or damage of the existing bridge footings during excavation and construction of new spread footings at the north pier.

The geotechnical resistances quoted above 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.

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 in a 6 m span.

The sliding resistance of mass concrete poured on the native clay till soil may be computed on the basis of an ultimate coefficient of friction of 0.45. This is an "ultimate" value and requires a degree of sliding movement to occur to fully mobilize the resistance.

The bases of the foundation excavations should be inspected by a geotechnical engineer to confirm that the exposed footing subgrade conforms to the design requirements and has been adequately prepared to receive concrete. Where subexcavation is required to remove unsuitable material from below the design founding level, the founding surface should be re-established using mass concrete of the same class as the footing concrete or engineered fill. The engineered fill must consist of OPSS Granular "A" placed in 150 mm lifts, compacted to 100% of its SPMDD at ±2% of optimum moisture content.

8.1.1 Construction of the Spread Footings for the North Pier

The recommended founding elevation for spread footing at the north pier is 168.5 m, which is 1.0 m below the adjacent existing bridge footing base at elevation 169.5 m, indicated in the GA drawings. However, prior to finalizing the design, it is imperative to confirm the actual base elevation of the existing footings. Special attention/care should be given to excavation operations in close proximity to the existing pier footings to avoid any damage to the existing structures. The alternatives to prevent undermining, settlement or damage of the existing footings and bridge structure are presented as follows:

1. It is understood that the new and existing footings at the piers are separated by a horizontal distance of about 1.5 m. One option would be to undertake the new footing excavation to elevation 168.5 m by maintaining an undisturbed 1.5H : 1V soil wedge between the base of the existing footing and the base of the new footing. This footing construction should be carried out expediently and if practical in short, say 5 m, sections. This approach carries some risk of destabilizing the existing footing.

2. The second option would be to excavate the new footing to the base elevation of the existing footing (elevation 169.5 m), then proceed to excavate the remaining 1 m vertically to elevation 168.5 m. Once the founding conditions are confirmed, place a 1.0 m thick layer of mass concrete of the same class as that of the footing (from elevation 168.5 to 169.5 m). Footings for the new structure may then be formed on the hardened mass concrete at elevation 169.5 m. This final 1 m of vertical excavation and backfilling with mass

concrete should be carried out in short, say 5 m, sections. This approach is expected to reduce the risk of destabilizing the existing footings.

3. The option that carries relatively lower risk would be to construct the new north pier footing within a fully supported, shored enclosure. The shoring should be rigid enough not to destabilize the adjacent existing bridge footing and must be installed prior to the start of footing excavation.

For the proposed alternatives 1 and 2, a methodology to minimize time of construction should be implemented to reduce the risk of undermining the existing footings.

For all three alternatives, settlement monitoring of the existing north pier footings should be conducted before, during and after construction.

The recommended option for excavation at the north pier is Alternative 2 if no railway protection is planned, and Alternative 3 if railway protection is to be installed. Option 1 is not recommended.

The site has a narrow space at the north pier for construction operations such as advancing protection systems and excavation for construction of the new footings. However, it is understood from the project designers, SNC-Lavalin, that the space is adequate to advance the protection systems and construct the north pier foundations. Measures must be taken during detail design to control undermining, settlement or damage of the existing footings.

Once an alternative for constructing the spread footing at the north pier is selected, Thurber will prepare an NSSP on the required procedures and operational constraints.

8.2 Spread Footings on Engineered Fill

Spread footings on engineered fill are not recommended at this site. At the piers, this option is not appropriate since competent native soils are present at shallow depths below existing ground. At the abutments, native soils founding levels for engineered fill is at a large depth below the embankment fill.

8.2 Augered Caissons (Drilled Shafts)

Augered caisson foundations were also considered for the support of the structure. However, in order to achieve a higher geotechnical resistance for the caissons, they must be socketed 3.0 m to 4.0 m into the very dense silty sand or bedrock.

At this site, the silty sand and bedrock were encountered at 10.7 m to 25.0 m below original ground surface. The base of the caissons would be in the order of 6.0 m to 11.0 m below the groundwater level and therefore subject to high hydrostatic heads.

Potential installation problems with caisson construction in the silty sand below the water table are likely to include side sloughing, difficulty in sealing the liner and potential base boiling. Cobbles and boulders may also need to be dislodged and removed from caisson holes.

Installation of caissons into the very dense silty sand or bedrock is also expected to be a more expensive option than driven piles.

For these reasons, the use of a caisson foundation is not recommended at this site.

8.3 Driven Piles

The subsurface conditions at the site are considered suitable for the design of foundations supported on steel H-piles driven to achieve resistance in the very dense silty sand and hard silty clay till. However, piles are only recommended for the abutments.

Driven piles are not recommended for the piers for two major reasons:

(i) to avoid vibration due to pile driving close to the existing spread footings;

(ii) competent soils exist at relatively shallow depths making spread footings a viable option.

It is recommended that the new piles for the abutments be founded at the tip elevations recommended in Table 8.3. The GA drawings show that the existing pile tips are at Elevations 155.0 and 154.0 m in rock at the north and south abutments, respectively.

The piles should be driven to termination at the design ultimate capacity (see later section) within the very dense native silty sand and hard silty clay till.

The elevations at which the piles are expected to develop the required resistance are given in Table 8.3.

Table 8.3 – Estimated Pile Tip Elevation

Foundation Element		Borehole	Anticipated Pile Length below original ground (m)	Anticipated Pile Tip Elevation To Develop Required Resistance (m)	Anticipated Founding Material
South Abutment	Median	CNH-01	25.0	155.3	Shale Bedrock
	Median	CNH-05	23.2	157.0	Very dense silty sand
North Abutment	Median	CNH-04	20.3	161.0	Very dense silty sand
	Median	CNH-08	14.3	167.0	Hard silty clay till

The pile tip elevations shown in Table 8.3 should be used for estimating purposes only. The actual pile tip elevations will be controlled as described in Section 8.3.3 Pile Installation.

8.3.1 Axial Resistance

It is recommended that the following geotechnical resistances be used to design the steel HP 310 x 110 piles driven to, or below, the approximate elevations presented in Table 8.3:

- Factored Geotechnical Resistance at Ultimate Limit States (ULS) of 1,400 kN per pile.
- Geotechnical Resistance at Serviceability Limit State (SLS) of 1,200 kN per pile.

The structural resistance of the pile must be checked by the structural designer.

8.3.2 Pile Tips

Due to the presence of cobbles and boulders in the expected founding layer, the tips of all piles should be fitted with cast steel, H-section pile points from an approved manufacturer such as Titus Steel (Standard H-point) or approved equivalent.

The use of pile points is recommended since all the piles will be driven into very dense or hard soils containing cobbles and boulders.

8.3.3 Pile Installation

Pile installation should be in accordance with Special Provision No. 903S01.

The Contract Documents should contain a NSSP alerting the Bidders to:

- The presence of cobbles and boulders in the soils through which the piles will be driven.
- The possibility of piles within a group achieving the specified resistance at different elevations.
- The possibility of some piles meeting refusal on a large boulder.

Suggested texts for NSSP's are included in Appendix F.

8.3.4 Pile Driving

Pile driving must be controlled by the Hiley Formula and an ultimate pile resistance should be specified by the designer in accordance with Clause 3.3.2 (b) Construction Stage of the Structural Manual. The Hiley formula need not be used until the piles are approaching the bearing stratum below Elevation 158.0 m at the south abutment and 162.0 to 168.0 m at the north abutment. The appropriate pile driving note is "Piles to be driven in accordance with Standard SS 103-11 using an ultimate resistance of "R" kN per pile". "R" must have the minimum value of 2,800 kN for a HP 310 x 110 pile section.

Piles should not be damaged by overdriving. The NSSP should require the QVE to monitor pile driving and terminate driving of the pile before the pile is damaged by overdriving.

To facilitate pile installation, embankment fill through which piles will be driven must not contain oversize material, i.e. no particles exceeding 75 mm in size.

8.3.5 Downdrag

Downdrag on the piles is not considered to be an issue at this site.

8.3.6 Integral Abutment Considerations

The preliminary GA drawings provided by SNC-Lavalin indicate that conventional abutments similar to the existing abutments will be adopted for the widening structures. Integral abutments are not being considered for this bridge widening.

8.3.7 Lateral Resistance

The lateral resistance of a pile may be calculated using a value for the coefficient of horizontal subgrade reaction (k_s) and ultimate lateral resistance (p_{ult}) as follows:

<u>Cohesive soils:</u>

k_s = $125 * S_u / D$ (kN/m^3)

p_{ult} = $9 * S_u$ (kPa)

where

D = pile width in metres

S_u = undrained shear strength

<u>Cohesionless soils:</u>

k_s = $n_h . z / D$ (kN/m^3)

p_{ult} = $3 . \gamma . z . K_p$ (kPa)

where

z = depth of embedment of pile in metres

D = pile width in metres

n_h = value from Table 8.4

γ = unit weight (Table 8.4)

K_p = passive earth pressure coefficient (Table 8.4)

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The above equations and recommended parameters may be used to analyze the interaction between a pile and the surrounding soil. The lateral pressures obtained from the analysis should not exceed the ultimate lateral resistance.

The spring constant, K, for analysis may be obtained by the expression, $K = k_s*L*D$ (kN/m), where k_s is the coefficient of horizontal subgrade reaction (kN/m^3), D is the pile width (m) and L is the length (m) of the pile segment or element used in the analysis. The ultimate lateral resistance on any one segment of pile, P_{ult}, may be obtained from the expression, $P_{ult} = p_{ult}*L*D$. This represents the ultimate load at which the pile fails and will not support any additional load at greater displacements. It is recommended, however, that the total lateral resistance assumed in one pile be limited to no more than 200 kN at ULS and 110 kN at SLS.

Parameters for lateral pile resistance are shown in Table 8.4.

Table 8.4 – Parameters for Lateral Pile Resistance

Location	Elevation (m)	n_h (kN/m^3)	K_p	S_u (kPa)	Unit Weight (kN/m^3)	Soil Conditions
South Abutment (Boreholes CNH-01 and CNH-05)	OGL to 171.0	-	2.9	65	20	Stiff to very stiff silty clay fill
	171.0 to 166.0	-	3.1	200	22	Hard silty clay till
	166.00 to 159.9 (below water)	-	3.1	200	12*	
	159.0 to 154.0	10,000	3.4	-	10*	Very dense silty sand till
North Abutment (Boreholes CNH-04 and CNH-08)	OGL to 176.0	2,500	3.0	-	20	Loose to very dense silt and sand fill
	176.0 to 169.8	-	3.1	175	22	Very stiff to hard silty clay till
	169.8 to 164.0 (below water)	-	3.1	175	12*	
	164.0 to 161.0	10,000	3.4	-	10*	Very dense silty and sand/silty sand

* Buoyant unit weight below water table for cohesionless soils

Interaction of piles bearing in soil should be considered with reference to CHBDC Clause 6.8.9.2.

For lateral soil/pile group interaction analysis, the modulus of subgrade reaction (k_s) should be reduced based on pile spacing.

Where a pile group is oriented ***perpendicular*** to the direction of loading, group action may be considered by reducing values for k_s by a reduction factor R as follows:

Pile Spacing Perpendicular to Direction of Loading	Horizontal Subgrade Reaction Reduction Factor, R
4 D*	1.00
1 D*	0.50

* D is the width of the pile, and spacing is measured centre to centre

Where a pile group is oriented ***parallel*** to the direction of loading, group action may be considered by reducing values for k_s by a reduction factor R as follows:

Pile Spacing Parallel to Direction of Loading	Horizontal Subgrade Reaction Reduction Factor, R
8 D	1.00
6 D	0.70
4 D	0.40
3 D	0.25

Intermediate values may be obtained by interpolation.

For conventional abutments, the lateral resistance may be provided by battered piles.

8.4 Frost Protection

The design depth of frost penetration at this site through overburden soils is 1.2 m. All footing base and pile caps should be provided with 1.2 m of earth cover. It is possible to reduce the thickness of earth cover by the substitution of synthetic insulation and typically 25 mm of Styrofoam is equivalent to 600 mm of earth cover. Synthetic insulation must itself be covered to provide protection where it is used.

9 TEMPORARY EXCAVATION

9.1 General

All excavations must be carried out in accordance with the requirements of the Occupational Health and Safety Act (OHSA). For the purposes of the OHSA, the soils within the likely depth of excavation at this site may be classed as Type 3 soils for fill and Type 2 for native stiff to hard silty clay till.

The selection of the method of excavation is the responsibility of the contractor and must be based on his equipment, experience and interpretation of the site conditions. Excavations should be inspected regularly for evidence of instability if they have been left open for extended periods of time and following periods of heavy rain or thawing. If required, remedial actions must be taken to ensure the stability of the excavation and the safety of workers.

The requirements for unwatering during excavation are discussed in Section 11.

9.2 Foundations

The excavation and backfilling for foundations must be carried out in accordance with SP 902S01.

9.3 Earth Excavation

Earth excavations required at this site will penetrate through a variety of overburden soils including native silty clay till. The soils, especially the tills, may contain cobbles and boulders. It is anticipated that temporary excavations through a majority of soils at this site may be formed unsupported with side slopes not steeper than 1H : 1V. Flatter slopes may be required at locations where the soils are less competent than what is assumed during design or where water seepage affects surficial stability.

A NSSP should be included in the contract alerting the Contractor to the possible presence of cobbles and boulders.

10 ROADWAY AND RAILWAY PROTECTION

It is anticipated that roadway (Highway 427) and railway (CN tracks) protection will be required during construction.

An item titled "Protection System" as per SP 105S19 should be included in the contract documents. A Performance Level 2 is recommended for Highway 427 protection.

Rail track protection will have to be implemented for construction of piers. Discussions with the railway authorities should be carried out to determine the required level of protection. CN Rail may require a more stringent performance level for railway protection.

The design of roadway and railway protection should be the responsibility of the Contractor. However, one option that is considered to be suitable for use as temporary shoring at this site is a soldier pile and lagging wall. It is anticipated that the soldier piles will need to be socketted into the very stiff to hard silty clay till or very dense silty sand to develop the required toe resistance.

A temporary soldier pile and lagging wall may be designed using the parameters given below:

γ	=	20 kN/m^3
γ_w	=	10 kN/m^3
K_a	=	0.35 (road embankment fill)
(active earth pressure)	=	0.32 (silty clay till)
K_p	=	2.9 (road embankment fill)
(passive earth pressure)	=	3.0 (silty clay till)

The designer of the roadway protection system should check whether the socket in the hard clay till is sufficiently deep to provide base fixity.

The actual pressure distribution acting on the shoring system is a function of the construction sequence and the relative flexibility of the wall and these factors must be considered when designing the shoring system. All shoring systems should be designed by a Professional Engineer experienced in such designs.

11 UNWATERING

Temporary excavations for footing and pile cap construction are generally 2.0 m to 10.0 m above the groundwater level measured in the piezometers. However, perched water was observed at elevations ranging from 170.0 to 171.1 m during the previous investigation. Considering the consistency and low permeability of the silty clay till soils, groundwater control measures such as perimeter ditches and pumping from filtered sumps should be implemented to remove any accumulation of water from the excavation base prior to placing concrete. The possibility exists that additional pumps may be required if localized zones of perched water are encountered. All footings must be constructed in the dry.

The design of the unwatering systems is the responsibility of the Contractor.

12 APPROACH EMBANKMENTS

The foundation soils governing stability of the approach embankments consist of existing native very stiff to hard silty clay till underlain by compact to very dense silty sand. The proposed embankment heights are approximately 10 m at the north and south approaches. Since the existing median is more or less at grade, it is expected that the additional fill that may be required to construct the new abutments should be minimal. The additional fill will be used generally as backfill of the existing abutment with an approximate height of 1.0 m to 1.5 m.

Embankment construction should be in accordance with OPSS 206, as amended by Special Provision “Amendment to OPSS 206, December 1993”, dated November 2002. It is recommended that earth fill should consist of SSM or granular materials in compliance with Special Provision 110F13, “Amendment to OPSS 1010 March 1993”. Any existing fill slopes must be benched in accordance with OPSD 208.010 prior to placing new fill.

Considering the embankment height and consistency of the foundation soils, post construction settlement induced by additional fill loading will be less than 25 mm.

The global, internal and surficial stability of the approach embankment fills will depend on the slope geometry and also to a large degree on the material used to construct the embankments. Embankments constructed using granular material, select subgrade material or non-cohesive earth fill will have stable side slopes at inclinations not steeper than 2H:1V.

The existing north and south approach embankments are up to 10 m high with a slope inclination of 2H : 1V but without mid-height berms. Stability analyses were conducted for the cases with and without the berm to assess the global stability of the existing approach embankments. The computed factors of safety for the south approach are as shown in Table 12.1. Slope stability computation outputs are included in Appendix E.

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

Table 12.1 Computed Factors of Safety

Location / Material	Condition	Factor of Safety	Figure (Appendix E)
South Approach			
Earth Fill	Undrained	2.7	1
Earth Fill with a 2-m wide berm		2.8	2
Earth Fill	Drained	1.5	3
Earth Fill with a 2-m wide berm		1.6	4

In each case, the factor of safety against global instability was greater than 1.5. These factors of safety are considered to be acceptable for the proposed embankments.

All topsoil and organic soils should be stripped from the footprint of the approach fills. Particular attention should be paid to removing all softened material from existing ditches that fall within the footprint of the new embankment.

It is noted that the rock protection in front of the abutment walls has undergone settlement and/or lateral movement. The observed distress appears worse at the south abutment. The stability analysis summarized in Table 12.1 above indicates that the foundation soils are capable of sustaining global embankment stability. It is recommended that all displaced rock protective facings, including any underlying disturbed embankment fill, be removed and appropriately reinstated. For all existing and new rock protection for slopes, reference should be made to Drawings SS-16-20 or SS-16-21 in the Structural Manual for general layout design. Construction and material specifications should conform with OPSS 511 and OPSS 1004. Earth fill embankment slopes must be provided with erosion protection in accordance with SP572S01.

13 BACKFILL TO ABUTMENTS

Backfill to the abutments should consist of Granular A or Granular B Type II material meeting the requirements of Special Provision 110F13 "Amendment to OPSS 1010, March 1993". The backfill must be in accordance with OPSS 902 as amended by Special Provision 902S01, and placed to the extents shown in OPSD 3101.150.

Compaction equipment to be used adjacent to retaining structures must be restricted in accordance with SP105S01. The design of the abutment must include a subdrain as shown in OPSD 3102.100.

14 STATIC EARTH PRESSURE

Earth pressures acting on the structure may be assumed to be triangular and to be governed by the characteristics of the abutment backfill. For a fully drained condition, the pressures should be computed in accordance with the CHBDC but generally are given by the expression:

$$P_h = K*(\gamma h + q)$$

where:

P_h = horizontal pressure on the wall at depth h (kPa)
K = earth pressure coefficient (see Table 14.1)
γ = unit weight of retained soil (see Table 14.1)
H = depth below top of fill where pressure is computed (m)
q = value of any surcharge (kPa)

Earth pressure coefficients for backfill to the abutment wall are dependent on the material used as backfill. Typical values are shown in Table 14.1.

Table 14.1 – Earth Pressure Coefficients (K)

Condition	Earth Pressure Coefficient (K)					
	OPSS Granular A $\phi = 35°, \gamma = 22.8$ kN/m^3		OPSS Granular B Type II $\phi = 35°, \gamma = 22.8$ kN/m^3		OPSS Granular B Type I $\phi = 32°, \gamma = 21.2$ kN/m^3	
	Horizontal Surface Behind Wall	Sloping Backfill (2H:1V)	Horizontal Surface Behind Wall	Sloping Backfill (2H:1V)	Horizontal Surface Behind Wall	Sloping Backfill (2H:1V)
Active (Unrestrained Wall)	0.27	0.40*	0.27	0.40*	0.31	0.48*
At rest (Restrained Wall)	0.43	-	0.43	-	0.47	-
Passive	3.7	-	3.7	-	3.3	-

* For wing walls.

In accordance with Clause 6.9.3 of the CHBDC, a compaction surcharge should be added. The magnitude should be 12 kPa at the top of fill and decreasing to 0 kPa at a depth of 2.0 m for Granular B Type I or 1.7 m for Granular A or Granular B Type II.

In conventional design, the use of a material with a high friction angle and low active pressure coefficient (e.g. Granular A, Granular B Type II) might be preferred as it results in lower earth pressures acting on the wall.

The factors in Table 14.1 are "ultimate" values requiring certain movements for the respective conditions to be mobilized. The values to use in design can be estimated from Figure C6.9.1 (a) in the Commentary to the CHBDC.

15 SEISMIC CONSIDERATIONS

15.1 Seismic Design Parameters

The following seismic parameters should be used for design:

- Velocity Related Seismic Zone 0
- Zonal Velocity Ratio 0.05
- Acceleration Related Seismic Zone 1
- Zonal Acceleration Ratio 0.05
- Peak Horizontal Acceleration 0.05

The soil profile type at this site has been classified as Type I. Therefore, according to Table 4.4.6.1 of the CHBDC, a Site Coefficient "S" (ground motion amplification factor) of 1.0 should be used in seismic design.

15.2 Liquefaction Potential

There is no potential for liquefaction of structures founded on hard or very dense soils. The foundation soils at the site are assessed as not being prone to liquefaction.

15.3 Retaining Wall Dynamic Earth Pressures

In accordance with Clause 4.6.4 of the CHBDC, retaining structures should be designed using active (K_{AE}) and passive (K_{PE}) earth pressure coefficients that incorporate the effects of earthquake loading.

For the design of retaining walls, the coefficients of horizontal earth pressure in Table 15.1 may be used:

Table 15.1 – Earth Pressure Coefficient for Earthquake Loading

Earth Pressure Coefficient (K) for Earthquake Loading				
	Granular A or Granular B Type II $\phi = 35°$; $\gamma = 22.8$ kN/m^3		OPSS Granular B Type I $\phi = 32°$; $\gamma = 21.2$ kN/m^3	
Wall Condition	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)	Horizontal Surface Behind Wall	Sloping Surface Behind Wall (2H:1V)
Active (K_{AE})*	0.29	0.44	0.33	0.53
Passive (K_{PE})	3.6	3.6	3.2	3.2
At Rest (K_{OE})**	0.59	-	0.63	-

* After Mononobe and Okabe, passive case assumes a horizontal surface in front of the wall.
** After Woods

16 ADJACENT STUCTURES AND BURIED UTILITIES

Fibre optics cables are present in the vicinity of the new foundation construction areas (south piers). It is recommended that the exact locations and elevations of these and any other utilities be established by the designer, and compared with the extent of the potential work zones related to the foundations of the proposed widening structures and associated works. The settlement and displacement/rotation tolerances of these utilities should also be obtained by the designer from the owner/designer of these utilities. These utilities should not be undermined or damaged during new footing construction. It may be prudent to expose the fibre optics cables and protect them during construction of the new foundations.

Settlement monitoring of the existing north pier structures must be conducted before, during and after construction of the new footings which will be adjacent to the existing pier footings. Existing footings at the north piers should not be undermined or damaged during new footing construction.

If buried conduits such as sewer or watermain are present within the abutment construction areas, it is recommended that the following be carried out prior to the commencement of foundation construction:

- Carry out pre-construction condition survey to include documentation of any existing distress associated with the conduits/utilities.
- Implement instrumentation and monitoring programs to prevent damage or settlement of the existing conduits/utilities.
- Carry out post-construction condition survey.

Relocation of, and/or special protective measures for some or all of these affected utilities may be required.

17 CONSTRUCTION CONCERNS

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

1. Footing construction adjacent to the existing north pier footings.

   Special attention should be paid to the following issues:

   a) New footing construction must not undermine the existing bridge footings.
   b) A practical and appropriate construction method outlined in Section 8.1.1 should be selected for the new footing.
   b) Settlement monitoring of the existing bridge footings should be conducted before, during and after construction.

2. Pile refusal at higher elevation.

   There is some indication that the glacial till deposits at this site contain occasional boulders. It is possible that a pile will achieve refusal at a higher elevation than anticipated due to encountering boulders. If it is suspected that this is happening, the QVE must immediately bring it to the attention of the CA. If the CA cannot resolve the issue, it must be referred to the design team for resolution. A pile must not be damaged by overdriving.

3. Pile fails to develop specified resistance.

   If a pile does not develop the specified resistance after being driven 2 m beyond the anticipated pile tip elevation, stop driving and check the Hiley calculation and all input values. If the calculation still shows that the pile has not reached the specified resistance, the following procedure should be implemented:

   a) Stop driving in that pile group for 48 hours (minimum).
   b) After 48 hours, warm up the hammer on another pile, then retap the subject pile and measure the resistance.
   c) If the pile still does not reach the specified resistance, the QVE must immediately advise the CA who, in turn, should refer the issue to the design team.

4. Destabilization of excavations

   Perched water may be encountered within the upper sandy layers in the silty clay fill. The impact of this perched groundwater could destabilize the sides and or base of the excavation. The Contractor's unwatering plan must be available for rapid implementation should the need arise. Proper groundwater and surface water control measures must be in place prior to commencing excavation. All footings must be constructed in the dry.

5. Excavations

   Care must be exercised during excavation to avoid disturbing the founding subgrade. The exposed subgrade soils should be expeditiously inspected, approved and protected from disturbance.

6. Underground utilities

   Any information on the location of the buried CNCP telecommunication cables should also be carefully reviewed. All new foundation footprints should be clear of any buried utility. Vibration and settlement monitoring for buried utilities, where required, should be provided by qualified personnel.

7. Existing slopes

   The forward and side embankment slopes should be inspected after construction for surficial disturbance. Where necessary, remedial measures such as re-vegetation and/or placement of gravel sheeting may be required.

18 CLOSURE

Engineering analysis and preparation of this preliminary foundation design report was carried out by Ms. Rocío Palomeque Reyna, P.Eng. and Dr. Sydney Pang, 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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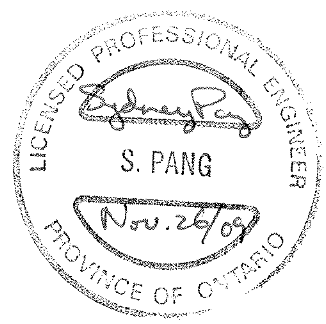


P.K. Chatterji, P.Eng.
Review Principal

Appendix A

Record of Borehole Sheets

(Present Investigation)

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

Ministry of Transportation Ontario

RECORD OF BOREHOLE No CNH-01

METRIC

G.W.P. 202-95-00	LOCATION N 4 845 049.2 E 294 356.2	ORIGINATED BY GA
HWY 427	BOREHOLE TYPE Solid Stem Auger	COMPILED BY AN
DATUM Geodetic	DATE 2008.12.01 - 2008.12.03	CHECKED BY SKP

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20, 40, 60, 80, 100

SHEAR STRENGTH kPa: ○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 40, 80, 120, 160, 200

PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%): 20, 40, 60

UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%): GR SA SI CL

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
180.3								
0.0	**TOPSOIL** (50mm)							
	Silty **CLAY**, with sand, trace gravel Stiff to Very Stiff Brown (FILL)	1	SS	16				
		2	SS	17	8	24	34	34
		3	SS	27				
		4	SS	30				
		5	SS	15	7	31	37	25
		6	SS	24				
171.1 9.1	Silty **CLAY**, trace to some sand, trace gravel, occasional iron oxide Hard Brown (TILL)	7	SS	50				

ELEVATION SCALE: 180, 179, 178, 177, 176, 175, 174, 173, 172, 171

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

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

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No CNH-01

METRIC

G.W.P. 202-95-00	LOCATION N 4 845 049.2 E 294 356.2	ORIGINATED BY GA
HWY 427	BOREHOLE TYPE Solid Stem Auger	COMPILED BY AN
DATUM Geodetic	DATE 2008.12.01 - 2008.12.03	CHECKED BY SKP

Continued From Previous Page

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Silty **CLAY**, trace to some sand, trace gravel, occasional iron oxide Hard Brown (TILL)				170	
	Occasional layers of clayey silt	8	SS	70		0 4 79 17
					169	
		9	SS	63	168	
					167	
		10	SS	81	166	
					165	
	with sand	11	SS	41		6 35 43 16
					164	
		12	SS	51	163	
					162	
		13	SS	50	161	
160.5 19.8						

Continued Next Page

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: O UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE; 40 80 120 160 200
PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L
WATER CONTENT (%): 20 40 60
UNIT WEIGHT γ kN/m³

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

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No CNH-01

METRIC

G.W.P. 202-95-00 LOCATION N 4 845 049.2 E 294 356.2 ORIGINATED BY GA
HWY 427 BOREHOLE TYPE Solid Stem Auger COMPILED BY AN
DATUM Geodetic DATE 2008.12.01 - 2008.12.03 CHECKED BY SKP

Continued From Previous Page

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Silty **SAND**, trace gravel, trace clay Very Dense Grey Wet Hard augering	14	SS	100	o	
		15	SS	100/ 0.150	o	
157.7 / 22.6	Compact	16	SS	20	o	4 80 16 (SI+CL)
156.5 / 23.8		17	SS	112	o	
155.3 / 25.0	**SHALE**, highly weathered, thinly bedded, frequent limestone and siltstone interbeds Grey	18	SS	100/ 0.100	o	
153.3 / 27.0	becoming moderately weathered	1	RUN			RUN 1# TCR=80%, SCR=7%, RQD=7%
		2	RUN			RUN 2# TCR=100%, SCR=7%, RQD=7%

Elevation scale: 160, 159, 158, 157, 156, 155, 154, 153, 152, 151

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: O UNCONFINED + FIELD VANE ● QUICK TRIAXIAL X LAB VANE: 40 80 120 160 200
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   (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No CNH-01

METRIC

G.W.P. 202-95-00 | LOCATION N 4 845 049.2 E 294 356.2 | ORIGINATED BY GA
HWY 427 | BOREHOLE TYPE Solid Stem Auger | COMPILED BY AN
DATUM Geodetic | DATE 2008.12.01 - 2008.12.03 | CHECKED BY SKP

ELEV DEPTH	DESCRIPTION (Continued From Previous Page)	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 40 80 120 160 200)	WATER CONTENT (%) (PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; 20 40 60)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
149.4	**SHALE**, moderately weathered, thinly bedded, frequent limestone and siltstone interbeds Grey		3	RUN			150				RUN 3# TCR=100%, SCR=23%, RQD=7%
30.9	END OF BOREHOLE AT 30.9m. BOREHOLE BACKFILLED WITH BENTONITE GROUT TO SURFACE.										

+³, ×³: Numbers refer to Sensitivity

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

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No CNH-02

METRIC

G.W.P. 202-95-00 | LOCATION N 4 845 073.9 E 294 349.3 | ORIGINATED BY GA
HWY 427 | BOREHOLE TYPE Solid Stem Auger | COMPILED BY MFA
DATUM Geodetic | DATE 2008.12.08 - 2008.12.09 | CHECKED BY SKP

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
171.1 / 0.0	Silty **CLAY**, with sand, trace gravel Stiff to Very Stiff Brown (TILL)	1	SS	13		171	
		2	SS	28		170	4 28 49 19
	Occasional layers of grey clayey silt	3	SS	22		169 / 168	0 1 83 16
	Grey	4	SS	25		167 / 166	
165.3 / 5.8	Hard	5	SS	48		165	3 26 37 34
		6	SS	56	∇	164 / 163	
		7	SS	79		162	

Plot headings: DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 40 80 120 160 200); 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

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

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

ONTMT4S 9270.GPJ 6/29/09

Ministry of Transportation Ontario

RECORD OF BOREHOLE No CNH-02

METRIC

G.W.P. 202-95-00 LOCATION N 4 845 073.9 E 294 349.3 ORIGINATED BY GA

HWY 427 BOREHOLE TYPE Solid Stem Auger COMPILED BY MFA

DATUM Geodetic DATE 2008.12.08 - 2008.12.09 CHECKED BY SKP

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Continued From Previous Page						
	Silty CLAY, with sand, trace gravel Hard Grey (TILL)				161		
160.5 10.7	Silty SAND, trace clay, trace gravel Very Dense Grey Wet	8	SS	105	160	o	
		9	SS	107	159	o	3 64 24 9
		10	SS	112	158, 157	o	
	occasional cobbles	11	SS	111	156, 155	o	
		12	SS	112	154	o	
	Layer of sand and gravel	13	SS	104/.150	153	o	
152.4 18.7	END OF BOREHOLE AT 18.7m. BOREHOLE OPEN TO 18.7m AND WATER LEVEL AT 8.2m UPON COMPLETION OF DRILLING. BOREHOLE BACKFILLED WITH BENTONITE GROUT TO 2.1m, THEN SEALED WITH BENTONITE HOLEPLUG TO SURFACE.						

Column headings: SOIL PROFILE; STRAT PLOT; SAMPLES; GROUND WATER CONDITIONS; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa O UNCONFINED + FIELD VANE ● QUICK TRIAXIAL X LAB VANE 40 80 120 160 200; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³

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

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

Ministry of Transportation Ontario

RECORD OF BOREHOLE No CNH-03

METRIC

G.W.P. 202-95-00 | LOCATION N 4 845 094.6 E 294 347.1 | ORIGINATED BY GA
HWY 427 | BOREHOLE TYPE Solid Stem Auger | COMPILED BY MFA
DATUM Geodetic | DATE 2008.12.11 - 2008.12.11 | CHECKED BY SKP

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
171.6										
0.0	SUB-BALLAST (FILL)									
0.2	Silty CLAY, with sand, trace gravel Stiff Brown (TILL)	1	SS	13						
					171					
		2	SS	8	170					
168.9 2.7	Very Stiff to Hard				169					
		3	SS	18			1	23	53	23
					168					
	Occasional layers of grey clayey silt				167					
		4	SS	30			0	1	74	25
					166					
	Grey	5	SS	37	165					
164.0 7.6	Sandy SILT, trace clay Compact Grey Wet	6	SS	15	164		0	29	68	3
					163					
162.5 9.1	Silty CLAY, trace to some sand, trace gravel Hard Grey (TILL)	7	SS	55	162					

Groundwater level symbol shown at approx. elevation 166.2.

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

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

Ministry of Transportation Ontario

RECORD OF BOREHOLE No CNH-03

 METRIC

G.W.P. 202-95-00 LOCATION N 4 845 094.6 E 294 347.1 ORIGINATED BY GA

HWY 427 BOREHOLE TYPE Solid Stem Auger COMPILED BY MFA

DATUM Geodetic DATE 2008.12.11 - 2008.12.11 CHECKED BY SKP

Continued From Previous Page

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)
	Silty **CLAY**, trace to some sand, trace gravel Hard Grey (TILL)					
160.9 / 10.7	Silty **SAND**, trace to some gravel, occasional cobbles Very Dense Grey Wet	8	SS	116	161	o
					160	
	Shale fragments, occasional inferred cobbles and boulders	9	SS	123	159	o
					158	
157.7 / 13.9		10	SS	109/.150		o

END OF BOREHOLE AT 13.9m. BOREHOLE OPEN TO 12.8m AND WATER LEVEL AT 0.3m UPON COMPLETION OF DRILLING. Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.

WATER LEVEL READINGS:

DATE	DEPTH (m)	ELEV. (m)
2009.01.21	6.1	165.5
2009.05.05	5.6	166.0
2009.06.08	5.5	166.1

ONTMT4S 9270.GPJ 6/29/09

+ 3, × 3: Numbers refer to Sensitivity

15 20 5 10 (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No CNH-04

METRIC

G.W.P. 202-95-00 | LOCATION N 4 845 119.7 E 294 338.5 | ORIGINATED BY WB

HWY 427 | BOREHOLE TYPE Solid Stem Auger | COMPILED BY MFA

DATUM Geodetic | DATE 2008.12.15 - 2008.12.15 | CHECKED BY SKP

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
181.3						
0.0 / 0.1	ASPHALT: (75mm)					
	SILT and SAND, some gravel, trace clay; Dense to Very Dense; Brown; Moist; (FILL)	1	SS	60	181	
		2	SS	43	180	
		3	SS	31	179	
		4	SS	60		0 45 51 4
		5	SS	52	178	
177.3 / 4.0	Silty CLAY, with sand, trace gravel; Very Stiff to Hard; Brown; (TILL)				177	
		6	SS	23	176	
		7	SS	25	175	2 23 40 35
					174	
		8	SS	48	173	
		9	SS	44	172	

Column headings: SOIL PROFILE; SAMPLES; GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH kPa (O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, X LAB VANE; 40 80 120 160 200); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³; STRAT PLOT.

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

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

Ministry of Transportation Ontario

RECORD OF BOREHOLE No CNH-04

METRIC

G.W.P. 202-95-00 | LOCATION N 4 845 119.7 E 294 338.5 | ORIGINATED BY WB

HWY 427 | BOREHOLE TYPE Solid Stem Auger | COMPILED BY MFA

DATUM Geodetic | DATE 2008.12.15 - 2008.12.15 | CHECKED BY SKP

Continued From Previous Page

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	GR	SA	SI	CL
	Silty **CLAY**, with sand, trace gravel Hard Brown (TILL)					171				
		10	SS	30						
					∇	170				
		11	SS	100/ 275		169				
						168				
		12	SS	80			0	3	70	27
						167				
						166				
		13	SS	89			2	29	52	17
						165				
		14	SS	79						
						164				
163.4 17.8	**SILT** and **SAND**, some clay, trace gravel Very Dense Grey Moist									
		15	SS	100/ 225		163	5	37	42	16
						162				
		16	SS	100/						

Continued Next Page

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, X LAB VANE; 40 80 120 160 200

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 (%)

+³, ×³: Numbers refer to Sensitivity

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

ONTMT4S 9270.GPJ 6/29/09

RECORD OF BOREHOLE No CNH-04

METRIC

G.W.P. 202-95-00	LOCATION N 4 845 119.7 E 294 338.5	ORIGINATED BY WB
HWY 427	BOREHOLE TYPE Solid Stem Auger	COMPILED BY MFA
DATUM Geodetic	DATE 2008.12.15 - 2008.12.15	CHECKED BY SKP

Continued From Previous Page

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)
	SILT and **SAND**, some clay, trace gravel Very Dense Grey Moist			100/ .100	161	
		17	SS	100/ .100	160	o (~15)
	Moist to Wet				159	
158.0		18	SS	100/ .225		o (~17)
23.2	END OF BOREHOLE AT 23.2m AND WATER LEVEL AT 11.6m UPON COMPLETION OF DRILLING. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG AND CUTTINGS TO 0.075m, THEN ASPHALT TO SURFACE.					

Column headings: SOIL PROFILE (ELEV DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa (O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 40, 80, 120, 160, 200); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) (20, 40, 60); UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) (GR SA SI CL)

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

Ministry of Transportation Ontario

RECORD OF BOREHOLE No CNH-05

METRIC

G.W.P. 202-95-00 | LOCATION N 4 845 053.1 E 294 358.8 | ORIGINATED BY GA

HWY 427 | BOREHOLE TYPE Solid Stem Auger | COMPILED BY AN

DATUM Geodetic | DATE 2008.12.04 - 2008.12.04 | CHECKED BY SKP

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
180.2						
0.0 / 0.1	TOPSOIL (75mm)					
	Silty **CLAY**, with sand, trace gravel, Stiff to Very Stiff, Brown (FILL)	1	SS	14		
		2	SS	17		
		3	SS	20		6 30 36 28
		4	SS	18		
		5	SS	22		
		6	SS	27		
171.6 / 8.5	Silty **CLAY**, some sand, trace gravel, Hard, Brown to Grey (TILL)	7	SS	31		0 11 51 38

Elevation scale: 180, 179, 178, 177, 176, 175, 174, 173, 172, 171

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 40 80 120 160 200

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

RECORD OF BOREHOLE No CNH-05

METRIC

G.W.P. 202-95-00	LOCATION N 4 845 053.1 E 294 358.8		ORIGINATED BY GA
HWY 427	BOREHOLE TYPE Solid Stem Auger		COMPILED BY AN
DATUM Geodetic	DATE 2008.12.04 - 2008.12.04		CHECKED BY SKP

SOIL PROFILE: ELEV / DEPTH; DESCRIPTION; STRAT PLOT. SAMPLES: NUMBER; TYPE; "N" VALUES. GROUND WATER CONDITIONS. ELEVATION SCALE. DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100). SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE (40, 80, 120, 160, 200). 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

Silty **CLAY**, some sand, trace gravel
Hard
Brown
(TILL)

Hard augering

Sample Number	Type	"N" Values	Remarks & Grain Size Distribution (%) GR SA SI CL
8	SS	41	
9	SS	38	
10	SS	60	
11	SS	48	
12	SS	54	3 27 47 23
13	SS	80	

Elevation scale: 170, 169, 168, 167, 166, 165, 164, 163, 162, 161

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

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

ONTMT4S 9270.GPJ 6/29/09

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No CNH-05

METRIC

G.W.P. 202-95-00 | LOCATION N 4 845 053.1 E 294 358.8 | ORIGINATED BY GA

HWY 427 | BOREHOLE TYPE Solid Stem Auger | COMPILED BY AN

DATUM Geodetic | DATE 2008.12.04 - 2008.12.04 | CHECKED BY SKP

Column headings: SOIL PROFILE (ELEV/DEPTH, DESCRIPTION, STRAT PLOT); SAMPLES (NUMBER, TYPE, "N" VALUES); GROUND WATER CONDITIONS; ELEVATION SCALE; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa (○ UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE; 40, 80, 120, 160, 200); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L, WATER CONTENT (%) (20, 40, 60); UNIT WEIGHT γ kN/m³; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	GR	SA	SI	CL
	Continued From Previous Page								
	Silty **CLAY**, some sand, trace gravel Hard Brown (TILL)	14	SS	92	160				
158.9 / 21.3	Silty **SAND**, trace clay, trace gravel Very Dense Grey Wet	15	SS	121	159	5	64	23	8
	Hard augering				158				
		16	SS	128	157				
					156				
155.8 / 24.4	Some gravel, some clay, occasional shale fragments, occasional cobbles and boulders Hard augering	17	SS	115		11	45	29	15
	Highly weathered shale				155				
154.1 / 26.1		18	SS	105/ 0.150					

END OF BOREHOLE AT 26.1m UPON REFUSAL ON PROBABLE BEDROCK.
BOREHOLE OPEN TO 26m AND WATER LEVEL AT 11.8m UPON COMPLETION OF DRILLING.
Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.
WATER LEVEL READINGS:

DATE	DEPTH (m)	ELEV. (m)
2009.01.21	14.5	165.7
2009.05.05	14.2	166.0
2009.06.08	14.2	166.0

+ ³, × ³ : Numbers refer to Sensitivity

15 ⊕ 5 (20 above, 10 below) (%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No CNH-06

METRIC

G.W.P. 202-95-00	LOCATION N 4 845 080.9 E 294 358.3		ORIGINATED BY GA
HWY 427	BOREHOLE TYPE Solid Stem Auger		COMPILED BY MFA
DATUM Geodetic	DATE 2008.12.09 - 2008.12.10		CHECKED BY SKP

SOIL PROFILE | SAMPLES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100) | SHEAR STRENGTH kPa (O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, X LAB VANE; 40, 80, 120, 160, 200) | PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L — WATER CONTENT (%) (20, 40, 60) | UNIT WEIGHT γ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
171.4 / 0.0	Silty **CLAY**, with sand, trace gravel Stiff to Very Stiff Brown (TILL)	1	SS	11	3	23	34	40
	Occasional iron oxide staining	2	SS	28				
168.5 / 2.9	Hard trace sand	3	SS	50	0	3	68	29
	Grey	4	SS	48				
		5	SS	34				
	with sand	6	SS	48	2	31	47	20
		7	SS	69				

Elevation scale: 171, 170, 169, 168, 167, 166, 165, 164, 163, 162

Continued Next Page

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

Ministry of Transportation Ontario

RECORD OF BOREHOLE No CNH-06

 METRIC

G.W.P. 202-95-00 LOCATION N 4 845 080.9 E 294 358.3 ORIGINATED BY GA

HWY 427 BOREHOLE TYPE Solid Stem Auger COMPILED BY MFA

DATUM Geodetic DATE 2008.12.09 - 2008.12.10 CHECKED BY SKP

Continued From Previous Page

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	ELEVATION SCALE	WATER CONTENT (%)	GR	SA	SI	CL
	Silty **CLAY**, with sand, trace gravel; Hard; Grey; (TILL)				161					
160.7 / 10.7	Silty **SAND**, some gravel, trace clay; Very Dense; Grey; Wet	8	SS	101		o	11	55	25	9
					160					
		9	SS	110	159	o				
	Hard augering				158					
		10	SS	122	157	o				
155.8 / 15.5		11	SS	101	156	o				

END OF BOREHOLE AT 15.5m.
BOREHOLE OPEN TO 15.2m AND WATER LEVEL AT 5.8m UPON COMPLETION OF DRILLING.
Piezometer installation consists of 25mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.
WATER LEVEL READINGS:

DATE	DEPTH (m)	ELEV. (m)
2009.01.21	6.1	165.3
2009.05.05	4.9	166.5
2009.06.08	4.9	166.5

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH kPa: O UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE; 40 80 120 160 200
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 (%)

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

(%) STRAIN AT FAILURE

Ministry of Transportation Ontario

RECORD OF BOREHOLE No CNH-07

METRIC

G.W.P. 202-95-00	LOCATION N 4 845 100.9 E 294 354.5		ORIGINATED BY GA
HWY 427	BOREHOLE TYPE Solid Stem Auger		COMPILED BY MFA
DATUM Geodetic	DATE 2008.12.12 - 2008.12.12		CHECKED BY SKP

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION
171.6 / 0.0	Silty **CLAY**, with sand, trace gravel Stiff Mottled Brown to Grey (TILL)
	Occasional iron oxide staining Very Stiff
167.1 / 4.4	Hard Grey
165.6 / 5.9	Layer of sandy silt Very Dense
164.7 / 6.9	

SAMPLES

NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	SS	10	
2	SS	9	
3	SS	26	
4	SS	30	
5	SS	60	0 46 50 4
6	SS	79	
7	SS	71	

STRAT PLOT | GROUND WATER CONDITIONS | ELEVATION SCALE: 171, 170, 169, 168, 167, 166, 165, 164, 163, 162

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE: 40 80 120 160 200

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

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

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

Ministry of Transportation Ontario

RECORD OF BOREHOLE No CNH-07

METRIC

G.W.P. 202-95-00 | LOCATION N 4 845 100.9 E 294 354.5 | ORIGINATED BY GA

HWY 427 | BOREHOLE TYPE Solid Stem Auger | COMPILED BY MFA

DATUM Geodetic | DATE 2008.12.12 - 2008.12.12 | CHECKED BY SKP

Continued From Previous Page

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%)
160.9	Silty **CLAY**, with sand, trave gravel Hard Grey (TILL)						161		
10.7	Silty **SAND**, trace gravel Very Dense Grey Wet		8	SS	101		160	o	
			9	SS	115		159	o	
	Hard augering								
	occasional inferred cobbles						158		
			10	SS	111		157	o	
156.0			11	SS	122				
15.5	END OF BOREHOLE AT 15.5m. BOREHOLE OPEN TO 14.6m AND WATER LEVEL AT 0.5m UPON COMPLETION OF DRILLING. BOREHOLE BACKFILLED WITH BENTONITE GROUT TO 1.5m, THEN SEALED WITH BENTONITE HOLEPLUG TO SURFACE.								

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, X LAB VANE; 40 80 120 160 200

PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60

UNIT WEIGHT γ kN/m³

GR SA SI CL

+³, ×³: Numbers refer to Sensitivity

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

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No CNH-08

METRIC

G.W.P. 202-95-00	LOCATION N 4 845 128.7 E 294 354.8		ORIGINATED BY WB
HWY 427	BOREHOLE TYPE Solid Stem Auger		COMPILED BY AN
DATUM Geodetic	DATE 2008.12.18 - 2008.12.18		CHECKED BY SKP

SOIL PROFILE | SAMPLES | GROUND WATER CONDITIONS | ELEVATION SCALE | DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100) | SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, X LAB VANE (40, 80, 120, 160, 200) | PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L — WATER CONTENT (%) (20, 40, 60) | UNIT WEIGHT γ kN/m³ | REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GR	SA	SI	CL
181.3									
0.0 / 0.1	**ASPHALT:** (75mm)								
	Gravelly **SAND**, Very Dense, Brown, Moist (FILL)		1	SS	53				
180.3 / 1.1	**SILT** and **SAND**, trace clay, Loose, Brown, Moist (FILL)		2	SS	7	0	55	39	6
176.8 / 4.6	Silty **CLAY**, with sand, trace gravel, Hard, Brown (TILL)		3	SS	30	0	22	45	33
	Occasional layers of silty sand		4	SS	42				
			5	SS	30				

Elevation scale: 181, 180, 179, 178, 177, 176, 175, 174, 173, 172

Continued Next Page

+ ³, × ³: Numbers refer to Sensitivity

15 ⊕ 5 (20 above, 10 below) (%) STRAIN AT FAILURE

Ministry of Transportation Ontario

RECORD OF BOREHOLE No CNH-08

METRIC

G.W.P. 202-95-00 | LOCATION N 4 845 128.7 E 294 354.8 | ORIGINATED BY WB

HWY 427 | BOREHOLE TYPE Solid Stem Auger | COMPILED BY AN

DATUM Geodetic | DATE 2008.12.18 - 2008.12.18 | CHECKED BY SKP

ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	UNIT WEIGHT kN/m3	GR	SA	SI	CL
	Continued From Previous Page												
	Silty **CLAY**, with sand, trace gravel Hard Brown (TILL)						171						
			6	SS	35			plotted		1	21	38	40
							170						
			7	SS	100/ 0.275		169	plotted					
							168						
			8	SS	100/ 0.225			plotted					
							167						
	Hard augering						166						
165.7			9	SS	100/ 0.250			plotted		4	32	43	21
15.6	END OF BOREHOLE AT 15.6m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.075m THEN ASPHALT TO SURFACE.												

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE; 40 80 120 160 200

PLASTIC LIMIT w_P — NATURAL MOISTURE CONTENT w — LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60

REMARKS & GRAIN SIZE DISTRIBUTION (%)

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

(%) STRAIN AT FAILURE

Ministry of Transportation
Ontario

RECORD OF BOREHOLE No CNH-09

METRIC

G.W.P. 202-95-00 | LOCATION N 4 845 035.8 E 294 359.8 | ORIGINATED BY GA

HWY 427 | BOREHOLE TYPE Solid Stem Auger | COMPILED BY AN

DATUM Geodetic | DATE 2008.12.05 - 2008.12.05 | CHECKED BY SKP

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
179.8 / 0.0	TOPSOIL (50mm)						
	Silty **CLAY**, with sand, trace gravel Stiff to Very Stiff Brown (FILL)	1	SS	12			
						179	
		2	SS	16		178	
						177	
		3	SS	8			3 27 41 29
						176	
		4	SS	27		175	
						174	
173.1 / 6.7		5	SS	26			
	END OF BOREHOLE AT 6.7m. BOREHOLE OPEN AND DRY UPON COMPLETION OF DRILLING. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.						

SOIL PROFILE; SAMPLES; STRAT PLOT; DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100; SHEAR STRENGTH kPa: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, X LAB VANE; 40 80 120 160 200; PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) 20 40 60; UNIT WEIGHT γ kN/m³

ONTMT4S 9270.GPJ 6/29/09

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

Ministry of Transportation Ontario

RECORD OF BOREHOLE No CNH-10

METRIC

G.W.P. 202-95-00
LOCATION N 4 845 130.8 E 294 336.8
ORIGINATED BY WB

HWY 427
BOREHOLE TYPE Solid Stem Auger
COMPILED BY MFA

DATUM Geodetic
DATE 2008.12.17 - 2008.12.17
CHECKED BY SKP

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
181.3 / 0.0					
0.1	**ASPHALT:** (75mm)				
	SILT and **SAND**, trace clay Dense to Compact Brown Moist (FILL)	1	SS	47	
		2	SS	47	
		3	SS	25	
		4	SS	24	0 51 45 4
		5	SS	14	
177.0 / 4.3	Silty **CLAY**, with sand, trace gravel Very Stiff Brown (TILL)	6	SS	16	0 25 48 27
		7	SS	15	
174.6 / 6.7	END OF BOREHOLE AT 6.7m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO 0.075m, THEN ASPHALT TO SURFACE.				

Column headings: STRAT PLOT; GROUND WATER CONDITIONS; ELEVATION SCALE (181, 180, 179, 178, 177, 176, 175); DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100); SHEAR STRENGTH kPa (O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, X LAB VANE; 40, 80, 120, 160, 200); PLASTIC LIMIT w_P, NATURAL MOISTURE CONTENT w, LIQUID LIMIT w_L; WATER CONTENT (%) (20, 40, 60); UNIT WEIGHT γ kN/m³

+ ³, X ³: Numbers refer to Sensitivity

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

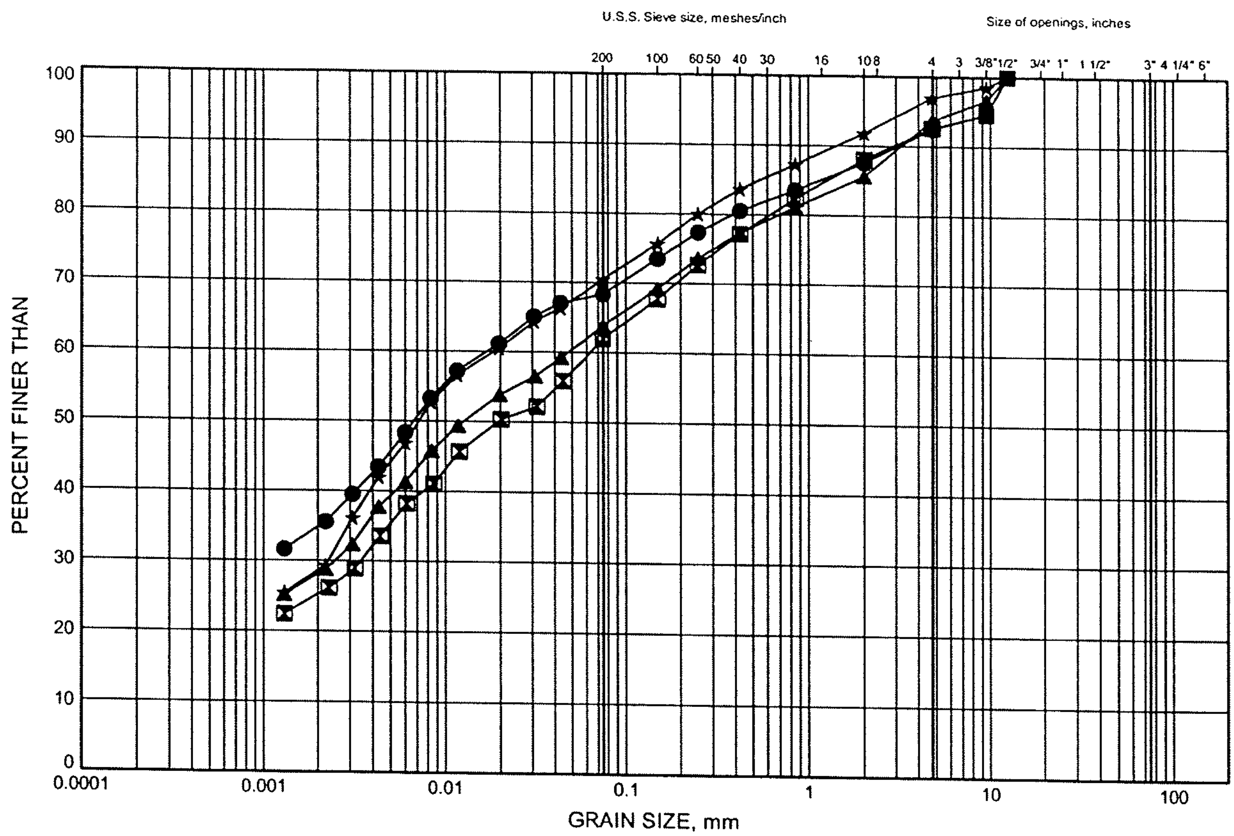
ONTMT4S 9270.GPJ 6/29/09

Appendix B

Laboratory Test Results

Hwy 427 Northbound and Southbound GRAIN SIZE DISTRIBUTION	FIGURE B1

SILTY CLAY FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CNH-01	1.83	178.44
⊠	CNH-01	6.40	173.87
▲	CNH-05	3.35	176.81
★	CNH-09	3.35	176.45

W.P.# 19-92-70
Prepared By AN
Checked By RPR

THURBER

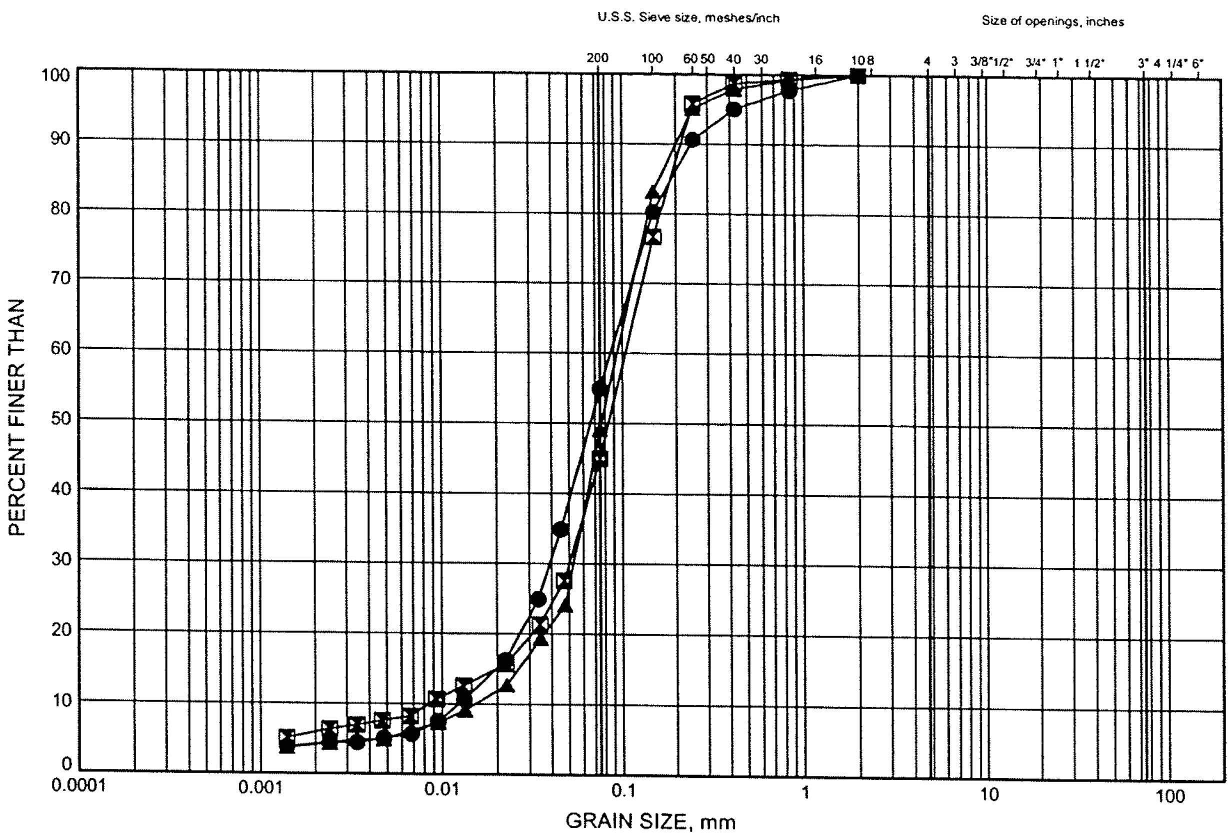
GRAIN SIZE DISTRIBUTION - THURBER 9270.GPJ 5/1/09

Hwy 427 Northbound and Southbound

GRAIN SIZE DISTRIBUTION

FIGURE B2

SILT & SAND FILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CNH-04	2.59	178.68
⊠	CNH-08	3.35	177.97
▲	CNH-10	2.59	178.70

W.P.# 202-95-00

Prepared By AN

Checked By RPR

THURBER

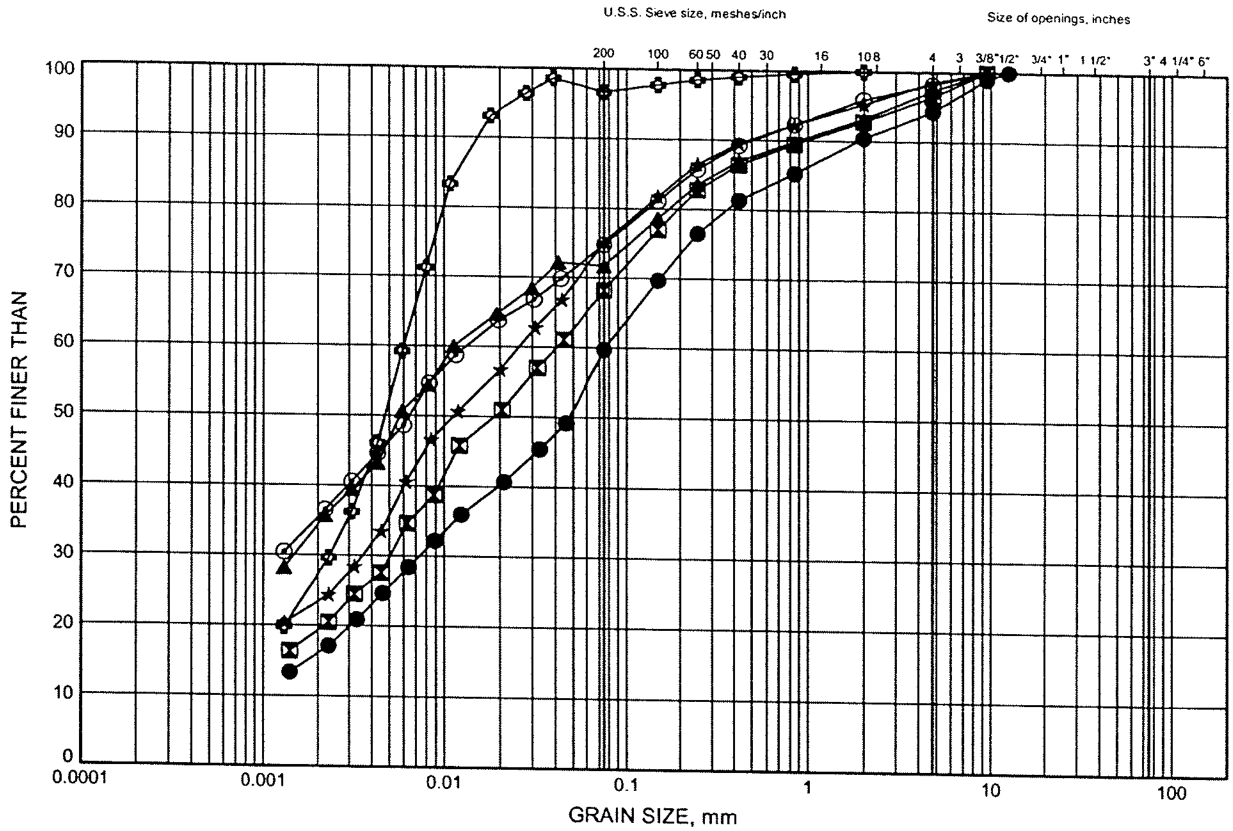
GRAIN SIZE DISTRIBUTION - THURBER 9270.GPJ 7/8/09

Hwy 427 Northbound and Southbound

GRAIN SIZE DISTRIBUTION

FIGURE B3

SILTY CLAY TILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CNH-01	15.54	164.73
⊠	CNH-02	1.83	169.30
▲	CNH-02	6.40	164.73
★	CNH-03	3.35	168.24
⊙	CNH-04	6.40	174.87
✪	CNH-04	14.02	167.25

W.P.# 19-92-70

Prepared By AN

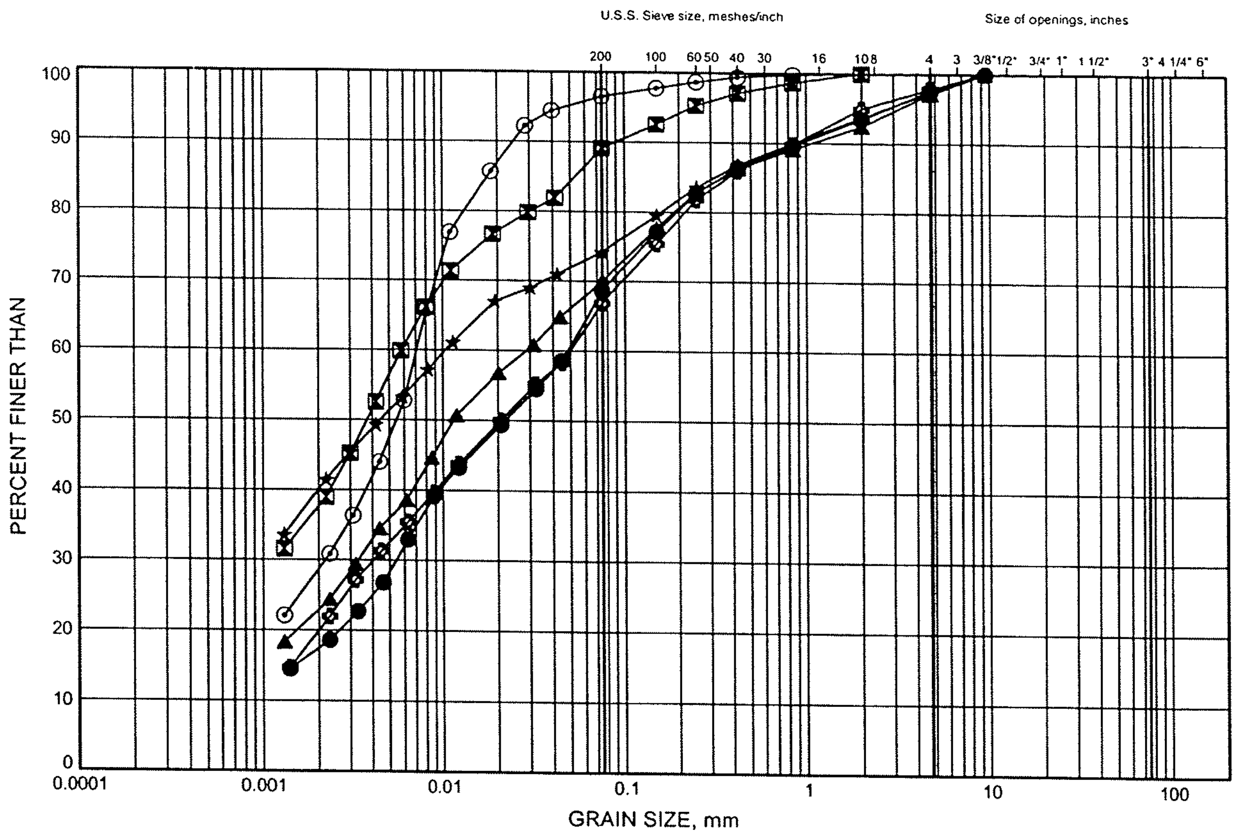
Checked By RPR

THURBER

Hwy 427 Northbound and Southbound
GRAIN SIZE DISTRIBUTION

FIGURE B4

SILTY CLAY TILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CNH-04	15.54	165.73
⊠	CNH-05	9.45	170.72
▲	CNH-05	17.07	163.10
★	CNH-06	0.30	171.08
⊙	CNH-06	3.35	168.03
✪	CNH-06	7.92	163.46

W.P.# 19-92-70

Prepared By AN

Checked By RPR

THURBER

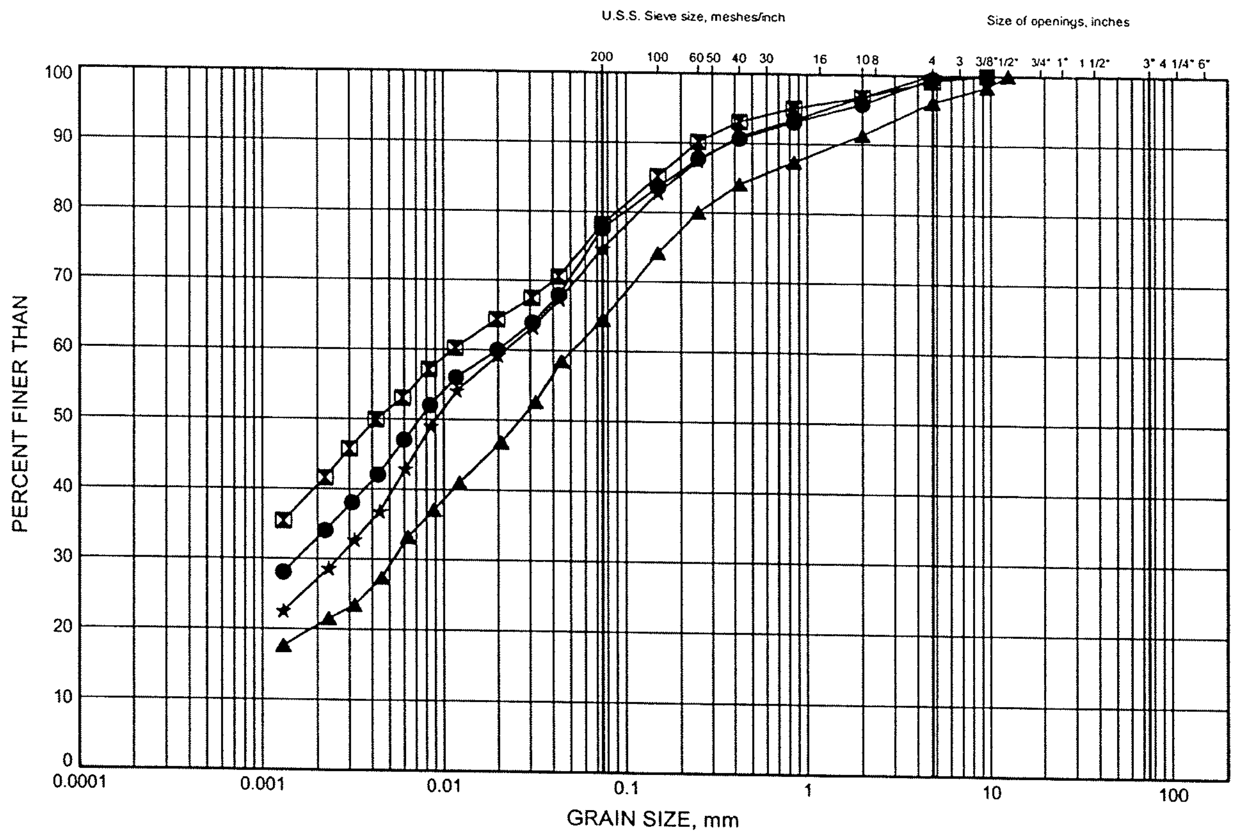
GRAIN SIZE DISTRIBUTION - THURBER 9270.GPJ 5/1/09

Hwy 427 Northbound and Southbound

GRAIN SIZE DISTRIBUTION

FIGURE B5

SILTY CLAY TILL



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CNH-08	6.40	174.92
⊠	CNH-08	10.97	170.35
▲	CNH-08	15.44	165.88
★	CNH-10	4.88	176.42

W.P.# 19-92-70

Prepared By AN

Checked By RPR

THURBER

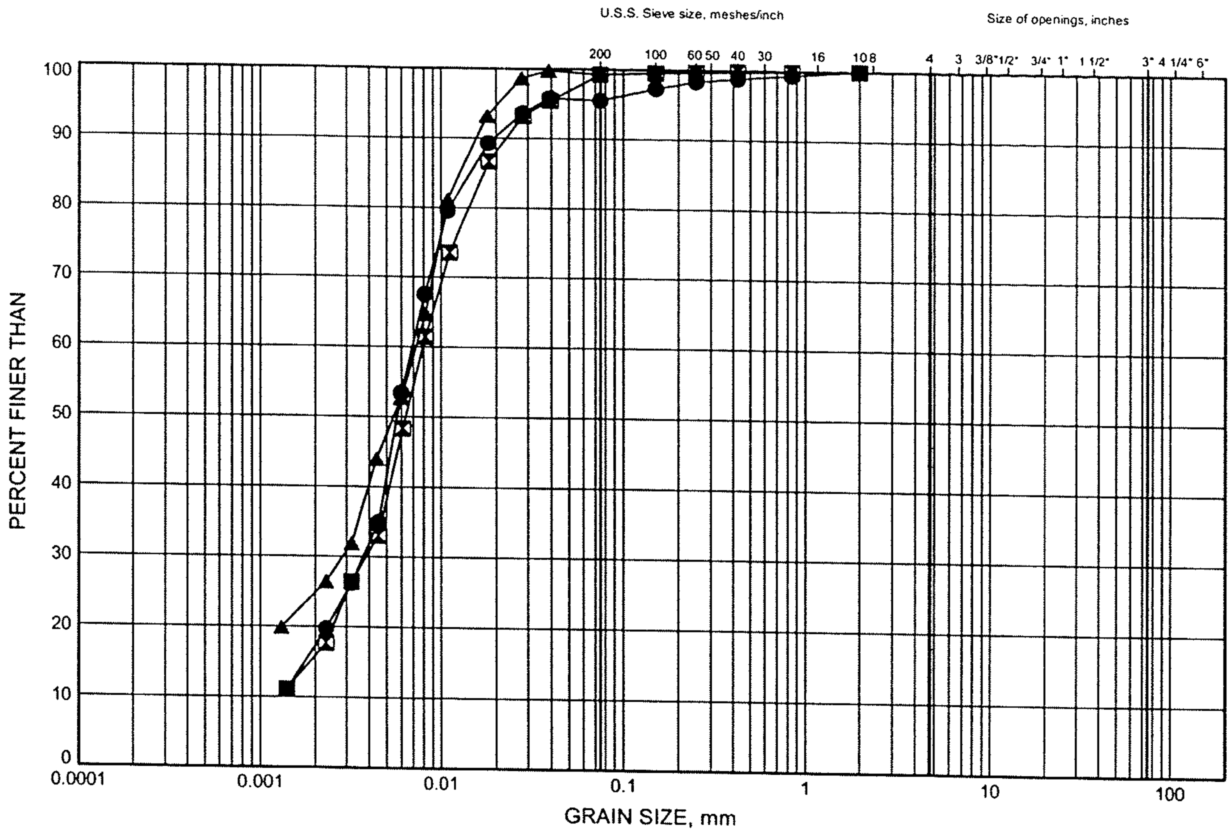
GRAIN SIZE DISTRIBUTION - THURBER 9270.GPJ 5/1/09

Hwy 427 Northbound and Southbound

GRAIN SIZE DISTRIBUTION

FIGURE B6

CLAYEY SILT



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CNH-01	10.97	169.30
⊠	CNH-02	3.35	167.78
▲	CNH-03	4.88	166.72

W.P.# 19-92-70

Prepared By AN

Checked By RPR

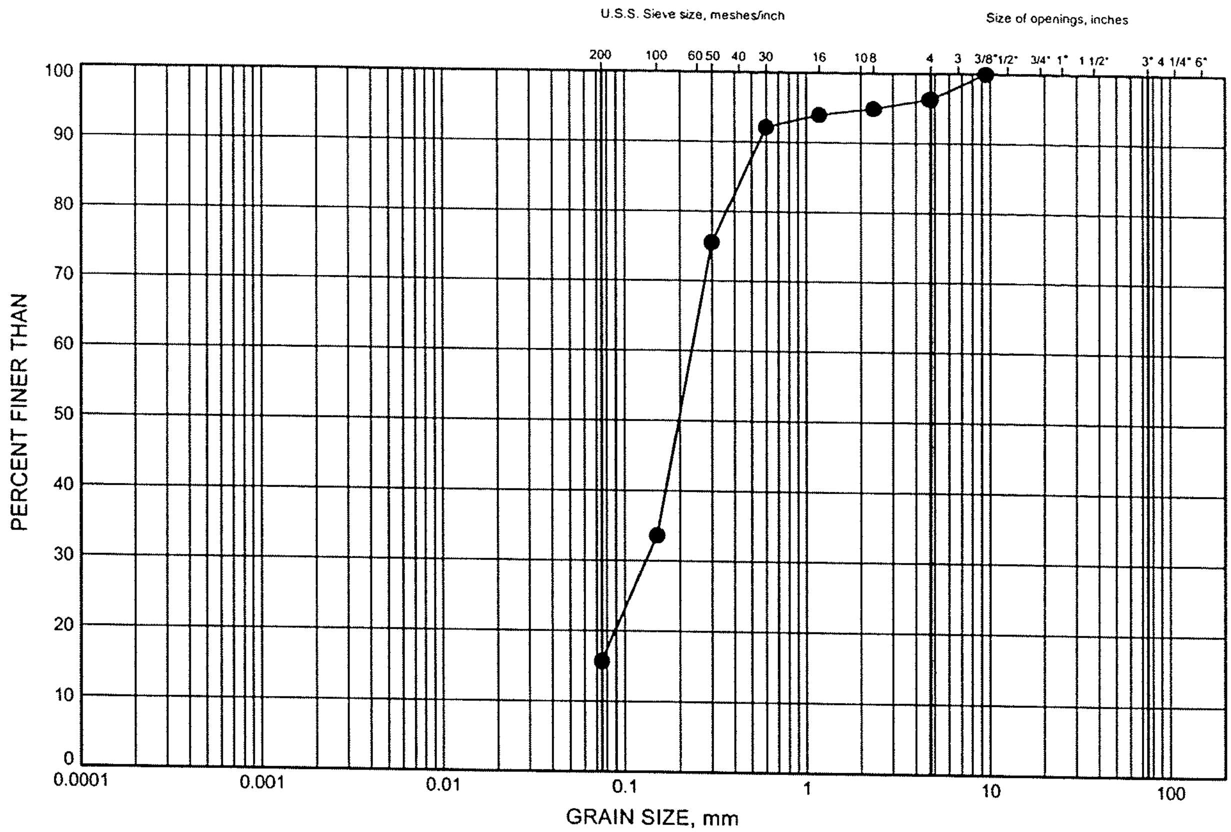
THURBER

Hwy 427 Northbound and Southbound

GRAIN SIZE DISTRIBUTION

FIGURE B7

SAND



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CNH-01	23.16	157.11

W.P.# 19-92-70
Prepared By AN
Checked By RPR

THURBER

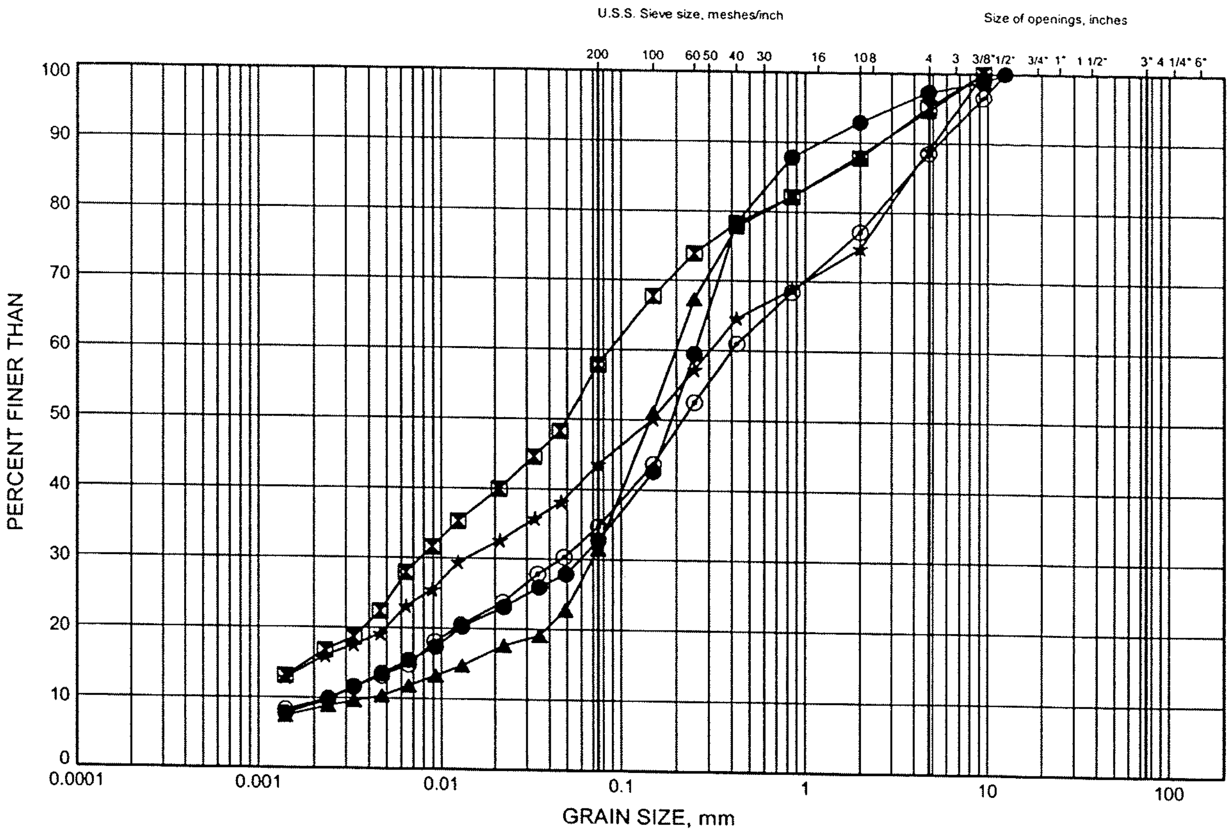
GRAIN SIZE DISTRIBUTION - THURBER 9270.GPJ 5/1/09

Hwy 427 Northbound and Southbound

GRAIN SIZE DISTRIBUTION

FIGURE B8

SILTY SAND



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CNH-02	12.50	158.63
⊠	CNH-04	18.48	162.79
▲	CNH-05	21.64	158.52
★	CNH-05	24.69	155.48
⊙	CNH-06	10.97	160.41

W.P.# 202-95-00

Prepared By MFA

Checked By RPR

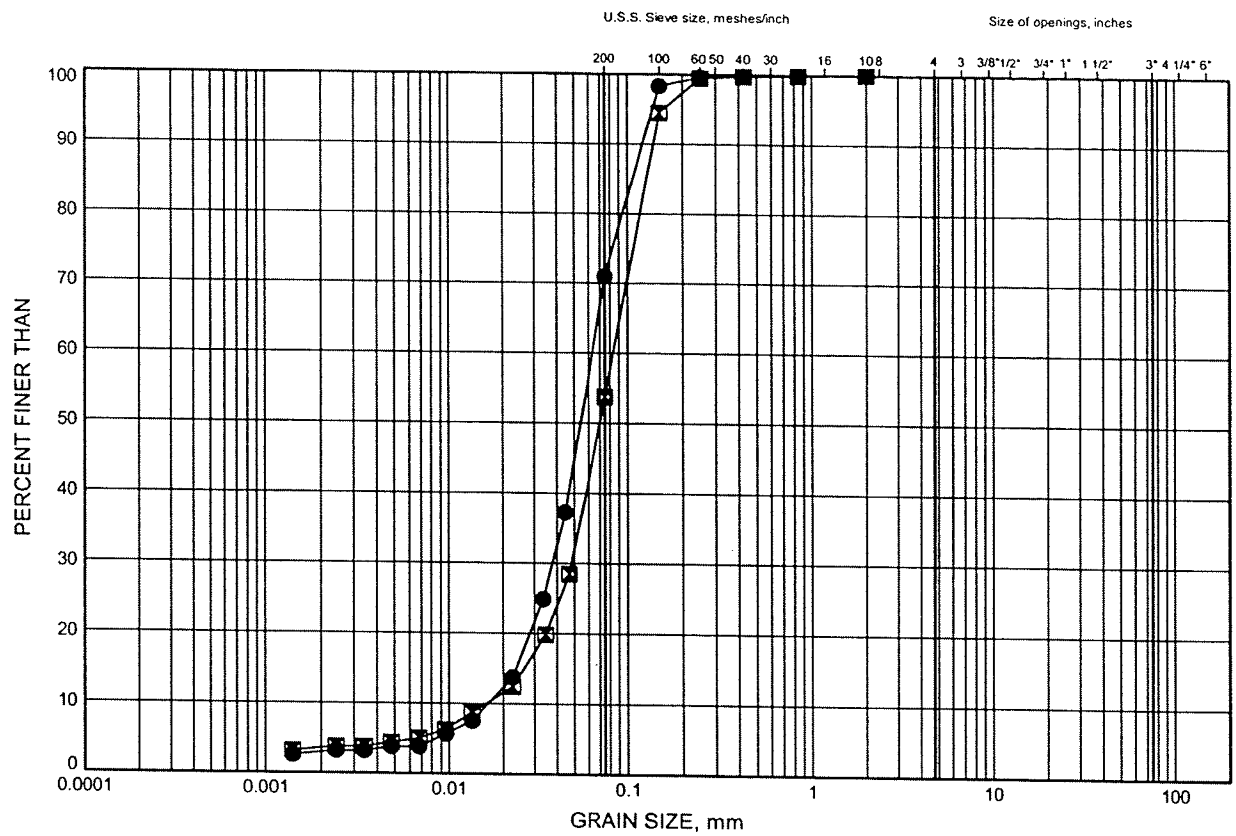
THURBER

GRAIN SIZE DISTRIBUTION - THURBER 9270.GPJ 6/29/09

GRAIN SIZE DISTRIBUTION

FIGURE B9

SANDY SILT



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	CNH-03	7.92	163.67
⊠	CNH-07	6.40	165.15

W.P.# 202-95-00
Prepared By MFA
Checked By RPR

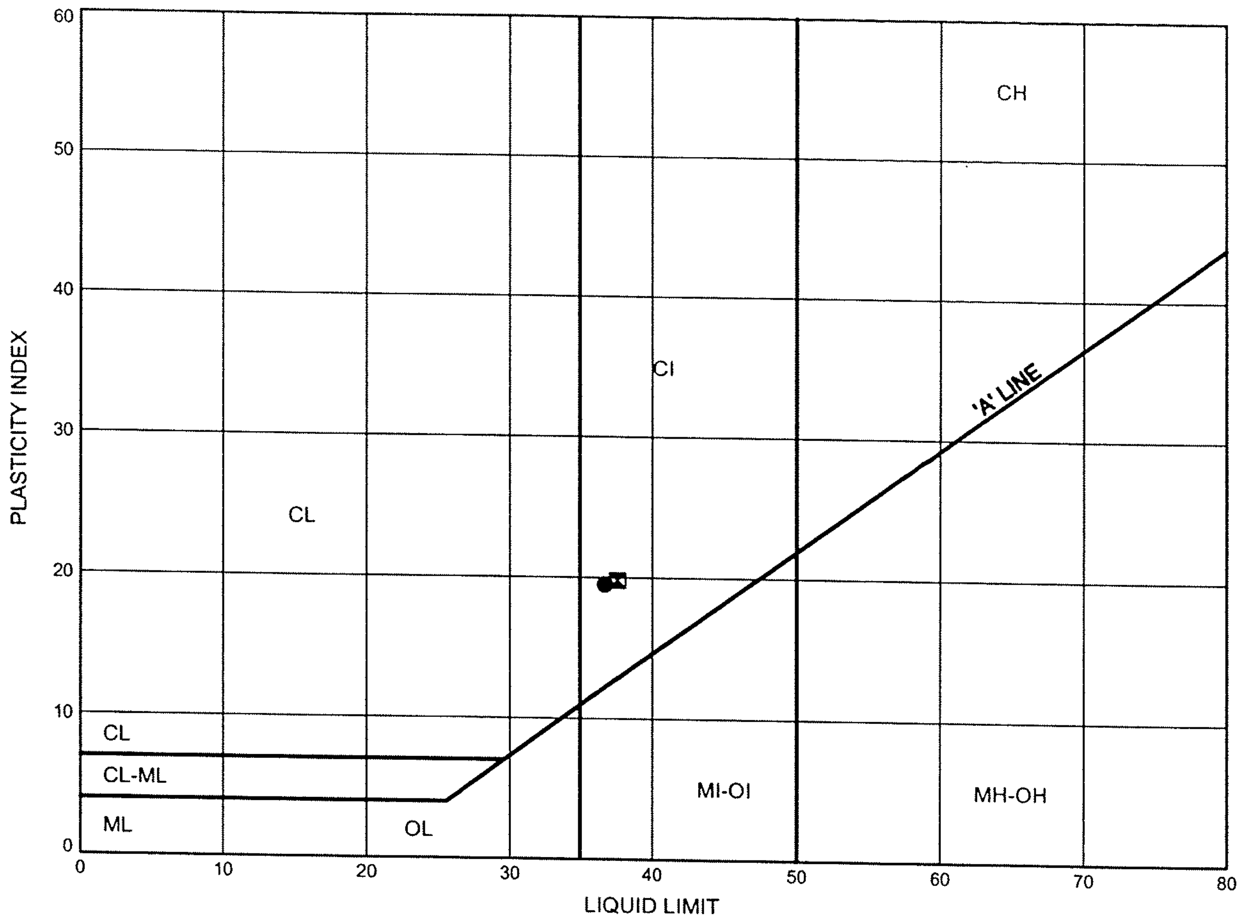
THURBER

Hwy 427 Northbound and Southbound

ATTERBERG LIMITS TEST RESULTS

FIGURE B10

SILTY CLAY FILL



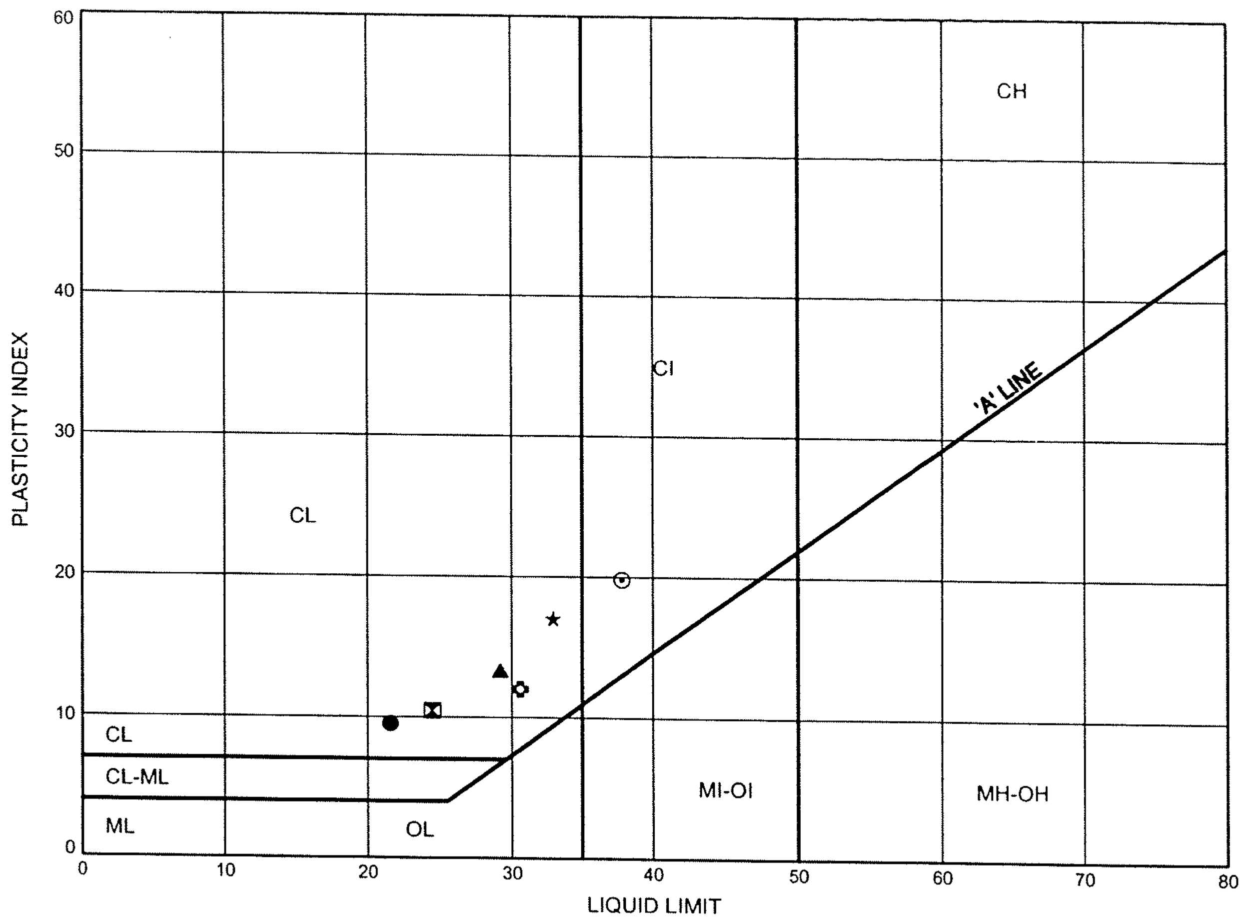
SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	CNH-01	6.40	173.87
⊠	CNH-09	3.35	176.45

Hwy 427 Northbound and Southbound

ATTERBERG LIMITS TEST RESULTS

FIGURE B11

SILTY CLAY TILL



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	CNH-01	15.54	164.73
⊠	CNH-02	1.83	169.30
▲	CNH-02	6.40	164.73
★	CNH-03	3.35	168.24
⊙	CNH-04	6.40	174.87
✪	CNH-04	14.02	167.25

Date May 2009

Project 19-92-70

THURBER

Prep'd AN

Chkd. RPR

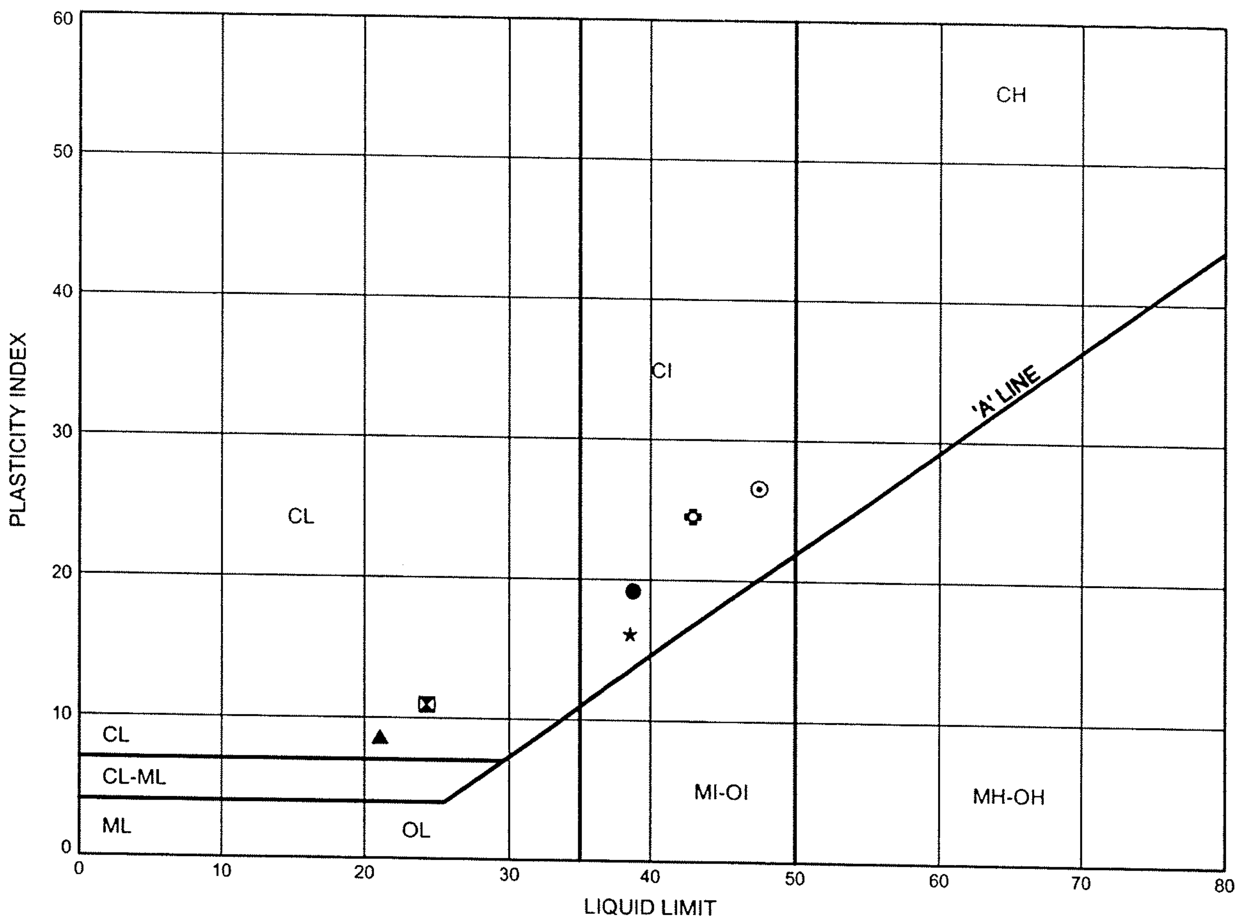
THURBALT 9270.GPJ 5/1/09

Hwy 427 Northbound and Southbound

ATTERBERG LIMITS TEST RESULTS

FIGURE B12

SILTY CLAY TILL



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	CNH-05	9.45	170.72
⊠	CNH-05	17.07	163.10
▲	CNH-06	7.92	163.46
★	CNH-07	1.83	169.72
⊙	CNH-08	6.40	174.92
✪	CNH-08	10.97	170.35

THURBALT 9270.GPJ 5/1/09

Date May 2009

Project 19-92-70

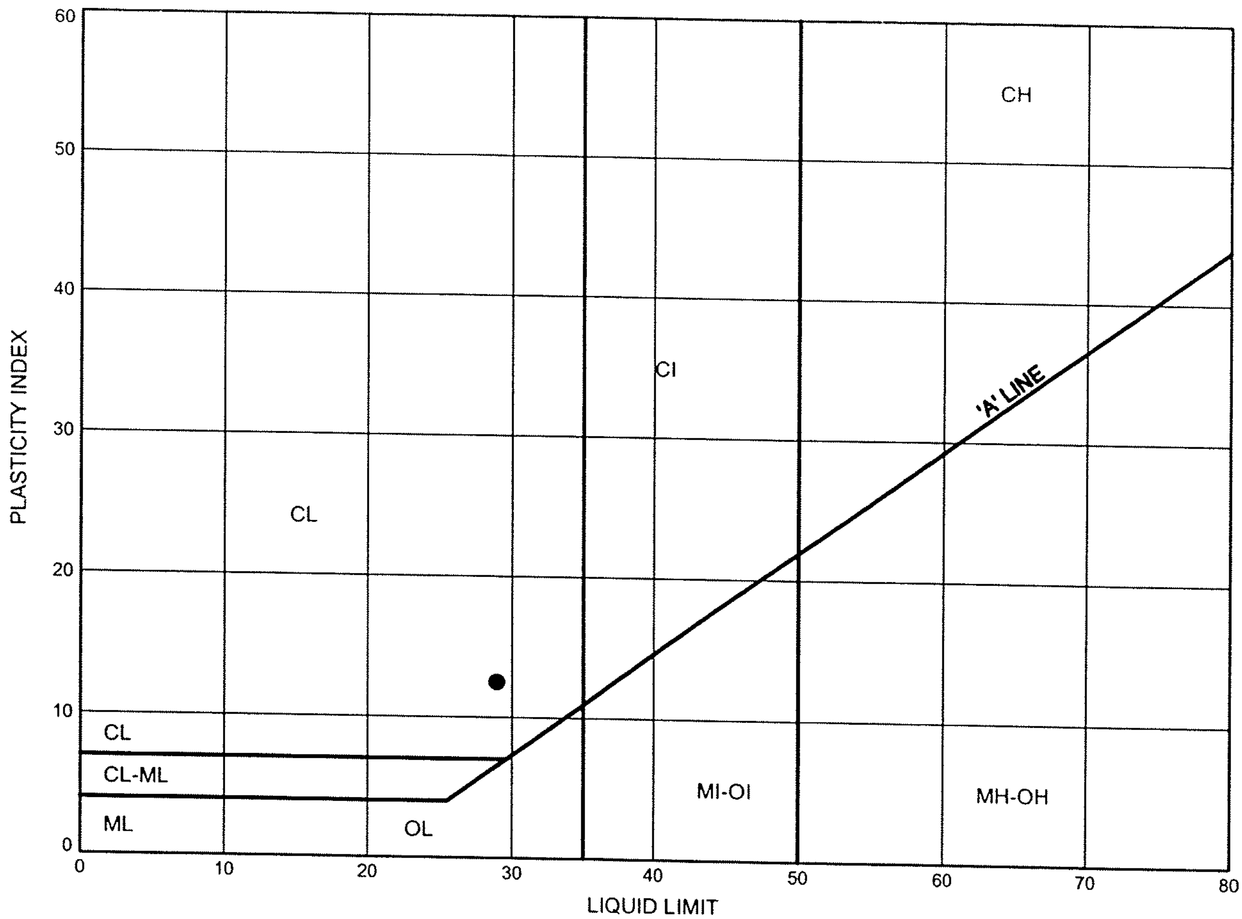
THURBER

Prep'd AN

Chkd. RPR

Hwy 427 Northbound and Southbound ATTERBERG LIMITS TEST RESULTS	FIGURE B13

SILTY CLAY TILL



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	CNH-10	4.88	176.42

THURBALT 9270.GPJ 5/1/09

Date May 2009

Project 19-92-70

THURBER

Prep'd AN

Chkd. RPR

Appendix C

Record of Borehole Sheets

(Previous Investigation)

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RECORD OF BOREHOLE No 1

METRIC

W P 153-80-02 LOCATION Co-ords. N 4 844 821.2; E 294 328.3 ORIGINATED BY V.P.
DIST 6 HWY 427 BOREHOLE TYPE Hollow Stem Augers and Cone Test COMPILED BY V.P.
DATUM Geodetic DATE 81-12-10 to 81-12-11 CHECKED BY [signature]

ELEV / DEPTH	DESCRIPTION (SOIL PROFILE)	SAMPLE NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
171.9	Ground Surface						
0.0	Mottled	1	SS	9	* (water level)		
		2	SS	13		170	2-20-45-33
	Brown / Grey	3	SS	29			
	(Glacial Till) Silty Clay with Sand trace of Gravel	4	SS	27			
		5	SS	21		168	3-20-57-20
		6	SS	35			
						166	
	Stiff to Hard	7	SS	14			
		8	SS	16		164	
		9	SS	53		162	
		10	SS	37			0-28-42-30
160.0 / 11.9 / 39.0	Silty Sand Dense	11	SS	37		160	
158.0 / 13.9 / 45.6	Boulder	12	RC	-			
	Break corebarrel in borehole Abandon hole End of Borehole						
	* Borehole caved at shallow depth. Perched water level at 0.5 metres.						

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100 — 110/28 cm
SHEAR STRENGTH: O UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE
PLASTIC LIMIT W_p — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30
UNIT WEIGHT γ

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

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Ontario

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RECORD OF BOREHOLE No 2

METRIC

W P 153-80-02 LOCATION Co-ords. N 4 844 846.8; E 294 360.0 ORIGINATED BY V.P.

DIST 6 HWY 427 BOREHOLE TYPE Hollow Stem Augers COMPILED BY V.P.

DATUM Geodetic DATE 81-12-11, 81-12-14, 81-12-15 CHECKED BY [signature]

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
171.6	Ground Surface							
0.0					▽ *			
	(Glacial Till) Silty Clay with Sand trace of Gravel	1	SS	27				
		2	SS	32		170		
	Brown / Grey	3	SS	51			Wp ≈ 10, w ≈ 13–16	5-28-32-15
		4	SS	32		168		
		5	SS	47				
		6	SS	43		166		
		7	SS	33				12-15-41-32
	Silty Sand	8	SS	40		164		
	Very Stiff to Hard	9	SS	78		162		
161.5 / 10.1	Grey Silty Sand to Sand	10	SS	91				25-37-35-3
		11	SS	40		160		25-43-30-2
		12	SS	52				
		13	SS	94		158		1-72-16-11
		14	SS	55				
	Sand and Gravel with varying Amounts of Gravel	15	SS	106/18 cm		156		31-53-(16)
	Occasional Cobbles and Boulders throughout	16	SS	70/15 cm		154		2-65-32-1
		17	SS	100/15 cm		152		30-56-(14)
	Dense to Very Dense					150		
148.2 / 23.4	Refusal to Augering End of Borehole							

* Note: Perched water table, B.H. caved at 3.5 metres.

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH: ○ UNCONFINED + FIELD VANE; ● QUICK TRIAXIAL × LAB VANE
PLASTIC LIMIT W_p, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30
UNIT WEIGHT γ

•3, ×5 : Numbers refer to Sensitivity

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

RECORD OF BOREHOLE No 3

METRIC

W P 153-80-02 LOCATION Co-ords. N 4 844 869.0; E 294 354.2 ORIGINATED BY V.P.

DIST 6 HWY 427 BOREHOLE TYPE Hollow Stem Augers/Solid Stem Augers 24.4 m to 33.4 m and Cone Test COMPILED BY V.P.

DATUM Geodetic DATE 81-12-16, 81-12-17 CHECKED BY [signature]

SOIL PROFILE

ELEV DEPTH	DESCRIPTION
171.5	Ground Surface
0.0	(Glacial Till)
	Brown / Grey
	Silty Clay with Sand trace of Gravel
	occ. Cobbles and Boulders
	Stiff to Hard
161.1 / 10.4	boulder
	Grey
	Silty Sand to Sand Varying Amounts of Gravel
	Occasional Cobbles and Boulders throughout
	Alternating Seams and Layers of Silt, Sand and Gravel
	Dense to Very Dense
138.1 / 33.4	Refusal to Solid Augers, Possible Boulder or Bedrock
	End of Borehole

* Perched Water Table at 0.9 m
Borehole Caved at 3.5 m

Note: This borehole is a combination of two borings the first meeting refusal at 10.7 metres on a probable boulder.

SAMPLES

NUMBER	TYPE	'N' VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	SS	9	
2	SS	26	
3	SS	49	2-22-55-21
4	SS	50	
5	SS	38	
6	SS	21	5-12-51-32
7	SS	26	
8	SS	30	
9	SS	44	
10	SS	36	22-48-25-5
11	SS	105	
12	SS	58	2-71-25-2
13	SS	58/15 cm	44-42-(14)
14	SS	105/13 cm	

GROUND WATER CONDITIONS: water level shown near sample 1; * at sample 2.

ELEVATION SCALE: 170, 168, 166, 164, 162, 160, 158, 156, 154, 152, 150, 140

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100 — 100/17 cm

SHEAR STRENGTH: o UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE

PLASTIC LIMIT W_p, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L — WATER CONTENT (%) 10 20 30

UNIT WEIGHT γ

$+^3$, x^5: Numbers refer to Sensitivity

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

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RECORD OF BOREHOLE No 4

METRIC

W P 153-80-02 | LOCATION Co-ords N 4 844 838.7; E 294 313.7 | ORIGINATED BY V.P.

DIST 6 HWY 427 | BOREHOLE TYPE Hollow Stem Auger and Cone Test | COMPILED BY V.P.

DATUM Geodetic | DATE 81-12-18 to 81-12-21 | CHECKED BY [signature]

SOIL PROFILE

ELEV / DEPTH	DESCRIPTION
171.4	Ground Surface
0.0	(Glacial Till) — Brown / Grey — Silty Sand — Silty Clay some Sand trave of Gravel — Hard
159.8 / 11.6 (38.1)	Cobbles — Grey — Compact — Silty Sand to Gravel and Cobble Layers — Sand — Varying Amounts of Gravel — occasional Cobbles and Boulders throughout — Very Dense
148.5 / 22.9 (75.1)	End of Borehole

* Borehole caved at 9.3 metres.

Perched Water Table

SAMPLES

NUMBER	TYPE	'N' VALUES	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
1	SS	42	
2	SS	60	1-17-67-15
3	SS	46	
4	SS	75	
5	SS	33	5-15-60-20
6	SS	83	
7	SS	45	
8	SS	20	15-53-30-2
9	SS	84	
10	SS	105/15 cm	6-75-(19)
11	SS	115/13 cm	12-51-33-4
12	SS	120/3 cm	

GROUND WATER CONDITIONS: water level symbol at approx. elev. 170.5 *

ELEVATION SCALE: 170, 168, 166, 164, 162, 160, 158, 156, 154, 152, 150

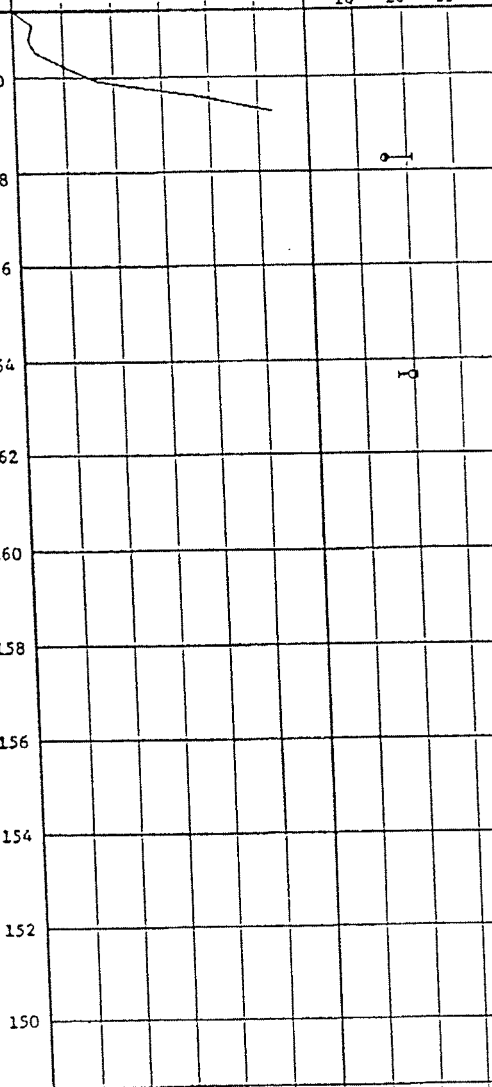
DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH: ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE

PLASTIC LIMIT W_p — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L

WATER CONTENT (%) 10 20 30

UNIT WEIGHT γ



+3, ×5 : Numbers refer to Sensitivity

15 ◇ 5 (%) STRAIN AT FAILURE (20 above, 10 below)

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RECORD OF BOREHOLE No 5

METRIC

W P 153-80-02 LOCATION Co-ords. N 4 844 920.5; E 294 356.5 ORIGINATED BY V.P.

DIST 6 HWY 427 BOREHOLE TYPE Solid Stem Auger/BW Casing and Cone Test COMPILED BY V.P.

DATUM Geodetic DATE 81-12-16 to 81-12-17 CHECKED BY [signature]

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	WATER CONTENT (%)	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
171.5	Ground Surface							
0.0	(Glacial Till) Silty Clay	1	SS	12		170		
		2	SS	15				
	Brown / Grey	3	SS	37				1-18-66-15
		4	SS	35		168		
	with Sand trace of Gravel	5	SS	27				
	Stiff to Hard	6	SS	15		166		
	Cobble	7	SS	20	▽ *			6-26-46-22
	Gravel Cobbles & Boulders	8	SS	41		164		
162.4 / 9.1 (27.9)	Grey Silty Sand to Sand	9	SS	124		162		23-46-27-4
		10	SS	77		160		
	Varying Amounts of Gravel	11	SS	53				0-85-11-4
	occasional Cobbles and Boulders throughout	12	SS	145		158 / 156		
		13	SS	148/23 cm		154		43-46-(11)
	Very Dense					152		
149.8		14	SS	147/23 cm		150		0-23-64-8
21.7 (71.2)	End of Borehole							

Dynamic cone penetration resistance plot: 100/23 cm at approx. elev. 168.

* Note: W.L. after 24 hours

Refusal to augering at 8.2 metres
Move BH 1.2 m south

Drive BW casing and run bi-cone 18.3 to 21.3 metres.

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100
SHEAR STRENGTH ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE
PLASTIC LIMIT W_p, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L — WATER CONTENT (%) 10 20 30
UNIT WEIGHT γ

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

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Ontario

RECORD OF BOREHOLE No 6

METRIC

W P 153-80-02 LOCATION Co-ords. N 4 844 864.4; E 294 316.3 ORIGINATED BY V.P.
DIST 6 HWY 427 BOREHOLE TYPE Solid Stem Auger/Drive "B" Casing COMPILED BY V.P.
DATUM Geodetic DATE 81-12-21 CHECKED BY [signature]

ELEV DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
170.6	Ground Surface						
0.0	(Glacial Till)	1	SS	31	*	170	
		2	SS	44			4-26-52-18
	Brown / Grey	3	SS	47		168	
		4	SS	35			2-4-82-12
	Silty Clay with Sand trace of Gravel	5	SS	40			
		6	SS	100/	8 cm	166	
		7	SS	36		164	
	Hard	8	SS	40			
	Gravel & Cobbles					162	
		9	SS	31			2-10-56-32
160.5 / 10.1 (33.1)	Grey	10	SS	36		160	24-47-25-4
	Silty Sand to	11	SS	74		158	3-56-35-6
	Cobbles						
	Sand					156	
		12	SS	149/	23 cm		
	Varying Amounts of Gravel					154	
	Occasional Cobbles and Boulders throughout	13	SS	168/	23 cm	152	
	Dense to Very Dense					150	
149.0		14	SS	145/	23 cm		15-47-32-6
21.6 (70.9)	End of Borehole						

* Perched Water Level at Ground Surface. BH Caved at 6.9 m.

Dynamic Cone Penetration Resistance Plot: 20 40 60 80 100
Shear Strength: ○ Unconfined + Field Vane ● Quick Triaxial × Lab Vane
Plastic Limit W_p, Natural Moisture Content W, Liquid Limit W_L — Water Content (%) 10 20 30
Unit Weight γ

$+^3, \times^5$: Numbers refer to Sensitivity

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

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RECORD OF BOREHOLE No 7

METRIC

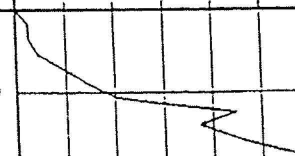
W P 153-80-02 LOCATION Co-ords. N 4 844 880.0; E 294 310.4 ORIGINATED BY V.P.

DIST 6 HWY 427 BOREHOLE TYPE Hollow Stem Augers and Cone Test COMPILED BY V.P.

DATUM Geodetic DATE 81-12-22 CHECKED BY [signature]

ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE
171.7	Ground Surface					
0.0	(Glacial Till)	1	SS	27	*	170
	Brown / Grey	2	SS	44		168
	Silty Clay with Sand trace of Gravel occ. cobbles	3	SS	30		166
		4	SS	75		
	Very Stiff to Hard	5	SS	122/22 cm		164
161.6 / 10.1 / 33.1		6	SS	40		162
	Grey Silty Sand to Sand	7	SS	107		160
		8	SS	79		
	Varying Amounts of Gravel	9	SS	103		158
	occasional Cobbles and Boulders throughout	10	SS	102		156 / 154
151.5	Very Dense	11	SS	157/20 cm		152
20.2 / 66.3	End of Borehole					
	* Note: W.L. not established at time of investigation.					

DYNAMIC CONE PENETRATION RESISTANCE PLOT 20 40 60 80 100



SHEAR STRENGTH: O UNCONFINED, + FIELD VANE, ● QUICK TRIAXIAL, × LAB VANE

PLASTIC LIMIT W_p — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L; WATER CONTENT (%)

UNIT WEIGHT γ

REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

+3, ×5 : Numbers refer to Sensitivity

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

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RECORD OF BOREHOLE No 8

METRIC

W P 153-80-02 LOCATION Co-ords. N 4 844 895.5; E 294 357.7 ORIGINATED BY V.P.

DIST 6 HWY 427 BOREHOLE TYPE Solid Stem Auger/"B" Casing COMPILED BY V.P.

DATUM Geodetic DATE 81-12-22 CHECKED BY [signature]

ELEV / DEPTH	DESCRIPTION	NUMBER	TYPE	'N' VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE
170.8	Ground Surface					
0.0	(Glacial Till)				*	170
		1	SS	31		
	Brown / Grey					168
	Silty Clay with Sand trace of Gravel	2	SS	25		
		3	SS	23		166
	Silty Sand	4	SS	27		
	Very Stiff to Hard					164
		5	SS	109		
162.0 / 8.8	Grey					162
	Silty Sand to Sand	6	SS	100		
		7	SS	118		160
		8	SS	11		158
	Varying Amounts of Gravel	9	SS	156		
	occasional Cobbles and Boulders Throughout					156
		10	SS	111		154
						152
	Very Dense	11	SS	100/15 cm		
						150
147.7		12	SS	100/8 cm		148
23.1	End of Borehole					

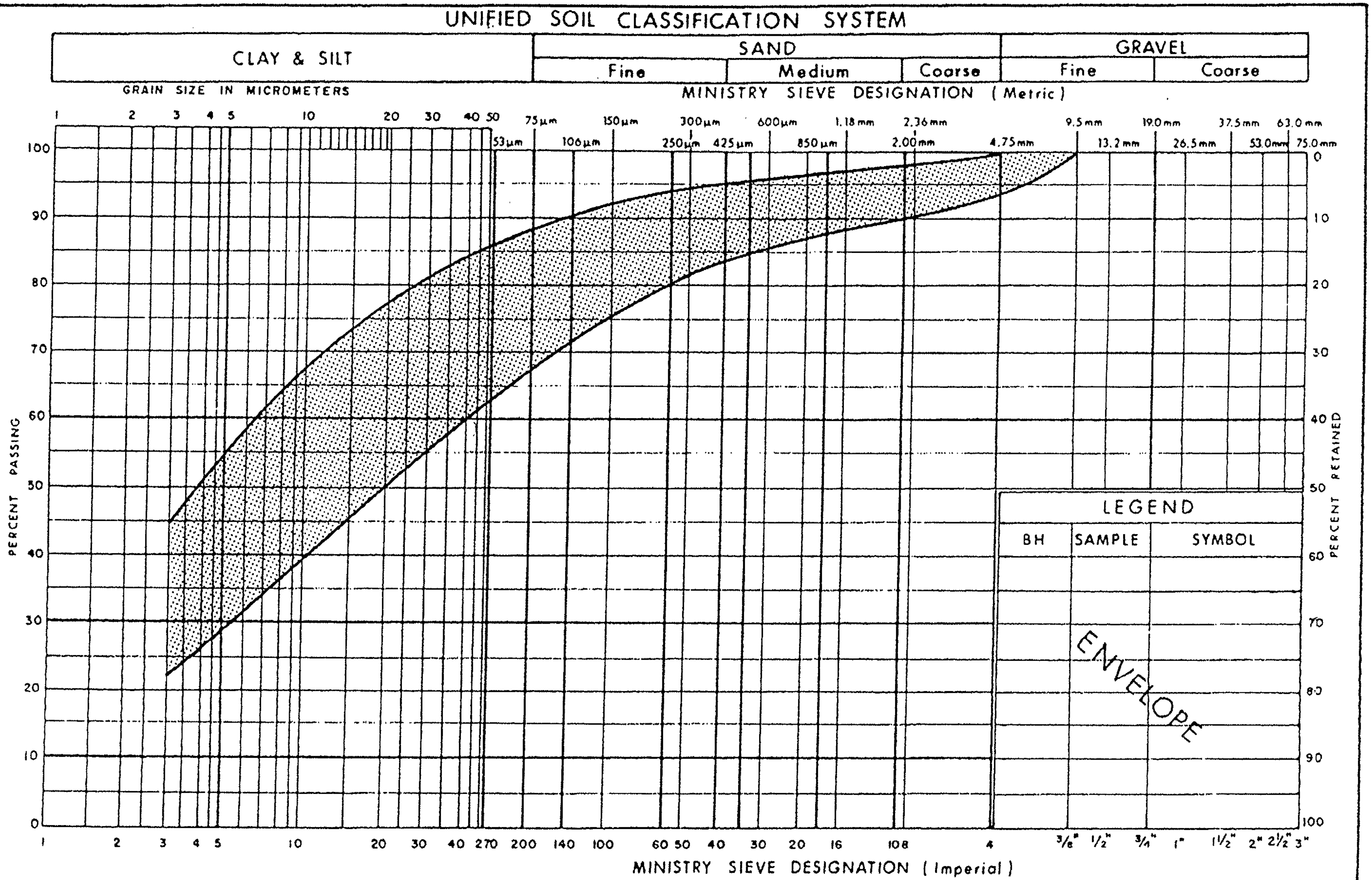
* W.L. not established at time of investigation.

Other columns: STRAT PLOT; DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH (o UNCONFINED, + FIELD VANE, • QUICK TRIAXIAL, x LAB VANE); PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%); UNIT WEIGHT γ; REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL

+3, x5 : Numbers refer to Sensitivity

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

78 12 M



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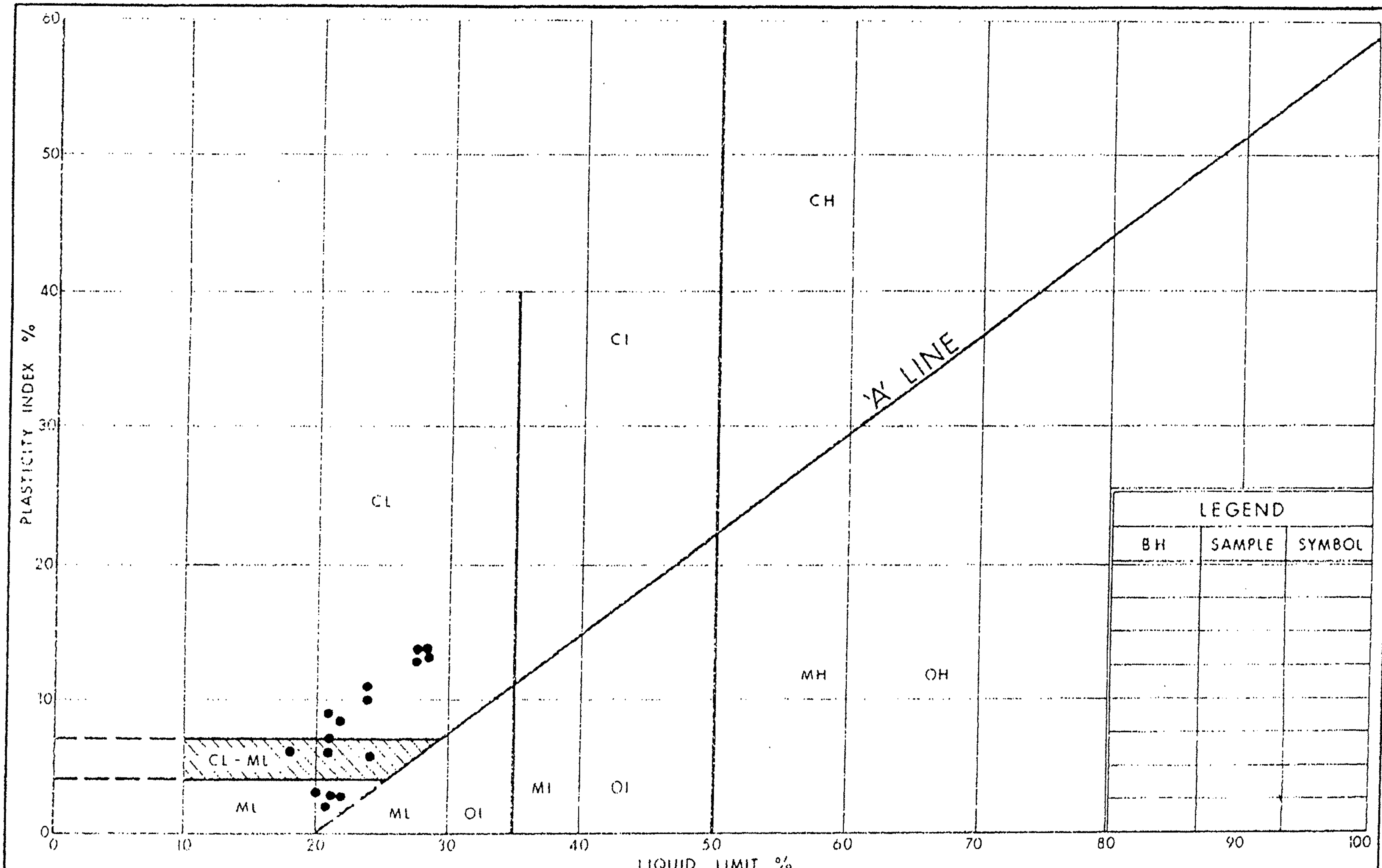
GRAIN SIZE DISTRIBUTION

SILTY CLAY, WITH SAND TRACE OF GRAVEL
(Glacial Till)

FIG No 1

WP 153-80-02

Oct 75, FF-S-21



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PLASTICITY CHART

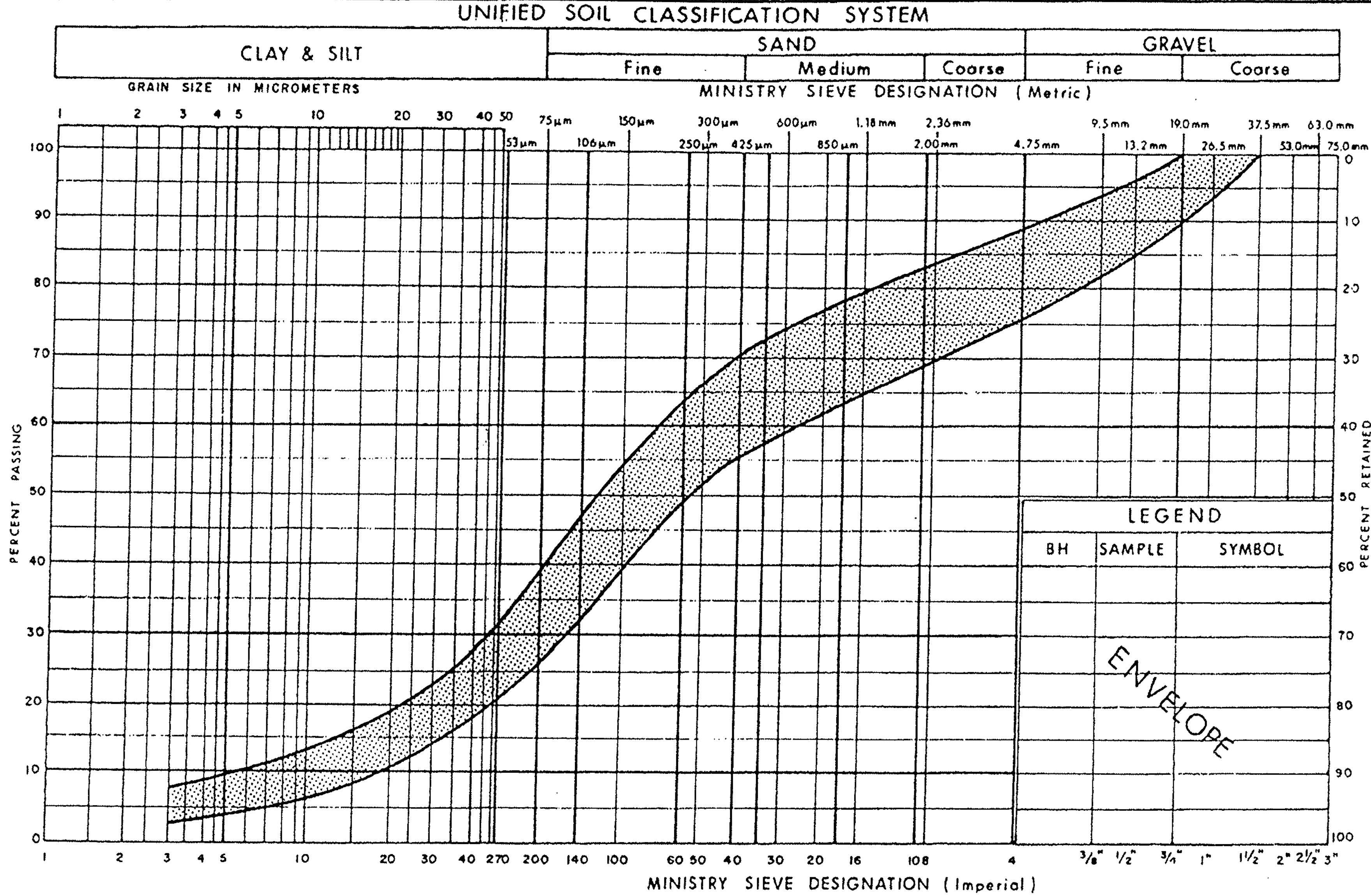
SILTY CLAY Matrix (Glacial Till)

FIG No 2

WP 153-80-02

17

78 12 M



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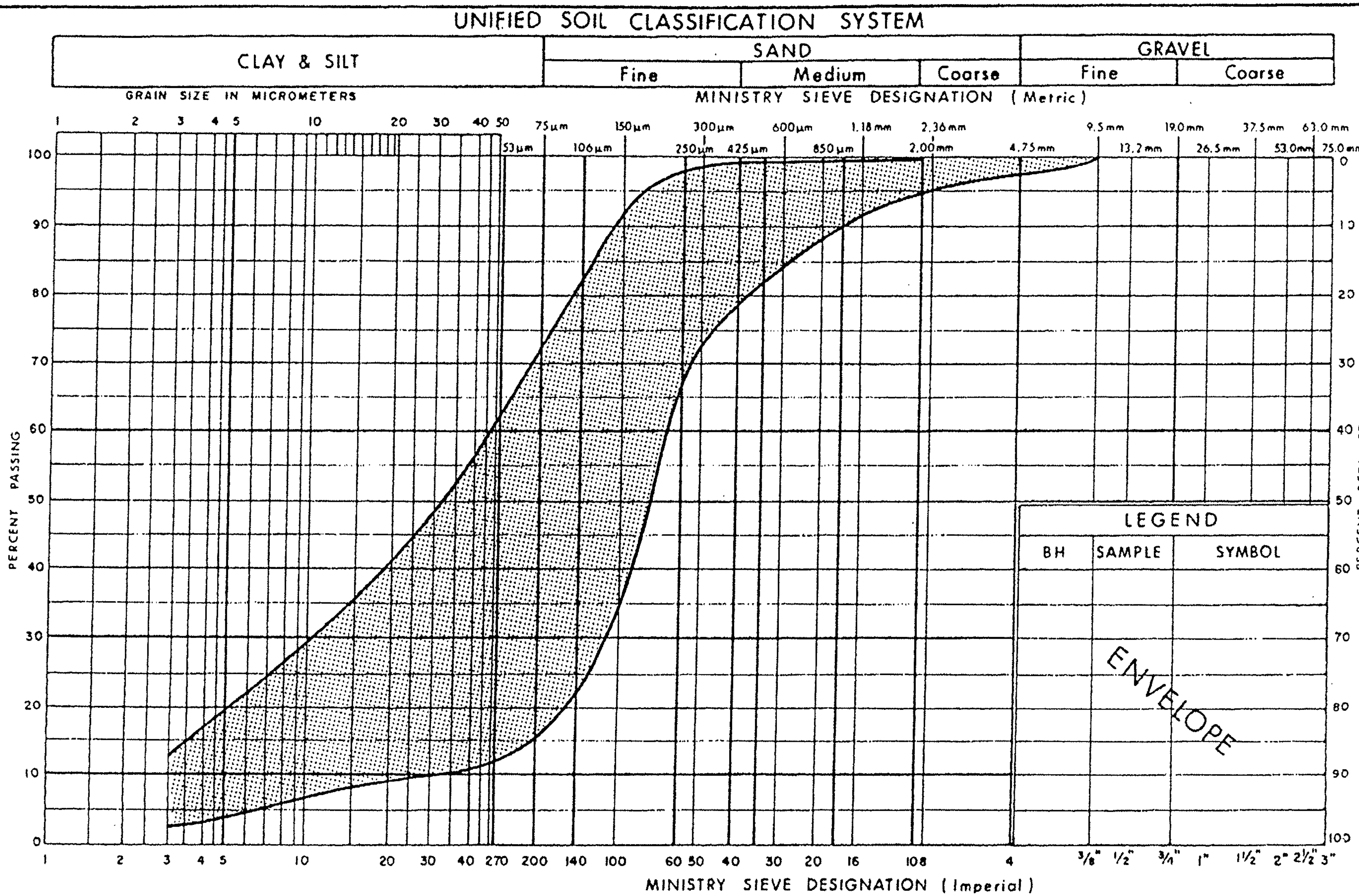
GRAIN SIZE DISTRIBUTION

SAND WITH SILT SOME GRAVEL

FIG No 3A

W P 153-80-02

78 12 M



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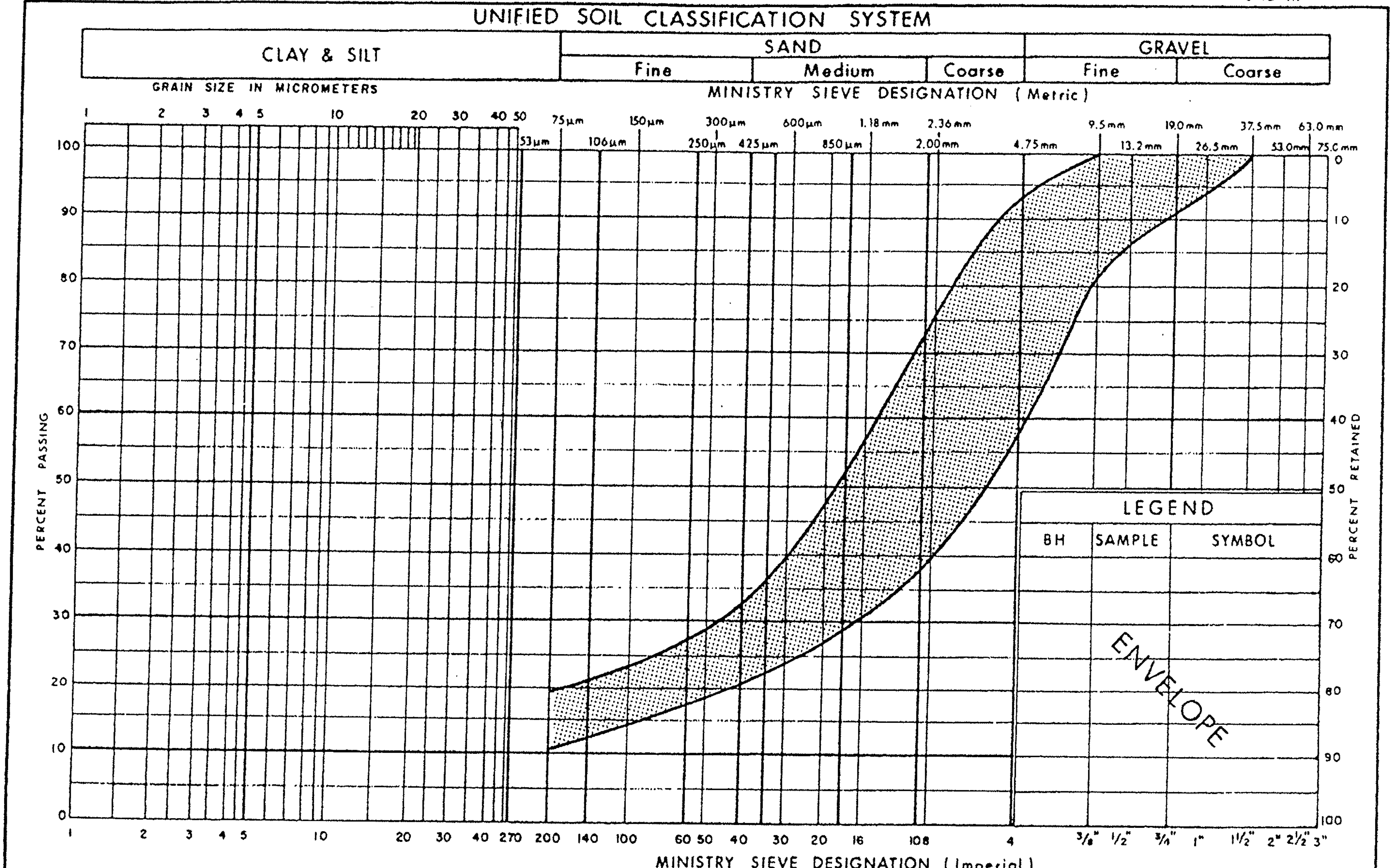
GRAIN SIZE DISTRIBUTION

SILTY SAND

FIG No 3 B

W P 153-80-02

78 12 M



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GRAIN SIZE DISTRIBUTION

SAND WITH VARYING AMOUNTS OF GRAVEL TRACE OF SILT

FIG No 3C

W P 153-80-02

Appendix D

Foundation Comparison

COMPARISON OF FOUNDATION ALTERNATIVES

Footings on Native Soil	Spread Footings on Engineered Fill	Driven Piles	Caissons
Advantages: i. Ease of construction. ii. Relatively high geotechnical resistance is available on the till deposits. iii. Lower cost than deep foundations.	***Advantages:*** i. Generally less costly construction than deep foundation elements. ii. Founding level can be adjusted. iii. Slightly higher bearing resistance than native soils.	***Advantages:*** i. Piles will develop high geotechnical resistance in hard/dense soils. ii. Installation of piles could continue in freezing weather. iii. Foundation construction requires less volume of excavation than footings	***Advantages:*** i. High resistance is available for caissons founded in dense till/bedrock. ii. Construction of caissons could continue in freezing weather. iii. Subexcavation of fill and variable material not required.
Disadvantages: i. Subexcavation will be required to penetrate fill. ii. If used for abutments, much higher walls will be required.	***Disadvantages:*** i. Not appropriate at piers due to presence of competent tills at shallow depth. ii. Dewatering may be required, depending on depth of excavation. iii. Cost of engineered fill placement	***Disadvantages:*** i. Higher unit costs than footings. ii. Possibility that cobbles and boulders may be encountered in till. iii. Impractical for use at piers.	***Disadvantages:*** i. Higher cost than spread footings ii. Installation of deep caissons will be required. iii. Possibility of boulders being encountered during augering. iv. Will encounter groundwater and potential basal instability. v. Potential difficulty in cleaning and inspecting bases.
RECOMMENDED AT THE PIERS	**NOT RECOMMENDED**	**RECOMMENDED AT THE ABUTMENTS**	**NOT RECOMMENDED**

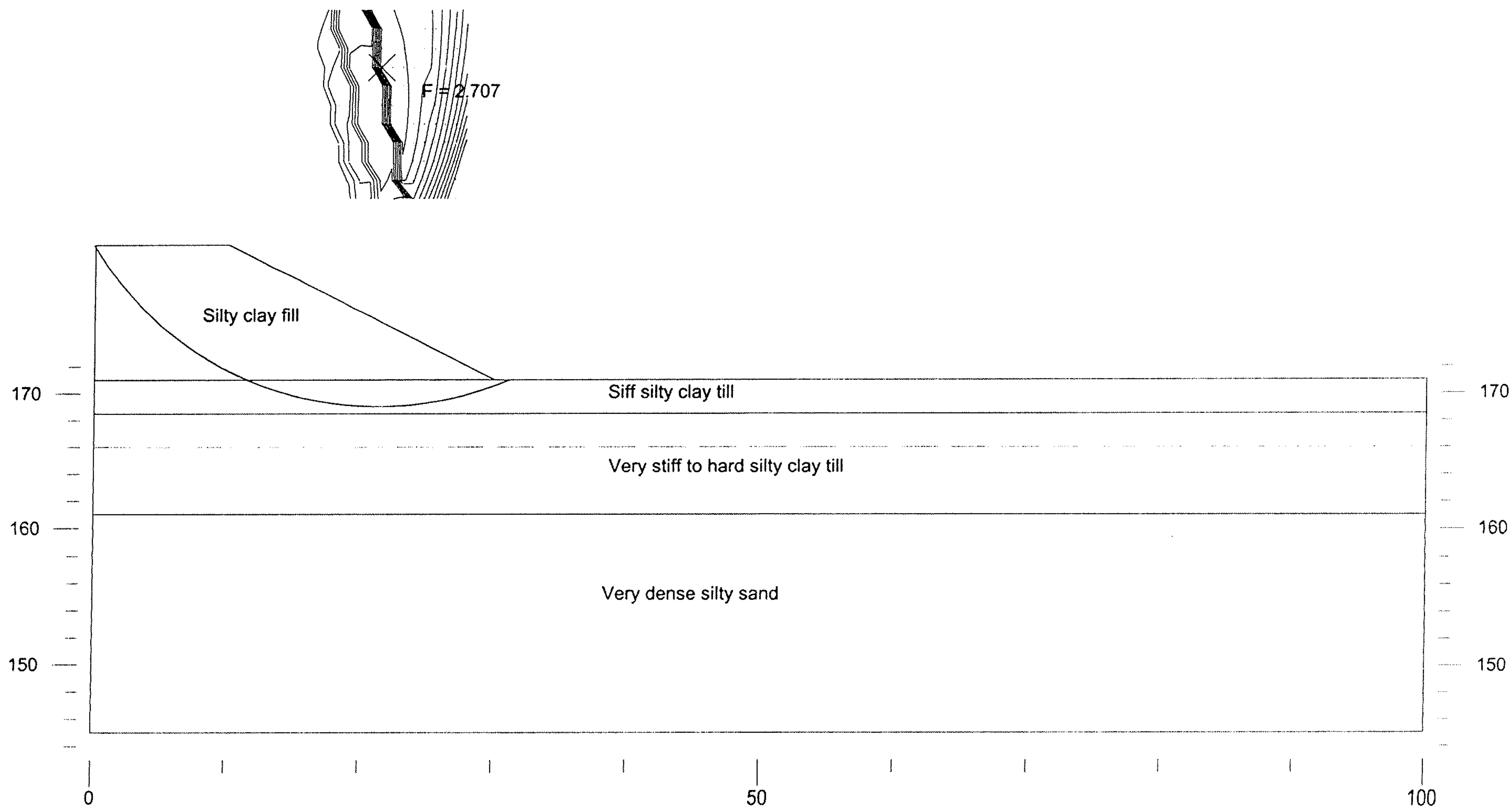
THURBER

Appendix E

Slope Stability Output

Thurber Engineering Ltd. - Toronto
19-92-70 Highway 427 Widening at Disco Road
CN Halton Subdivision Overhead
July 8, 2009
South abutment, Embankment height: 10 m
Undrained Analysis

	Gamma kN/m3	C kPa	Phi deg	Min c/p	Piezo Surf.
Silty clay fill	20	50	0	0	1
Silty clay till	21	100	0	0	1
Silty clay till	21	175	0	0	1
Silty Sand	21	0	35	0	1



7/8/2009 2:21:57 PM H:\19\92\70HWY4~1\REPORT~1\CNROVE~1\1NABUT.GSL Thurber Engineering Ltd. - Toronto F = 2.707

FIGURE 1

	Gamma kN/m3	C kPa	Phi deg	Min c/p	Piezo Surf.
Silty clay fill	20	50	0	0	1
Silty clay till	21	100	0	0	1
Silty clay till	21	175	0	0	1
Silty Sand	21	0	35	0	1

Thurber Engineering Ltd. - Toronto
19-92-70 Highway 427 Widening at Disco Road
CN Halton Subdivision Overhead
July 8, 2009
South abutment, Embankment height: 10 m, 2-m wide berm
Undrained Analysis

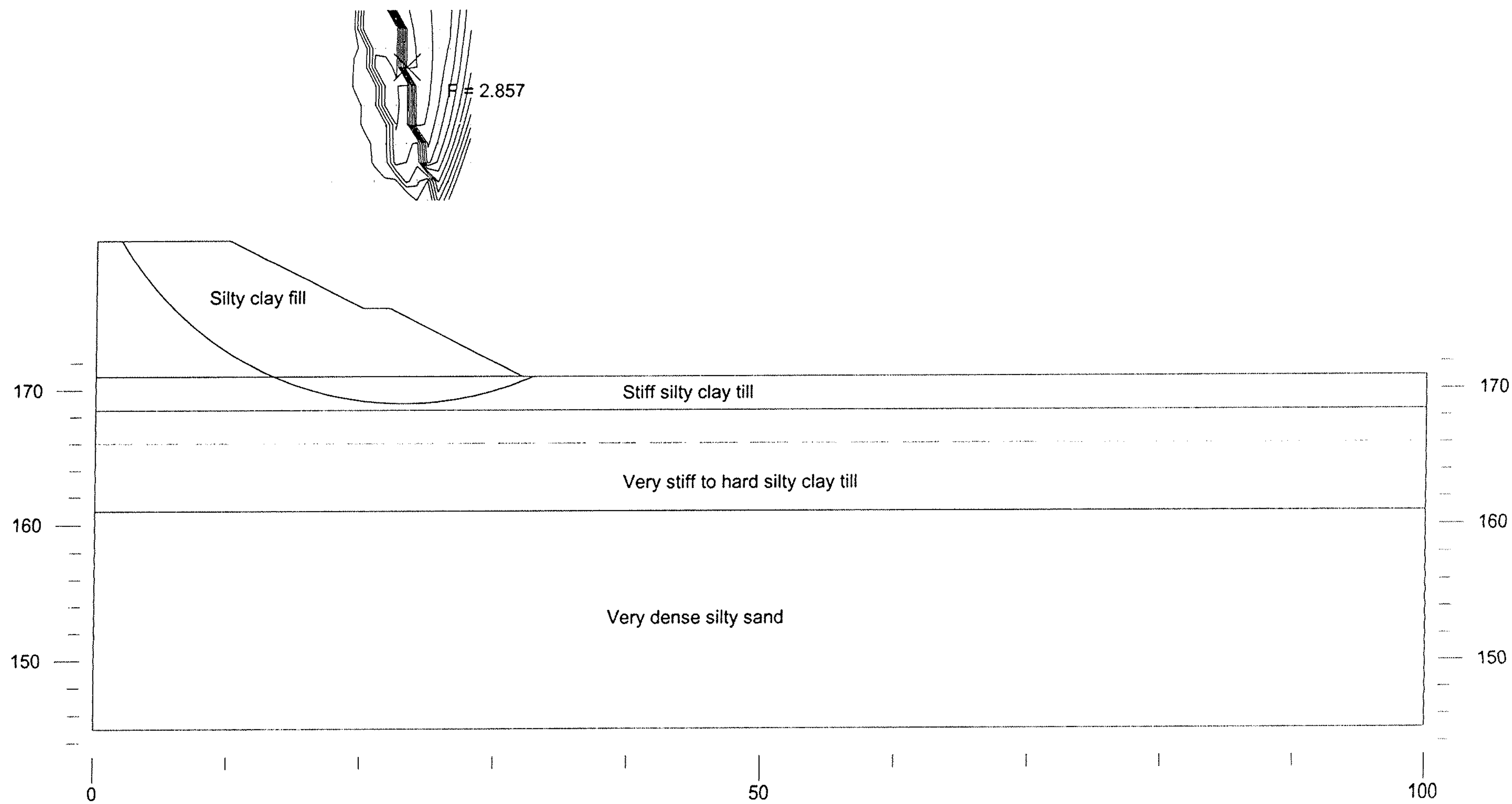


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FIGURE 2

	Gamma kN/m3	C kPa	Phi deg	Min c/p	Piezo Surf.
Silty clay fill	20	0	30	0	1
Silty clay till	21	0	31	0	1
Silty clay till	21	0	33	0	1
Silty Sand	21	0	35	0	1

Thurber Engineering Ltd. - Toronto
19-92-70 Highway 427 Widening at Disco Road
CN Halton Subdivision Overhead
July 8, 2009
South abutment, Embankment height: 10 m
Drained Analysis

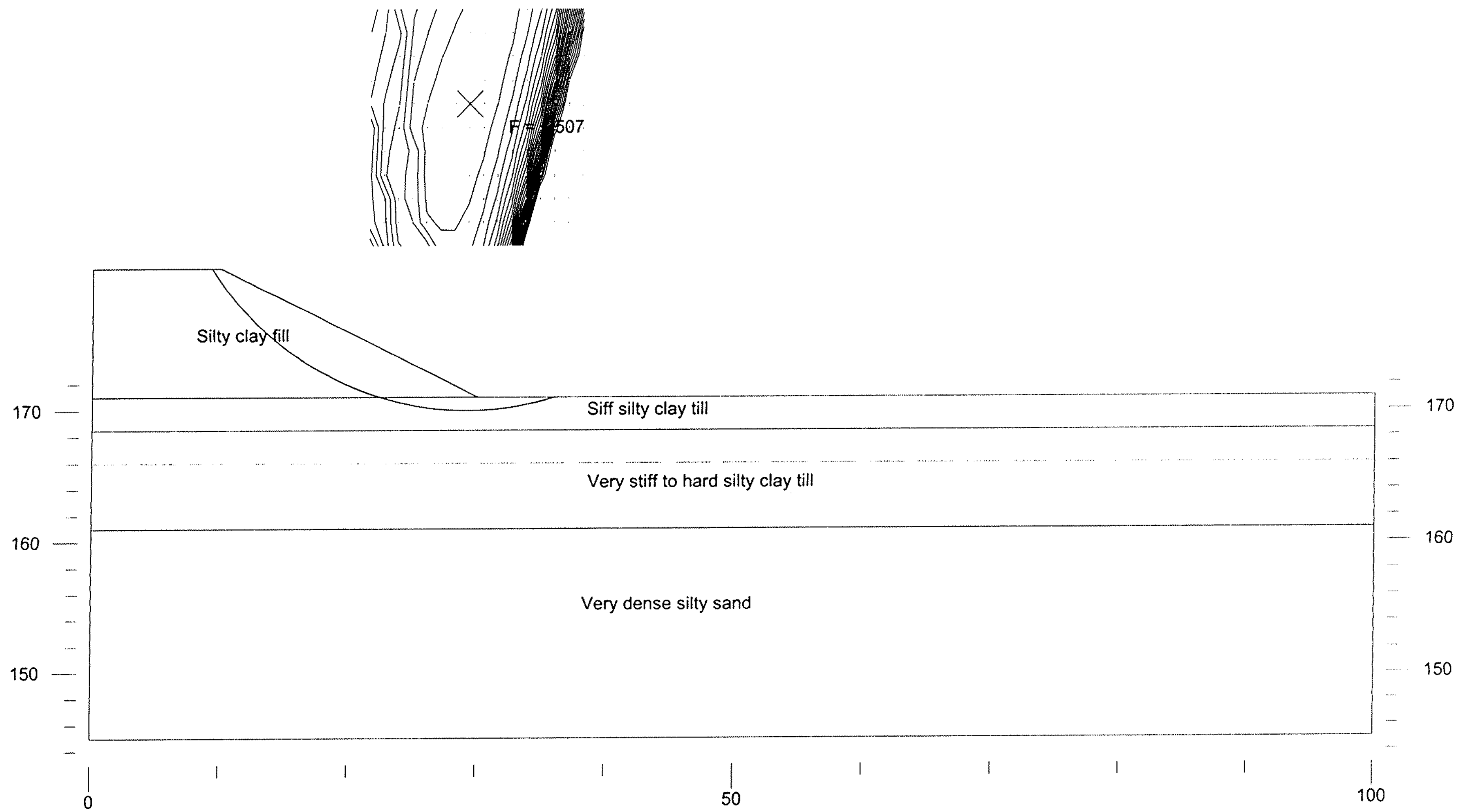

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FIGURE 3

Thurber Engineering Ltd. - Toronto
19-92-70 Highway 427 Widening at Disco Road
CN Halton Subdivision Overhead
July 8, 2009
South abutment, Embankment height: 10 m, 2-m wide berm
Drained Analysis

	Gamma kN/m3	C kPa	Phi deg	Min c/p	Piezo Surf.
Silty clay fill	20	0	30	0	1
Silty clay till	21	0	31	0	1
Silty clay till	21	0	33	0	1
Silty Sand	21	0	35	0	1

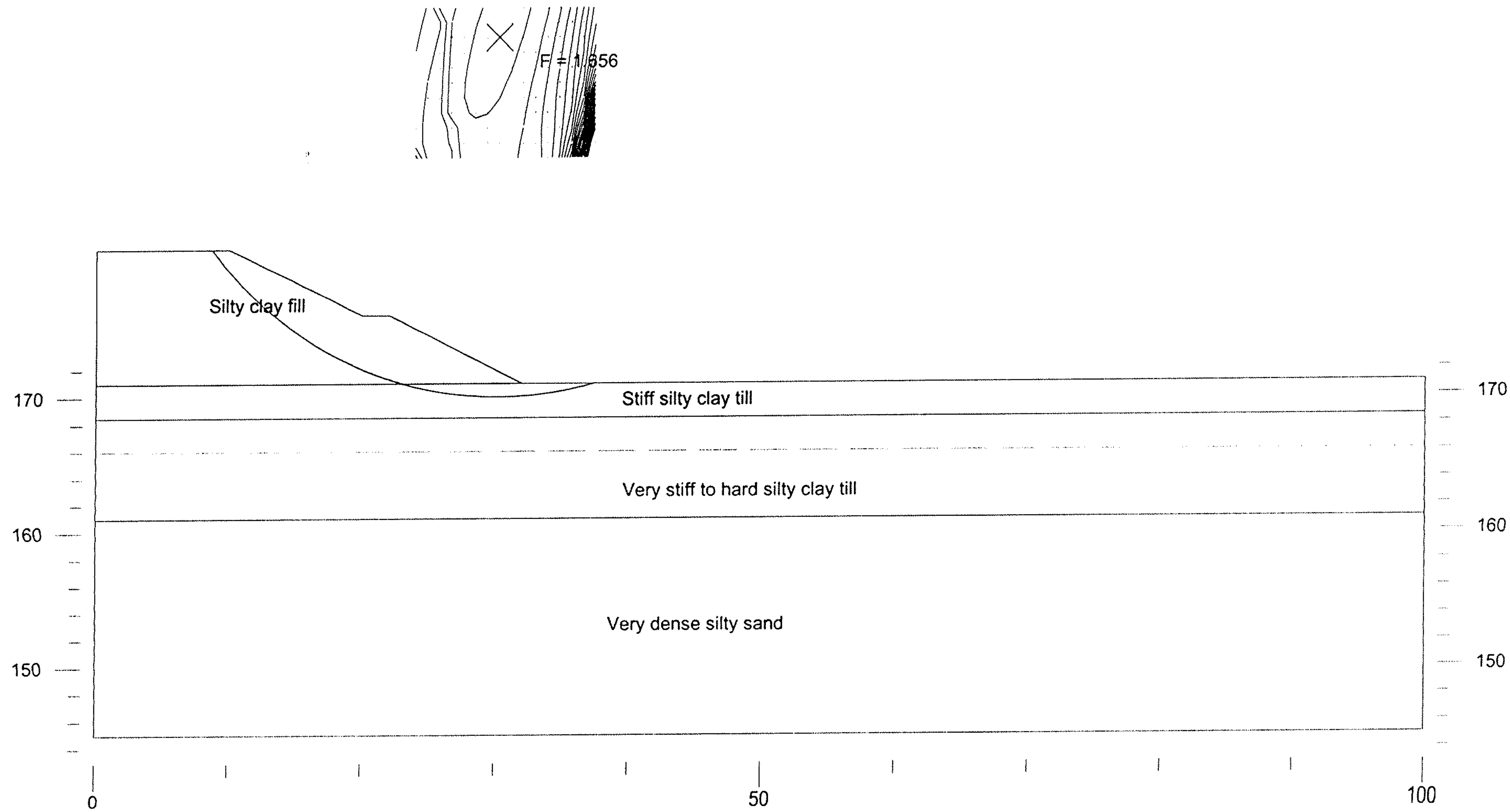

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FIGURE 4

Appendix F

List of SPs and OPSS

Suggested Text for Selected NSSP

1. List of Special Provisions and OPSS Documents Referenced in this Report

- SP 902 S01.
- SP 572 S01
- OPSS 120, 1994
- SP 105S19
- OPSS 206
- OPSS 1010
- OPSD 208.010
- OPSS 902
- Special Provision 902S01
- OPSD 3101.150.
- OPSD 3102.100

OPSS 206, as amended by Special Provision "Amendment to OPSS 206, December 1993", dated November 2002.

All granular material should meet the specifications of Special Provision 110F13 "Amendment to OPSS 1010, March 1993".

2. Suggested Text for NSSP on "Impact on Adjacent Structure"

It is critical that Contractor's excavation and construction activities do not undermine or have any adverse impact on the integrity and performance of the following adjacent structures:

- *The lanes of the Highway 427 during excavation and foundation construction at the new north and south abutments and piers.*
- *Protection of the existing underpass foundations during excavation and removal of existing abutment.*

Protection of existing approach fills.

3. **Suggested Text for NSSP on "Pile Installation" should contain the following:**

"The glacial till soil overlying the bedrock contains cobbles, boulders and rock slabs. The existing fill may contain obstructions such as rubble and, rock slabs. The presence of these obstructions will potentially have an impact on the installation of piles at the site. Some possible impacts that must be taken into consideration include, but are not necessarily limited to:

- *The obstructions in the fill or cobbles and boulders in the till may impede the driving of the piles resulting in more arduous driving*
- *Some piles may meet refusal on boulders that are large enough not to be dislodged or broken by the pile driving*
- *As a result of the presence of boulders, piles may meet refusal at varying depths*
- *Pile driving must be controlled according to the criteria specified for the site*
- *If a pile meets refusal at a depth less than the anticipated depth, the QVE must terminate driving before the pile is damaged due to over-driving*

Appendix G

Site Photographs

Photo 1. Looking at the existing north abutment, Highway 427 SBL

Photo 2. Looking at the south abutment and south pier, Highway 427 SBL

Photo 3. Looking at the existing south abutment and pier, Hwy 427 SBL (Boreholes CNH-02 and CNH-06)

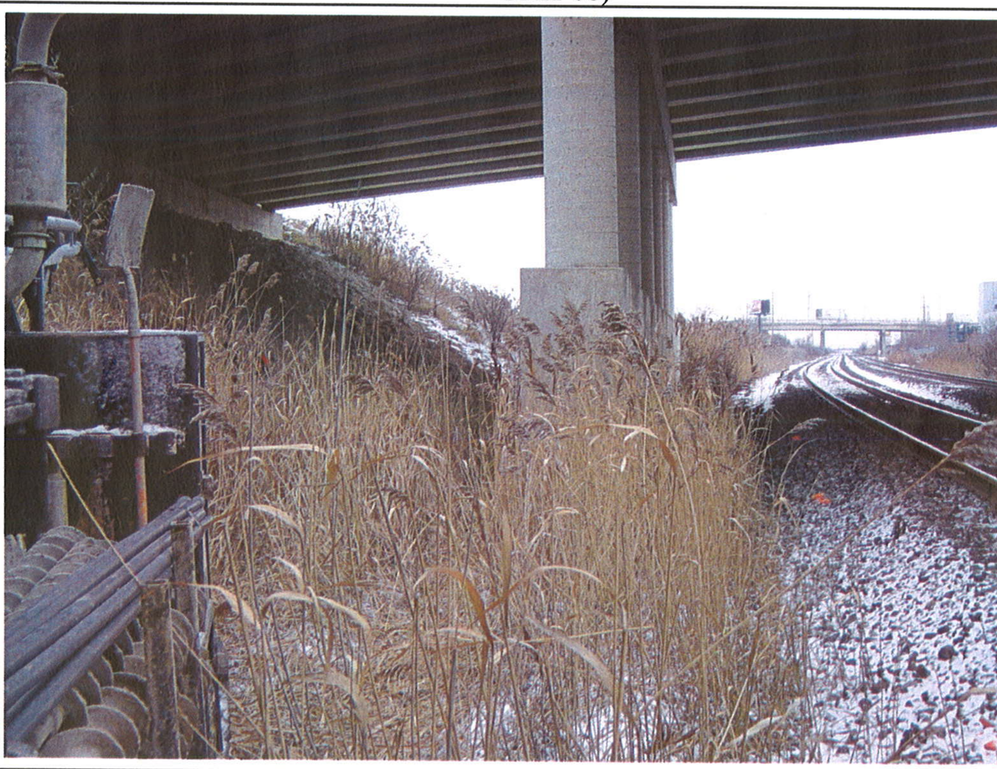
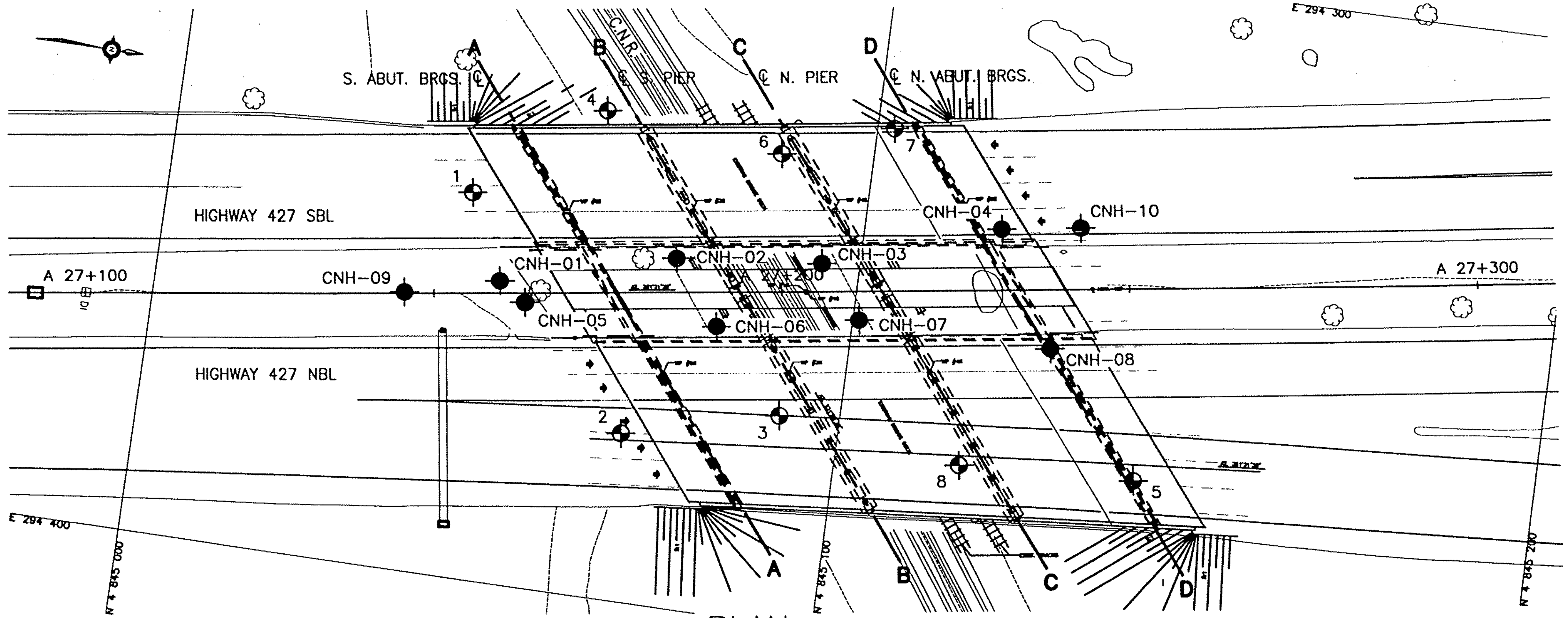


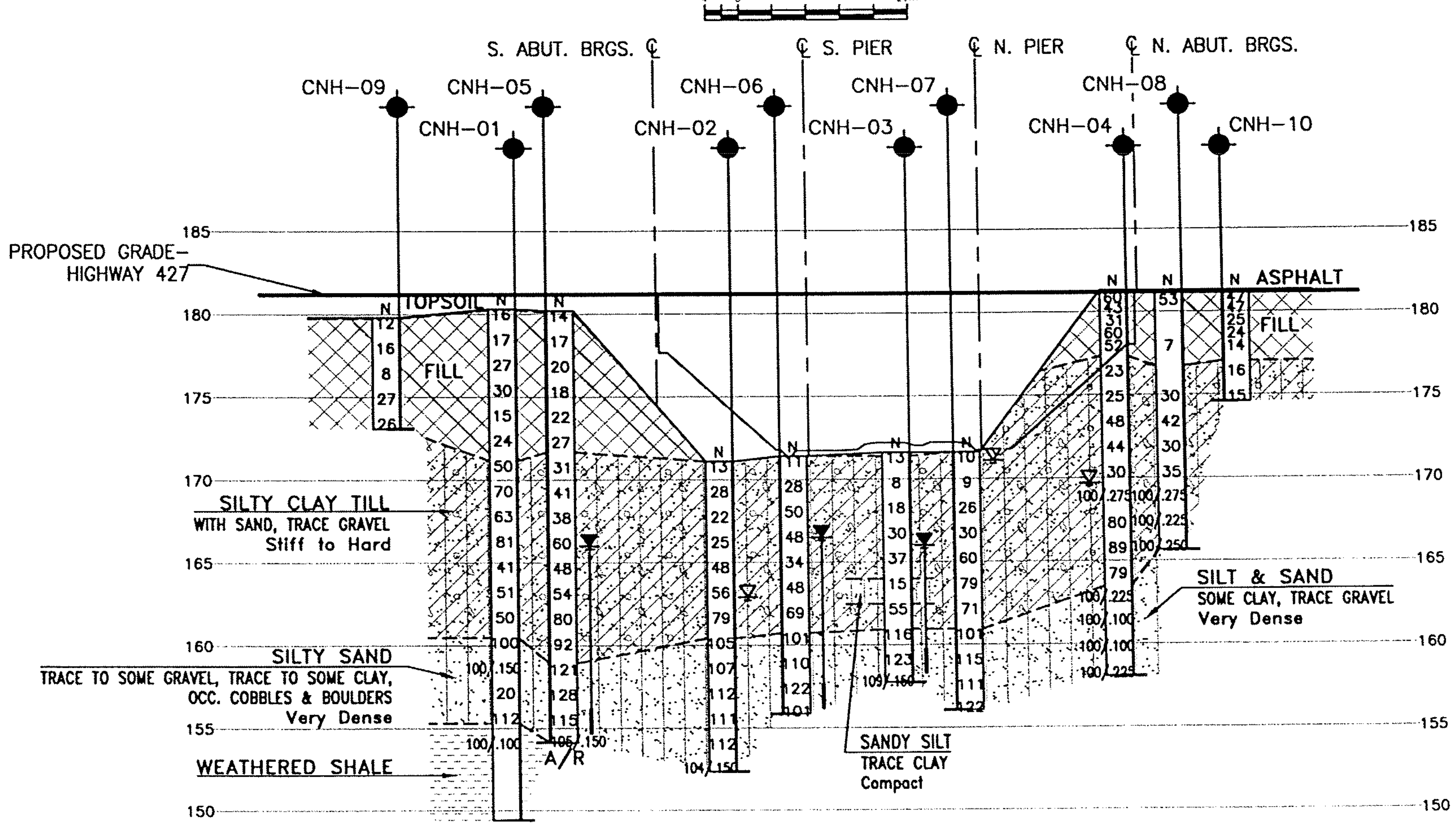
Photo 4. Looking at the existing north abutment and pier, Hwy 427 NBL (Boreholes CNH-03 and CNH-07)

Appendix H

Borehole Locations and Soil Strata Drawing



PLAN



HIGHWAY 427 ℄ PROFILE

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

CONT No
GWP No 202-95-00

HIGHWAY 427
C.N.R. OVERHEAD
REHABILITATION & WIDENING
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

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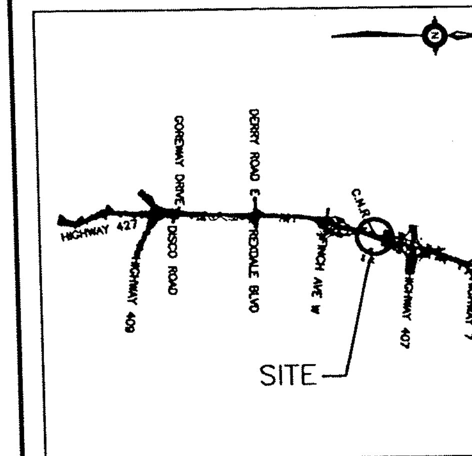

KEYPLAN

LICENSED PROFESSIONAL ENGINEER
R. Palomeque Reyna
100083209
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
Nov 26/09
PROVINCE OF ONTARIO

LEGEND

⌖	Borehole by Thurber (Present Investigation)
⌖	Borehole by Others (Previous Investigation)
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
▽	Water Level in Open Borehole
▼	Head Artesian Water
	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
CNH-01	180.3	4 845 049.2	294 356.2
CNH-02	171.1	4 845 073.9	294 349.3
CNH-03	171.6	4 845 094.6	294 347.1
CNH-04	181.3	4 845 119.7	294 338.5
CNH-05	180.2	4 845 053.1	294 358.8
CNH-06	171.4	4 845 080.9	294 358.3
CNH-07	171.6	4 845 100.9	294 354.5
CNH-08	181.3	4 845 128.7	294 354.8
CNH-09	179.8	4 845 035.8	294 359.8
CNH-10	181.3	4 845 130.8	294 336.8

-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.

GEOCRES No. 30M12-288

REVISIONS	DATE	BY	DESCRIPTION

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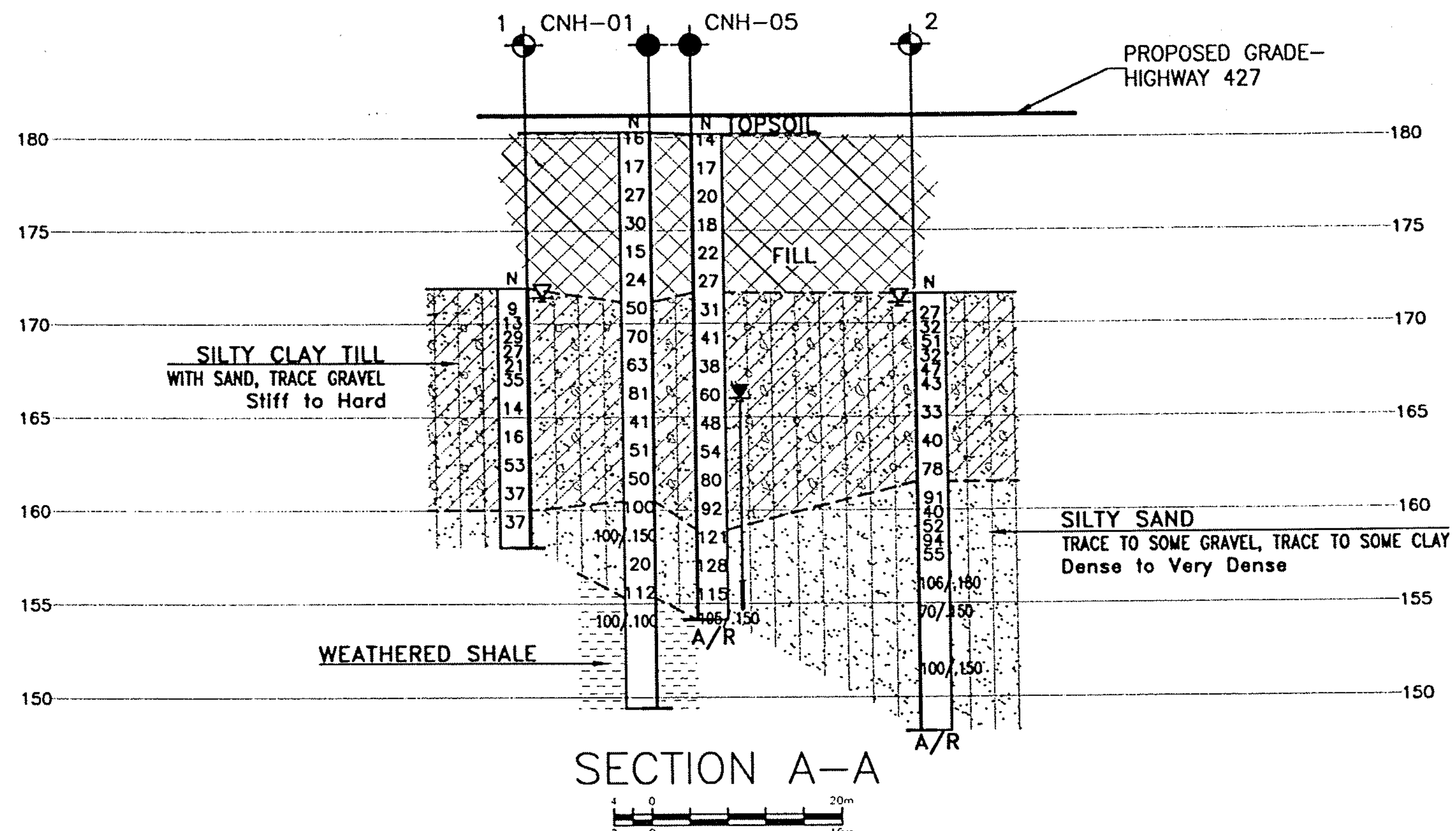
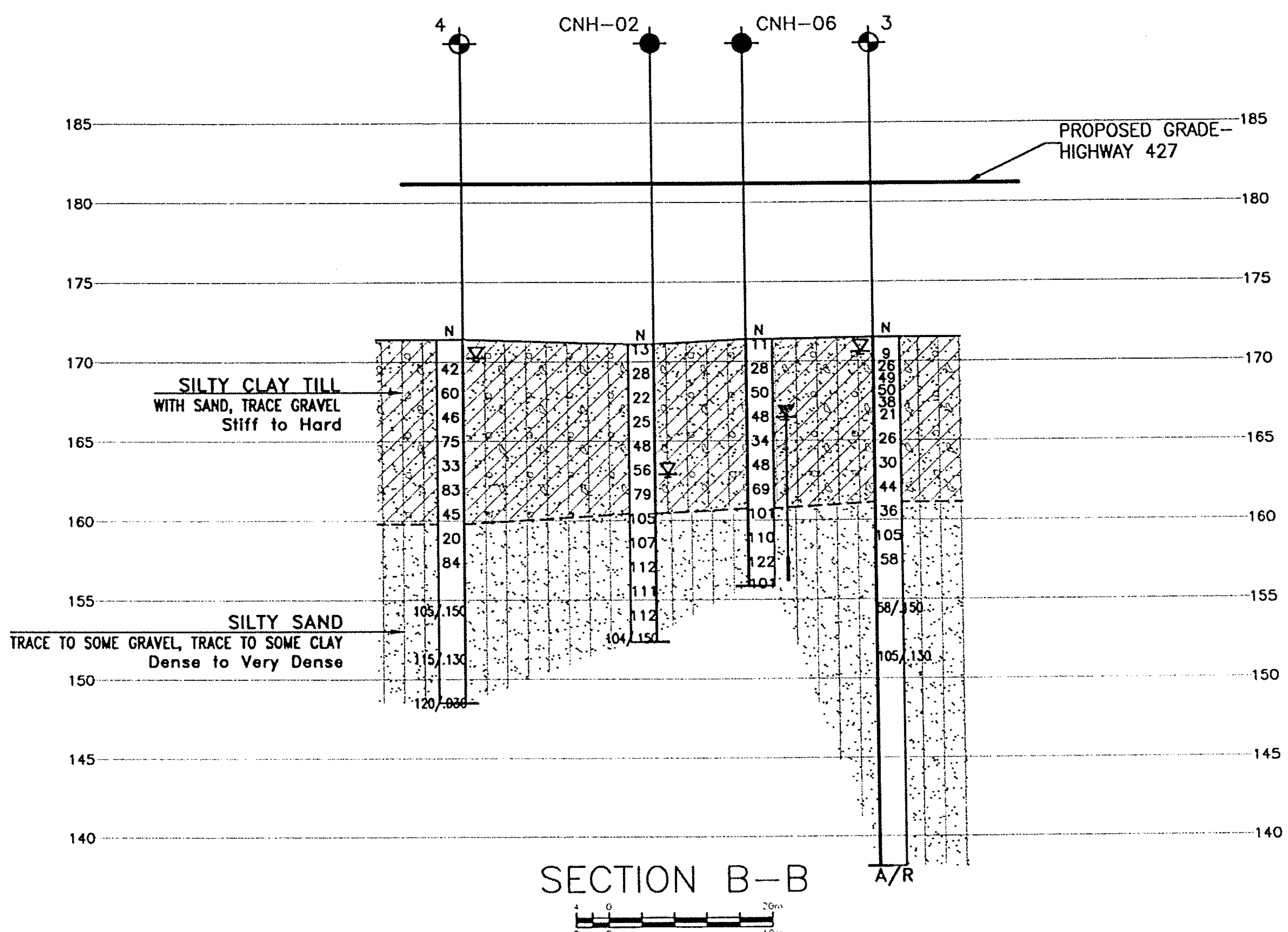


SECTION A-A



SECTION B-B

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

LICENSED PROFESSIONAL ENGINEER
R. Palomeque Reyna
100083209
PROVINCE OF ONTARIO

LICENSED PROFESSIONAL ENGINEER
P. K. CHATTERJI
PROVINCE OF ONTARIO

CONT No
GWP No 202-95-00

HIGHWAY 427
C.N.R. OVERHEAD
REHABILITATION & WIDENING
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

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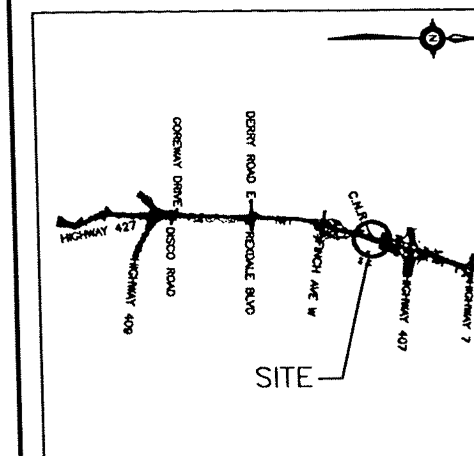

KEYPLAN

	LEGEND
◆	Borehole by Thurber (Present Investigation)
◈	Borehole by Others (Previous Investigation)
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
▽	Water Level in Open Borehole
▼	Head Artesian Water
┃	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
CNH-01	180.3	4 845 049.2	294 356.2
CNH-02	171.1	4 845 073.9	294 349.3
CNH-03	171.6	4 845 094.6	294 347.1
CNH-04	181.3	4 845 119.7	294 338.5
CNH-05	180.2	4 845 053.1	294 358.8
CNH-06	171.4	4 845 080.9	294 358.3
CNH-07	171.6	4 845 100.9	294 354.5
CNH-08	181.3	4 845 128.7	294 354.8
CNH-09	179.8	4 845 035.8	294 359.8
CNH-10	181.3	4 845 130.8	294 336.8

-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.

GEOCRES No. 30M12-288

REVISIONS	DATE	BY	DESCRIPTION

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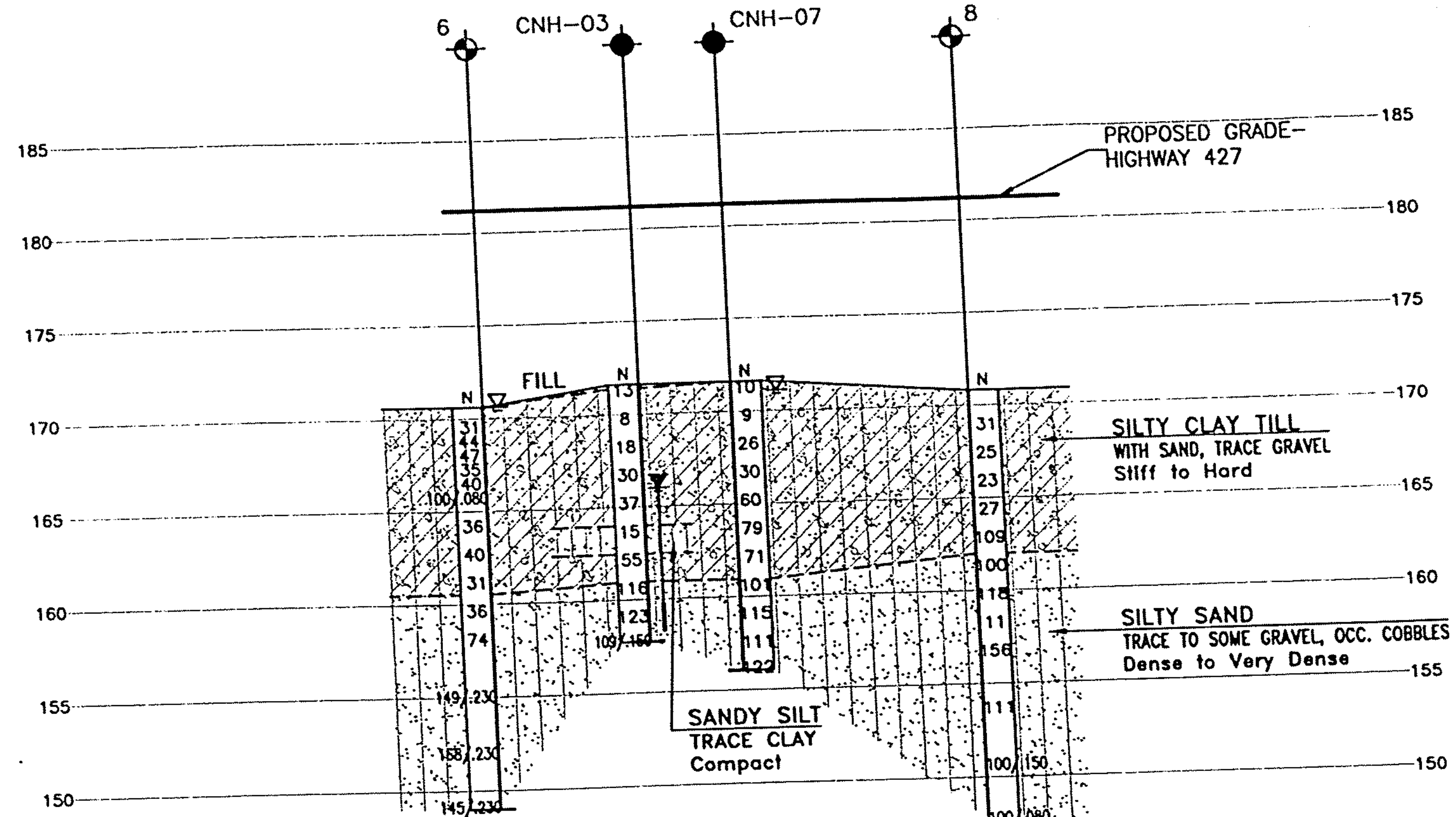
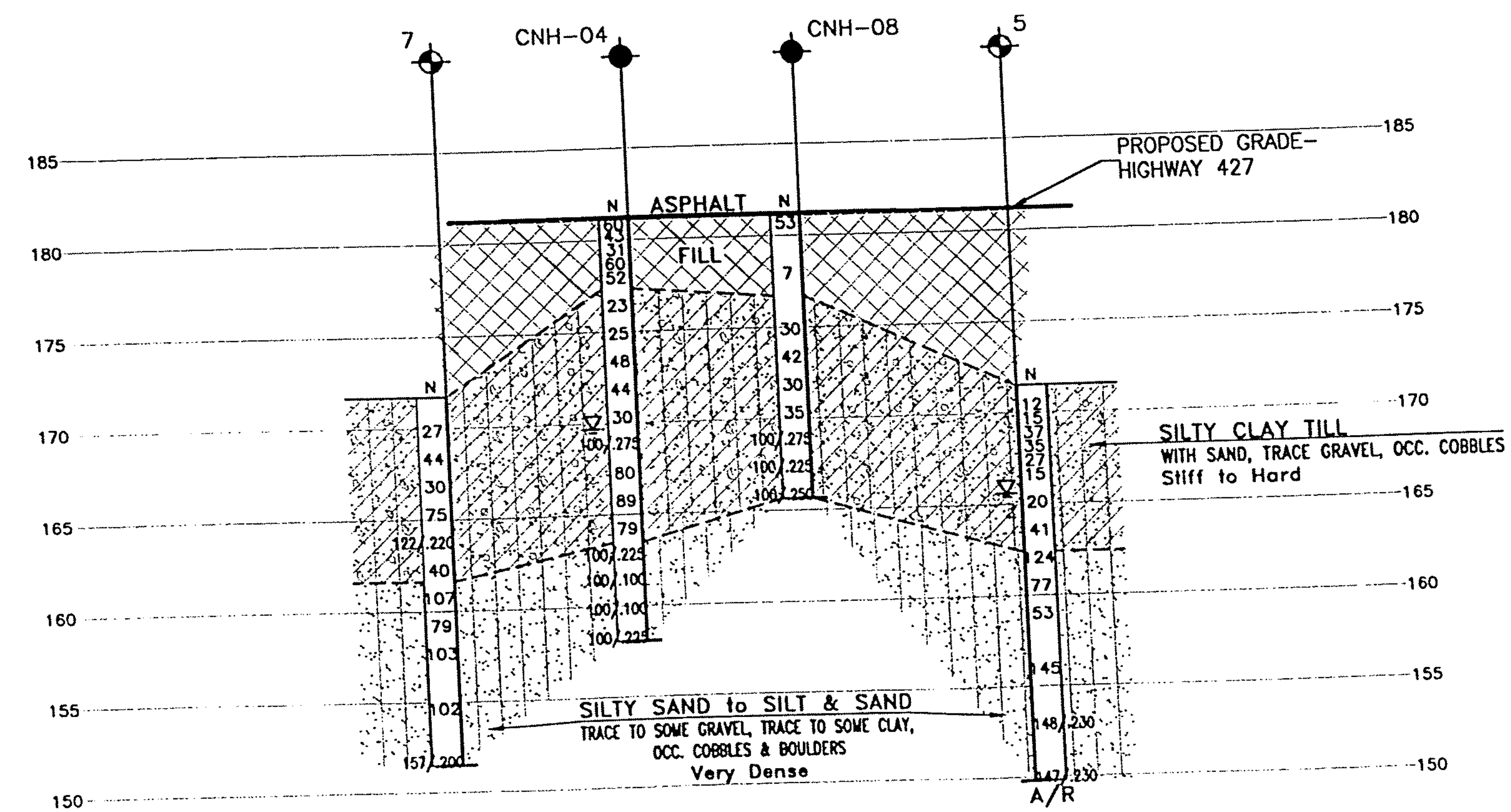


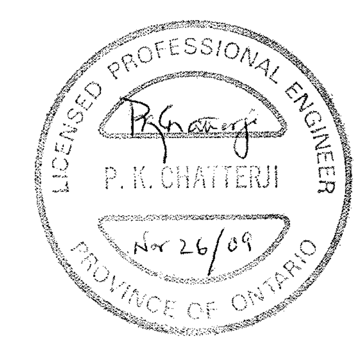
SECTION C–C



SECTION D–D

METRIC

DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN



CONT No
GWP No 202-95-00

HIGHWAY 427
C.N.R. OVERHEAD
REHABILITATION & WIDENING
BOREHOLE LOCATIONS AND SOIL STRATA

SHEET

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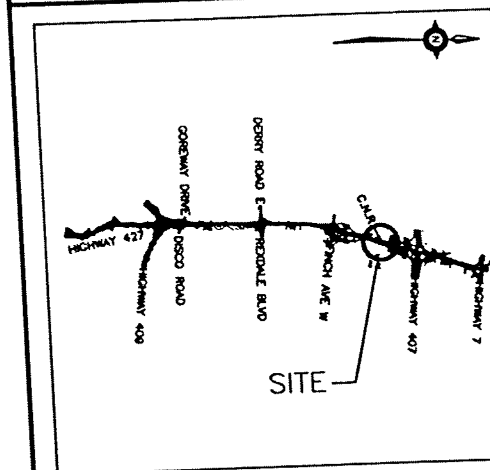

KEYPLAN

LEGEND

	Borehole by Thurber (Present Investigation)
	Borehole by Others (Previous Investigation)
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
	Water Level in Open Borehole
	Head Artesian Water
	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING
CNH-01	180.3	4 845 049.2	294 356.2
CNH-02	171.1	4 845 073.9	294 349.3
CNH-03	171.6	4 845 094.6	294 347.1
CNH-04	181.3	4 845 119.7	294 338.5
CNH-05	180.2	4 845 053.1	294 358.8
CNH-06	171.4	4 845 080.9	294 358.3
CNH-07	171.6	4 845 100.9	294 354.5
CNH-08	181.3	4 845 128.7	294 354.8
CNH-09	179.8	4 845 035.8	294 359.8
CNH-10	181.3	4 845 130.8	294 336.8

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GEOCRES No. 30M12-288

REVISIONS	DATE	BY	DESCRIPTION

DESIGN SKP	CHK PKC	CODE	LOAD	DATE NOV. 200
DRAWN MFA	CHK PKC	SITE	STRUCT	DWG 3