

**FOUNDATION INVESTIGATION AND DESIGN REPORT  
HIGHWAY 427 WIDENING  
FROM FASKEN DRIVE TO STEELES AVENUE  
DISCO ROAD / GOREWAY DRIVE OVERPASS  
TORONTO, ONTARIO  
G.W.P. 202-95-00**

**Geocres Number: 30M12-289**

**Report to**

**SNC-Lavalin**

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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 inside widening of the existing mainline bridge structures at the Highway 427 overpass at Disco Road / Goreway Drive 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, Highway 427 overpass at Disco Road, W.P. 387-65, Site No. 37-994, Municipality of Metropolitan Toronto & Peel Borough of Etobicoke & City of Mississauga”, 1972 (Reference 1).

**2 PROJECT AND SITE DESCRIPTION**

The project involves the inside widening of the northbound and southbound (NBL and SBL) bridges of the Highway 427 overpass at Disco Road / Goreway Drive in the air gap between the existing bridges.

The site is located approximately 1.8 km west of Highway 27 in Toronto, Ontario. Lands surrounding the site have been developed for commercial and industrial uses.

A concrete culvert carrying the realigned Mimico Creek is located under Disco Road/Goreway Drive, running approximately perpendicular to the existing Highway 427 NBL and SBL.

An aerial photograph of the site is included in Appendix F and shows the general lay of the land in the vicinity of the site.

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. 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 October 28 to November 19, 2008. The field program consisted of drilling and sampling eleven (11) boreholes (numbered GD-01 to GD-07, GD-07A, GD-08 to GD-10) at the site. Boreholes were drilled at locations of the structure abutments, piers and approaches along the alignment of the existing Highway 427 bridges.

Boreholes GD-02, GD-04 to GD-06, GD-07A and GD-08 and GD-10 were terminated in dense soils at depths ranging from 15.3 m to 27.5 m (Elevations 143.5 to 154.6 m). Boreholes GD-01 and GD-07 encountered auger refusal at 22.9 m and 13.7 m depth (Elevations 146.6 and 147.5 m) on weathered shale bedrock in Borehole GD-01 and on possible boulders or hard limestone slabs in Borehole GD-07, and were further advanced below these depths by coring to 25.9 m and 18.0 m (Elevations 143.5 and 143.2 m). Borehole GD-03 was terminated upon refusal on weathered shale bedrock at 15.7 m depth (Elevation 145.5 m).

The approximate borehole locations are shown on the Borehole Locations and Soil Strata Drawing in Appendix G. 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, 2, 3, 6, 7, 8, 11, 12, 13, 16, 17 and 18) drilled during the previous investigation (1972) are enclosed in Appendix C.

Prior to commencement of drilling, utility clearances were obtained for all borehole locations.

Solid stem augers were used to advance the boreholes in the overburden and into the shale bedrock. 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 advance Boreholes GD-01 and GD-07 into bedrock. 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**

<b>Foundation Unit</b>	<b>Borehole</b>	<b>Piezometer Tip Depth/ Elevation (m)</b>	<b>Completion Details</b>
<b>South Approach</b>	GD-09	None installed	Bentonite to surface.
<b>South Abutment</b>	GD-01	None installed	Bentonite to surface.
	GD-05	26.0/144.0	Piezometer with 1.5 m slotted screen installed with sand filter to 21.4 m, then bentonite holeplug to ground surface.
<b>Pier 1 (south)</b>	GD-02	None installed	Bentonite to surface.
	GD-06	None installed	Bentonite to surface.
<b>Pier 2 (north)</b>	GD-03	None installed	Bentonite to surface.
	GD-07	None installed	Bentonite to surface.
<b>North Abutment</b>	GD-04	25.9/145.1	Piezometer with 1.5 m slotted screen installed with sand filter to 22.8 m, then bentonite holeplug to ground surface.
	GD-08	None installed	Bentonite to surface.
<b>North Approach</b>	GD-10	None installed	Bentonite to surface.

#### **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. Record of Borehole sheets and laboratory testing results from the previous investigation (Reference 1) are also included in Appendix C.

## 5 DESCRIPTION OF SUBSURFACE CONDITIONS

Reference is made to the Record 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 G. 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 comprises clayey silt fill with layers of silty clay, silty sand and sandy silt fill, underlain by native clayey silt and sand till, with occasional silty clay till overlying clayey silt fill with frequent shale and limestone slabs. Weathered shale bedrock was contacted below clayey silt fill at the south abutment area. More detailed descriptions of the individual strata are presented below.

### 5.1 Fill

Fill consisting predominantly of clayey silt with interlayers of various soils was encountered in all the boreholes drilled for the present investigation and in Boreholes 11, 16 and 17 drilled in 1972. The fill consisted of the following soils:

- Brown, black and grey silty clay fill containing trace to some sand, trace to some gravel and occasional rootlets and organics was contacted surficially in Boreholes GD-01, GD-04 and GD-10, and at 3.0, 3.7, 7.2 m depths in Boreholes GD-03, GD-06, GD-07, respectively. Thickness of the silty clay fill ranged from 1.5 to 2.1 m.
- Brown to black sandy silt fill containing some clay and occasional rootlets and organics was contacted surficially in Borehole GD-05. A layer of reddish brown sandy silt fill containing trace gravel and trace clay was contacted below the clayey silt fill at 3.5 m depth (Elevation 157.4 m) in Borehole GD-02. The thickness of the sandy silt fill was 1.5 m and 2.6 m in Boreholes GD-05 and GD-02, respectively. A 200-mm thick layer of sandy silt fill was encountered at 6.4 m depth (Elevation 154.5 m) in Borehole GD-06.
- Layers of brown to black silty sand containing trace to some gravel and trace to some clay was contacted below the silty clay fill at 2.1 m depth (Elevation 168.1 m) in Borehole GD-10 and surficially in Borehole GD-09. Occasional organics were observed in the silty sand fill in Borehole GD-09. The thickness of the silty sand fill was 0.8 m where encountered.
- Brown and, mottled brown to grey clayey silt and sand fill was contacted below the silty clay fill in Boreholes GD-01 and GD-04, below the sandy silt and silty sand fill in Boreholes GD-05, GD-09 and GD-10 and surficially in Boreholes GD-02, GD-03 and GD-06 to GD-08. The clayey silt and sand fill was also contacted at 6.1 m depth (Elevation 154.8) in Borehole GD-02. The thickness of the clayey silt and sand fill

ranged from 1.1 m to 13.7 m. The fill contains occasional wood pieces, organics and pieces or slabs of shale.

- Layers of fill ranging from clayey silt fill underlain by garbage fill were encountered surficially in the 1972 Boreholes 11, 16 and 17 (in Appendix C). The fill thickness ranged from 1.4 m to 6.6 m. A 3.4 m to 4.3 m thick layer of garbage fill was encountered at Elevations 157.7 and 158.9 m in Boreholes 11 and 16, respectively.

In Boreholes GD-01 to GD-10, the depths to the base of the fill ranged from 7.2 m to 15.2 m (Elevations 152.0 to 162.6 m).

Based on SPT 'N' values ranging from 6 to 85 blows for 0.3 m of penetration, the cohesive clayey silt fill is described as firm to hard in consistency. An occasional SPT 'N' value of 62 blows for 0.2 m of penetration indicating a hard consistency was measured in Borehole GD-03 near Elevation 160.3 m. SPT 'N' values of 15 and 33 blows per 0.3 m of penetration were measured within the sandy silt/silty sand fill, indicating a compact to dense relative density. The moisture contents of the fill samples recovered ranged from 4% to 35%.

Grain size distribution curves for samples of clayey silt and sand, and silty clay, fill are presented on the Record of Borehole sheets and on Figures B1 to B4 of Appendix B. Grain size distribution curves for samples of silty sand fill are presented on the Record of Borehole sheets and on Figure B5 of Appendix B. Atterberg Limit test results for the clayey silt and sand fill, and silty clay fill are presented on Figures B11 to B13 of Appendix B.

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

The results of the laboratory tests are summarized as follows:

<b>Soil Particles</b>	<b>Clayey Silt and Sand Fill (%)</b>	<b>Silty Sand Fill (%)</b>
Gravel	0 to 11	8 to 22
Sand	20 to 39	52 to 61
Silt	29 to 46	26
Clay	19 to 38	14
Silt & Clay	-	17
Liquid Limit	28 to 37	-
Plasticity Index	13 to 19	-

The above results show that the cohesive fill is typically of low to medium plasticity with group symbols of CL-CI.



## 5.2 Upper Clayey Silt and Sand Till

Native brown and mottled brown to grey clayey silt and sand till containing trace to some gravel and occasional boulders and shale fragments was encountered below the fill in Boreholes GD-01, GD-02, GD-04, GD-05 and GD-08 to GD-10 drilled during the present investigation and in all the boreholes drilled during the previous investigation. Thickness of the clayey silt till ranged from at least 3.2 m to 9.2 m in Boreholes GD-01, GD-02, GD-04, GD-05, GD-08 to GD-10, and from at least 6.2 m to 15.2 m in the 1972 boreholes.

The depth to the base of the clayey silt and sand till ranged from 10.7 m to 23.0 m (Elevations 148.1 to 153.0 m) in Boreholes GD-01, GD-02 and GD-04 to GD-08. Boreholes GD-09 and GD-10 were terminated within the clayey silt and sand till at 15.8 m and 15.6 m depth (Elevations 154.2 and 154.6 m), respectively. The base of the entire unit of glacial till is noted at Elevation 140.4 to 145.3 m in the 1972 boreholes.

Layers of silty clay and sand till were encountered below the fill in Boreholes GD-06 and GD-07, and within the upper clayey silt till in Borehole GD-10. Where encountered, these layers are 1.4 m to 2.5 m thick with base elevations ranging between 149.6 and 155.5 m. Layers of sand and gravel were encountered within the upper clayey silt and sand till in Borehole 7.

Based on SPT 'N' values ranging from 8 to 100 blows for less than 0.3 m of penetration, the upper clayey silt to silty clay and sand till is described as stiff to hard in consistency. SPT 'N' values of 2 and 4 were measured in Borehole 13. In Borehole GD-10 an SPT 'N' value of 150 blows per 0.225 m of penetration was measured near borehole termination depth (15.6 m). High SPT 'N' values, generally 100 blows for less than 0.3 m of penetration, were measured below Elevation 149.0 to 146.0 in the 1972 boreholes.

The natural moisture contents of the clayey silt and sand till samples ranged from 8% to 29%.

Grain size distribution curves for upper clayey silt and sand till samples tested are presented on the Record of Borehole sheets and on Figures B6 to B8 of Appendix B. Atterberg Limit test results are presented on Figures B14 and B15 of Appendix B.

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

The results of laboratory tests are summarized as follows:

<b>Soil Particles</b>	<b>Clayey Silt and Sand Till (%)</b>	<b>Sand and Gravel (%)</b>
Gravel	0 to 36	21 to 34
Sand	5 to 44	24 to 29
Silt	27 to 59	31 to 35
Clay	8 to 48	11 to 15

Liquid Limit	20 to 38	-
Plasticity Index	12 to 21	-

The above results show that the upper clayey silt and sand till is typically of low to medium plasticity with group symbols of CL-CI.

Glacial tills inherently contain cobbles and boulders and the lower part of the till contains pieces and slabs of bedrock which may account for some high blow counts.

### 5.3 Silty Clay

Native grey silty clay containing trace sand and trace gravel was contacted within the upper clayey silt till or below the fill at 20.0 m, 8.7 m and 18.0 m depth (Elevations 149.4, 152.5 and 153.0 m) in Boreholes GD-01, GD-03 and GD-08, respectively. Thickness of the silty clay ranged from 1.3 m to 2.3 m.

The depths to the base of the silty clay were 21.3 m, 11.0 m and 20.0 m (Elevations 148.1, 150.2 and 151.0 m) in Boreholes GD-01, GD-03 and GD-08, respectively.

Based on SPT 'N' values of 23, 33 and 83 blows for 0.3 m of penetration, the silty clay is described as very stiff to hard in consistency. The natural moisture contents of the silty clay samples ranged from 19% and 25%.

Grain size distribution curves for the silty clay samples tested are presented on the Record of Borehole sheets and on Figure B9 of Appendix B. Atterberg Limit test results are presented on Figure B16 of Appendix B.

The results of laboratory tests are summarized as follows:

<b>Soil Particles</b>	<b>Silty Clay (%)</b>
Gravel	0
Sand	7 to 13
Silt	42 to 44
Clay	44 to 50

Liquid Limit	37 to 39
Plasticity Index	18 to 20

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

#### 5.4 Lower Clayey Silt Till with Shale and Limestone Slabs

Native grey clayey silt till with frequent shale and limestone slabs, trace of sand to some sand and boulders was contacted below the upper clayey silt and sand till in Boreholes GD-02, GD-04 and GD-05, below the silty clay till in GD-06 and GD-07, and below the silty clay in Boreholes GD-01, GD-03 and GD-08. The thickness of the lower clayey silt till with slabs of bedrock was 1.6 m and 4.4 m in Boreholes GD-01 and GD-03.

Borehole GD-07 encountered auger refusal at 13.7 m depth (Elevation 147.5 m). Coring was conducted below this depth. Cores confirmed the presence of limestone and shale slabs within the clayey silt till. Thickness of the limestone slabs varied from 50 mm to 90 mm and the thickness of a shale slab was approximately 80 mm.

The depth to the base of this lower clayey silt till with slabs of bedrock was 22.9 m and 15.4 m (Elevations 146.6 and 145.8 m) in Boreholes GD-01 and GD-03, respectively.

Boreholes GD-02 and GD-04 to GD-08 were terminated within this lower clayey silt till with slabs of rock at depths ranging from 15.3 m to 27.5 m (Elevations 143.2 to 145.9 m). The lower part of the glacial till below about Elevations 149 to 146 in the 1972 boreholes are reported to contain boulders and shale fragments.

Based on SPT 'N' values ranging from 80 to 149 blows for less than 0.3 m of penetration, the lower clayey silt till with slabs of rock is described as hard in consistency. SPT 'N' values of 128 blows per 0.275 m of penetration to 100 blows per 0.0 m of penetration were measured in Borehole GD-08 below Elevation 149.8 m.

The natural moisture contents of the samples recovered from this lower clayey silt till with slabs of rock layer ranged from 5% to 21%.

Grain size distribution curves for the lower clayey silt till samples are presented on the Record of Borehole sheets and on Figure B10 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	Clayey Silt Till with frequent shale and limestone slabs (%)
Gravel	0 to 6
Sand	7 to 24
Silt	53 to 76
Clay	17 to 20

As indicated earlier, this hard till layer contains boulders, pieces and slabs of shale and limestone which may account for the consistent high blow counts.

### 5.5 Shale Bedrock

The soils described above were found to be underlain by grey highly to moderately weathered shale bedrock. The shale encountered in the boreholes is described as thinly bedded and contains numerous very strong interbedded limestone layers/slabs.

An SPT 'N' value obtained in the weathered shale bedrock was 100 blows per 0.3 m penetration in Borehole GD-03. Moisture contents were measured at 6% and 17%.

Elevations of the top of bedrock are presented in Table 5.1.

**Table 5.1 – Elevation of Top of Weathered Bedrock**

Foundation Element	Borehole	Depth (m)	Bedrock Elevation (m)
South Abutment	GD-01	22.9**	146.6**
	2	12.2	142.9
	3	11.6*	144.8*
Pier 1 (south)	7	12.6*	143.1*
	8	12.2	144.1
Pier 2 (north)	GD-03	15.4*	145.8*
	12	15.2	140.4
	13	12.3*	144.1*
North Abutment	17	11.0	145.2

\* Probable bedrock – split spoon refusal

\*\* Bedrock proven by coring

Bedrock cores were collected using NQ sized coring equipment in Borehole GD-01. Total core recovery (TCR) in the bedrock were 80% and 100% in the two core runs.

RQD values recorded in the core runs were 0% and 8%, 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. The thickness of limestone layers generally ranges from 50 to 120 mm. Clay seams were also observed within the rock cores. It is noted that sampling and interpretation from small diameter boreholes may underestimate the frequency, thickness and strength of the

strong layers and therefore geological expertise and past experience must be applied in any decision making process regarding the bedrock.

### 5.6 Water Levels

Water levels were observed in the boreholes during and upon completion of drilling. Standpipe piezometers were installed in three 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	GD-05	May 5, 2009 June 8, 2009	13.7 13.6	156.3 156.4	In piezometer
	1	February 3, 1972	2.0	153.3	In open borehole
	2	February 1, 1972	1.5	153.6	In open borehole
	3	January 27, 1972	2.5	153.9	In open borehole
Pier 1 (south)	6	February 3, 1972	1.9	153.6	In open borehole
	7	February 3, 1972	1.9	153.8	In open borehole
	8	January 28, 1972	1.9	154.4	In open borehole
Pier 2 (north)	11	February 4, 1972	5.4	153.9	In open borehole
	12	February 1, 1972	1.7	153.9	In open borehole
	13	February 31, 1972	2.5	153.9	In open borehole
North Abutment	GD-04	May 5, 2009 June 8, 2009	14.4 14.3	156.6 156.7	In piezometer
	17	February 3, 1972	2.3	153.9	In open borehole
	16	February 2, 1972	7.1	154.1	In open borehole
North Approach	18	February 1, 1972	1.3	153.9	In open borehole

Groundwater levels measured in the piezometers ranged from Elevations 156.4 to 156.7 m.

Lower water levels were noted in the open boreholes at elevations ranging from 153.3 to 154.4 m during the 1972 investigation.

The above values are short-term readings and seasonal fluctuations of the groundwater level are to be expected. In particular, the groundwater level may reach higher elevations 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

Borehole locations and ground surface elevations 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. Luke Gilarski 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, 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 widening of the NBL and SBL bridges at the Highway 427 overpass at Disco Road / Goreway Drive in Toronto, Ontario.

Based on the General Arrangement (GA) drawing 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 Disco Road / Goreway Drive. Each of the SBL and NBL bridges measures approximately 75.3 m in total span length between abutment bearings. Each bridge is supported on two abutments and two piers. The conventional abutments and piers (north and south) are supported on battered driven steel H-piles. The approach slopes are approximately 10 m high with a design inclination of 2H : 1V for the side and forward slopes.

A concrete culvert is located approximately 0.9 m below and running parallel to Disco Road / Goreway Drive. This culvert is to allow the realigned Mimico Creek to flow under Disco Road / Goreway Drive. It is understood that the culvert is approximately 5.5 m wide and 11.0 m high. The culvert invert level is at Elevation 152.8 m. The culvert is supported on spread footings founded at approximate Elevation 151.6 m.

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 in 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 fill of predominantly firm to hard clayey silt overlying an upper deposit of native stiff to hard clayey silt till. A lower deposit of hard clayey silt till with frequent shale and limestone slabs was contacted below the upper clayey silt and sand till. Weathered shale bedrock was contacted below the lower clayey silt till at two locations. Piezometers installed in boreholes revealed that the groundwater level is located between Elevations 156.4 to 156.7 m. During the 1972 investigation, water level in open boreholes was observed at elevations ranging from 153.3 to 154.4 m. Perched water may be encountered at higher levels within the sandy silt/silty sand fill layers.

Initial consideration was given to the following foundation types:

- Spread footings on upper deposit of native clayey silt and sand 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. both abutments and piers to be founded on driven steel H-piles.

### **8.1 Spread Footings on Native Soil**

Spread footings on native soils are not recommended at the abutments due to the presence of embankment fill of extensive thickness. Deep excavations ranging up to the order of 10 m in depth would be required to penetrate the fill and to build the spread footings on competent very stiff to hard clayey silt till.

Construction of spread footings at Piers 1 and 2 (south and north) would also require penetration of 7.2 to 9.1 m of existing fill to reach competent very stiff to hard clayey silt till contacted at depths ranging from 8 to 11 m. Due to the extensive depth of excavation, the presence of the existing culvert below Disco Road / Goreway Drive and other space



restrictions at the site, spread footings are also not considered to be a feasible foundation option for the piers.

## 8.2 Spread Footings on Engineered Fill

Spread footings on engineered fill are not recommended at this site. This is not a feasible option for this bridge widening due to the presence of more than 7 to 9 m of fill above the competent native soils at the piers and more than 12 m of embankment fill at the abutments.

## 8.3 Augered Caissons (Drilled Shafts)

Augered caisson (drilled shaft) foundations socketted into shale bedrock or the lower deposit of hard clayey silt till with frequent shale and limestone slabs may be employed to support the structural loads at this site. Table 8.1 presents the recommended founding depths and elevations for caissons at each abutment and pier location. Caisson lengths should be at least 6 m and each caisson should extend at least 4 m into the “100-blow” soils, or at least 3 m into bedrock.

**Table 8.1 – Founding Depths and Elevations for Augered Caissons**

Foundation Element	Borehole	Founding Depth (m)	Founding Elevation (m)
South Abutment	GD-01	25.4*	144.0*
	GD-05	25.3	144.7
	2	-	144.8
Pier 1 (south)	GD-02	16.2	144.7
	GD-06	16.2	144.7
	7	-	143.0
Pier 2 (north)	GD-03	16.2*	145.0*
	GD-07 / GD-07A	14.7	146.5
North Abutment	GD-04	26.9	144.1
	GD-08	25.3	145.7
	17	-	145.0

\* Caisson possibly founded within shale bedrock

The following Table 8.2 presents geotechnical resistances calculated for typical 1.2 and 1.5 m diameter caissons associated with the founding depths given in Table 8.1.

**Table 8.2 – Vertical Geotechnical Resistance for Caisson Foundations**

<b>Caisson Diameter (m)</b>	<b>Axial Geotechnical Resistance For Caissons Founded on Lower, Hard Native Clayey Silt Till</b>	
	<b>Factored ULS<sub>r</sub> (kN)</b>	<b>SLS (kN)</b>
1.2	6,500	5,000
1.5	7,500	6,000

### 8.3.1 Caisson Installation

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

The soil providing the resistance, whether it is skin friction or end bearing, must be protected from disturbance.

The caisson installation equipment should be able to dislodge and remove any obstructions such as cobbles, boulders and rock slabs in the till deposit. The glacial till above the shale bedrock is hard at this site and augering might be laboured. It should also be noted that hard layers were encountered in the till and shale bedrock. Hard interbedded layers of limestone in the shale bedrock and in the lower deposit of clayey silt till may require the use of coring or rock breaking equipment in addition to the auger equipment. The contract documents must contain a statement to alert bidders of these facts. The suggested wording for an NSSP addressing this issue is included in Appendix E.

The resistance value provided above is based on the assumption that the walls and base of each caisson are cleaned of loose material prior to placement of concrete. The caisson excavation should be dewatered (if necessary) to allow cleaning of the base and walls and prior to placing concrete. Concrete should be placed with a minimum delay after the socket is drilled and cleaned. A delay of 24 hours is considered to be the maximum permissible and the caisson must be maintained in a dewatered condition throughout any delay before concrete placement.

### 8.4 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 lower deposit of hard clayey silt till with frequent shale and limestone slabs.

Based on the GA drawings, the existing abutments and piers were founded on steel H-piles. It is recommended that the new piles be founded at or below the same design tip elevations as the adjacent existing piles. The existing piles were designed to be driven to approximate

Elevations 147.2 and 148.4 m at the north and south abutments, respectively, and to Elevations 146.3 and 147.8 m at Piers 1 and 2, respectively.

The piles should be driven to termination at the design ultimate capacity (see section 8.4.4) within the hard clayey silt 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**

<b>Foundation Element</b>	<b>Borehole</b>	<b>Anticipated Pile Length below Existing Ground (m)</b>	<b>Anticipated Pile Tip Elevation to Develop Required Resistance (m)</b>
<b>South Abutment</b>	GD-01	22.4	147.0
	GD-05	23.0	147.0
	2	-	147.8
<b>Pier 1 (south)</b>	GD-02	13.9	147.0
	GD-06	14.9	146.0
	7	-	144.8
<b>Pier 2 (north)</b>	GD-03	13.2	148.0
	GD-07 / GD-07A	12.2	149.0
<b>North Abutment</b>	GD-04	24.5	146.5
	GD-08	23.0	148.0
	17	-	146.3

The pile tip elevations shown in Table 8.3 should be used for estimating purposes only. The presence of boulders, cobbles, shale and limestone slabs makes it difficult to predict the depth at which piles will achieve the required resistance. The actual pile tip elevations will be controlled as described in Section 8.4.4 Pile Driving.

Prior to pile driving operations, it is imperative to confirm the location of the existing structure foundations and the culvert. Particular attention should be paid to pile driving operations at the piers to avoid damaging the existing culvert and foundations.

#### **8.4.1 Axial Resistance**

The factored, axial, geotechnical resistances for a typical pile sections when driven into the lower deposit of hard clayey silt till containing rock slabs at the approximate elevations presented in Table 8.3 at the piers and abutments are presented in Table 8.4.

**Table 8.4 – Axial Resistance of a HP 310 X 110 Pile Section**

Foundation Element	Piles Driven Into Clayey Silty Till	
	ULS (Factored) (kN)	SLS (kN)
Pier (approx. length of pile at least 12 m)	1,400	1,200
Abutment (approx. length of pile at least 22 m)	1,800	1,600

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

#### **8.4.2 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 driving shoes 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 hard tills containing cobbles, boulders and limestone and shale slabs.

#### **8.4.3 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 E.

#### **8.4.4 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 pile tips have reached an elevation at about 2 m above the anticipated pile tip elevation. 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". For a HP 310 x 110 pile section, "R" must have a minimum value of 3,600 kN at the abutments and 2,800 kN at the piers.

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

#### 8.4.5 Downdrag

As the cohesive soils at this site are very stiff to hard and the existing median is almost at grade, settlements induced in the foundation soils due to placement of a small volume of additional approach fill is expected to be of small magnitudes and substantially complete by the end of embankment construction. Downdrag on the piles is not considered to be an issue at this site.

#### 8.4.6 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.

#### 8.4.7 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:

$$k_s = 125 \cdot S_u / D \quad (\text{kN/m}^3)$$

$$p_{ult} = 9 \cdot S_u \text{ (kPa) at and below a depth of } 3 \cdot D \text{ (m) reduced to zero at ground surface}$$

where

$$D = \text{pile width in metres}$$

$$S_u = \text{undrained shear strength (kPa)}$$

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,  $K = k_s \cdot L \cdot D$  (kN/m), where  $k_s$  is the coefficient of horizontal subgrade reaction (kN/m<sup>3</sup>),  $D$  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,  $P_{ult} = p_{ult} \cdot L \cdot D$ . 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.

Parameter values for lateral pile resistance are shown in Table 8.6.

**Table 8.6 – Parameters for Lateral Pile Resistance**

<b>Elevation (m)</b>	<b><math>K_p</math></b>	<b><math>S_u</math> (kPa)</b>	<b>Unit Weight (kN/m<sup>3</sup>)</b>	<b>Soil Conditions</b>
OGI to 153	3.0	100	19	Stiff to hard clayey silt and sand fill
Below 153	3.3	200	21	Very stiff to hard clayey silt and sand till

The vertical resistance will not be significantly affected by the pile spacing for piles driven to refusal. 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 ( $k_s$ ) may have to 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:

<b>Pile Spacing Perpendicular to Direction of Loading</b>	<b>Horizontal Subgrade Reaction Reduction Factor, R</b>
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:

<b>Pile Spacing Parallel to Direction of Loading</b>	<b>Horizontal Subgrade Reaction Reduction Factor, R</b>
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.

## **8.5 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.

### **8.5.1 Recommended Foundation**

From a foundations technical, constructability and cost-effectiveness perspective, the recommended foundations at the piers and abutments at this site are steel H-piles driven to achieve resistance in the lower deposit of hard native hard clayey silt till with frequent limestone and shale slabs.

## **9 TEMPORARY EXCAVATION**

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 clayey silt 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.

Earth excavations for pile caps required at this site will penetrate through a variety of overburden soils including fill and possibly native clayey silt till. The soils, especially the tills, may contain cobbles, boulders and shale fragments. It is anticipated that temporary excavations through a majority of soils at this site may be formed with temporary 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.

## **10 ROADWAY PROTECTION**

It is anticipated that roadway (Highway 427) protection will be required during construction. An item titled “Protection System” as per SP 105S19 should be included in the contract documents. It is recommended that Performance Level 2 as per Clause 539.04.02.01 and the alignment of the shoring be specified on the contract drawings.

The design of roadway 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 clayey silt till to develop the required toe resistance. It is anticipated that the shoring system may be stiffened by cross bracings, where applicable.

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

$\gamma$	=	20 kN/m <sup>3</sup>
$\gamma_w$	=	10 kN/m <sup>3</sup>
$K_a$	=	0.33 (road embankment fill)
	=	0.31 (clayey silt till)
$K_p$	=	3.0 (road embankment fill)
	=	3.2 (clayey silt till)

The designer of the roadway protection system should check whether the socket 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

Groundwater level is anticipated to be between Elevations 156.4 to 156.7 m, based on piezometer readings taken during the present investigation. Water was also observed at elevations ranging from 153.3 to 154.4 m during the previous investigation. Perched water may be encountered within the cohesionless fill layers.

Considering the consistency and low permeability of the clayey soils, groundwater control measures such as perimeter ditches and pumping from filtered sumps should be implemented to remove any accumulation of water from the pile cap base prior to placing concrete. The possibility exists that additional pumps may be required if localized zones of perched water are encountered.

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 firm to hard clayey silt fill overlying very stiff to hard native clayey silt till underlain by hard clayey silt till with shale and limestone slabs. The existing approach heights are approximately 9 m at the north and south approaches. Since the existing median is more or less at grade, the additional fill that may be required to construct the new abutments should be minimal.

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.



The embankment foundation soils are considered adequate to provide stability to new earth fills inclined at 2H:1V or flatter.

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

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

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:

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

where:

$P_h$  = horizontal pressure on the wall at depth  $h$  (kPa)

$K$  = earth pressure coefficient (see Table 14.1)

$\gamma$  = 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)

Wall Condition	Earth Pressure Coefficient (K)					
	OPSS Granular A $\phi = 35^\circ, \gamma = 22.8 \text{ kN/m}^3$		OPSS Granular B Type II $\phi = 35^\circ, \gamma = 22.8 \text{ kN/m}^3$		OPSS Granular B Type I $\phi = 32^\circ, \gamma = 21.2 \text{ kN/m}^3$	
	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 and require 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 Canadian Highway Bridge Design Code.

## 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 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 Coefficients for Earthquake Loading**

Earth Pressure Coefficients (K) for Earthquake Loading				
Wall Condition	Granular A or Granular B Type II $\phi = 35^\circ$ ; $\gamma = 22.8 \text{ kN/m}^3$		OPSS Granular B Type I $\phi = 32^\circ$ ; $\gamma = 21.2 \text{ kN/m}^3$	
	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 STRUCTURES AND BURIED UTILITIES

A major concrete culvert carrying the realigned Mimico Creek is present in the vicinity of the new foundation area for the piers, approximately 0.9 m below Disco Road / Goreway Drive. Buried utilities might also be present in the new foundation construction areas. It is recommended that the exact locations and elevations of the culvert and 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 the culvert and utilities should also be established.

Pile driving will be required at locations some 6 to 8 m from the outside edges of the culvert. It is anticipated that the resulting vibration would not induce liquefaction of the very dense or hard foundation soils. However, it is recommended that vibration and settlement monitoring be carried out during piling to assess any adverse impact on the culvert.

It is recommended that the following be carried out prior to the commencement of construction:

- Carry out pre-construction condition survey including documentation of any existing distress associated with the existing bridge foundations, culvert and utilities. Any distress should be reported to and discussed with the owners of these facilities.
- Implement an instrumentation and monitoring program to include vibration and settlement monitoring during construction. Establish review and alert level criteria for allowable settlement and lateral movement following discussions with the owner of the bridge foundations, culvert and utilities. Establish review and alert level criteria for vibration levels (in terms of peak particle velocity, ppv) during pile driving. Establish and agree on remedial action, if required, prior to start of construction.
- Carry out post-construction condition survey of the existing bridge foundations, culvert and utilities.

## 17 CONSTRUCTION CONCERNS

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

### 1. Pile refusal at higher elevation.

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

### 2. Pile fails to develop specified resistance.

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

- a) Stop driving in that pile group for 48 hours (minimum)
- b) After 48 hours, warm up the hammer on another pile, then 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.

### 3. Destabilization of excavations

Perched water may be encountered within the cohesionless fill layers. The impact of this perched groundwater might destabilize the sides and/or base of an 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 pile caps must be constructed in the dry.

### 4. Adjacent structures

All new foundation footprints should be clear of any existing and adjacent structure. Vibration and settlement monitoring for adjacent structures, where required, should be provided by qualified personnel.

### 5. 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 for erosion control.

## 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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**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 <sup>(1)</sup> 'N' VALUE
Very Soft	12 or less	Less than 2
Soft	12 to 25	2 to 4
Firm	25 to 50	4 to 8
Stiff	50 to 100	8 to 15
Very Stiff	100 to 200	15 to 30
Hard	Greater than 200	Greater than 30

NOTE: Hierarchy of Soil Strength Prediction

- 1) Laboratory Triaxial Testing
- 2) Field Insitu Vane Testing
- 3) Laboratory Vane Testing
- 4) SPT value
- 5) Pocket Penetrometer

## 4. TERMS DESCRIBING DENSITY (COHESIONLESS SOILS ONLY)

DESCRIPTIVE TERM	SPT "N" VALUE
Very Loose	Less than 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	Greater than 50

## 5. LEGEND FOR RECORDS OF BOREHOLES

SYMBOLS AND ABBREVIATIONS FOR SAMPLE TYPE	SS Split Spoon Sample	WS Wash Sample	AS Auger (Grab) Sample
	TW Thin Wall Shelby Tube Sample		TP Thin Wall Piston Sample
	PH Sampler Advanced by Hydraulic Pressure		PM Sampler Advanced by Manual Pressure
	WH Sampler Advanced by Self Static Weight		RC Rock Core
			SC Soil Core

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



Water Level

C<sub>pen</sub>

Shear Strength Determination by Pocket Penetrometer






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



# UNIFIED SOILS CLASSIFICATION

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

## EXPLANATION OF ROCK LOGGING TERMS

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

DISCONTINUITY SPACING		STRENGTH CLASSIFICATION			
Bedding	Bedding Plane Spacing	Rock Strength	Approximate Uniaxial Compressive Strength		Field Estimation of Hardness*
			(MPa)	(psi)	
Very thickly bedded	Greater than 2m	Extremely Strong	Greater than 250	Greater than 36,000	Specimen can only be chipped with a geological hammer
Thickly bedded	0.6 to 2m				
Medium bedded	0.2 to 0.6m	Very Strong	100-250	15,000 to 36,000	Requires many blows of geological hammer to break
Thinly bedded	60mm to 0.2m				
Very thinly bedded	20 to 60mm	Strong	50-100	7,500 to 15,000	Requires more than one blow of geological hammer to break
Laminated	6 to 20mm				
Thinly Laminated	Less than 6mm	Medium Strong	25.0 to 50.0	3,500 to 7,500	Breaks under single blow of geological hammer.

TERMS		Weak	Very Weak	Extremely Weak (Rock)
Total Core Recovery: (TCR)	Core recovered as a percentage of total core run length.	5.0 to 25.0	1.0 to 5.0	0.25 to 1.0
Solid Core Recovery: (SCR)	Percent Ratio of solid core of full cylindrical shape recovered. Expressed with respect to the total length of core run.	750 to 3,500	150 to 750	35 to 150
Rock Quality Designation: (RQD)	Total length of sound core recovered in pieces 0.1m in length or larger as a percentage of total core run length.			
Uniaxial Compressive Strength (UCS)	Axial stress required to break the specimen			
Fracture Index: (FI)	Frequency of natural fractures per 0.3m of core run.			

RECORD OF BOREHOLE No GD-01

1 OF 3

METRIC

G.W.P. 202-95-00 LOCATION N 4 840 128.4 E 295 955.1 Disco Rd./Goreway Dr. ORIGINATED BY GA  
HWY 427 BOREHOLE TYPE Solid Stem Auger COMPILED BY AN  
DATUM Geodetic DATE 2008.11.12 - 2008.11.17 CHECKED BY SKP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL								
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED    + FIELD VANE ● QUICK TRIAXIAL    × LAB VANE						WATER CONTENT (%) w <sub>p</sub> w    w <sub>L</sub>							
169.4 0.0	Silty CLAY, trace sand, occasional rootlets Firm Brown to Black (FILL)		1	SS	6																
167.9 1.5	Clayey SILT and sand, trace gravel Very Stiff Brown (FILL)		2	SS	17																
166.8 2.6	Stiff Mottled brown and grey																				
			3	SS	14																
165.3 4.1			Very Stiff	4	SS	28															
	5			SS	27																
	6			SS	26																
			7	SS	27																
																			</		

Continued Next Page

+ 3 X 3: Numbers refer to 20 15 10 5 0 Sensitivity (%) STRAIN AT FAILURE

ONTMT4S 9270.GPJ 7/29/09




# RECORD OF BOREHOLE No GD-01

3 OF 3

METRIC

G.W.P. 202-95-00 LOCATION N 4 840 128.4 E 295 955.1 Disco Rd./Goreway Dr. ORIGINATED BY GA  
 HWY 427 BOREHOLE TYPE Solid Stem Auger COMPILED BY AN  
 DATUM Geodetic DATE 2008.11.12 - 2008.11.17 CHECKED BY SKP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>P</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT  Y  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa										WATER CONTENT (%)		
								○ UNCONFINED	+	FIELD VANE	● QUICK TRIAXIAL	×						LAB VANE		
								20	40	60	80	100								
Continued From Previous Page																				
20.0	Silty CLAY, trace sand Hard Brown		14	SS	33		149										GR SA SI CL			
148.1																				
21.3	Clayey SILT, with frequent shale and limestone slabs Hard Grey (TILL)		15	SS	100/ 0.225		148													
146.6							147													
22.9	SHALE, highly to moderately weathered, with limestone interbeds, very thinly to thinly bedded, grey Zones of broken core  Limestone (50mm) at 24m Clay seams (50mm) at 25m Limestone (120mm) at 25.5m		16	SS	50/ 0.0		146													
			1	RUN			145													
			2	RUN			144													
143.5																				
25.9	END OF BOREHOLE AT 25.9m. BOREHOLE BACKFILLED WITH BENTONITE TO SURFACE.																			

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity 20 15 10 5 0 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No GD-02

1 OF 2

METRIC

G.W.P. 202-95-00 LOCATION N 4 840 157.8 E 295 941.7 Disco Rd./Goreway Dr. ORIGINATED BY GA  
 HWY 427 BOREHOLE TYPE Solid Stem Auger COMPILED BY AN  
 DATUM Geodetic DATE 2008.11.18 - 2008.11.18 CHECKED BY SKP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa							
160.9								○ UNCONFINED + FIELD VANE							
								● QUICK TRIAXIAL × LAB VANE							
0.0	Clayey SILT and sand, trace to some gravel, occasional rootlets Very Stiff to Hard Brown (FILL)		1	SS	21	160	159	158	157	156	155	154	153	152	151
			2	SS	57										
	Mottled Brown to Grey		3	SS	40										
			4	SS	24										
157.4			5	SS	85										
3.5	Sandy SILT, trace clay, trace gravel Very Dense to Compact Reddish Brown Moist (FILL)					157	156	155	154	153	152	151			
	Occasional shale pieces		6	SS	21										
154.8			7	SS	19	154	153	152	151						
6.1	Clayey SILT and sand, trace gravel Very Stiff to Hard Mottled Brown to Grey (FILL)														
153.7			8	SS	42	153	152	151							
7.2	Clayey SILT and sand, trace gravel Hard Grey (TILL)														
			9	SS	39										

Continued Next Page

+ 3 . X 3 : Numbers refer to 20 15 5 (% ) STRAIN AT FAILURE

# RECORD OF BOREHOLE No GD-02

2 OF 2

METRIC

G.W.P. 202-95-00 LOCATION N 4 840 157.8 E 295 941.7 Disco Rd./Goreway Dr. ORIGINATED BY GA  
 HWY 427 BOREHOLE TYPE Solid Stem Auger COMPILED BY AN  
 DATUM Geodetic DATE 2008.11.18 - 2008.11.18 CHECKED BY SKP

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			20 40 60 80 100	PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	
	Continued From Previous Page						SHEAR STRENGTH kPa				
							○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB VANE				
							WATER CONTENT (%)				
							40 80 120 160 200	20 40 60			
148.7	Clayey SILT and sand, trace gravel Hard Grey (TILL)  Highly weathered shale fragments		10	SS	65	150					
12.2	Frequent shale and limestone slabs, trace sand		11	SS	100/ 0.050	149					
			12	SS	100/ 0.200	147					
			13	SS	100/ 0.100	146					
144.1			14	SS	100/ 0.050	145					
16.8	END OF BOREHOLE AT 16.8m. BOREHOLE BACKFILLED WITH BENTONITE TO SURFACE.										

ONTMT4S 9270.GPJ 7/7/09

# RECORD OF BOREHOLE No GD-03

1 OF 2

METRIC

G.W.P. 202-95-00 LOCATION N 4 840 184.5 E 295 932.2 Disco Rd./Goreway Dr. ORIGINATED BY GA  
 HWY 427 BOREHOLE TYPE Solid Stem Auger COMPILED BY AN  
 DATUM Geodetic DATE 2008.10.28 - 2008.10.28 CHECKED BY SKP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT  $\gamma$  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)		
								20 40 60 80 100							
								20 40 60							
						UNCONFINED + FIELD VANE			PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT						
						● QUICK TRIAXIAL x LAB VANE									
161.2															
0.0	Clayey SILT and sand, trace gravel, rootlets Stiff to Very Stiff Brown (FILL)		1	SS	19		161								7 38 34 21
			2	SS	62/ 0.200		160								
			3	SS	22		159								
			4	SS	16		158								
158.2			5	SS	17		157								4 27 38 31
3.0	Silty CLAY and sand, trace gravel Very Stiff to Stiff (FILL)		6	SS	10		156								
			7	SS	10		155								
156.7			8	SS	8		154								
4.5	Occasional shale slabs		9	SS	25		153								
			10	SS	23		152								0 8 42 50
152.5															
8.7	Silty CLAY, trace sand, trace gravel Very Stiff Grey														

Continued Next Page

+<sup>3</sup>, X<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15  
10

(%) STRAIN AT FAILURE



# RECORD OF BOREHOLE No GD-03

2 OF 2

METRIC

G.W.P. 202-95-00 LOCATION N 4 840 184.5 E 295 932.2 Disco Rd./Goreway Dr. ORIGINATED BY GA  
 HWY 427 BOREHOLE TYPE Solid Stem Auger COMPILED BY AN  
 DATUM Geodetic DATE 2008.10.28 - 2008.10.28 CHECKED BY SKP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT		
	Continued From Previous Page						SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE						
							WATER CONTENT (%) w <sub>p</sub> w w <sub>L</sub>						
150.2	Silty CLAY, trace sand, trace gravel Very Stiff Grey		11	SS	25								
11.0	Clayey SILT, with frequent shale and limestone slabs, trace sand Hard Grey (TILL)		12	SS	80/ 0.225								
			13	SS	100								
			14	SS	100/ 0.225								
145.8													
15.4	SHALE, highly weathered, thinly bedded, grey, limestone interbeds		15	SS	100								
145.5													
15.7	END OF BOREHOLE AT 15.7m. BOREHOLE BACKFILLED WITH BENTONITE HOLEPLUG TO SURFACE.												

ONTMT4S 9270.GPJ 7/7/09

# RECORD OF BOREHOLE No GD-04

1 OF 3

METRIC

G.W.P. 202-95-00 LOCATION N 4 840 212.4 E 295 915.5 Disco Rd./Goreway Dr. ORIGINATED BY GA  
 HWY 427 BOREHOLE TYPE Solid Stem Auger COMPILED BY AN  
 DATUM Geodetic DATE 2008.11.06 - 2008.11.07 CHECKED BY SKP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	
171.0												
0.0	Silty CLAY, trace sand, trace gravel, occasional rootlets Very Stiff Brown (FILL)		1	SS	17		171					
							170					
169.5												
1.5	Clayey SILT and sand, trace gravel Very Stiff Mottled Brown to Grey (FILL)		2	SS	21		169					
							168					
			3	SS	18		167					
							166					
			4	SS	16		165					
							164					
	Grey		5	SS	18		163					
							162					
			6	SS	20							
	Mottled Brown to Grey											
			7	SS	41							
	Becoming hard											

Continued Next Page

+ 3 . X 3 : Numbers refer to  
Sensitivity

20  
15  
10  
5

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No GD-04

2 OF 3

METRIC

G.W.P. 202-95-00 LOCATION N 4 840 212.4 E 295 915.5 Disco Rd./Goreway Dr. ORIGINATED BY GA  
HWY 427 BOREHOLE TYPE Solid Stem Auger COMPILED BY AN  
DATUM Geodetic DATE 2008.11.06 - 2008.11.07 CHECKED BY SKP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	
	Continued From Previous Page							SHEAR STRENGTH kPa ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL X LAB VANE	WATER CONTENT (%) 20 40 60			GR SA SI CL
	Clayey SILT and sand, trace gravel Hard Mottled Brown to Grey (FILL)		8	SS	49		161					
							160					
			9	SS	46		159					
							158					
			10	SS	49		157					
							156					
155.8							155					
15.2	Clayey SILT and sand, trace gravel Hard Mottled Brown to Grey (TILL)		11	SS	36		154					4 43 31 22
							153					
	Brown		12	SS	84		152					
			13	SS	68							

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+ <sup>3</sup> , X <sup>3</sup> : Numbers refer to  
Sensitivity

20  
15 5  
5  
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No GD-04

3 OF 3

METRIC

G.W.P. 202-95-00 LOCATION N 4 840 212.4 E 295 915.5 Disco Rd./Goreway Dr. ORIGINATED BY GA  
HWY 427 BOREHOLE TYPE Solid Stem Auger COMPILED BY AN  
DATUM Geodetic DATE 2008.11.06 - 2008.11.07 CHECKED BY SKP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>P</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
	Continued From Previous Page													
	Clayey SILT and sand, trace gravel Hard Grey (TILL)		14	SS	32		151							
			15	SS	74		150							
							149							
148.1	Frequent shale and limestone slabs		16	SS	92/ 0.250		148							
23.0			17	SS	114/ 0.225		147							
			18	SS	100/ 0.075		146							
			19	SS	100/ 0.075		145							
143.5	END OF BOREHOLE AT 27.5m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.						144							
27.5	WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2009.05.05 14.4 156.6 2009.06.08 14.3 156.7													

ONTMT4S 9270.GPJ 7/3/09

+ 3 × 3 : Numbers refer to  
Sensitivity 20 15 10 (% STRAIN AT FAILURE

## METRIC

[illegible]

+ 3, X 3: Numbers refer to Sensitivity



RECORD OF BOREHOLE No GD-05

3 OF 3

METRIC

G.W.P. 202-95-00 LOCATION N 4 840 127.4 E 295 961.7 Disco Rd./Goreway Dr. ORIGINATED BY GA  
HWY 427 BOREHOLE TYPE Solid Stem Auger COMPILED BY AN  
DATUM Geodetic DATE 2008.11.11 - 2008.11.12 CHECKED BY SKP

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES		20	40	60	80	100		
	Continued From Previous Page						SHEAR STRENGTH kPa						
							O UNCONFINED + FIELD VANE ● QUICK TRIAXIAL X LAB VANE						
							WATER CONTENT (%)						
							PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT W <sub>p</sub> W W <sub>L</sub>						
148.7	Clayey SILT and sand, trace gravel Very Stiff to Hard Grey (TILL)		14	SS	25								
21.3	Frequent shale and limestone slabs, some sand		15	SS	100								
			16	SS	149/ 0.225								1 12 67 20
			17	SS	149								
144.0			18	SS	100/ 0.075								
26.0	END OF BOREHOLE AT 26.0m. Piezometer installation consists of 19mm diameter Schedule 40 PVC pipe with a 1.52m slotted screen.  WATER LEVEL READINGS: DATE DEPTH (m) ELEV. (m) 2009.05.05 13.7 156.3 2009.06.08 13.6 156.4												

+ 3 . X 3 : Numbers refer to  
Sensitivity

20  
15 10 5  
(%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No GD-06

1 OF 2

METRIC

G.W.P. 202-95-00 LOCATION N 4 840 157.1 E 295 946.8 Disco Rd./Goreway Dr. ORIGINATED BY GA  
 HWY 427 BOREHOLE TYPE Solid Stem Auger COMPILED BY AN  
 DATUM Geodetic DATE 2008.10.30 - 2008.10.30 CHECKED BY SKP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			UNIT WEIGHT  $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					WATER CONTENT (%)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
								20	40	60			80	100	UNCONFINED	FIELD VANE	QUICK TRIAXIAL	LAB VANE	PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
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+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15  
10

(%) STRAIN AT FAILURE

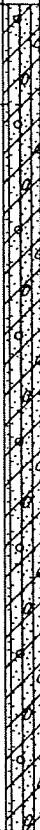


RECORD OF BOREHOLE No GD-06

2 OF 2

METRIC

G.W.P. 202-95-00 LOCATION N 4 840 157.1 E 295 946.8 Disco Rd./Goreway Dr. ORIGINATED BY GA  
HWY 427 BOREHOLE TYPE Solid Stem Auger COMPILED BY AN  
DATUM Geodetic DATE 2008.10.30 - 2008.10.30 CHECKED BY SKP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								20 40 60 80 100	○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE			WATER CONTENT (%)					
	Continued From Previous Page						40 80 120 160 200	20 40 60									
150.2	Clayey SILT and sand, trace gravel Very Stiff to Hard Grey (TILL)																
10.7	Frequent shale and limestone slabs, sandy		11	SS	31		150							○			
							149										
			12	SS	86		148							○			6 24 53 17
							147							○			
			13	SS	118/ 0.225		146										
145.4			14	SS	64/ 0.225								○				
15.5	END OF BOREHOLE AT 15.5m. BOREHOLE BACKFILLED WITH BENTONITE TO SURFACE.																

# RECORD OF BOREHOLE No GD-07

1 OF 2

METRIC

G.W.P. 202-95-00 LOCATION N 4 840 184.9 E 295 934.3 Disco Rd./Goreway Dr. ORIGINATED BY GA  
 HWY 427 BOREHOLE TYPE Solid Stem Auger COMPILED BY AN  
 DATUM Geodetic DATE 2008.10.29 - 2008.10.30 CHECKED BY SKP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT  $\gamma$  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
								WATER CONTENT (%)						
161.2							20 40 60 80 100							
0.0	Clayey SILT and sand, trace gravel, occasional rootlets Very Stiff to Stiff Brown (FILL)		1	SS	18									
			2	SS	14									
			3	SS	26									
			4	SS	20									
			5	SS	21									
			6	SS	12									
			7	SS	10									
			8	SS	25									
154.0														
7.2	Silty CLAY and sand, trace gravel Hard Brown (FILL)		9	SS	32									
152.0														
9.1	Silty CLAY and sand, trace gravel Very Stiff Grey (TILL)		10	SS	20									

Continued Next Page

+ <sup>3</sup>, x <sup>3</sup>: Numbers refer to  
Sensitivity

20  
15  
10

(%) STRAIN AT FAILURE

ONTMT4S 9270.GPJ 7/29/09

# RECORD OF BOREHOLE No GD-07

2 OF 2

METRIC

G.W.P. 202-95-00 LOCATION N 4 840 184.9 E 295 934.3 Disco Rd./Goreway Dr. ORIGINATED BY GA  
 HWY 427 BOREHOLE TYPE Solid Stem Auger COMPILED BY AN  
 DATUM Geodetic DATE 2008.10.29 - 2008.10.30 CHECKED BY SKP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa						
								WATER CONTENT (%)						
	Continued From Previous Page						20 40 60 80 100							
	Silty CLAY and sand, trace gravel Hard Grey (TILL)						40 80 120 160 200							
	Layer of grey sand (200mm)		11	SS	33									
149.6														
11.6	Clayey SILT and sand, trace gravel, Frequent shale and limestone slabs Hard Grey (TILL)		12	SS	87									
	Coring started at 13.7m Limestone (90mm) at 14.0m Shale (80mm) at 14.6m		1	RUN										
			2	RUN										
	Limestone pieces		3	RUN										
	Limestone pieces (50mm) at 16.3m		4	RUN										
			5	RUN										
143.2														
18.0	END OF BOREHOLE AT 17.9m. BOREHOLE BACKFILLED WITH BENTONITE TO SURFACE.													

ONTMT4S 9270.GPJ 8/13/09

+<sup>3</sup>, X<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15  
10

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No GD-07A

1 OF 2

METRIC

G.W.P. 202-95-00 LOCATION N 4 840 184.9 E 295 934.3 Disco Rd./Goreway Dr. ORIGINATED BY GA  
HWY 427 BOREHOLE TYPE Solid Stem Auger COMPILED BY AN  
DATUM Geodetic DATE 2008.11.19 - 2008.11.19 CHECKED BY SKP

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC NATURAL LIQUID LIMIT MOISTURE CONTENT LIMIT			UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	SHEAR STRENGTH kPa	WATER CONTENT (%)	W <sub>P</sub>	W		
161.2 0.0	Augered to 10.7m.						20 40 60 80 100 O UNCONFINED + FIELD VANE ● QUICK TRIAXIAL X LAB VANE	40 80 120 160 200	20 40 60				
						161							
						160							
						159							
						158							
						157							
						156							
						155							
						154							
						153							
						152							

Continued Next Page

+ <sup>3</sup> . X <sup>3</sup> : Numbers refer to  
Sensitivity

20  
15  
10  
5  
0

(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No GD-07A

2 OF 2

METRIC

G.W.P. 202-95-00 LOCATION N 4 840 184.9 E 295 934.3 Disco Rd./Goreway Dr. ORIGINATED BY GA  
HWY 427 BOREHOLE TYPE Solid Stem Auger COMPILED BY AN  
DATUM Geodetic DATE 2008.11.19 - 2008.11.19 CHECKED BY SKP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								20 40 60 80 100 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE									
Continued From Previous Page							WATER CONTENT (%) PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT w <sub>p</sub> w w <sub>L</sub>										
150.5	Clayey SILT, with frequent shale slabs and limestone fragments Hard Grey (TILL)		1	SS	120/ 0.200	151											
10.7																	
					2	SS	100	149									
			3	SS	100	148											
							147										
145.9			4	SS	100/ 0.075	146											
15.3	END OF BOREHOLE AT 15.3m. BOREHOLE BACKFILLED WITH BENTONITE TO SURFACE.																

+<sup>3</sup>, X<sup>3</sup>: Numbers refer to  
Sensitivity

20  
15  
10

(%) STRAIN AT FAILURE



# RECORD OF BOREHOLE No GD-08

2 OF 3

METRIC

G.W.P. 202-95-00 LOCATION N 4 840 211.8 E 295 922.3 Disco Rd./Goreway Dr. ORIGINATED BY GA  
 HWY 427 BOREHOLE TYPE Solid Stem Auger COMPILED BY AN  
 DATUM Geodetic DATE 2008.11.07 - 2008.11.10 CHECKED BY SKP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL		
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	SHEAR STRENGTH kPa								W <sub>p</sub> W W <sub>L</sub>	
								○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE	WATER CONTENT (%)									
	Continued From Previous Page						161											
	Clayey SILT and sand, trace gravel Hard Mottled Brown to Grey (TILL)		8	SS	71		160											
				9	SS	65		159										
							158											
			10	SS	50		157											
			11	SS	80		156											
							155											
			12	SS	100		154											
153.0							153											
18.0	Silty CLAY, some sand Hard Grey		13	SS	83		152											
151.0																		

Continued Next Page

+ 3, X 3: Numbers refer to 20 15 5 / 101 STD IN AT FAILURE


ONTMT4S 9270.GPJ 7/7/09

# RECORD OF BOREHOLE No GD-08

3 OF 3

METRIC

G.W.P. 202-95-00 LOCATION N 4 840 211.8 E 295 922.3 Disco Rd./Goreway Dr. ORIGINATED BY GA  
 HWY 427 BOREHOLE TYPE Solid Stem Auger COMPILED BY AN  
 DATUM Geodetic DATE 2008.11.07 - 2008.11.10 CHECKED BY SKP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL			
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa								WATER CONTENT (%)		
								○ UNCONFINED    + FIELD VANE										
	Continued From Previous Page							● QUICK TRIAXIAL    x LAB VANE										
20.0	Clayey SILT, with frequent shale and limestone slabs Hard Mottled Brown to Grey (TILL)		14	SS	31		151											
								150										
			15	SS	128/ 0.275			149										
								148										
			16	SS	100/ 0.175			147										
								146										
145.0																		
26.1	END OF BOREHOLE AT 26.1m. BOREHOLE BACKFILLED WITH BENTONITE TO SURFACE.		18	SS	100/ .0		145											

ONTMT4S 9270.GPJ 7/3/09




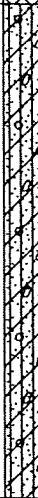


# RECORD OF BOREHOLE No GD-09

2 OF 2

METRIC

G.W.P. 202-95-00 LOCATION N 4 840 121.9 E 295 960.2 Disco Rd./Goreway Dr. ORIGINATED BY GA  
 HWY 427 BOREHOLE TYPE Solid Stem Auger COMPILED BY AN  
 DATUM Geodetic DATE 2008.11.08 - 2008.11.08 CHECKED BY SKP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT $\gamma$ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)				
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								UNCONFINED		FIELD VANE							
	Continued From Previous Page						20	40	60	80	100	PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT			
	Clayey SILT and sand, trace gravel Very Stiff Mottled Brown to Grey (FILL)		11	SS	20												
	Wood fragments																
157.4																	
12.6	Clayey SILT and sand, trace gravel, occasional organics Very stiff Grey to Brown (TILL)		12	SS	35												
			13	SS	22												
154.2			14	SS	22											3 29 41 27	
15.8	END OF BOREHOLE AT 15.8m. BOREHOLE BACKFILLED WITH BENTONITE TO SURFACE.																

ONTMT4S 9270.GPJ 7/29/09

# RECORD OF BOREHOLE No GD-10

1 OF 2

METRIC

G.W.P. 202-95-00 LOCATION N 4 840 225.3 E 295 912.6 Disco Rd./Goreway Dr. ORIGINATED BY GA  
 HWY 427 BOREHOLE TYPE Solid Stem Auger COMPILED BY AN  
 DATUM Geodetic DATE 2008.11.06 - 2008.11.06 CHECKED BY SKP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					
170.2 0.0	Silty <b>CLAY</b> , trace to some sand, trace gravel, occasional rootlets Firm to Very Stiff Brown to Grey (FILL)		1	SS	7	○ UNCONFINED      + FIELD VANE				PLASTIC LIMIT      NATURAL MOISTURE CONTENT      LIQUID LIMIT			
			2	SS	16	● QUICK TRIAXIAL      × LAB VANE				WATER CONTENT (%)			
			3	SS	22								
168.1 2.1	Silty <b>SAND</b> , some clay, trace gravel Compact Brown Moist to Wet (FILL)		4	SS	15								
167.3 2.9	Clayey <b>SILT</b> and sand, trace gravel Very Stiff to Hard Mottled Brown to Grey (FILL)		5	SS	31								
			6	SS	33								
			7	SS	25								
			8	SS	23								
162.6 7.6	Clayey <b>SILT</b> and sand, trace gravel Hard Grey (TILL)		9	SS	54								
			10	SS	64								

Continued Next Page

+ 3 . X 3 : Numbers refer to  
Sensitivity

20  
15 5  
20  
(%) STRAIN AT FAILURE

RECORD OF BOREHOLE No GD-10

2 OF 2

METRIC

G.W.P. 202-95-00 LOCATION N 4 840 225.3 E 295 912.6 Disco Rd./Goreway Dr. ORIGINATED BY GA  
 HWY 427 BOREHOLE TYPE Solid Stem Auger COMPILED BY AN  
 DATUM Geodetic DATE 2008.11.06 - 2008.11.06 CHECKED BY SKP

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				UNIT WEIGHT  γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED    + FIELD VANE ● QUICK TRIAXIAL    × LAB VANE						PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT
	Continued From Previous Page						20	40	60	80	100	W <sub>p</sub> W    W <sub>L</sub>		
	Clayey SILT and sand, trace gravel Hard Mottled brown to grey (TILL)		11	SS	37									
			12	SS	34									
156.9														
13.3	Silty CLAY and sand, trace gravel Hard (TILL)		13	SS	67									
155.5														
14.7														
154.6			14	SS	150/ 225									
15.6	END OF BOREHOLE AT 15.6m. BOREHOLE BACKFILLED WITH BENTONITE TO SURFACE.													

ONTMT4S 9270.GPJ 7/29/09

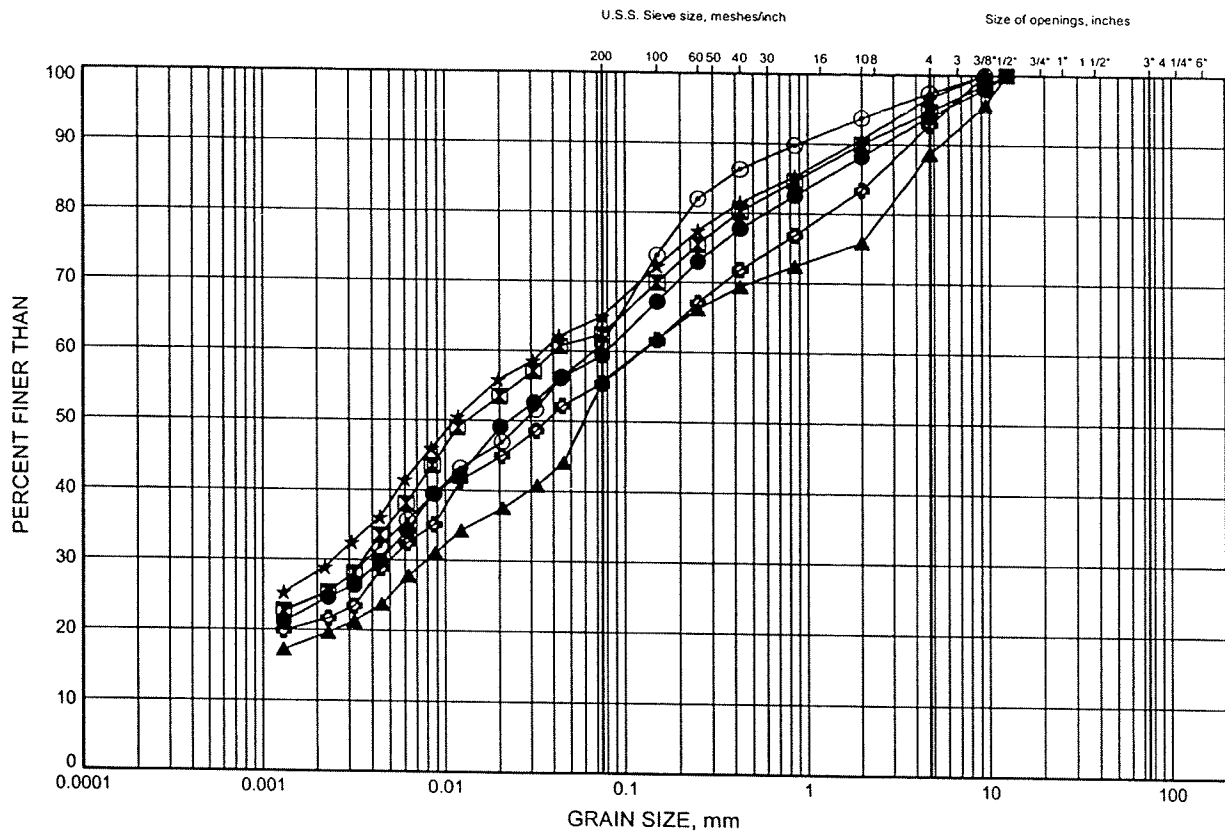
## **Appendix B**

### **Laboratory Test Results (Present Investigation)**

# Hwy 427 Northbound and Southbound GRAIN SIZE DISTRIBUTION

FIGURE B1

## Clayey SILT (FILL)



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	GD-01	1.83	167.59
⊠	GD-01	9.45	159.97
▲	GD-02	0.30	160.63
★	GD-02	2.59	158.34
⊙	GD-02	6.40	154.53
⊛	GD-03	0.23	160.95

GRAIN SIZE DISTRIBUTION - THURBER 9270.GPJ 6/22/09

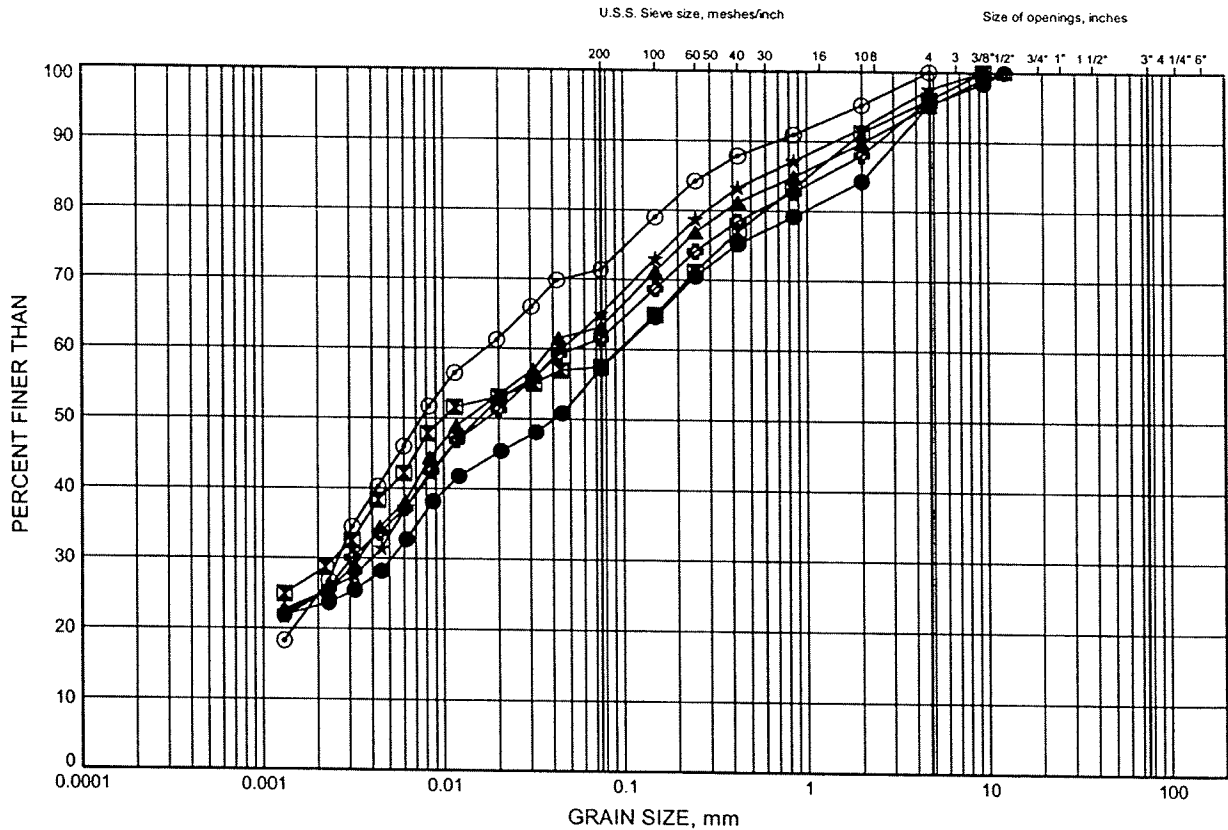
W.P.# 202-95-00.....  
Prepared By AN.....  
Checked By RPR.....



# Hwy 427 Northbound and Southbound GRAIN SIZE DISTRIBUTION

FIGURE B2

## Clayey SILT (FILL)



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	GD-04	3.35	167.69
⊠	GD-04	9.45	161.60
▲	GD-05	3.35	166.64
★	GD-05	9.45	160.55
⊙	GD-06	0.76	160.10
⊛	GD-07	1.07	160.09

GRAIN SIZE DISTRIBUTION - THURBER 9270.GPJ 7/29/09

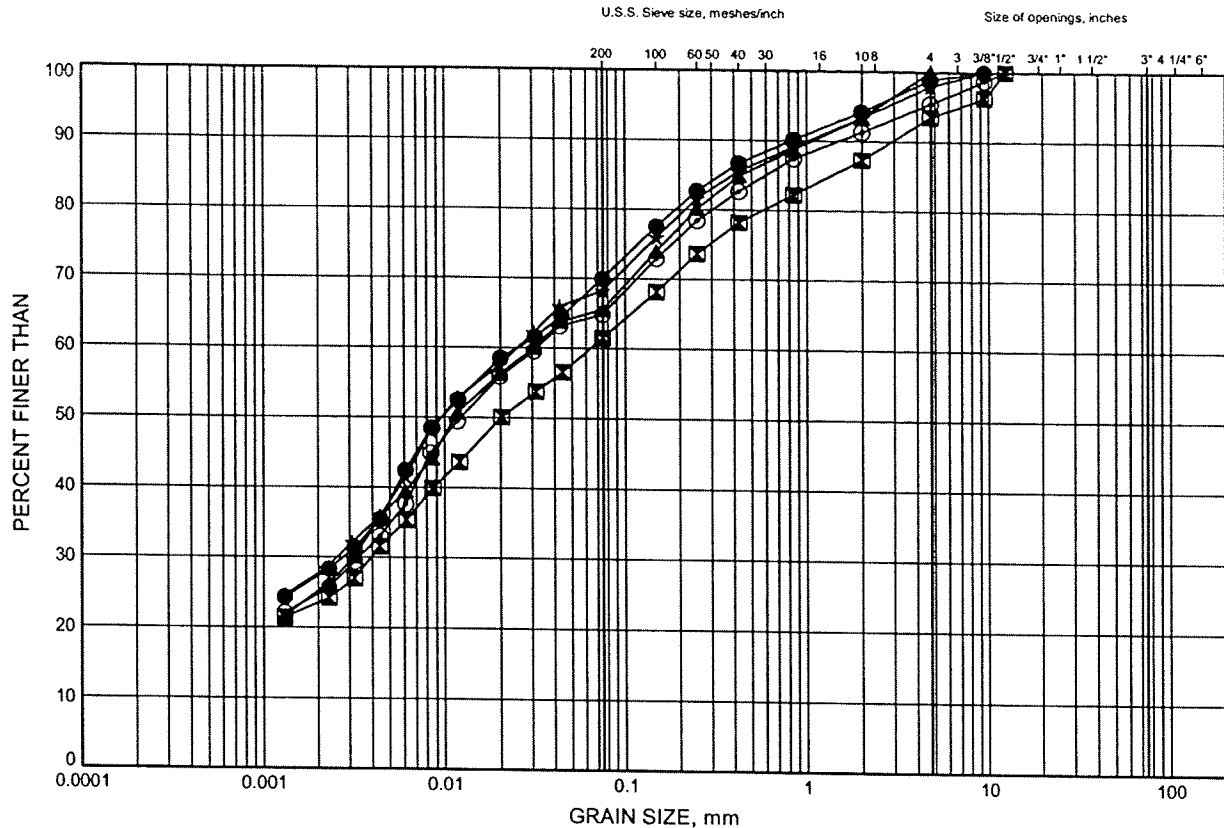
W.P.# .202-95:00.....  
Prepared By .AN.....  
Checked By .RPR.....



# Hwy 427 Northbound and Southbound GRAIN SIZE DISTRIBUTION

FIGURE B3

## Clayey SILT (FILL)



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	GD-07	4.11	157.04
⊠	GD-08	0.30	170.71
▲	GD-08	6.40	164.61
★	GD-09	4.11	165.91
⊙	GD-09	9.45	160.57

GRAIN SIZE DISTRIBUTION - THURBER 9270.GPJ 7/29/09

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

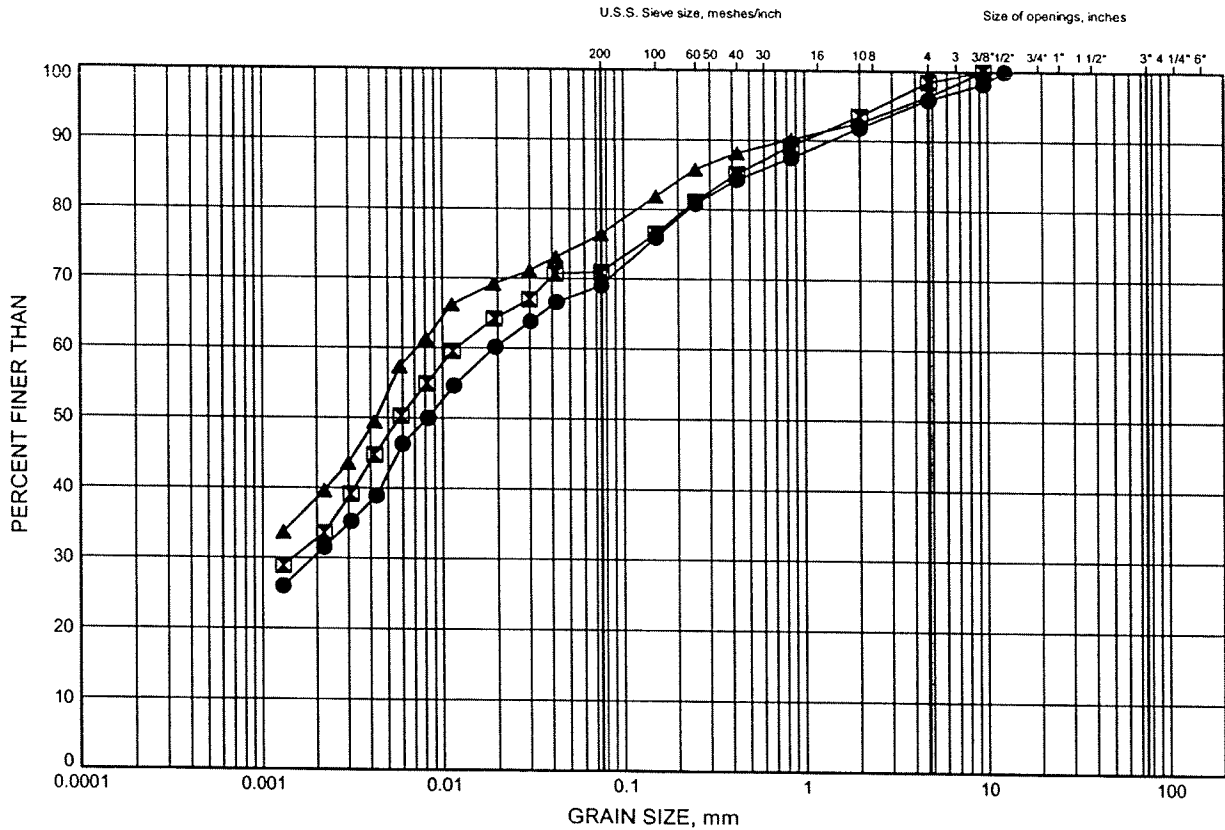




# Hwy 427 Northbound and Southbound GRAIN SIZE DISTRIBUTION

FIGURE B4

## Silty CLAY (FILL)



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	GD-03	3.35	157.82
⊠	GD-06	4.11	156.74
▲	GD-07	7.92	153.23

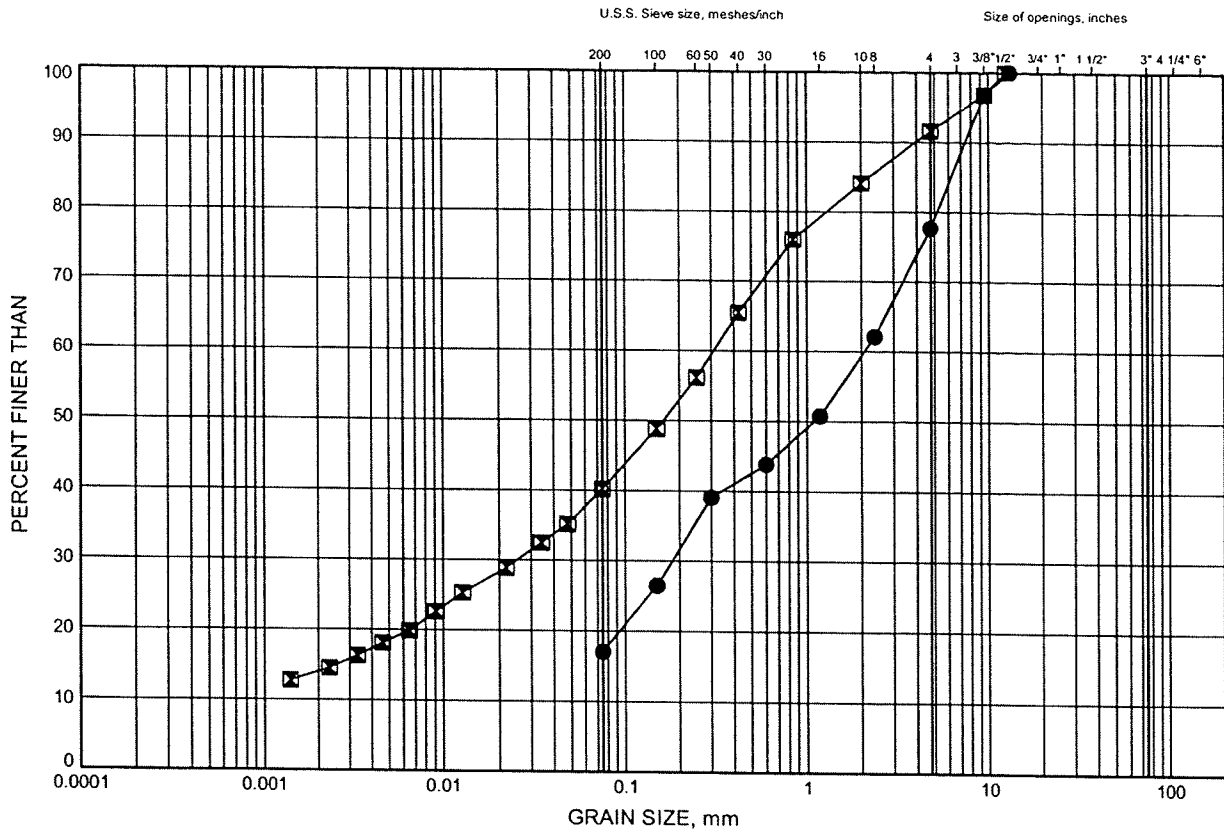


W.P.# 202-95-00.....  
Prepared By AN.....  
Checked By RPR.....

# Hwy 427 Northbound and Southbound GRAIN SIZE DISTRIBUTION

FIGURE B5

## Silty SAND (FILL)



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	GD-09	0.30	169.72
⊠	GD-10	2.59	167.61

GRAIN SIZE DISTRIBUTION - THURBER 9270.GPJ 6/22/09

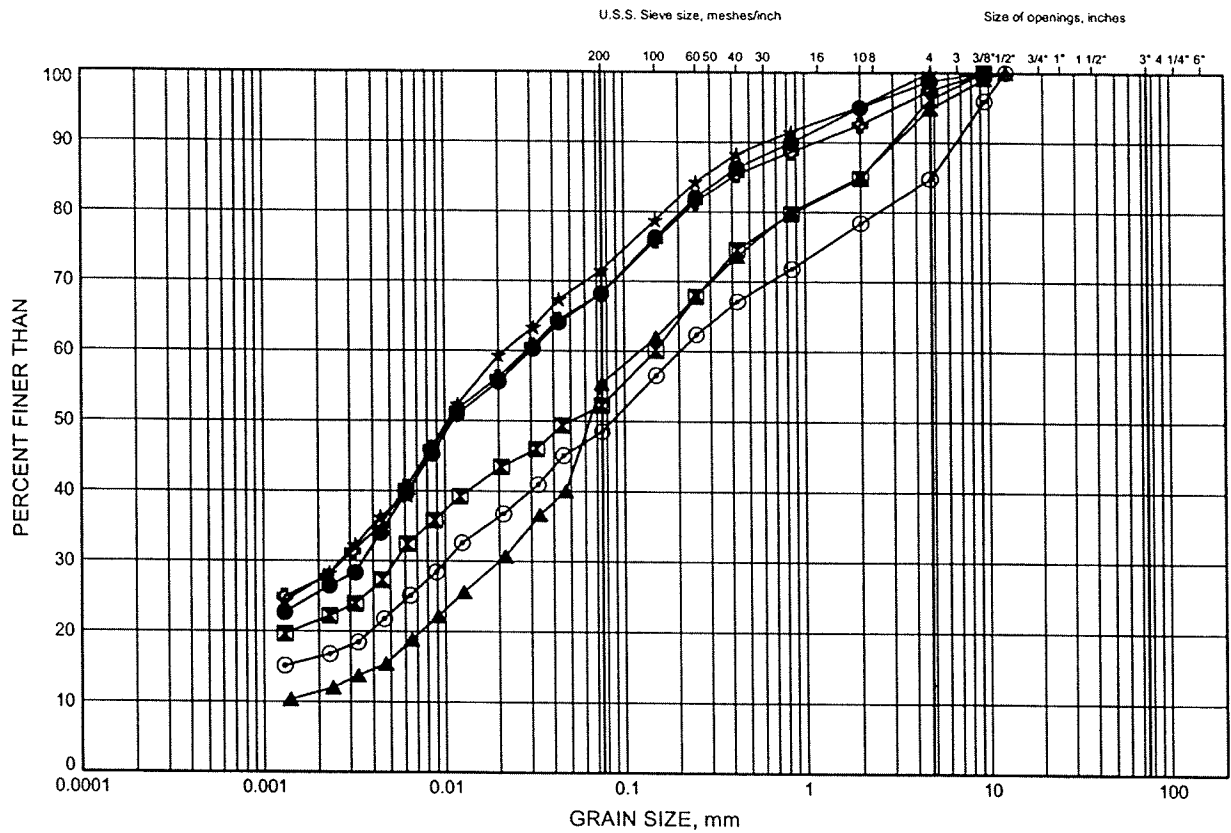
W.P.# 202-95:00  
Prepared By AN  
Checked By RPR



Hwy 427 Northbound and Southbound  
GRAIN SIZE DISTRIBUTION

FIGURE B6

Clayey SILT & Sand (TILL)



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	GD-01	14.02	155.40
⊠	GD-04	15.54	155.50
▲	GD-04	21.64	149.40
★	GD-05	15.54	154.45
⊙	GD-08	12.50	158.52
⊗	GD-09	15.54	154.48

GRAIN SIZE DISTRIBUTION - THURBER 9270.GPJ 7/29/09

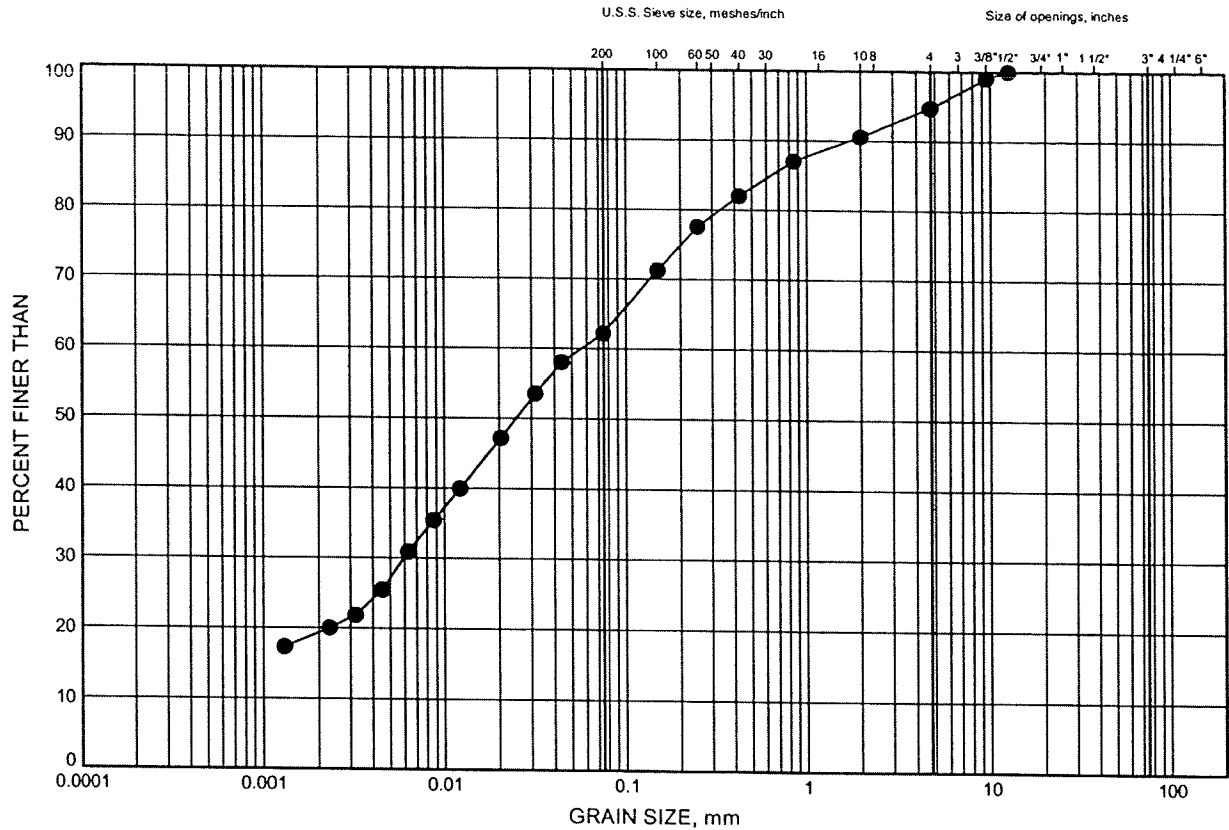
W.P.# 202-95-00.....  
Prepared By AN.....  
Checked By RPR.....



# Hwy 427 Northbound and Southbound GRAIN SIZE DISTRIBUTION

FIGURE B7

## Clayey SILT & Sand (TILL)



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	GD-10	7.92	162.28

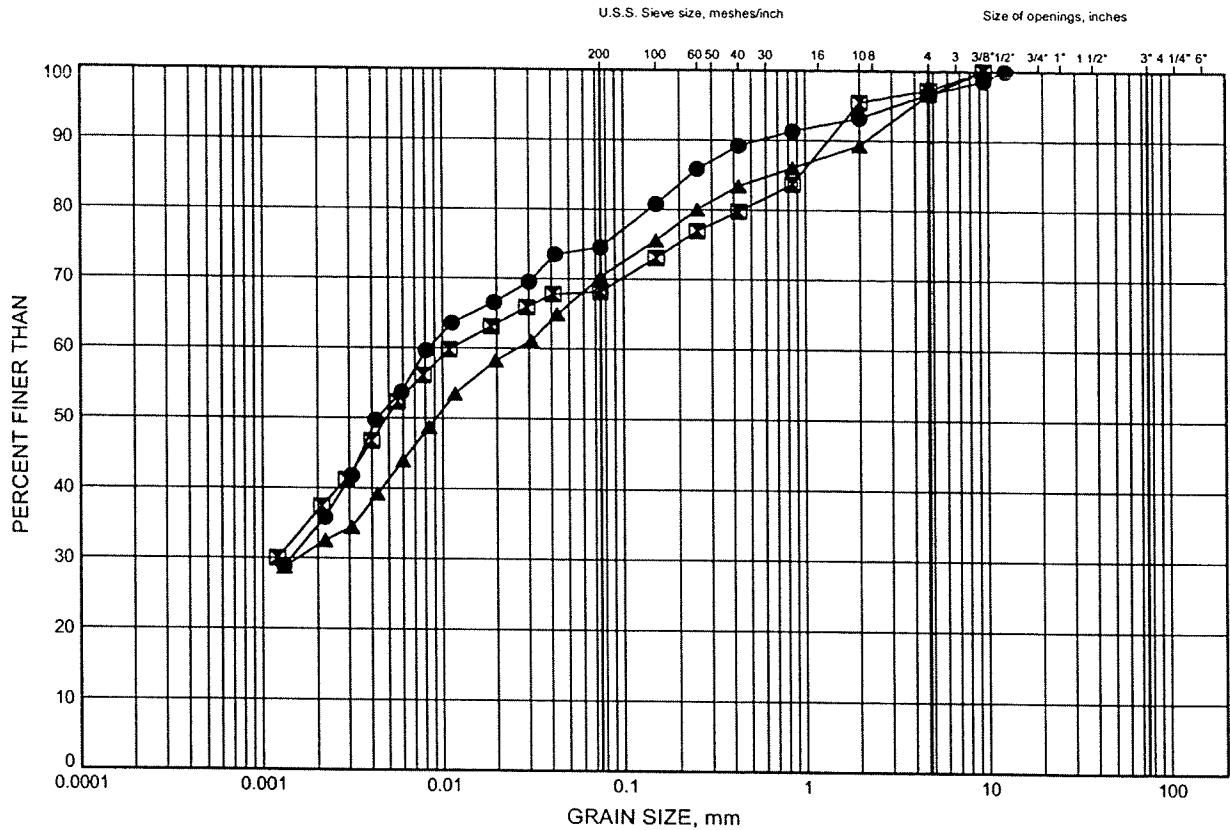


W.P.# .202-95-00.....  
Prepared By .AN.....  
Checked By .RPR.....

# Hwy 427 Northbound and Southbound GRAIN SIZE DISTRIBUTION

FIGURE B8

## Silty CLAY & Sand (TILL)



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

### LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	GD-06	7.92	152.93
⊠	GD-07	10.97	150.18
▲	GD-10	14.02	156.18

GRAIN SIZE DISTRIBUTION - THURBER 9270.GPJ 7/29/09

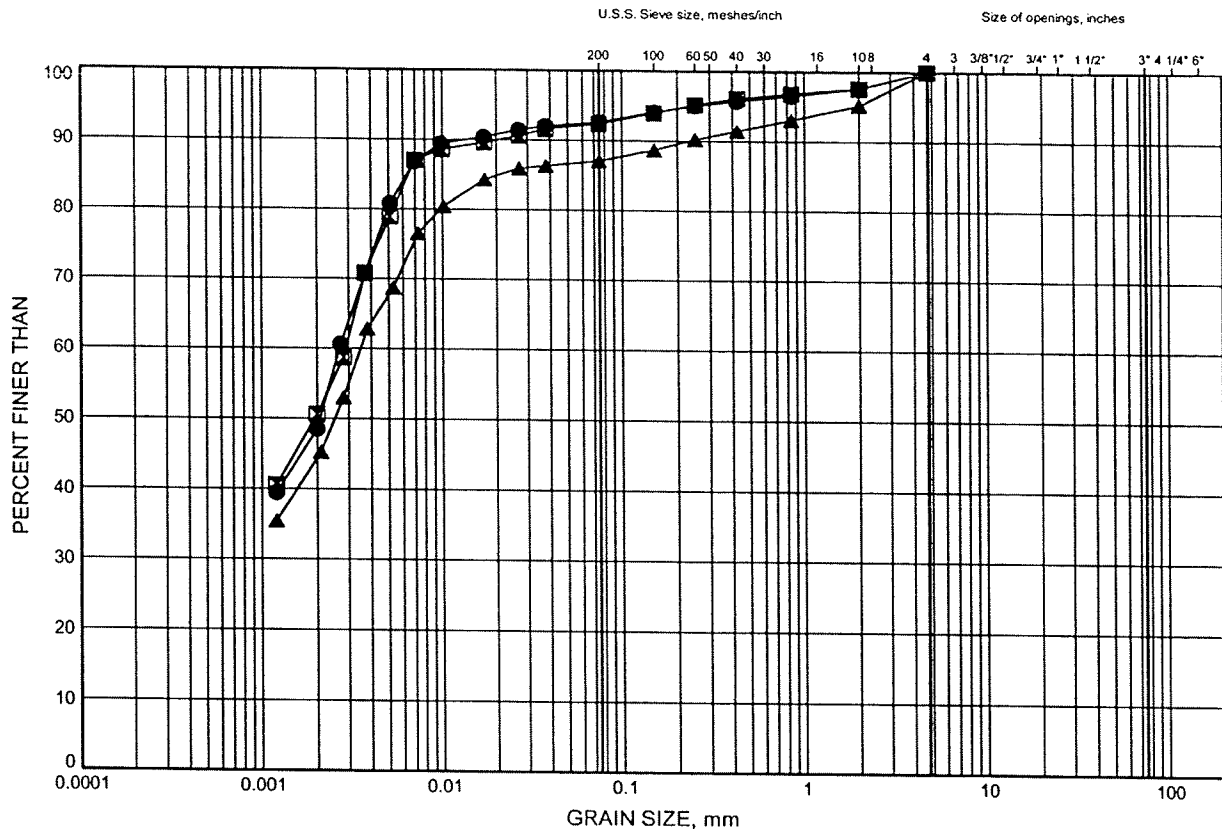
W.P.# .202-95-00.....  
Prepared By .AN.....  
Checked By .RPR.....



# Hwy 427 Northbound and Southbound GRAIN SIZE DISTRIBUTION

FIGURE B9

## Silty CLAY



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

## LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	GD-01	20.12	149.31
⊠	GD-03	9.45	151.73
▲	GD-08	18.59	152.42

GRAIN SIZE DISTRIBUTION - THURBER 9270.GPJ 7/29/09

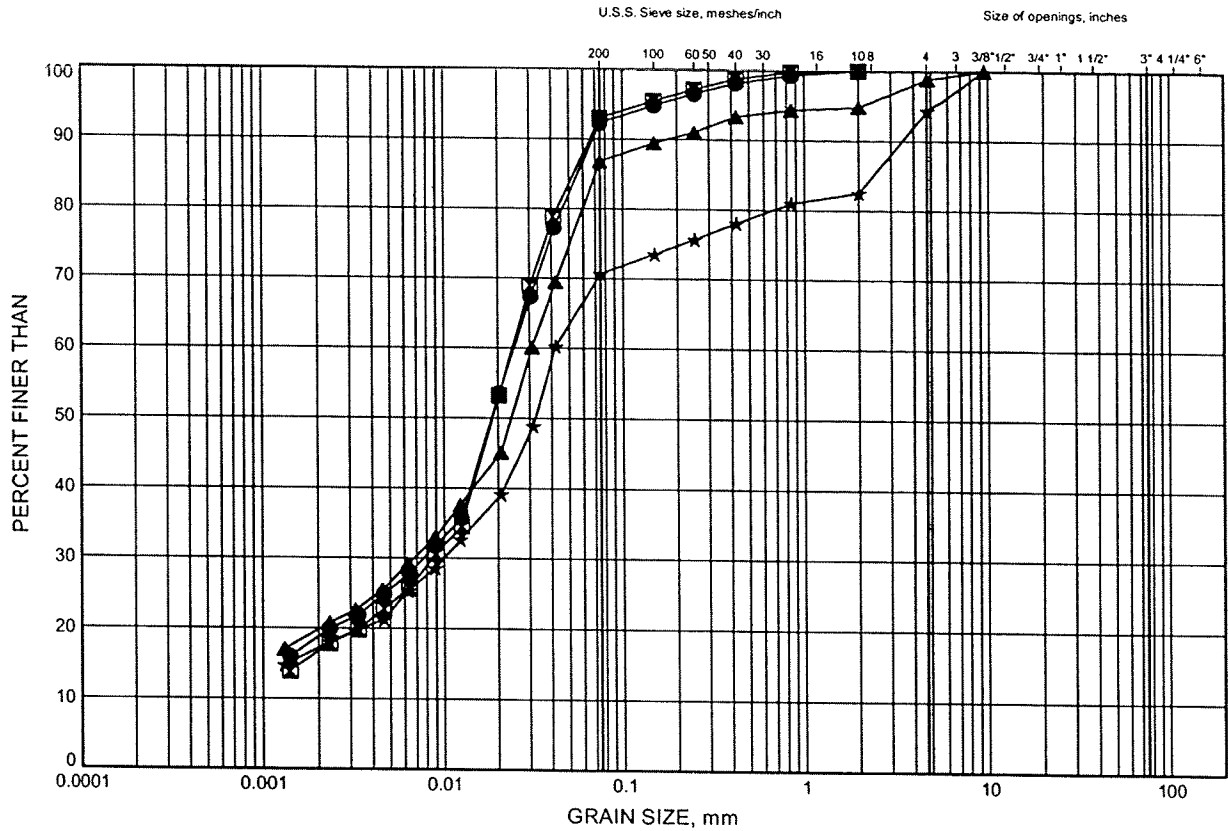
W.P.# 202-95-00  
Prepared By AN  
Checked By RPR



Hwy 427 Northbound and Southbound  
GRAIN SIZE DISTRIBUTION

FIGURE B10

Clayey SILT (TILL)  
with frequent shale & limestone slabs



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

LEGEND

SYMBOL	BOREHOLE	DEPTH (m)	ELEV. (m)
●	GD-02	13.72	147.22
⊠	GD-03	13.72	147.46
▲	GD-05	23.16	146.83
★	GD-06	12.50	148.36

GRAIN SIZE DISTRIBUTION - THURBER 9270.GPJ 7/29/09

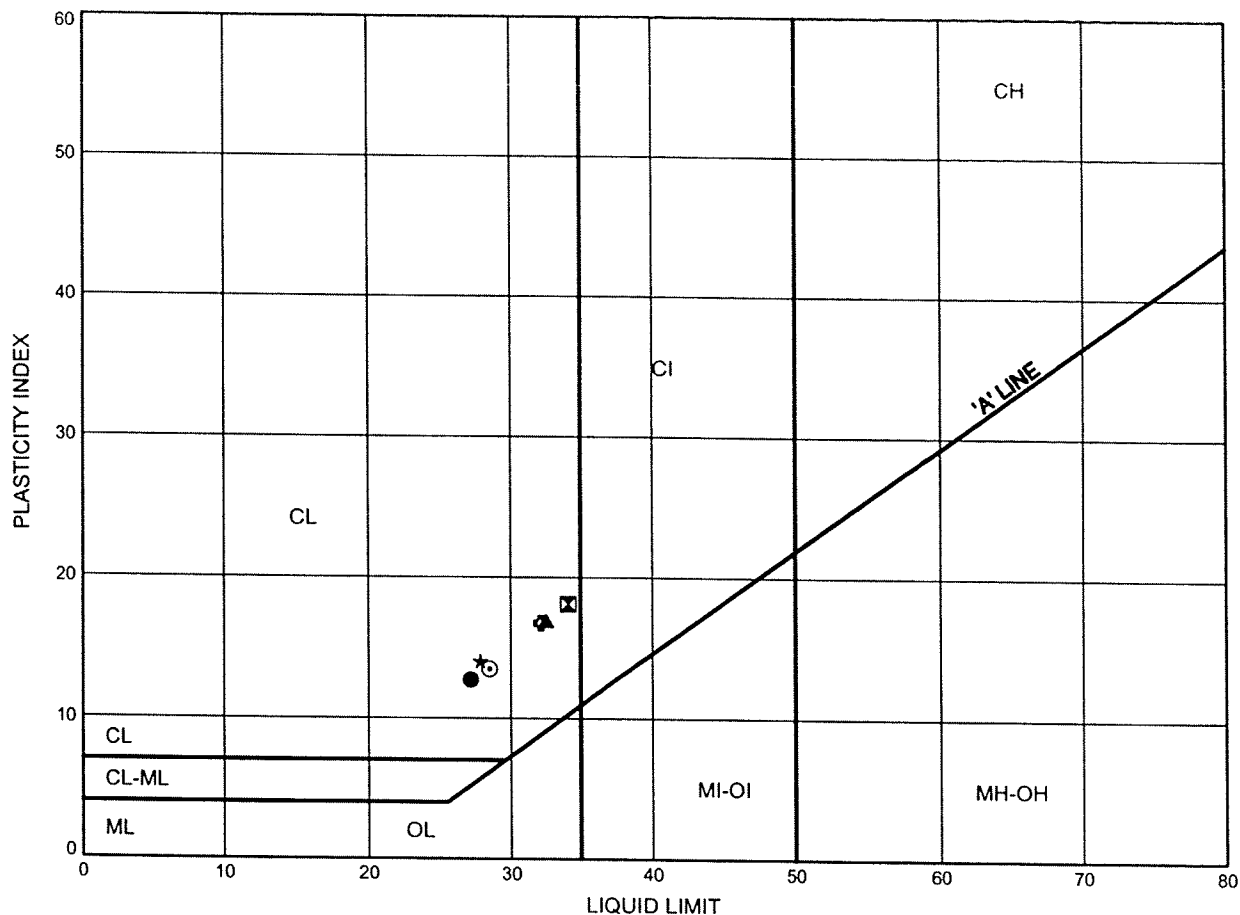
W.P.# 202-95:00  
Prepared By AN  
Checked By RPR



Hwy 427 Northbound and Southbound  
**ATTERBERG LIMITS TEST RESULTS**

FIGURE B11

Clayey SILT (FILL)



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	GD-01	9.45	159.97
⊠	GD-02	2.29	158.65
▲	GD-02	6.40	154.53
★	GD-04	9.45	161.60
⊙	GD-05	3.35	166.64
⊗	GD-06	1.07	159.79

Date July 2009

Project 202-95-00



Prep'd AN

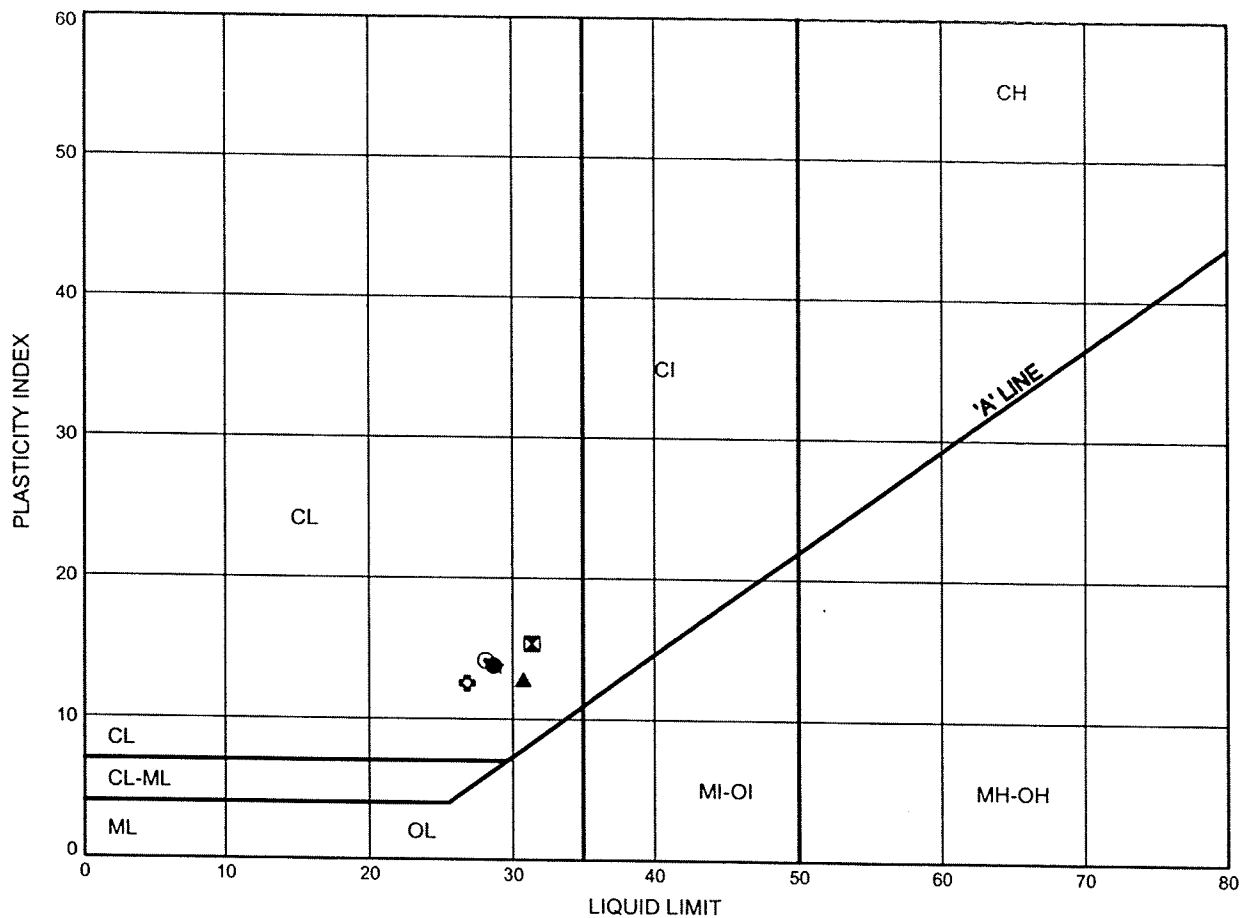
Chkd. RPR



Hwy 427 Northbound and Southbound  
**ATTERBERG LIMITS TEST RESULTS**

FIGURE B12

Clayey SILT (FILL)



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	GD-07	1.07	160.09
⊠	GD-07	4.11	157.04
▲	GD-08	0.30	170.71
★	GD-08	6.40	164.61
⊙	GD-09	4.11	165.91
⊕	GD-09	9.45	160.57

Date July 2009  
 Project 202-95-00

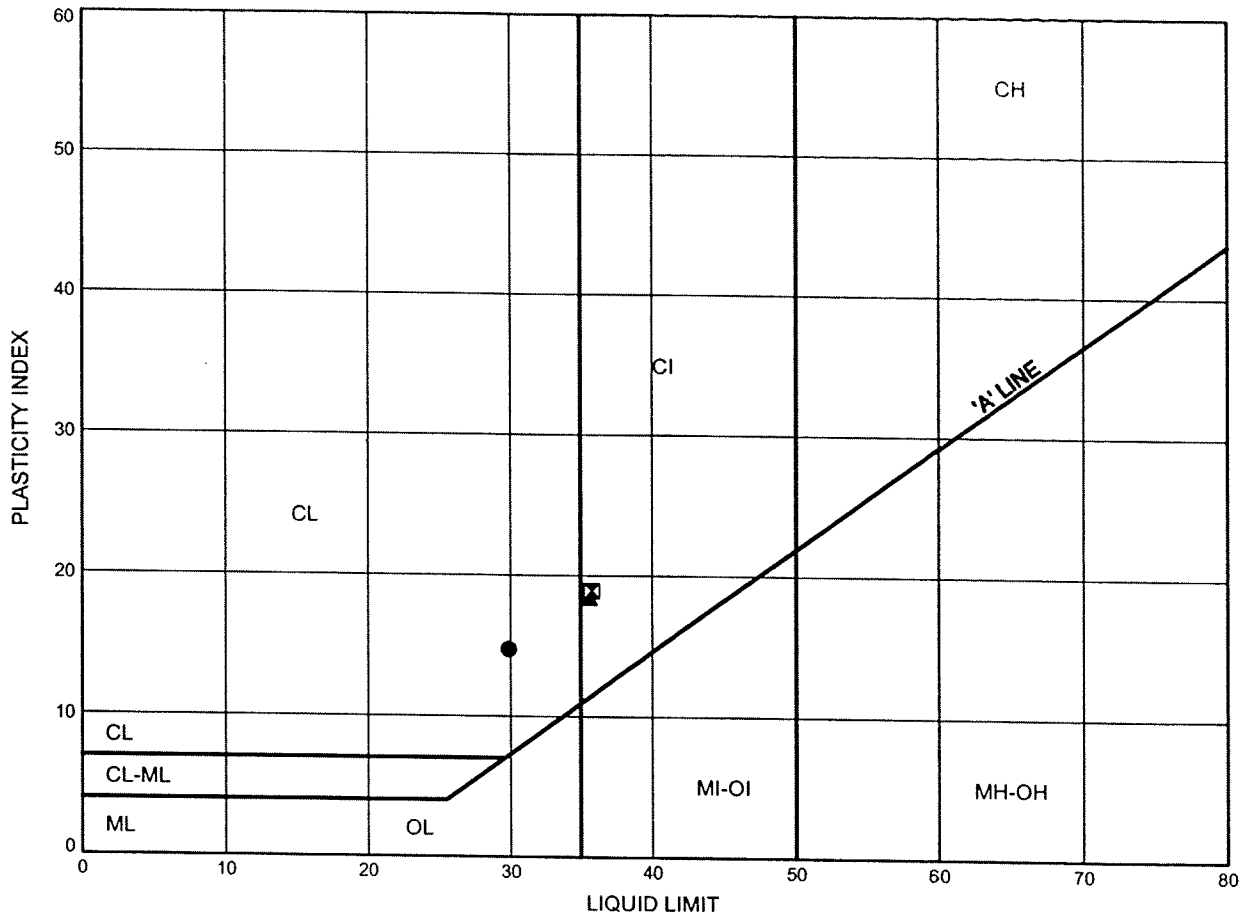


Prep'd AN  
 Chkd. RPR

Hwy 427 Northbound and Southbound  
**ATTERBERG LIMITS TEST RESULTS**

FIGURE B13

Silty CLAY (FILL)



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	GD-03	3.35	157.82
⊠	GD-06	4.11	156.74
▲	GD-07	7.92	153.23

Date July 2009

Project 202-95-00



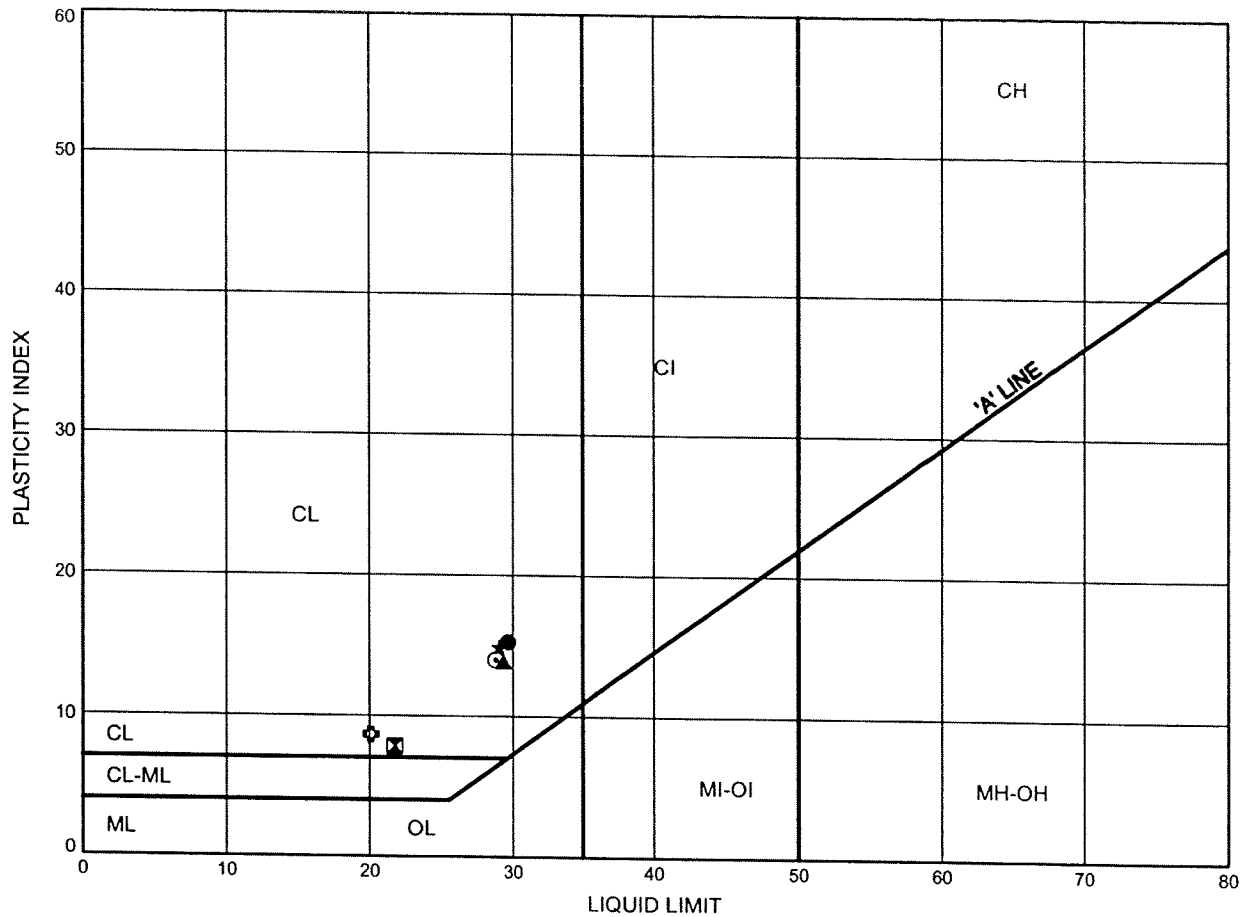
Prep'd AN

Chkd. RPR

Hwy 427 Northbound and Southbound  
**ATTERBERG LIMITS TEST RESULTS**

FIGURE B14

Clayey SILT & Sand (TILL)



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	GD-04	15.54	155.50
⊠	GD-04	21.64	149.40
▲	GD-05	15.54	154.45
★	GD-08	12.50	158.52
⊙	GD-09	15.54	154.48
⊗	GD-10	7.92	162.28

Date July 2009

Project 202-95-00



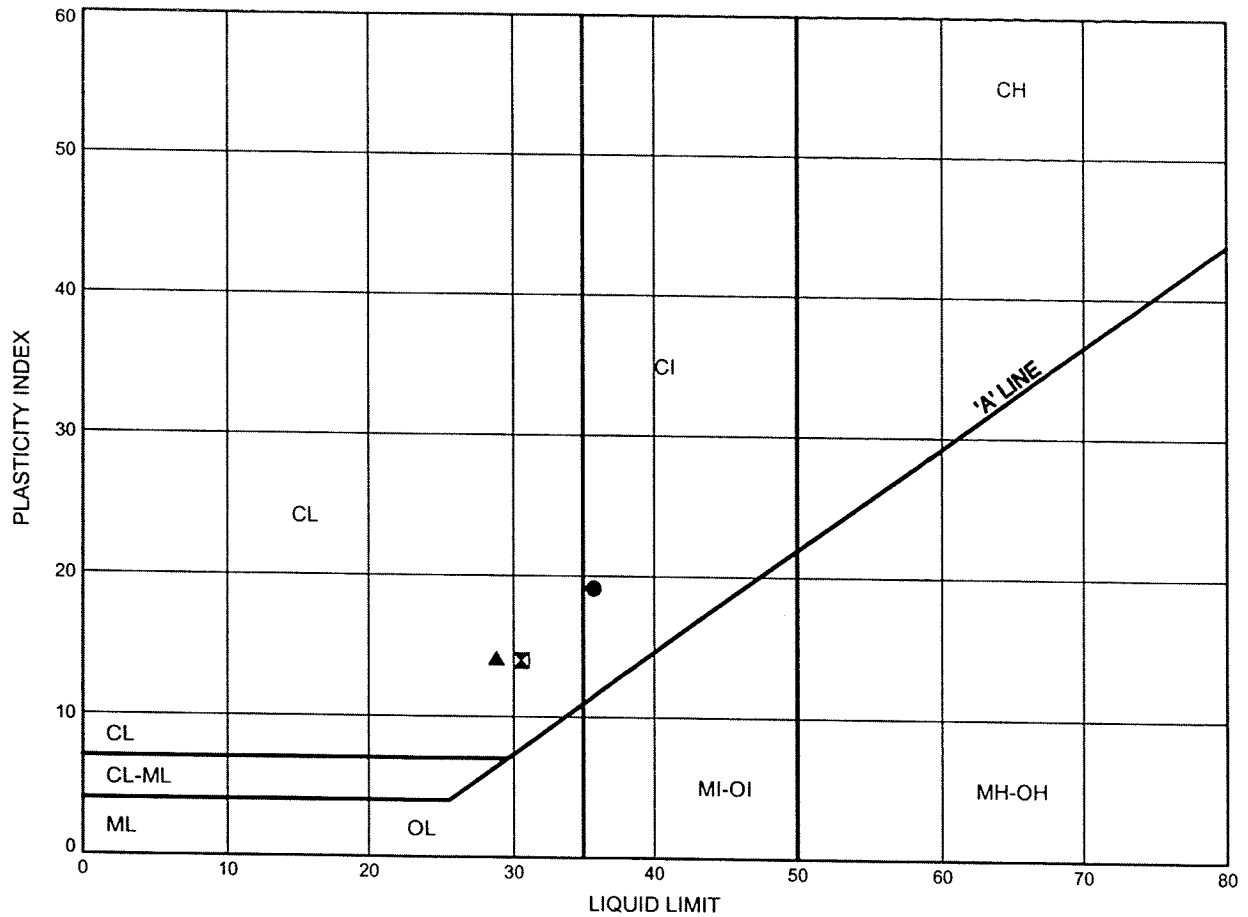
Prep'd AN

Chkd. RPR

Hwy 427 Northbound and Southbound  
**ATTERBERG LIMITS TEST RESULTS**

FIGURE B15

Silty CLAY & Sand (TILL)



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	GD-06	7.92	152.93
⊠	GD-07	10.97	150.18
▲	GD-10	14.02	156.18

Date July 2009

Project 202-95-00



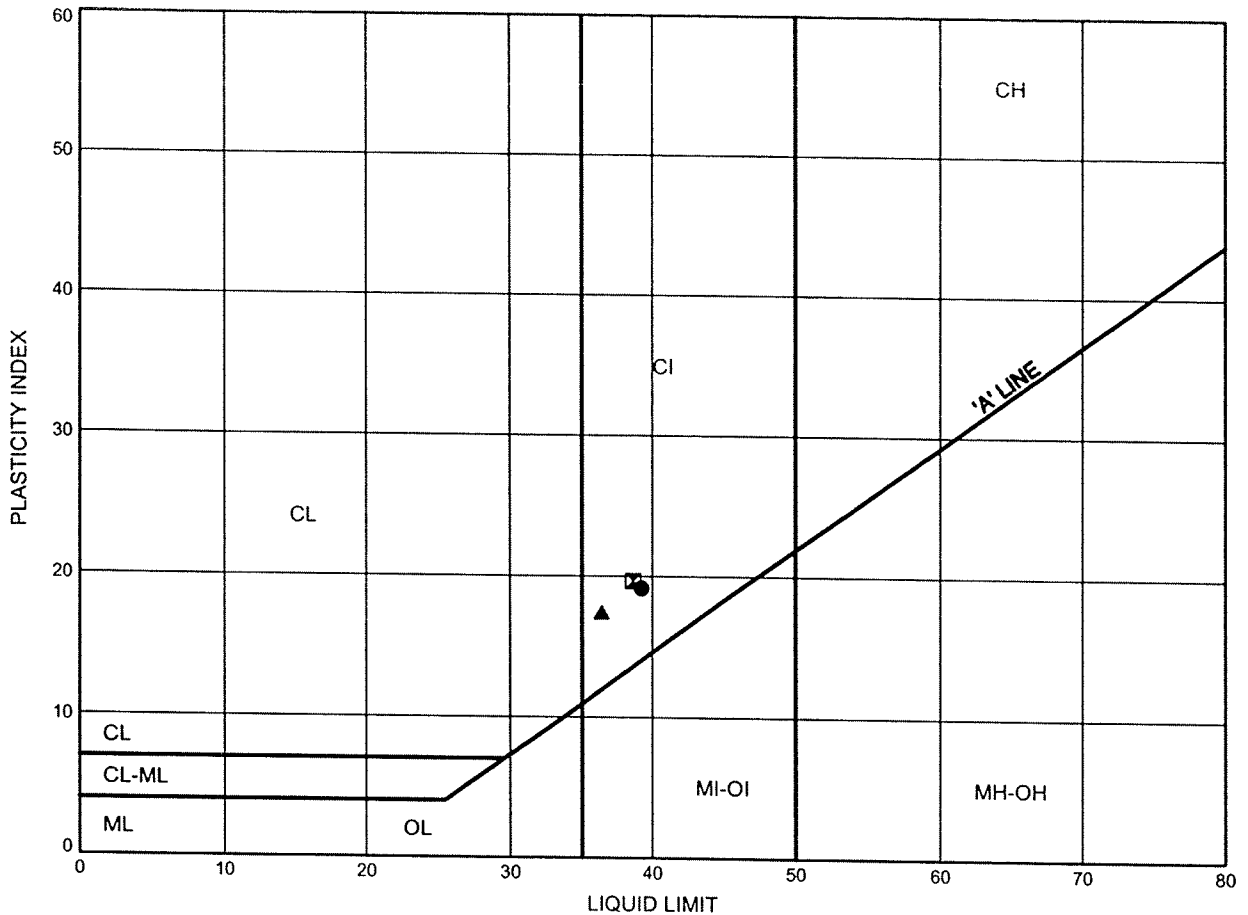
Prep'd AN

Chkd. RPR

Hwy 427 Northbound and Southbound  
**ATTERBERG LIMITS TEST RESULTS**

FIGURE B16

Silty CLAY



SYMBOL	BH	DEPTH (m)	ELEV. (m)
●	GD-01	20.12	149.31
⊠	GD-03	9.45	151.73
▲	GD-08	18.59	152.42

Date July 2009

Project 202-95-00



Prep'd AN

Chkd. RPR

**Appendix C**

**Record of Borehole Sheets and  
Laboratory Test Results  
(Previous Investigation)**



WP 658-93-01

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS &amp; TESTING OFFICE

JOB 72-11002

LOCATION

BORING DATE Feb. 1, 1972

W.P. 387-65

BORING TYPE

DATUM Geodetic

BOREHOLE TYPE

Author

## RECORD OF BOREHOLE No. 2 IMPERIAL FOUNDATION SECTION

Co-ords: N 4 839 918.3, E 295 944.3

ORIGINATED BY VK

COMPILED BY TST

CHECKED BY S.P.

ELEV. DEPTH	SOIL PROFILE DESCRIPTION	STRAIT. PLAT	SAMPLES		ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT		LIQUID LIMIT PLASTIC LIMIT WATER CONTENT %	BULK DENSITY $\gamma$	REMARKS
			NUMBER	TYPE		20	100			
508.9	Ground Level									
508.9	Het. mix. of clayey silt, sand and occ. gravel.		1	SS	7h					
			2	SS	17					
			3	SS	2h					
			4	SS	10					
			5	SS	20					
			6	SS	65					
			7	SS	65					
			8	SS	70/70"					
			9	SS	70/70"					
			10	SS	70/70"					
			11	SS	70/70"					
468.9	with occ. boulders									
468.9	weathered									
462.9	shale bedrock sound		12	BXL	1000"					
462.9	End of Borehole									



WP 658-93-01

DEPARTMENT OF HIGHWAYS - ONTARIO  
 MATERIALS & TESTING OFFICE  
 JOB 72-11002 LOCATION Co-ords: N 4 839 918.0, E 225 915.4  
 W.P. 387-65 BORING DATE Jan. 27, 1972  
 DATUM Geodetic BOREHOLE TYPE Auger

RECORD OF BOREHOLE No. 3 IMPERIAL FOUNDATION SECTION  
 ORIGINATED BY VK  
 COMPILED BY TST  
 CHECKED BY

ELEV. DEPTH (56.4)	SOIL PROFILE DESCRIPTION	SAMPLES		ELEV. SCALE	DYNAMIC PENETRATION BLOWS/FOOT	SHEAR STRENGTH P.S.F.		WATER CONTENT %	LIQUID LIMIT PLASTIC LIMIT WATER CONTENT	BULK DENSITY $\gamma$	REMARKS
		NUMBER	TYPE			UNCONFINED QUICK TRIAXIAL	FIELD VANE LAB. VANE				
513.0	Ground Level										
508.0	0.0 Sand and Gravel with clayey silt. Compact	1	SS	10							
5.0	Hot mix. of clayey silt, sand & gravel	2	SS	20							
	Glacial Till	3	SS	25							
	Very Stiff to Hard	4	SS	30							
		5	SS	20							
		6	SS	20							
		7	SS	20							
		8	SS	17							
		9	SS	50							
474.9		10	SS	60/70"							
38.1	End of Borehole Probably Bedrock	11	SS	11"							

36 29 27 8  
 505.



WP 658-93-01

DEPARTMENT OF HIGHWAYS-ONTARIO  
 MATERIALS & TESTING OFFICE  
 JOB 72-11002  
 W.P. 387-65  
 DATUM Geodetic

RECORD OF BOREHOLE No. 7 IMPERIAL FOUNDATION SECTION  
 Co-ords: N 4 839 935.7, E 295 936.4  
 LOCATION Co-ords. 15, 879, 051 N; 970, 920 E.  
 BORING DATE Feb. 3, 1972  
 BOREHOLE TYPE Auger

ORIGINATED BY VK  
 COMPILED BY TST  
 CHECKED BY C.K.

ELEV. DEPTH 155.7	SOIL PROFILE DESCRIPTION	SAMPLES		ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS/FOOT 20 40 60 80 100 SHEAR STRENGTH P.S.F. ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB. VANE	LIQUID LIMIT PLASTIC LIMIT WATER CONTENT % w <sub>p</sub> w <sub>L</sub> w <sub>P</sub>	BULK DENSITY γ P.C.F. GR. SA. S. CL.	REMARKS
		NUMBER	TYPE					
510.8	Ground Level			510				
0.0		1	SS					
	Sand and gravel	2	SS					
	Het. mix. of clayey silt and sand	3	SS					
	Glacial Till	4	SS					
	Stiff to Hard	5	SS					
	Sand and gravel	6	SS					
		7	SS					
		8	SS					
		9	SS					
		10	SS					
	with shale frags.	11	SS					
160.3				160				
17.5	End of Borehole Probable Bedrock			17				

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DEPARTMENT OF HIGHWAYS - ONTARIO  
MATERIALS & TESTING OFFICE  
JOB 72-11002  
W.P. 387-65  
DATUM Geodetic

RECORD OF BOREHOLE No. 8 IMPERIAL FOUNDATION SECTION  
Co-ords: N 4 839 935.7, E 295 905.0  
LOCATION Co-ords. 15, 879, 054 N; 970, 817 E.  
BORING DATE Jan. 28, 1972  
BOREHOLE TYPE Auger, EXL Core

ORIGINATED BY VI  
COMPILED BY TST  
CHECKED BY J.A.

ELEV. DEPTH	SOIL PROFILE DESCRIPTION	SAMPLES		ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS / FOOT		LIQUID LIMIT PLASTIC LIMIT WATER CONTENT %	BULK DENSITY $\gamma$	REMARKS
		NUMBER	TYPE		20	40			
512.8	Ground Level								
0.0	Mt. mix. of clayey sil. and sand, trace of gravel	1	SS	512					
	Glacial Till	2	SS	511					
	Stiff to Hard	3	SS	510					
		4	SS	509					
		5	SS	508					
		6	SS	507					
		7	SS	506					
		8	SS	505					
		9	SS	504					
		10	SS	503					
1172.8	with shale frags.			502					
110.0	weathered Shale bedrock		ML	1170					
145.8	Ground								

506.5  
355 LB LL  
0 5 L7 L8

DEPARTMENT OF HIGHWAYS - ONTARIO  
MATERIALS & TESTING OFFICE  
JOB 72-11002  
W.P. 387.-65  
DATUM Geodetic

## RECORD OF BOREHOLE No. 11 IMPERIAL FOUNDATION SECTION

CO-ORDS: N4 839 963.4, E 295 958.7  
 Co-ords. 15, 879, 115 N; 970, 993 E.  
 Feb. 11, 1972  
 Washborin, NX Casing  
 ORIGINATED BY WK  
 COMPILED BY TST  
 CHECKED BY S.R.

[illegible]

WP 658-93-01

DEPARTMENT OF HIGHWAYS - ONTARIO MATERIALS & TESTING OFFICE			RECORD OF BOREHOLE No. 12				IMPERIAL FOUNDATION SECTION						
A 72-11002			LOCATION Co-ords. 15,879,138 N; 970,951 E.				ORIGINATED BY VK						
M.P. 387 - 65			BORING DATE Feb. 1, 1972				COMPILED BY TST						
DATUM Geodetic			BOREHOLE TYPE A-1, BTL Core				CHECKED BY						
ELEV. DEPTH 55.0 510.5	SOIL PROFILE DESCRIPTION	STRAT. LOT	SAMPLES			ELEV. SCALE	DYNAMIC PENETRATION RESISTANCE BLOWS/FOOT 20 40 60 80 100				LIQUID LIMIT PLASTIC LIMIT WATER CONTENT	BULK DENSITY P.C.F.	REMARKS
			NUMBER	TYPE	BLOWS/FOOT		SHEAR STRENGTH P.S.F. O UNCONFINED + FIELD VANE X QUICK TRIAXIAL X LAB. VANE						
0.0	Ground Level												
	Het. mix. of clayey silt, sand & gravel		1	SS	0								
			2	SS	37								
	Glacial Till		3	SS	15								
	Stiff to Hard		4	SS	10								
			5	SS	11								
	Sand and Gravel		6	SS	12								
			7	SS	52								
			8	SS	13								
			9	SS	14								
			10	SS	15								
40.5			11	SS	100								
50.0	Weathered		12	SS	100								
			13	SS	100								
150.5	Shale Bedrock Sound		14	BTL	NR								
160.0	End of borehole		15	RC	90%								

20  
11-3 % STRAIN AT FAILURE  
M

WP 658-99-01

DEPARTMENT OF HIGHWAYS - ONTARIO

MATERIALS &amp; TESTING OFFICE

## RECORD OF BOREHOLE No. 13 IMPERIAL FOUNDATION SECTION

Co-ords: N 4 839 960.3, E 245 894.4

JOB 72-11002 LOCATION Co-ords. 15,872,135 N; 970,792 E. ORIGINATED BY VK

W.P. 387-65 BORING DATE Feb. 31, 1972 COMPILED BY TST

DATUM Ordnance BOREHOLE TYPE Auger CHECKED BY

ELEV. DEPTH	SOIL PROFILE DESCRIPTION	SAMPLES		ELEV. SCALE	DYNAMIC PENETRATION BLOWS / FOOT	SHEAR STRENGTH P.S.F. ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL x LAB. VANE	LIQUID LIMIT PLASTIC LIMIT WATER CONTENT %	BULK DENSITY	REMARKS
		NUMBER	TYPE						
513.0	Ground Level								
0.0	Het. mix. of clayey silt, sand & gravel	1	SS	510					0 44 42 16
		2	SS						505.0
	Glacial Till	3	SS						
		4	SS	50					
	Firm to Hard	5	SS						
		6	SS						
		7	SS	490					
	Sand & Gravel	8	SS						22 39 28 11
	shale frags.	9	SS	480					
		10	SS	470					
472.8	End of Borehole								
470.2	Probably Pedrock								

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DEPARTMENT OF HIGHWAYS - ONTARIO  
MATERIALS & TESTING OFFICE

## RECORD OF BOREHOLE No. 16 IMPERIAL FOUNDATION SECTION

CO-ORDS: N4 839 977.1, E 295 948.6  
 LOCATION Co-ords, 35, 978, 320 N; 970, 940 E  
 ORIGINATED BY MS & VK  
 W.P. 387-65 BORING DATE Feb. 2 & 27 Jan. 1972 COMPILED BY TST  
 DATUM Geodetic BOREHOLE TYPE Auger, HI Gasline, Washburn CHECKED BY S.R.

SOIL PROFILE						DYNAMIC PENETRATION RESISTANCE				LIQUID LIMIT — PLASTIC LIMIT — WATER CONTENT —			BULK DENSITY Y	REMARKS
ELEV. DEPTH 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170 180 190 200 210 220 230 240 250 260 270 280 290 300 310 320 330 340 350 360 370 380 390 400 410 420 430 440 450 460 470 480 490 500 510 520 530 540 550 560 570 580 590 600 610 620 630 640 650 660 670 680 690 700 710 720 730 740 750 760 770 780 790 800 810 820 830 840 850 860 870 880 890 900 910 920 930 940 950 960 970 980 990 1000	DESCRIPTION	STRAT. NOT	NUMBER	TYPE	BLOWS/FOOT	BLOWS/FOOT 20 40 60 80 100	SHEAR STRENGTH P.S.F. O UNCONFINED    • FIELD VANE • QUICK TRIAXIAL    X LAB. VANE	WATER CONTENT % 10 20 30	P.C.F.					
526.9	Ground level													
0.0	Fill material, clayey silt with sand and gravel.		1	SS	10									7 29 43 27
501.6			2	SS	11									
7.5			3	SS	22									
			4	SS	10									
	Garbage Fill		5	SS	3									
507.1			6	SS	5									
21.5			7	SS	23									
	Glacial Till		8	SS	23									505.5
	Het. mix. of clayey silt sand & gravel		9	SS	13									7 23 43 27
	Stiff to Hard		10	SS	117									
	Sand and gravel		11	SS	111									16 40 26 18
			12	SS	101									
			13	SS	101									
	with shale frags.		14	SS	101									
			15	SS	101									
63.9			16	SS	101									
65.0	weathered													
65.0	Shale Bedrock		17	SHL	101									
65.9	Soil													
70.0	End of Borehole													

20  
10-3 % STRAIN AT FAILURE  
10



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## DEPARTMENT OF HIGHWAYS - ONTARIO

## MATERIALS &amp; TESTING OFFICE

## RECORD OF BOREHOLE No. 17 IMPERIAL FOUNDATION SECTION

Co-ords: N 4 839 974.7, E 295 918.1

JOB 72-11002 LOCATION Co-ords. 15,879,182 N; 970,860 E.

ORIGINATED BY VK

W.P. 387-65 BORING DATE Feb. 3, 1972

COMPILED BY TST

DATUM Geodetic BOREHOLE TYPE Auger CHECKED BY

ELEV. DEPTH 156.7	SOIL PROFILE DESCRIPTION	SAMPLES		ELEV. SCALE	DYNAMIC PENETRATION BLOWS/FOOT	SHEAR STRENGTH P.S.F. ○ UNCONFINED ● QUICK TRIAXIAL x LAB. VANE	LIQUID LIMIT PLASTIC LIMIT WATER CONTENT %	BULK DENSITY $\gamma$	REMARKS
		STRAT. POT	NUMBER TYPE						
512.6	Ground Level								
508.1	Fill Material		1 SS 21	510					5 24 51 20
4.5	Glacial Till Het. mix. of clayey silt, sand & gravel		2 SS 77	500					1505.
			3 SS 75						
			4 SS 110						
			5 SS 115						
			6 SS 27						1 1/2 21 41 20
	Very Stiff to Hard		7 SS 31	490					
			8 SS 05						
	with shale frags.		9 SS 100-120"	480					
476.6			10 SS 100-120"						
36.0	weathered shale End of Borehole Probable Bedrock			470					

WP 658-93-01

DEPARTMENT OF HIGHWAYS - ONTARIO  
MATERIALS & TESTING OFFICE

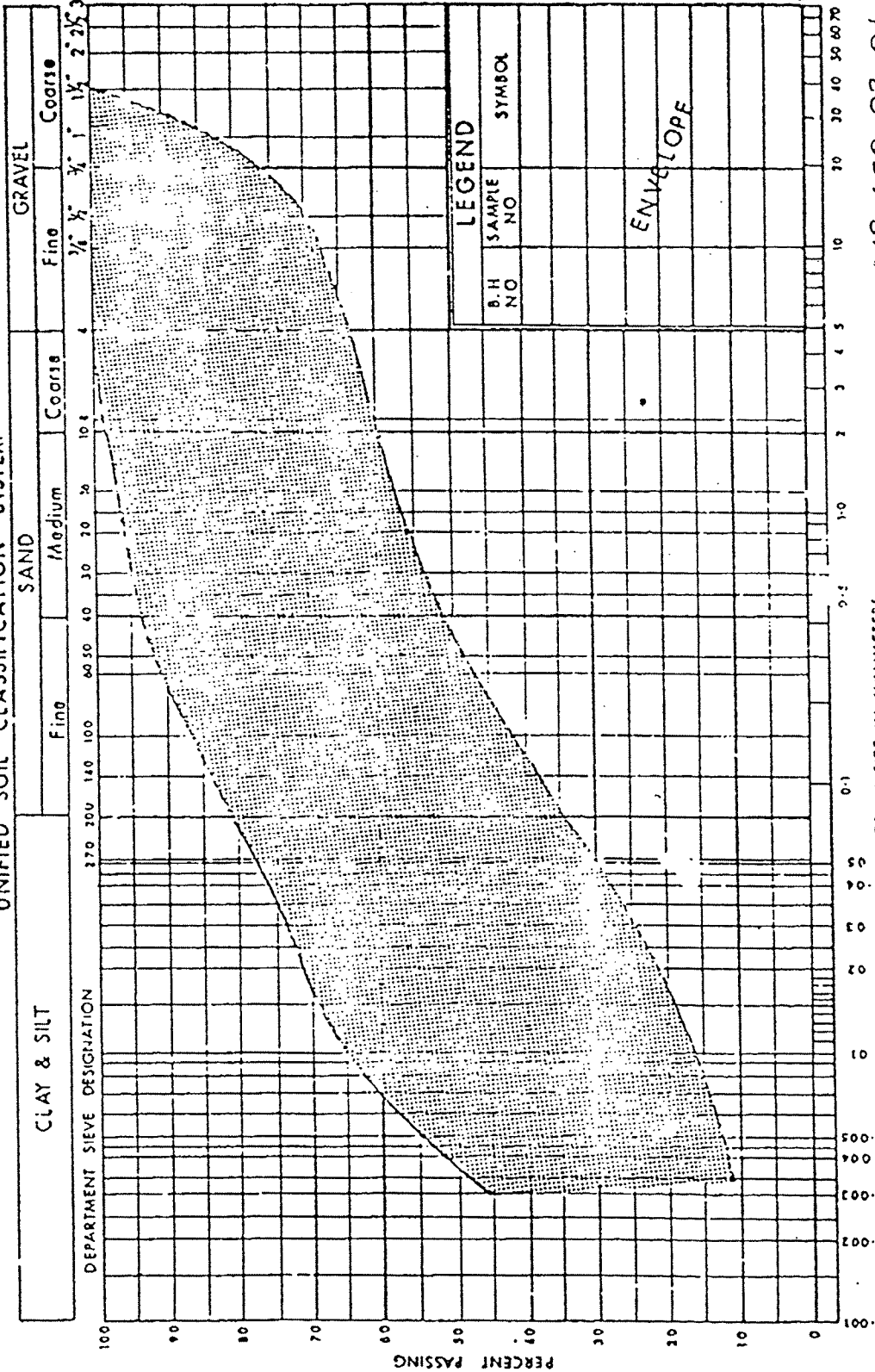
RECORD OF BOREHOLE No. 18 IMPERIAL FOUNDATION SECTION

Co-ords: N4839 948.7, E 295 883.1

JOB 72-11082 LOCATION Co-ords. 15,879,205 N; 970,715 E.  
W.P. 387.- 65 BORING DATE Feb. 1, 1972  
DATUM Geodetic BOREHOLE TYPE Auger, BXL Core  
ORIGINATED BY VK  
COMPILED BY TST  
CHECKED BY S.Z.

ELEV. DEPTH 508.3	SOIL PROFILE DESCRIPTION	STRAT. POS.	SAMPLES		ELEV. SCALE	DYNAMIC PENETRATION BLOWS / FOOT	SHEAR STRENGTH P.S.F. O UNCONFINED O QUICK TRIAXIAL	RESISTANCE + FIELD VANE x LAB. VANE	LIQUID LIMIT PLASTIC LIMIT WATER CONTENT	WATER CONTENT %	BULK DENSITY P.C.F.	REMARKS
			NUMBER	TYPE								
0.0	Hot mix. of clayey silt, sand & gravel	1	SS	5	500							
	Glacial Till	2	SS	69	500							
	Firm to Hard	3	SS	75	500							
		4	SS	50	500							
		5	SS	50	500							
		6	SS	63	500							
		7	SS	60	500							
		8	SS	60	500							
		9	SS	60	500							
		10	SS	60	500							
		11	SS	60	500							
167.8	Shale Bedrock	11	RC	60	500							
161.5	Sound											
162.8												
164.5	End of Borehole											

# UNIFIED SOIL CLASSIFICATION SYSTEM



WP 658-93-01

GRAIN SIZE DISTRIBUTION

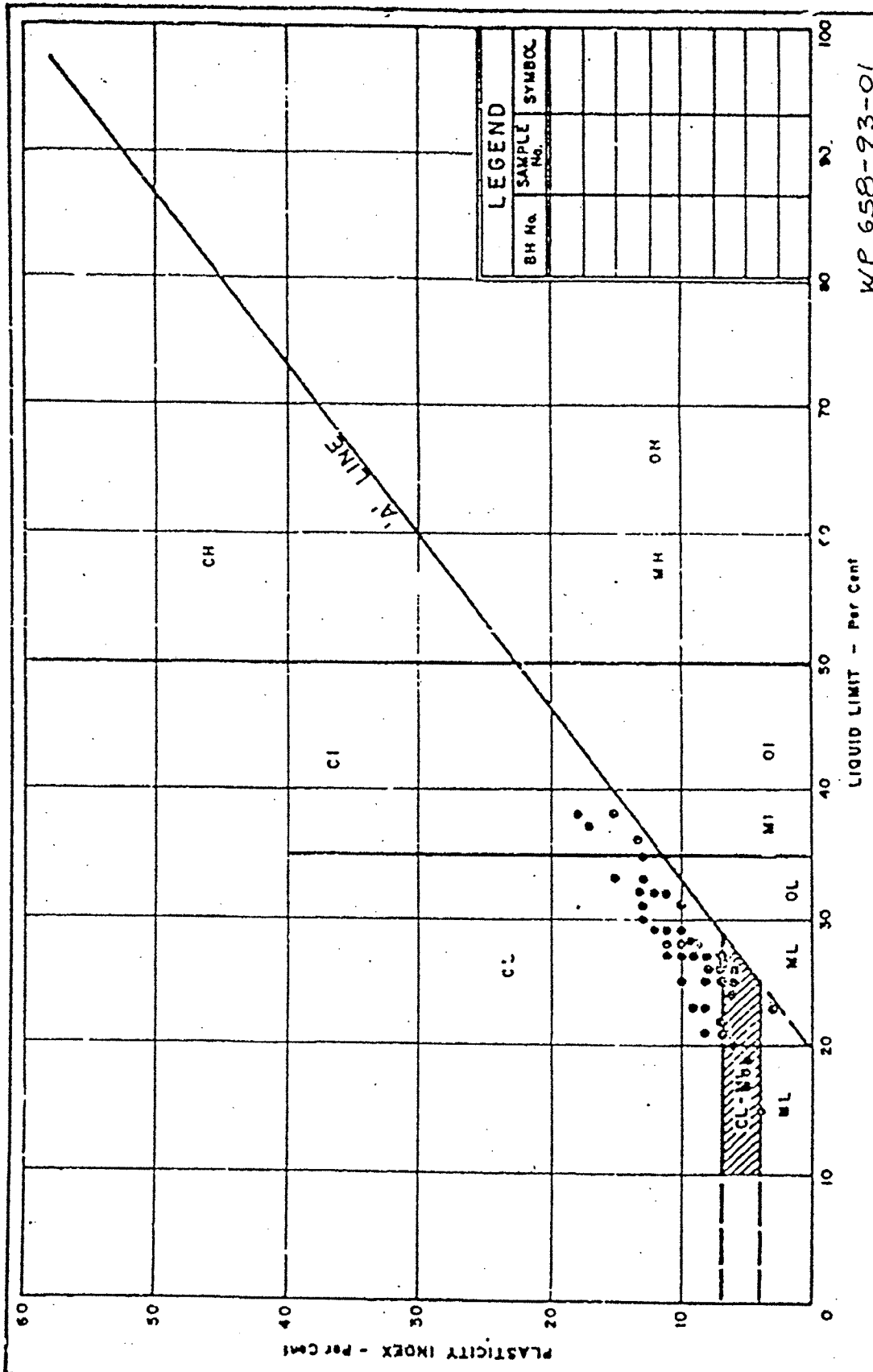
GLACIAL TILL

DEPARTMENT  
OF  
TRANSPORTATION AND COMMUNICATIONS  
DESIGN SERVICES  
BRANCH

W.P. No. 387 - 65

JOB No. 72 - 11002

FIG. 2



WP 658-93-01

DEPARTMENT OF HIGHWAYS  
MATERIALS and  
TESTING  
DIVISION

# PLASTICITY CHART

# GLACIAL TILL

к.р. №. 387 - 65

JOB No. 72 - 11C02

15

## **Appendix D**

### **Foundation Comparison**

**COMPARISON OF FOUNDATION ALTERNATIVES**

Footings on Native Soil	Spread Footings on Engineered Fill	Driven Piles	Caissons
<p><b>Advantages:</b></p> <ul style="list-style-type: none"> <li>i. Ease of construction.</li> <li>ii. Good geotechnical resistance is available on the till deposits.</li> <li>iii. Lower cost than deep foundations.</li> </ul> <p><b>Disadvantages:</b></p> <ul style="list-style-type: none"> <li>i. Subexcavation might be required to penetrate extensive layer of fill.</li> <li>ii. Dewatering may be required, depending on the depth of excavation.</li> </ul> <p><b>NOT RECOMMENDED</b></p>	<p><b>Advantages:</b></p> <ul style="list-style-type: none"> <li>i. Generally less costly construction than deep foundation elements.</li> <li>ii. Founding level can be adjusted.</li> <li>iii. Higher bearing resistance than native soils.</li> </ul> <p><b>Disadvantages:</b></p> <ul style="list-style-type: none"> <li>i. Better geotechnical resistance than spread footings on native.</li> <li>ii. Deep excavation will be required to penetrate the fill.</li> <li>iii. Dewatering may be required, depending on depth of excavation.</li> <li>iv. Cost of engineered fill placement.</li> </ul> <p><b>NOT RECOMMENDED</b></p>	<p><b>Advantages:</b></p> <ul style="list-style-type: none"> <li>i. Piles will develop high geotechnical resistance in hard soils.</li> <li>ii. Installation of piles could continue in freezing weather.</li> <li>iii. Readily installed.</li> <li>iv. Foundation construction requires less volume of excavation than footings</li> </ul> <p><b>Disadvantages:</b></p> <ul style="list-style-type: none"> <li>i. Higher unit costs than footings.</li> <li>ii. Potential difficulties penetrating hard limestone/shale slabs layers in the hard till</li> </ul> <p><b>RECOMMENDED FOR PIERS AND ABUTMENTS</b></p>	<p><b>Advantages:</b></p> <ul style="list-style-type: none"> <li>i. High resistance is available for caissons founded in hard till/bedrock.</li> <li>ii. Construction of caissons could continue in freezing weather.</li> <li>iii. Subexcavation of fill and variable material not required.</li> </ul> <p><b>Disadvantages:</b></p> <ul style="list-style-type: none"> <li>i. Higher cost than spread footings</li> <li>ii. Installation of deep caissons will be required.</li> <li>iii. Possibility of boulders, shale and limestone slabs being encountered during augering.</li> <li>iv. More likely to encounter groundwater.</li> <li>v. Potential difficulty in cleaning and inspecting bases.</li> </ul> <p><b>FEASIBLE</b></p>

## **Appendix E**

### **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 structure foundations and Mimico Creek culvert during excavation and pile driving.*
- *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 shale and limestone 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 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*

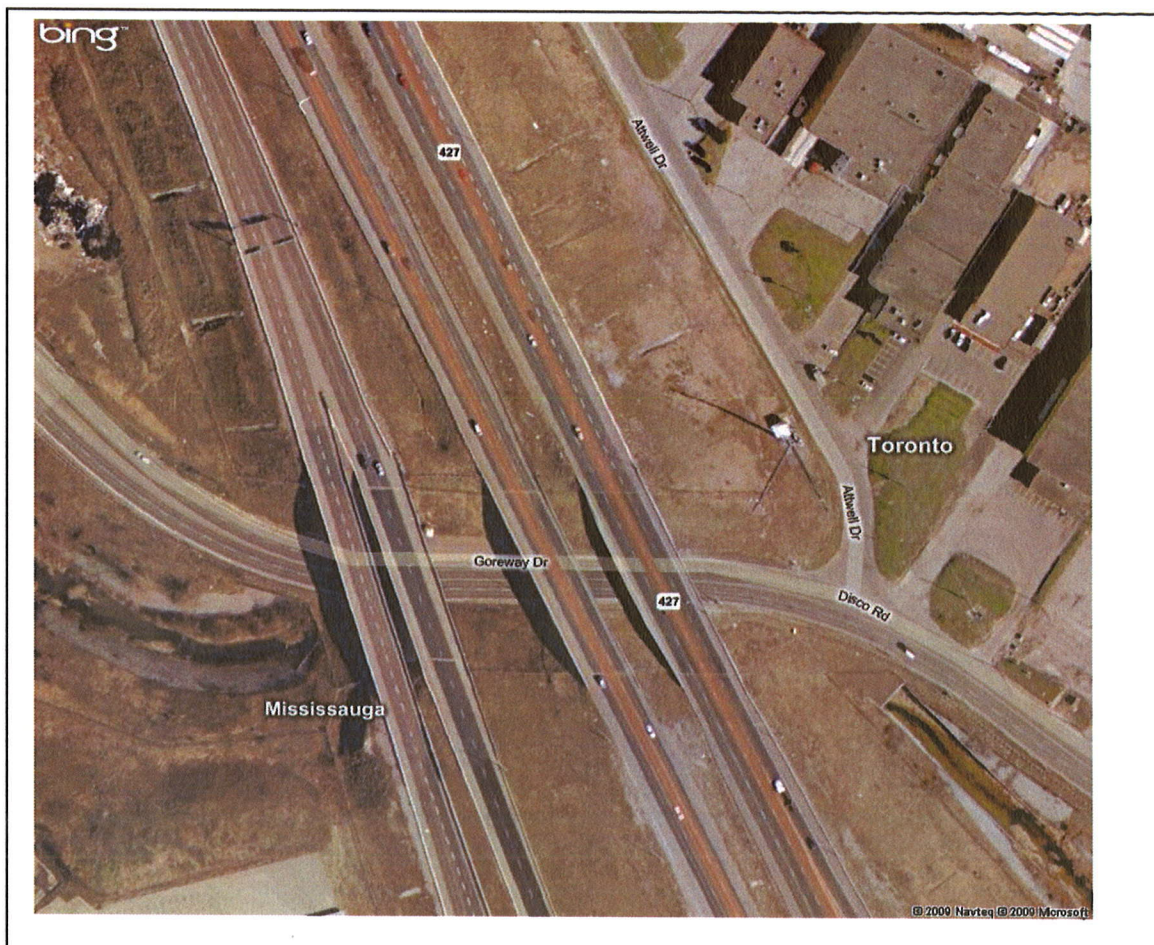
**4. Suggested Text for NSSP on “Drilling of Caisson Sockets”**

*Caisson installation through the till may encounter cobbles, boulders or rock slabs and the installation equipment should be capable of dislodging and removing such obstructions.*

*The native hard till increases in strength with depth and contains hard limestone interbeds. Excavation and augering through the hard interbeds may be difficult. As such, rock coring equipment or pneumatic rock splitting/breaking equipment should be available on site to assist in excavation and drilling of caisson sockets.*

## **Appendix F**

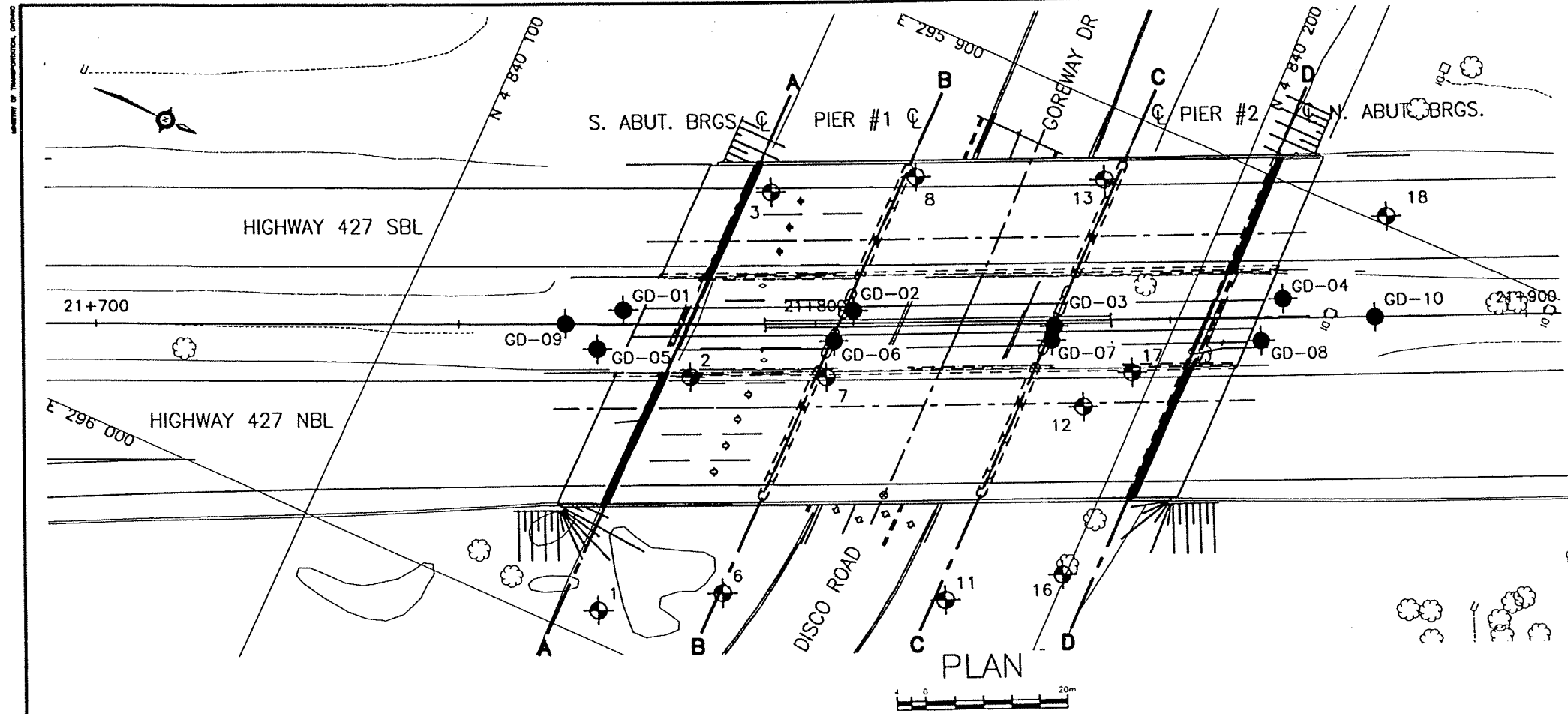
### **Site Photograph**



**Photo 1.** Aerial photograph of the site

## **Appendix G**

### **Borehole Locations and Soil Strata Drawings**



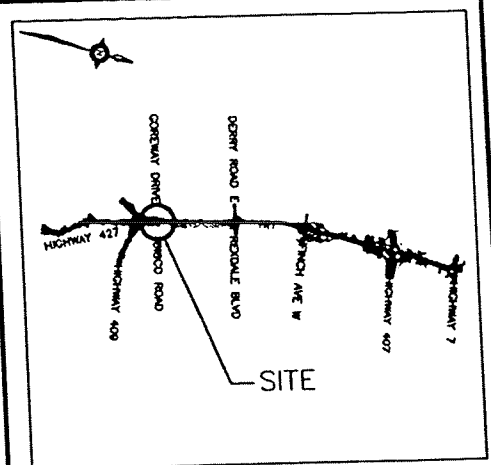
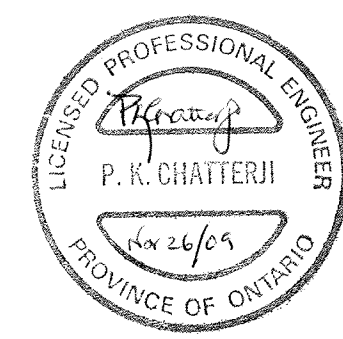
**METRIC**  
DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN

CONT No  
GWP No 202-95-00

HIGHWAY 427  
DISCO RD/GOREWAY DR OVERPASS  
REHABILITATION & WIDENING  
BOREHOLE LOCATIONS AND SOIL STRATA

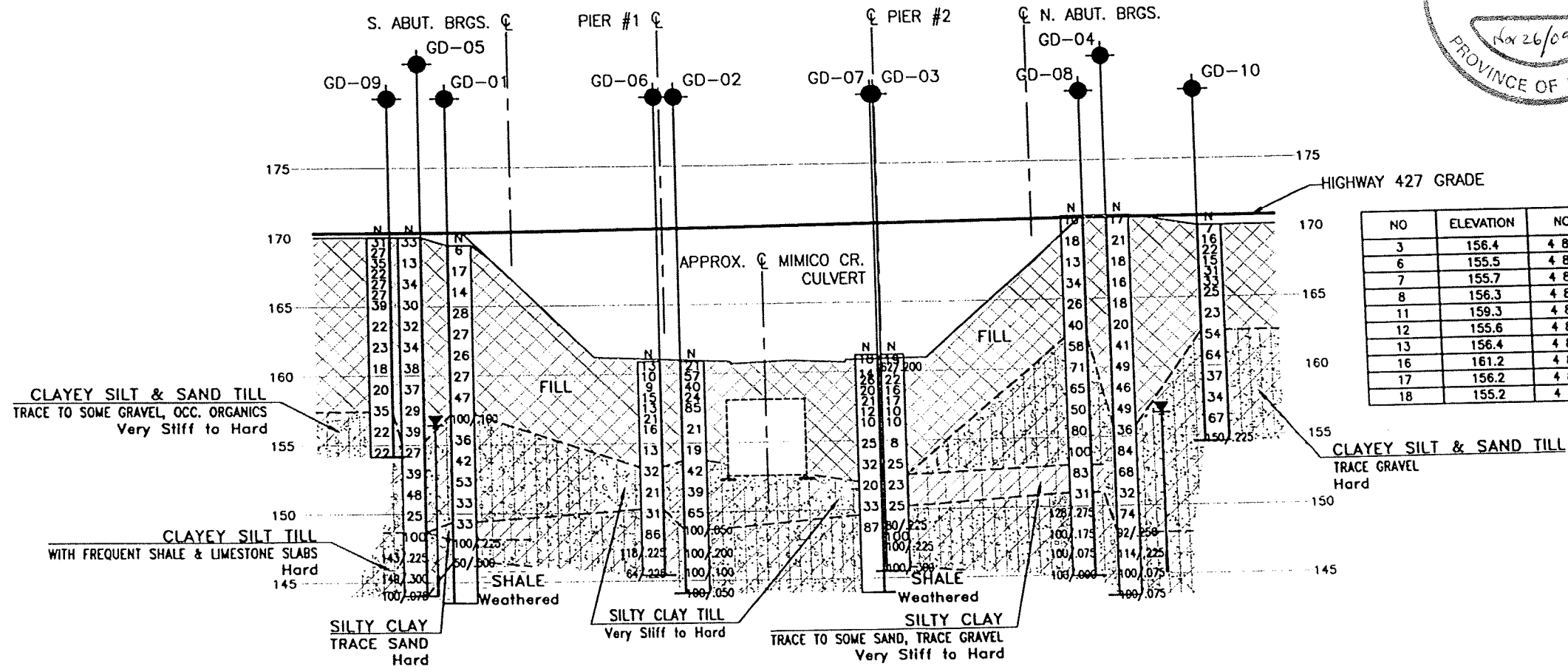
**SNC-LAVALIN**

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



**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
- W Water Level
- ⊕ Head Artesian Water
- ⊖ Piezometer
- 90% Rock Quality Designation (RQD)
- A/R Auger Refusal



NO	ELEVATION	NORTHING	EASTING	NO	ELEVATION	NORTHING	EASTING
3	156.4	4 840 140.5	295 931.1	GD-01	169.4	4 840 128.4	295 955.1
6	155.5	4 840 157.2	295 986.3	GD-02	160.9	4 840 157.8	295 941.1
7	155.7	4 840 158.2	295 952.1	GD-03	161.2	4 840 184.5	295 932.1
8	156.3	4 840 158.2	295 920.7	GD-04	171.0	4 840 212.4	295 915.1
11	159.3	4 840 185.9	295 974.4	GD-05	170.0	4 840 127.4	295 961.1
12	155.6	4 840 192.9	295 941.1	GD-06	160.9	4 840 157.1	295 946.1
13	156.4	4 840 182.8	295 910.1	GD-07	161.2	4 840 185.0	295 934.1
16	161.2	4 840 199.6	295 964.3	GD-08	171.0	4 840 211.8	295 922.1
17	156.2	4 840 197.2	295 933.8	GD-09	170.0	4 840 121.9	295 960.1
18	155.2	4 840 221.2	295 898.8	GD-10	170.2	4 840 225.3	295 912.1
				1	155.3	4 840 142.6	295 995.1
				2	155.1	4 840 140.8	295 960.1

- NOTES-**
- The boundaries between soil strata have been established only at Borehole locations. Between Boreholes the boundaries are assumed from geological evidence.
  - This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

GEOCRES No. 30M12-289

DATE	BY	DESCRIPTION	DATE	NOV
DESIGN	SKP	CHK PKC	CODE	
DRAWN	MFA	CHK PKC	SITE	
			STRUCT	
			DWG	

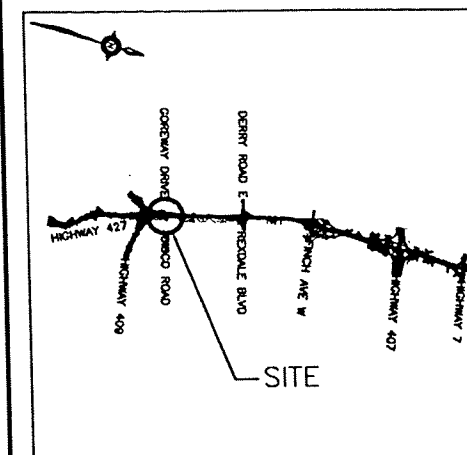
**METRIC**  
DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES  
UNLESS OTHERWISE SHOWN

CONT No  
GWP No 202-95-00








SHEET

HIGHWAY 427  
DISCO RD/GOREWAY DR OVERPASS  
REHABILITATION & WIDENING  
BORROW LOCATIONS AND SOIL STRATA



## KEYPLAN

LEGEND

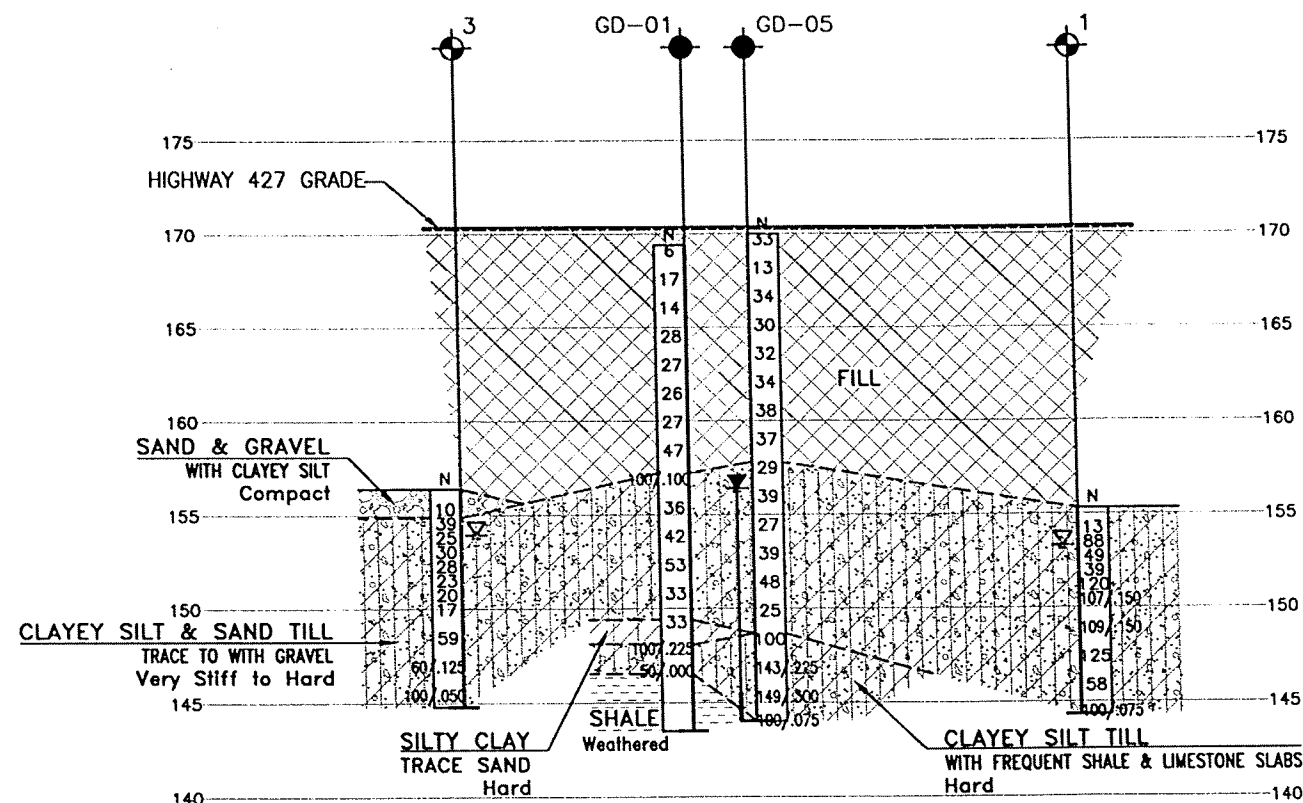
- |   |   |
|---|---|
|    | Borehole by Thurber (Present Investigation) |
|    | Borehole by Others (Previous Investigation) |
| N   | Blows /0.3m (Std Pen Test, 475J/blow)       |
| CONE  | Blows /0.3m (60° Cone, 475J/blow)           |
| PH  | Pressure, Hydraulic                         |
|  | Water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

NO	ELEVATION	NORTHING	EASTING	NO	ELEVATION	NORTHING	EASTING
3	156.4	4 840 140.5	295 931.1	GD-01	169.4	4 840 128.4	295 955.1
6	155.5	4 840 157.2	295 986.3	GD-02	160.9	4 840 157.8	295 941.8
7	155.7	4 840 158.2	295 952.1	GD-03	161.2	4 840 184.5	295 932.2
8	156.3	4 840 158.2	295 920.7	GD-04	171.0	4 840 212.4	295 915.5
11	159.3	4 840 185.9	295 974.4	GD-05	170.0	4 840 127.4	295 961.7
12	155.6	4 840 192.9	295 941.1	GD-06	160.9	4 840 157.1	295 946.9
13	156.4	4 840 182.8	295 910.1	GD-07	161.2	4 840 185.0	295 934.3
16	161.2	4 840 199.6	295 964.3	GD-08	171.0	4 840 211.8	295 922.3
17	156.2	4 840 197.2	295 933.8	GD-09	170.0	4 840 121.9	295 960.2
18	155.2	4 840 221.2	295 898.8	GD-10	170.2	4 840 225.3	295 912.6
				1	155.3	4 840 142.6	295 995.7
				2	155.1	4 840 140.8	295 960.0

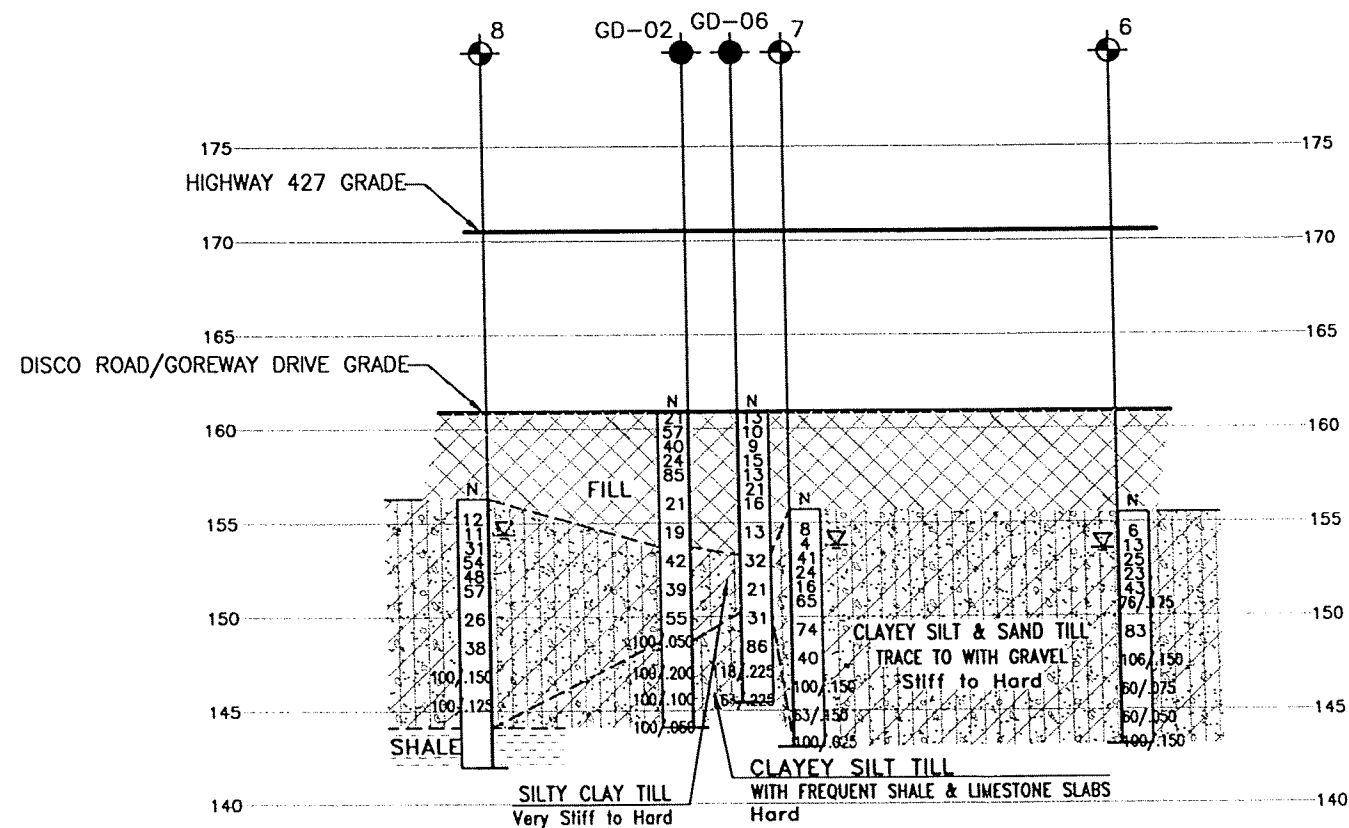
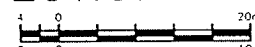
**-NOTES-**

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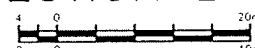
**GEOCRES No. 30M12-289**



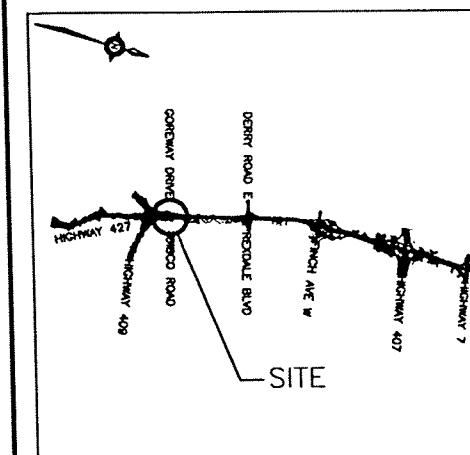
SECTION A-A



SECTION B-B






[illegible]





## KEYPLAN

## LEGEND

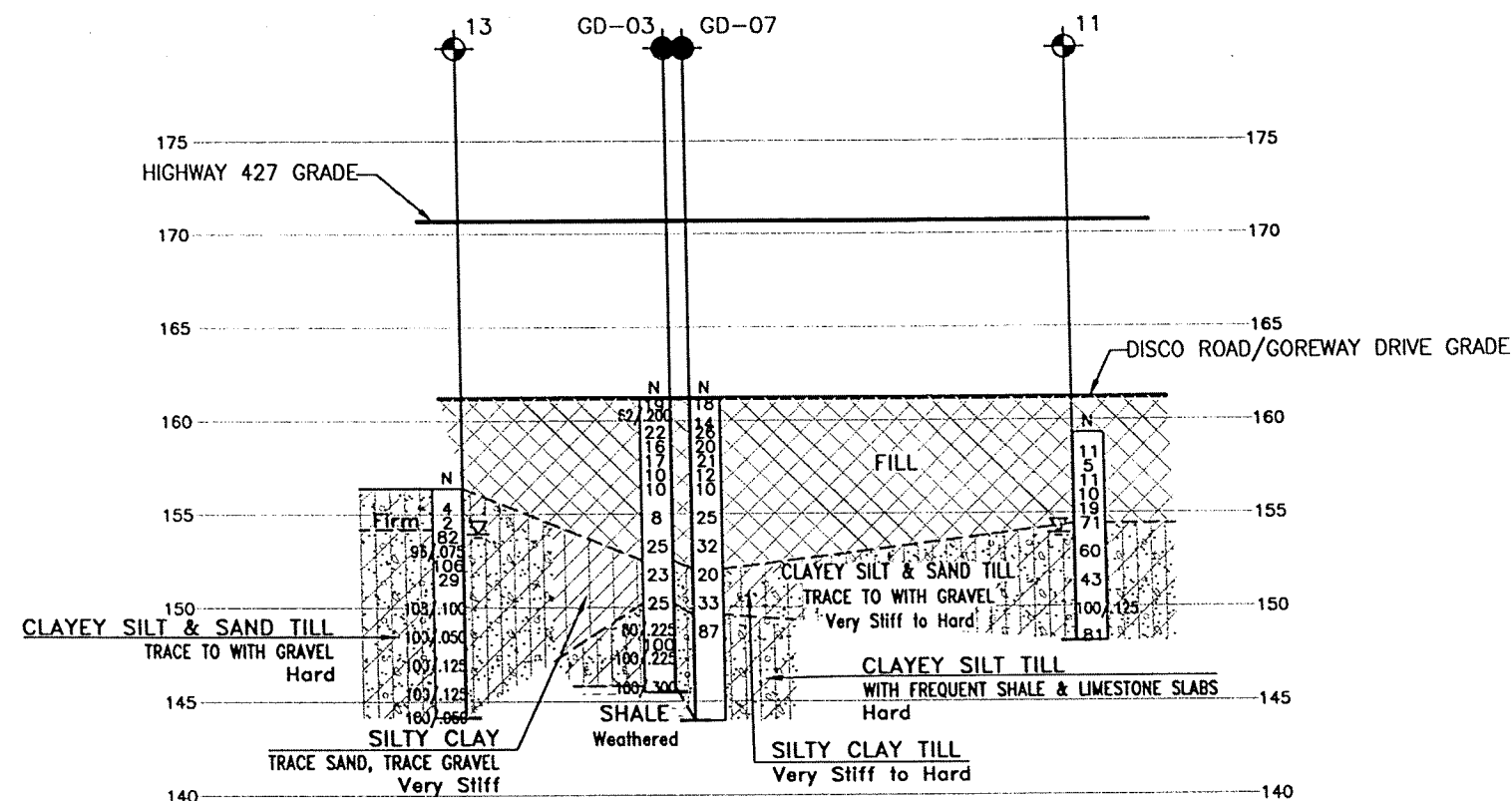
	Borehole by Thurber (Present Investigation)
	Borehole by Others (Previous Investigation)
N	Blows /0.3m (Std Pen Test, 475J/blow)
CONE	Blows /0.3m (60° Cone, 475J/blow)
PH	Pressure, Hydraulic
	Water Level
	Head Artesian Water
	Piezometer
90%	Rock Quality Designation (RQD)
A/R	Auger Refusal

NO	ELEVATION	NORTHING	EASTING	NO	ELEVATION	NORTHING	EASTING
3	156.4	4 840 140.5	295 931.1	GD-01	169.4	4 840 128.4	295 955.5
6	155.5	4 840 157.2	295 986.3	GD-02	160.9	4 840 157.8	295 941.8
7	155.7	4 840 158.2	295 952.1	GD-03	161.2	4 840 184.5	295 932.2
8	156.3	4 840 158.2	295 920.7	GD-04	171.0	4 840 212.4	295 915.5
11	159.3	4 840 185.9	295 974.4	GD-05	170.0	4 840 127.4	295 961.7
12	155.6	4 840 192.9	295 941.1	GD-06	160.9	4 840 157.1	295 946.9
13	156.4	4 840 182.8	295 910.1	GD-07	161.2	4 840 185.0	295 934.3
16	161.2	4 840 199.6	295 964.3	GD-08	171.0	4 840 211.8	295 922.3
17	156.2	4 840 197.2	295 933.8	GD-09	170.0	4 840 121.9	295 960.2
18	155.2	4 840 221.2	295 898.8	GD-10	170.2	4 840 225.3	295 912.6
				1	155.3	4 840 142.6	295 995.7
				2	155.1	4 840 140.8	295 960.0

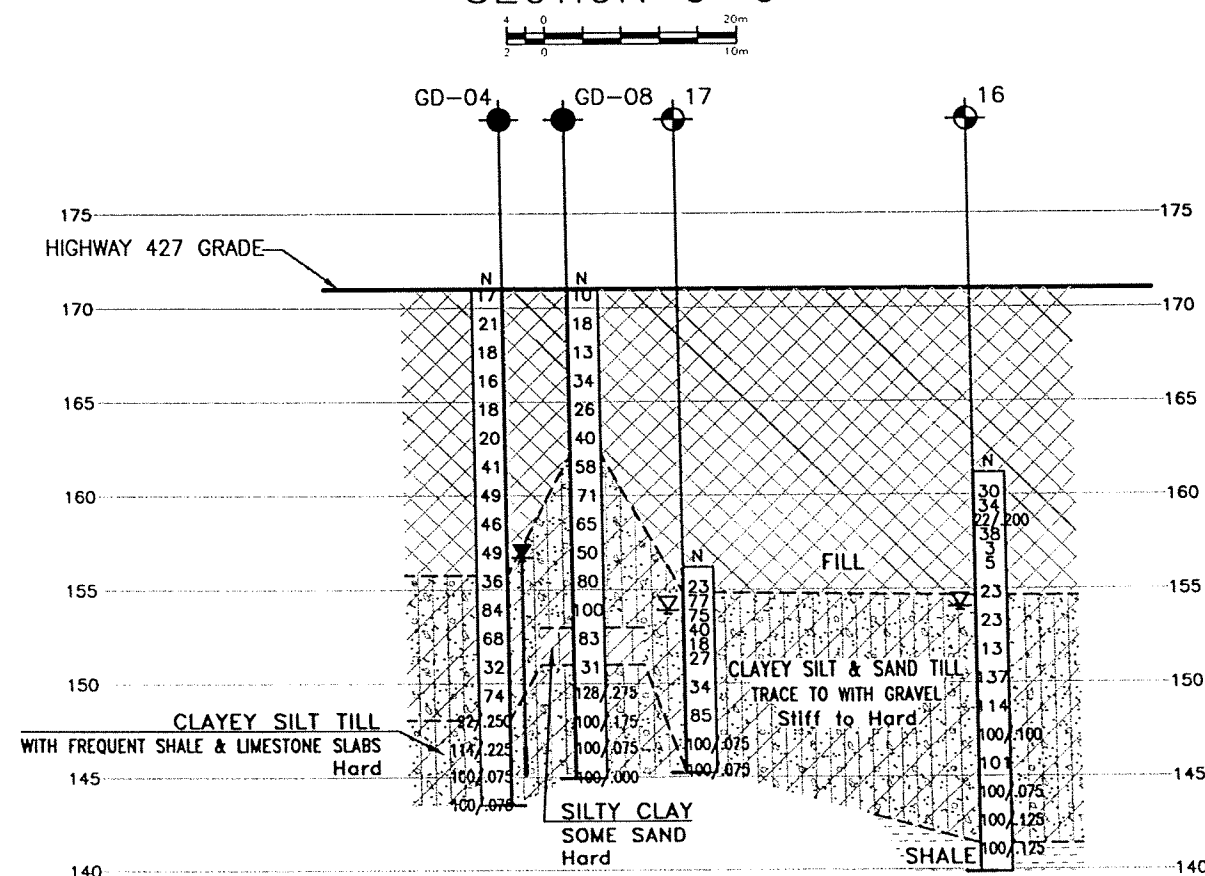
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**GEOCRES No. 30M12-289**



SECTION C-C



SECTION D-D

[illegible]