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**FOUNDATION INVESTIGATION AND DESIGN REPORT  
DETROIT – WINDSOR TRUCK FERRY ROAD  
INFRASTRUCTURE IMPROVEMENTS  
CITY OF WINDSOR  
GWP 3071-06-00, PURCHASE ORDER NO. 3006-E-0065  
MINISTRY OF TRANSPORTATION, ONTARIO  
– SOUTHWESTERN REGION**

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LIST OF ABBREVIATIONS

LIST OF SYMBOLS

LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

RECORD OF BOREHOLE SHEETS

FIGURE 1 - Site Location Map

FIGURE 2 - Proposed Site Layout

DRAWING 1 - Borehole Locations

APPENDIX A - Laboratory Test Data (Figures A-1 to A-17)

APPENDIX B - Site Photographs

# **PART A - FOUNDATION INVESTIGATION REPORT**

**DETROIT – WINDSOR TRUCK FERRY ROAD  
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MINISTRY OF TRANSPORTATION, ONTARIO – SOUTHWESTERN REGION**

## **1.0 INTRODUCTION**

Golder Associates Ltd. (Golder) has been retained by Stantec Consulting Ltd. (Stantec) on behalf of the Ministry of Transportation, Ontario (MTO) to carry out a foundation investigation as part of the detail design for the improvements to the Detroit – Windsor Truck Ferry facility, GWP 3071-06-00. The project includes the construction of a new access road, provision of a truck parking area, new illumination, dredging of the riverbed, installation of a sheet pile wall, installation of a single bumper dolphin and construction of an adjustable ramp to facilitate on and off loading of the ferry/barge.

This report addresses the foundation aspects of the installation of a Truck Ferry Administration Kiosk, sheet pile walls, dredging of the riverbed, the bumper dolphin, the construction of an adjustable ramp and a high mast light. The purpose of the foundation investigation is to determine the subsurface conditions at the locations of the proposed docking facility improvements by drilling boreholes and carrying out in situ testing and laboratory testing on selected samples. The original terms of reference for the scope of work are outlined in the MTO's Request for Proposal, in Golder's proposal P71-3011 dated April 18, 2007 and in Golder's letter for additional foundation engineering services dated July 25, 2007. The foundation investigation was conducted, as originally proposed in July 2007, and the preliminary results reported. Following a series of design revisions, the scope of work was modified to reflect the original terms of reference and the current preferred design concept, Option 6. An additional foundation investigation was carried out in October 2007 as outlined in our letter dated October 4, 2007. The work was carried out in accordance with our Quality Control Plan for Foundation Engineering dated June 21, 2007.

Stantec provided Golder with original design drawings, survey information and the proposed layout for the Truck Ferry facility.

## **2.0 SITE DESCRIPTION**

The Truck Ferry facility is located at 5550 Maplewood Road in Windsor, Ontario and transports trucks across the Detroit River to Detroit, Michigan by way of a tug boat propelled ferry barge. The site has been in use as a truck ferry terminal since 1994. According to the results of a recent Phase 1 Environmental Site Assessment, significant amounts of infilling into the Detroit River have occurred. The existing facility consists of a gravel parking lot and access road, a floating dock, a one-storey customs building, two sheds, a water well and a steel container. The concrete surfaced floating dock is approximately 52.8 metres long by 12.0 metres wide. Access to the dock is provided by a steel ramp located along the northeast side of the dock. An existing steel sheet pile wall runs along the northwest shoreline.

The International Great Lakes Datum (IGLD) for this site is elevation 174.0 metres.

The site location is shown on Figure 1 and select site photographs taken during the investigation are provided in Appendix B.

### **3.0 INVESTIGATION PROCEDURES**

The field work for this investigation was carried out in two stages. Initially, boreholes 1 to 5 were drilled between July 23 and 31, 2007 and subsequent boreholes 6 to 13 were drilled between October 9 and 15, 2007. Boreholes 2, 3, 10, 12, and 13 were drilled using a timber platform with safety rails cantilevered over a barge and the floating dock to depths between about 1.7 and 28.3 metres below the river water level. The remaining boreholes were advanced on land to depths between about 5.0 and 29.9 metres below the existing ground surface.

The tug and barge utilized to drill borehole 3 were provided by a specialist marine contractor.

The investigation was carried out using all-terrain vehicle and truck mounted CME-750 drill rigs supplied and operated by specialist drilling contractors. The boreholes were advanced using a combination of power auger, rotary mud drilling techniques in NW size casing and coring of the bedrock in NQ size in boreholes 1, 3, and 9. The remaining boreholes were advanced using a power auger, with the exception of boreholes 10, 12, and 13, which were advanced using manual drilling techniques. In the boreholes, samples of the overburden were obtained at regular intervals of depth using 50 millimetre outside diameter split-spoon samplers in accordance with the standard penetration test procedures. In situ vane shear testing was also carried out in the softer cohesive materials. In addition, thin walled tube samples were obtained from the cohesive soils, where feasible. Groundwater conditions in the boreholes were observed throughout the drilling operations and standpipes were installed in boreholes 5 and 7. The boreholes were backfilled using MTO recommended procedures and as required by Ontario Regulation 903 (amended by Ontario Regulation 128/03). The artesian flows in boreholes 1, 3 and 9 were sealed at their source in the bedrock.

The field work was supervised on a full-time basis by members of our engineering staff who located the boreholes in the field, directed the drilling, sampling and in-situ testing operations and logged the boreholes. The soil and rock samples were identified in the field, placed in labeled containers and transported to our laboratory in London, Ontario for further examination. Index and classification tests consisting of grain size analyses, Atterberg limits tests, consolidation testing and water content determinations were carried out on selected samples. The rock core and thin walled tube samples were transported to our laboratory in Mississauga, Ontario for additional examination of the rock core and triaxial testing. Triaxial testing was carried out on thin walled tube samples from boreholes 1 and 2. The results of the field and laboratory testing are given on the Record of Borehole sheets and in Appendix A.

The locations of the boreholes are shown on the Record of Borehole sheets and on Drawing 1. The table below summarizes the borehole locations, ground surface elevations at the borehole locations and borehole depths:

<u>BOREHOLE</u>	<u>LOCATION (m)</u>		<u>GROUND SURFACE ELEVATION</u>	<u>BOREHOLE DEPTH</u>
	<u>Northing</u>	<u>Easting</u>	<u>(m)</u>	<u>(m)</u>
1	4 681 695.5	326 636.1	176.43	29.14
2	4 681 717.2	326 635.8	174.78	22.71
3	4 681 705.2	326 604.2	174.76	28.25
4	4 681 681.4	326 647.5	176.63	5.03
5	4 681 674.5	326 639.4	176.98	6.55
6	4 681 640.5	326 616.7	177.23	5.03
7	4 681 677.9	326 691.3	177.47	11.13
8	4 681 673.1	326 622.3	176.97	17.22
9	4 681 658.5	326 615.2	176.99	29.87
10	4 681 672.7	326 611.4	174.60	1.68
11	4 681 647.4	326 634.3	177.24	5.79
12	4 681 664.7	326 599.9	174.60	3.35
13	4 681 668.1	326 604.9	174.60	3.05



## **4.0 SUBSURFACE CONDITIONS**

### **4.1 Site Geology**

The area of the Truck Ferry facility lies in the physiographic region of southern Ontario known as the St. Clair Clay Plains as identified in "The Physiography of Southern Ontario" by Chapman and Putnam (1984). The clay plains are described as till plains smoothed by shallow deposits of lacustrine clay which settled in the depressions.

Based on the Ontario Department of Mines and Northern Affairs Preliminary Map P.749 entitled "Quaternary Geology of the Windsor-Essex Area", the project site is located in an area of surficial gravel and gravely sand.

The bedrock is reported to be dolomite and limestone of the Dundee Formation of Middle Devonian Age (Geological Survey of Canada, Map 1263A entitled "Geology, Toronto-Windsor Area", dated 1969).

### **4.2 Site Stratigraphy**

The detailed subsurface water, soil and rock conditions encountered in the boreholes together with the results of the field and laboratory testing are shown on the Record of Borehole sheets following the text of this report and in Appendix A. The stratigraphic boundaries shown on the borehole sheets are inferred from non-continuous sampling and, therefore, may represent transitions between soil types rather than exact planes of geological change. Subsoil conditions will vary between and beyond the borehole locations.

In summary, the subsoils generally consist of variable but generally granular fill with miscellaneous debris (wood, bricks, concrete, etc.) overlying an upper layer of clayey silt, underlain by silty clay and an extensive layer of clayey silt which overlies clayey silt to sandy silt till and shaley limestone bedrock at about elevation 151 metres. Within the Detroit River, the river bed is composed of sandy silt, silt, silty sand or fill materials.

The locations and elevations of the borings are shown on the attached Drawing 1. A detailed description of the subsurface conditions encountered in the boreholes for this investigation is provided on the Record of Borehole sheets and a summary of the soil stratigraphy is provided in the following paragraphs.

#### **4.2.1 Fill**

Boreholes 1, 4, 5, 6, 7, 8, 9 and 11 encountered 3.7 to 5.2 metres of variable but generally granular fill at the ground surface. The fill consisted of layers of sand and gravel, sand, sandy silt, silty sand and gravel, crushed rock and clayey silt. Pieces of concrete, bricks, cobbles, boulders, glass and organics were also encountered throughout the fill layers. Boreholes 10, 12, and 13 encountered similar fill layers beneath about 1.2 to 1.7 metres of water. Boreholes 10 and 13 were terminated within the fill layers at depths of 1.7 and 3.1 metres, respectively.

Standard penetration tests in the fill gave N values ranging from 6 to about 50 blows per 0.3 metres depth indicating loose to dense relative density. Some higher values were obtained on rubble debris within the fill. Further, it should be noted that the initial attempt to drill borehole 9 resulted in practical auger refusal at a depth of 0.9 metres and larger pieces of concrete are also exposed on the river bank.

The natural water contents of the fill ranged from about 7 to 57 per cent. The higher water contents are attributable to the presence of organic materials. Grain size distribution curves for samples of the fill obtained from the standard penetration testing are shown on Figures A-1 and A-2.

The cohesive fill layers were of intermediate plasticity with liquid limits of 36 and 43 per cent, plastic limits of 19 and 23 per cent and plasticity indices of 17 and 20 per cent. The results of the Atterberg limits testing are presented on Figure A-9.

#### **4.2.2 Silt**

Beneath about 4.2 metres of water, a layer of very loose silt with trace amounts of organics was encountered in borehole 3 from elevation 170.6 metres. The silt deposit was about 0.9 metres thick and extended to elevation 169.7 metres. The natural water content of the silt was about 66 per cent.

#### **4.2.3 Sandy Silt**

Beneath about 1.9 metres of water, a layer of very loose sandy silt with wood was encountered in borehole 2 from elevation 172.9 metres. The sandy silt deposit was about 1.0 metres thick and extended to elevation 171.9 metres. Borehole 12 encountered and was terminated in a layer of compact sandy silt containing clay and gravel from elevation 171.6 to 171.3 metres. The natural water contents of the sandy silt were 25 and 126 per cent.

#### **4.2.4 Silty Sand**

A layer of very loose to loose silty sand with variable amounts of gravel was encountered beneath the silt in borehole 3 and beneath the granular fill in borehole 4 from elevations 169.7 and 172.5 metres, respectively. Borehole 3 also encountered bricks and borehole 4 encountered organics within the silty sand deposit. A grain size distribution curve for a sample of the silty sand is shown on Figure A-3. The natural water contents of the silty sand ranged from about 29 to 33 per cent with an average water content of about 31 per cent.

#### **4.2.5 Clayey Silt**

From elevations 174.9 to 172.6 metres, an upper layer of clayey silt was encountered beneath the fill in boreholes 7, 8, 9, 11 and 12. The upper clayey silt layer ranged in thickness from about 0.5 to 2.7 metres. From elevations 169.0 to 166.6 metres, a lower layer of clayey silt was encountered beneath the silty clay in boreholes 1, 2, 7, 8, and 9, and beneath the silty sand in borehole 3. Boreholes 7 and 8 were terminated within the lower clayey silt deposit. The lower clayey silt ranged in thickness from about 13.9 to 15.3 metres in the remaining boreholes. Grain size distribution curves for samples of the clayey silt are shown on Figures A-4 and A-5.

The clayey silt had N values ranging from 1 to 16 blows per 0.3 metres penetration. The results of in situ vane testing indicated undrained shear strengths ranging from 14 to over 144 kilopascals (kPa) but generally below 65 kPa. The in situ vane sensitivities ranged from 1.2 to 3.7. The testing indicated that the clayey silt has a soft to stiff consistency. The natural water contents of the clayey silt ranged from about 15 to 47 per cent with an average water content of about 24 per cent. Atterberg limits testing indicated plastic limits ranging from 13 to 18 per cent, liquid limits ranging from 21 to 35 per cent and plasticity indices of 8 to 15 per cent. The results of the Atterberg limits testing are presented on Figure A-9.

The results of consolidated, undrained triaxial laboratory testing carried out on two specimens of the clayey silt (sample 8) from borehole 1 are provided on Figures A-14 to A-17. The laboratory testing indicated that the sample had an effective angle of internal friction of 27 degrees and an effective cohesion of nil.

#### **4.2.6 Silty Clay**

From elevations 173.1 to 170.0 metres, a layer of silty clay was encountered beneath the fill in boreholes 1, 5, and 6, beneath the sandy silt in borehole 2, beneath the silty sand in borehole 4, and beneath the clayey silt in boreholes 7, 8, 9, and 11. Boreholes 4, 5, 6, and 11 were terminated within this deposit. Where fully penetrated, the silty clay ranged in thickness from about 1.7 to 5.3 metres. Grain size distribution curves for samples of the silty clay are shown on Figure A-6.

The silty clay had N values of 1 to 5 blows per 0.3 metres penetration. The results of in situ vane testing indicated undrained shear strengths ranging from 15 to 29 kPa with an average undrained shear strength of about 22 kPa. The in situ vane sensitivities ranged from 1.4 to 4.0. The testing indicated that the silty clay has a soft to firm consistency. The natural water contents of the silty clay ranged from about 23 to 53 per cent with an average water content of about 40 per cent. Atterberg limits testing indicated an intermediate to high plasticity soil with plastic limits ranging from 17 to 25 per cent, liquid limits ranging from 37 to 57 per cent and plasticity indices of 19 to 32 per cent. The results of the Atterberg limits testing are presented on Figure A-9.

The results of consolidated, undrained triaxial laboratory testing carried out on sample 5 of the silty clay from borehole 2 are provided on Figures A-10 to A-13. The laboratory testing indicated that the sample had an effective angle of internal friction of 21 degrees and an effective cohesion of nil.

#### **4.2.7 Sand**

A 1.4 metre thick layer of sand containing cobbles was encountered beneath the clayey silt in borehole 3 from elevation 153.0 metres. The sand had an N value of greater than 100 blows per 0.3 metres indicating a very dense deposit. The natural water content of the sand was about 20 per cent. A grain size distribution curve for a sample of the sand is shown on Figure A-7.

#### **4.2.8 Sandy Silt Till**

Beneath the clayey silt in borehole 1, a layer of sandy silt till was encountered from elevation 154.2 metres. The sandy silt till extended to the bedrock surface at elevation 152.4 metres. The sandy silt till had an N value of 31 blows per 0.3 metres indicating a dense deposit. A grain size distribution curve for a sample of the sandy silt till obtained from the standard penetration testing is shown on Figure A-8. The natural water content of the sandy silt till was about 11 per cent. Atterberg limits testing on a single sample indicated a borderline silt and clay of low plasticity with a plastic limit of 11 per cent, a liquid limit of 17 per cent and a plasticity index of 6 per cent. The results of the Atterberg limits testing are presented on Figure A-9.

Although cobbles and boulders were not specifically encountered in the sandy silt till deposit, their presence should be anticipated.

#### **4.2.9 Clayey Silt Till**

Beneath the lower clayey silt in boreholes 2 and 9, and beneath the sand in borehole 3, a layer of clayey silt till was encountered from elevations 153.1 to 151.6 metres. The clayey silt till extended to the bedrock surface at elevations 152.2 to 150.5 metres.

The clayey silt till had N values of from 9 blows per 0.3 metres to 80 blows for 25 millimetres of penetration indicating a stiff to hard but typically hard deposit. The natural water content of the clayey silt till was about 9 per cent.

Although cobbles and boulders were not specifically encountered in the boreholes advanced in the clayey silt till, the presence of these materials should be expected due to the depositional history of the glacial tills.

#### 4.2.10 Bedrock

The bedrock surface was encountered between elevations 152.4 and 150.5 metres in boreholes 1, 2, 3 and 9, some 24.1 to 25.0 metres below the ground surface or 22.6 to 24.2 metres below the river water level. Approximately 3.5 to 4.0 metres of the bedrock below elevation 151.0 metres was cored in NQ size in boreholes 1, 3 and 9. The bedrock was identified as pale grey to brown, medium strong, laminated, shaley limestone with bituminous partings of the Dundee formation. The total rock core recoveries (TCR) recorded were 0 to 100 per cent, with measured solid core recoveries (SCR) of 0 to 98 per cent and rock quality designations (RQD) of 0 to 98 per cent. The rock was found to be highly weathered above elevation 150.5 metres in boreholes 1 and 9. Based on the RQD values, the bedrock is typically of fair to excellent quality.

<u>BOREHOLE</u>	<u>ELEVATION (m)</u>		<u>RQD</u> (%)	<u>TCR</u> (%)	<u>SCR</u> (%)
	<u>From</u>	<u>To</u>			
1	151.0	150.3	0	56	8
	150.3	148.9	85	90	85
	148.9	147.3	90	93	90
3	150.5	149.6	74	74	74
	149.6	148.1	98	100	98
	148.1	146.5	93	95	93
9	150.6	150.2	0	0	0
	150.2	148.6	73	77	73
	148.6	147.1	93	98	93
AVERAGE			67	76	68

### 4.3 Water Conditions and River Bed Elevations

#### 4.3.1 Groundwater Conditions

Groundwater conditions were observed in the boreholes during and upon completion of drilling. Groundwater was encountered from elevation 171.6 to 174.3 metres at the time of drilling. Artesian conditions were encountered within the shaley limestone in boreholes 1, 3, and 9 at elevations of about 151.0, 148.0 and 150.5 metres, respectively. The artesian flows in the borehole casings were measured with 2.2 metres of head above ground surface in borehole 1, 2.3 metres of head above river level in borehole 3, and 1.7 metres of head above ground surface in

borehole 9. The average water level in the Detroit River was at elevation 174.8 metres during the period July 23 to 30, 2007.

Standpipes were installed in boreholes 5 and 7 to monitor groundwater levels. Groundwater was measured in the standpipe installed in borehole 5 at elevation 174.6 metres in the surficial till on August 17, 2007. Groundwater was measured in the standpipe piezometer installed in borehole 7 at elevation 176.1 metres in the clayey silt at depths of about 9 metres on October 15, 2007.

The long term groundwater level is inferred at elevation 175 metres in the near surface soil and at elevation 179 metres in the bedrock. The groundwater levels are expected to fluctuate seasonally and are expected to be higher during periods of sustained precipitation or during spring melt conditions.

The groundwater levels observed in the boreholes are shown on the attached Record of Borehole sheets and are summarized below:

BOREHOLE NUMBER	GROUND OR WATER SURFACE ELEVATION (m)	ENCOUNTERED WATER LEVEL		MEASURED GROUNDWATER LEVELS					
				July 31, 2007		August 17, 2007		October 15, 2007	
		Depth (m)	Elevation (m)	Depth (m)	Elevation (m)	Depth (m)	Elevation (m)	Depth (m)	Elevation (m)
1	176.43	2.13	174.30	-	-	-	-	-	-
		+2.23	178.66*						
3	174.76	+2.29	177.05*	-	-	-	-	-	-
4	176.63	2.74	173.89	-	-	-	-	-	-
5	176.98	2.29	174.69	5.36	171.62	2.35	174.63	-	-
6	177.23	Dry	Dry	-	-	-	-	-	-
7	177.47	4.27	173.20	-	-	-	-	1.40	176.07
8	176.97	3.96	173.01	-	-	-	-	-	-
9	176.99	+2.01	178.67*	-	-	-	-	-	-
11	177.24	Dry	Dry	-	-	-	-	-	-

\* Flowing artesian groundwater conditions encountered in boreholes 1, 3 and 9 from elevation 148.0 to 151.0 metres.

#### 4.3.2 River Bed Elevations

The measured water levels and river bed elevations are shown on the attached Record of Borehole sheets and are summarized below:

BOREHOLE NUMBER	RIVER WATER ELEVATION (m)	RIVER BED ELEVATION (m)
2	174.78	172.86
3	174.76	170.61
10	174.60	173.38
12	174.60	172.92
13	174.60	173.08

The monitoring station closest to the site is at Fort Wayne, Michigan, USA and is operated by the National Oceanic Atmospheric Administration (NOAA). According to NOAA records, the minimum and maximum recorded water levels for the Detroit River since 1970 are 173.81 and 175.79 metres above the IGLD, respectively. The mean water level for the month of July 2007 was 174.66 metres above IGLD. The river water level is subject to seasonal fluctuations.

## **5.0 MISCELLANEOUS**

The investigation was carried out using equipment supplied and operated by Lantech Drilling Services Inc. and Aardvark Drilling Inc. both of whom are Ontario Ministry of the Environment licensed well contractors. The tug and barge required for borehole 3 were provided by Cobby Marine & Crane Services. The field operations were supervised by Mr. David J. Mitchell and Mr. Brent Gusba. The routine laboratory testing was carried out at Golder's London laboratory under the direction of Mr. Chris M. Sewell. The laboratory is an accredited participant in the MTO Soil and Aggregate Proficiency Program and is certified by the Canadian Council of Independent Laboratories for testing Types C and D aggregates.

The triaxial testing was conducted in Golder's Mississauga laboratory. In addition to also being a participant in the MTO Soil and Aggregate Proficiency Program, the Mississauga laboratory is an MTO registered laboratory in the Specialty of Soil and Rock Including Testing for Foundation Engineering - Low and High Complexity.

This report was prepared by Ms. Dirka U. Prout, P. Eng. under the direction of the Project Manager, Mr. Philip R. Bedell, P. Eng. This report was reviewed by Mr. Fintan J. Heffernan, P. Eng., the Designated MTO Contact and Quality Control Auditor for this assignment.

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## **PART B - FOUNDATION DESIGN REPORT**

**DETROIT – WINDSOR TRUCK FERRY ROAD  
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CITY OF WINDSOR**

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## 6.0 ENGINEERING RECOMMENDATIONS

### 6.1 General

This section of the report provides our recommendations on the foundation aspects of the various elements of the proposed improvements to the Detroit – Windsor Truck Ferry Road. The marine element of the site layout provided by Shoreplan Engineering Limited (Shoreplan) currently under consideration is Option 6 with ramp (6 per cent grade). The proposed site layout is presented for reference purposes on Figure 2. The design elements under consideration in this report are the bumper dolphin, adjustable ramp, a high mast light, a Truck Ferry Administration Kiosk, realigned and new steel sheet pile wall, anchor walls and dredge area. The schedule of boreholes for each design element is provided in the table below:

<u>DESIGN ELEMENT</u>	<u>BOREHOLES</u>
Bumper Dolphin	9
New & Realigned Sheet Pile Wall	1, 8, 9
Anchor Walls For New Sheet Pile Walls	5, 6, 8, 11
Adjustable Ramp	1
High Mast Light	7
Dredging	10, 12, 13
Kiosk	7

Boreholes 2, 3 and 4 are not included in the above schedule since their locations were based on an earlier, now superseded, design.

Our recommendations are based on our interpretation of the factual information obtained during the investigation and the results of the field and laboratory testing. It should be noted that the interpretation and recommendations are intended for used only by the design engineer. Where comments are made on construction, they are provided only in order to highlight those aspects which could affect the design of the project.

### 6.2 Bumper Dolphin

The bumper dolphin is located at the southwest end of the project area. The subsurface conditions encountered in borehole 9 consist of 4.3 metres of compact to very dense surficial fill consisting of sand and sandy silt with brick, concrete and cinders. The fill is underlain by an extensive deposit of clayey silt from elevation 172.7 metres. The clayey silt is interlayered with a 1.7 metre thick silty clay layer at elevation 170.0 metres. A basal clayey silt till layer underlies the lower clayey silt from elevation 153.1 metres. Shaley limestone is present at elevation 152.0 metres below approximately 25.0 metres of overburden. The limestone is highly weathered to elevation 150.3 metres. During drilling, an artesian head at elevation 178.7 metres was encountered in the weathered bedrock zone near elevation 150.5 metres.

### 6.2.1 Foundations

It is anticipated that the bumper dolphin will likely be constructed with a group of three inclined pipe piles. Shoreplan has indicated that the bumper dolphin will consist of a single nominal 1200 millimetre diameter vertical tube pile and two 300 millimetre diameter battered piles. The bumper dolphin can be founded on steel H piles or steel tube piles driven to practical refusal on the bedrock. Pipe piles are preferred since they afford the opportunity to install anchors for additional uplift capacity, if required. Steel tube piles driven open ended into to the bedrock at approximately elevation 151 metres are considered suitable for support of the structure. The steel tube piles should be filled with concrete following anchor installation, if required.

#### Geotechnical Axial Resistance – Driven Steel Tube Piles

For design, the factored axial geotechnical resistance at Ultimate Limit States (ULS) for a nominal 325 millimetre steel tube pile driven open ended to refusal on the limestone bedrock below elevation 151 metres may be taken as 2,000 kilonewtons (kN) per pile. Alternatively, steel 310 x 110 H-piles may be used with the same capacity. This value takes into account the structural capacity of the pile.

Vertically driven piles should be equipped with Type I driving shoes in accordance with MTO's current practices (Ontario Provincial Standard Drawing (OPSD) 3000.100 for H-piles and OPSD 3001.100 for tube piles). Battered piles should be equipped with Type II driving shoes to ensure adequate seating into the bedrock. Reinforcement of the pipe pile tips is necessary in order to provide some protection against hard driving in the limestone. All piles should be installed and monitored in accordance with SP903S01, OPSD3000.150 and OPSD 3001.150, as applicable.

A Serviceability Limit States (SLS) value is not provided because the limestone bedrock is considered to be an unyielding medium. Under such conditions, SLS values (for 25 millimetres of settlement) do not govern design since the SLS value will be much higher than the ULS value.

The pile driving note to be added to the drawing is: "Piles to be driven to bedrock".

### Resistance to Lateral Loads

The lateral loading could be resisted fully or partially by the use of inclined piles. The horizontal reaction to the pile can be estimated using the following equation and ranges in subgrade reaction coefficient where:

$$k_s = \begin{aligned} &\text{coefficient of horizontal subgrade reaction (MPa/m)} \\ &= n_h (z/d) \quad \text{for cohesionless soils} \\ &= \frac{67 S_u}{d} \quad \text{for cohesive soils} \end{aligned}$$

$d$  = pile width or diameter (m)

$n_h$  = constant of horizontal subgrade reaction (MPa/m)

$S_u$  = undrained shear strength of the soil (MPa)

$z$  = depth below ground surface grade (m)

<u>SOIL TYPE</u>	<u>ELEVATION (m)</u>		$n_h$ (MPa/m)	$S_u$ (MPa)
	<u>From</u>	<u>To</u>		
Fill (sand and sandy silt)	Surface	172	2 – 5	-
Soft to firm clayey silt and silty clay	172	168	-	0.02
Firm to stiff clayey silt	168	153	-	0.022
Stiff clayey silt till	153	152	-	0.05

Group action for lateral loading should be considered when the pile spacing in the direction of the loading is less than six to eight pile diameters. Group action can be evaluated by reducing the coefficient of horizontal subgrade reaction in the direction of loading by a reduction factor  $R$  as follows:

<i>Pile Spacing in Direction of Loading, <math>d</math> = Pile Diameter</i>	<i>Subgrade Reaction Reduction Factor <math>R^1</math></i>
8d	1.00
6d	0.70
4d	0.40
3d	0.25

A maximum lateral resistance of 120 kN at ULS and 45 kN at SLS is recommended for nominal 325 millimetre diameter pipe piles.

<sup>1</sup> Foundations and Earth Structures – Design Manual 7.2, NAVFAC DM-7.2. Department of the Navy, Naval Facilities Engineering Command (1982).

### Scour Protection

The piles should be provided with adequate protection against scour.

### Uplift Considerations

Flowing artesian conditions were encountered in the limestone bedrock near elevation 150.5 metres during drilling. The design of the bumper dolphin must consider artesian conditions and if uplift is a concern, rock anchors can be used to resist the uplift forces. The installation methodology for the rock anchors must accommodate the artesian groundwater conditions in the bedrock.

The geotechnical axial resistance will be derived from the bond between the concrete grout and rock. Factored bond strengths at ULS of 400 kPa for the limestone can be used for design purposes. The available resistance should be confirmed in the field prior to construction using pullout tests. The field program should also include proof testing of the anchors. Anchors are to be designed, installed and tested in accordance with SP999S26. This special provision should be amended to specify that the installation methodology is to be compatible with the artesian conditions present in the bedrock.

## **6.3 Sheet Pile Walls**

The ferry berthing facility is to be reconfigured. The shoreline is currently protected with an existing sheet pile wall which runs along the east bank of the Detroit River from the outlet of the small creek at the northwest corner of the site to the area in front of the southwest corner of the customs building. A 40 metre section in the vicinity of the ramp area will remain in place. It has been proposed to realign and extend the sheet pile wall in the areas south of the ramp to the area south of the bumper barge. The new and realigned sheet pile walls will be secured by tie backs attached to anchor walls. The tie backs are to be installed using directional drilling methods and/or open cut trenching. The locations of the sections of new and realigned sheet pile walls at the shoreline and the anchor walls are shown on Figure 2.

### **6.3.1 Existing Sheet Pile Walls**

The original design plan of the docking area, Drawing No. MC-100-04-3 dated June 1995, indicates that the proposed elevation for the top of the existing sheet pile wall was 176.4 metres along the ramp and unloading barge area and elevation 177.5 metres in the vicinity of the customs building. According to the sheet pile details, Drawing Nos. MC-100-04-5 and MC-100-04-6, both dated August 1995, the sheet pile sections were BZ 250 with 12.8 metre long sections. Based on the information provided, the sheet piling extends to elevation 163.6 to 164.7 metres. A single line of tie rods were installed 1.2 metres below the top of the cedar pile cap. The anchors were affixed to an anchor wall 15.2 metres behind the main wall.

### **6.3.2 New Sheet Pile Walls**

The subsurface conditions encountered at boreholes 1, 8 and 9 typically consisted of 3.7 to 4.4 metres of surficial loose to very dense granular fill to about elevation 173 metres. The fill contained debris such as glass, bricks, concrete, cobbles and boulders. The fill is underlain by soft to stiff clayey silt to elevation 153 to 154 metres. A layer of silty clay was found within the clayey silt deposit between elevations 173 and 167 metres. A 1 to 2 metre thick layer of dense sandy silt till to stiff clayey silt till was encountered beneath the lower clayey silt. Shaley limestone bedrock was encountered at elevation 152 metres below 24 to 25 metres of overburden. Artesian groundwater conditions were noted near elevation 151 metres in the bedrock.

### **6.3.3 Anchor Walls for New Sheet Pile Walls**

Boreholes 5, 6, 8, 11 were advanced in the areas proposed for installation of the three sections of anchor walls. The subsurface conditions generally consist of 3.8 to 5.2 metres of primarily loose to dense granular fill containing bricks, concrete, wood, topsoil and glass. The fill was underlain by very soft to firm silty clay from elevation 172 to 173 metres at boreholes 5 and 6. Boreholes 8 and 11 encountered an upper very soft to firm clayey silt layer beneath the fill at elevation 173 metres. The upper clayey silt layer was underlain by very soft to soft silty clay from elevation 170 to 173 metres. A lower layer of firm to stiff clayey silt was encountered at elevation 167 metres. Groundwater was measured in the silty sand fill in borehole 5 at elevation 174.6 metres. The long term groundwater level is expected to reflect the river water levels.

#### Placement of Anchor Walls

The design for the anchored sheet pile walls features a ramp wall with anchors located between the existing sheet pile and anchor walls, and the anchor wall for the dock wall at right angles to both the anchor wall for the return wall and the return wall as outlined on Figure 2.

Where feasible, the walls should be designed to ensure that there is no overlap between either the passive zones in front of perpendicular anchor walls or overlap between active zones behind the sheet pile walls and passive zones in front of anchor walls.

Based on the proposed anchor wall configuration, some overlap does occur where the south end of the anchor wall for the return wall is within 12 metres of the anchor wall for the dock wall. In this case, the capacity of the return wall anchor wall should be reduced by 20 per cent for the southerly 8 metres or the bottom of the wall stepped to avoid overlap of the theoretical passive failure zones.

### 6.3.4 Geotechnical Parameters

The stratigraphy encountered in the boreholes is summarized in the preceding section and detailed on the Record of Borehole sheets. Pertinent details are summarized in the following table:

<u>BOREHOLE</u>	<u>EXISTING GROUND SURFACE ELEVATION</u> (m)	<u>BOTTOM OF DOCK FILL</u> (m)	<u>FILL DEPTH</u> (m)	<u>TILL SURFACE ELEVATION</u> (m)	<u>ROCK SURFACE ELEVATION</u> (m)
1	176.43	172.77	3.66	154.18	152.35
5	176.98	171.80	5.18	-	-
6	177.23	173.12	4.11	-	-
8	176.97	172.55	4.42	-	-
9	176.99	172.72	4.27	153.06	152.00
11	177.24	173.43	3.81	-	-

It is understood that soil parameters are required to analyze the stability of the existing sheet pile walls at the dock and to design the new and realigned sheet pile walls and their associated anchor walls. Based on the subsurface conditions encountered in the boreholes, the following parameters are recommended for the analyses and design of the sheet pile walls in accordance with the Canadian Highway Bridge Design Code (CHBDC)

<u>UNIT WEIGHT</u> (kN/m <sup>3</sup> )		<u>INTERNAL ANGLE OF FRICTION</u> (degrees)	<u>COEFFICIENTS OF LATERAL EARTH PRESSURE</u>		<u>UNDRAINED SHEAR STRENGTH</u> (kPa)
<u>Total</u>	<u>Submerged</u>		<u>'active', K<sub>a</sub></u>	<u>'passive', K<sub>p</sub></u>	
Existing Fill, Ground Surface to elevation 172 metres					
21	11	30	0.33	3.00	-
Silty Clay, elevation 172 to 167 metres					
-	7	21	0.47	2.10	20
Clayey Silt, elevation 167 to 153 metres					
-	11	28	0.36	2.77	22

The ground surface is at approximately elevation 177.0 metres. The Detroit River water level was at approximately elevation 174.8 metres.

Consistent with our assessment of the soil conditions, the earth pressure coefficients noted above have not been adjusted for wall friction. If granular backfill is to be used during construction, a total unit weight of 20 kilonewtons per cubic metre and an active coefficient of earth pressure of 0.3 can be assumed.

An unbalanced water head behind the sheeting of at least 0.3 metres should be included in the structural analyses. In addition, the analyses should address the potential for future dredging, if required, for dock and ferry operations and/or the potential for additional scour.

### **6.3.5 Geotechnical Considerations**

A conventional factor of safety of 1.3 should be applied to the calculated depth of embedment or alternatively, a factor of safety of 1.5 should be applied to  $K_p$ . The degree to which forces between the soil and steel sheeting can be mobilized will be dependent on the amount of relative movement which has or can occur.

### **6.3.6 Construction Considerations**

It should be noted that coarse debris such as bricks and large pieces of concrete (cobble to boulder sizes) were found in the fill along the riverbank and on the off shore slope. Therefore, it may be necessary to pre-excavate the fill to facilitate the installation of the sheeting. The Contract Documents should contain an NSSP relating to the potential need for pre-excavation.

The survey drawings provided by Stantec indicate that an underground Bell Telephone conduit is present in the area of the new anchor wall north of the Customs Building and a communications conduit is present in the anchor wall area south of the building. It will be necessary to identify, accurately locate and possibly relocate any buried utilities which are present in the footprints of the new sheet pile and anchor walls and related works.

## **6.4 Adjustable Ramp**

Design sections for the proposed adjustable ramp which will facilitate loading and unloading of the ferry were provided by Shoreplan Engineering Limited. The ramp will be designed to operate with design high and low river water levels of 175.5 and 174.0 metres, respectively.

The subsoils encountered in the single borehole advanced at this location consist of 3.7 metres of loose to very dense fill to elevation 173 metres. The fill is underlain by extensive deposits of typically soft to stiff silty clay to clayey silt which extends to elevation 154 metres. Dense sandy silt was encountered beneath the clayey silt to elevation 152 metres. The depth of overburden is approximately 24 metres with the bedrock surface being at approximately elevation 152 metres. Flowing artesian conditions were encountered within the shaley limestone with an estimated elevation head of 178.7 metres. Groundwater was also encountered in the casing at elevation 174.3 metres during drilling. The water level in the river varied during drilling from 174.8 to 174.9 metres.

Filling of the area behind the new steel sheet pile walls will induce settlements in the order of 200 millimetres and the use of deep foundations for the ramp is therefore recommended.



### **6.4.1 Deep Foundations**

H-piles or steel tube piles driven open ended to practical refusal into the bedrock are considered suitable for support of the ramp structure.

#### **Geotechnical Axial Resistance – Driven Steel H-Piles**

It is anticipated that HP 310 x 110 piles can be driven to practical refusal in the shaley limestone bedrock to about elevation 150.5 metres.

A factored resistance at ULS of 2,000 kN per pile can be used for H-piles driven and seated into the bedrock. This value takes into account the structural capacity of the pile. Since the piles will be terminated on bedrock, a SLS value is not provided because the limestone bedrock is considered to be an unyielding medium. Under such conditions, SLS values (for 25 millimetres of settlement) do not govern design since the SLS value will be much higher than the ULS value.

The H-piles should be equipped with Type I driving shoes as specified in OPSD 3000.100. The H-piles should be installed and monitored in accordance with SP903S01 and OPSD 3000.150.

The pile driving note to be added to the drawings is: "Piles to be driven to bedrock".

#### **Geotechnical Axial Resistance – Driven Steel Tube Piles**

It is anticipated that nominal 325 millimetre diameter pipe piles can be driven to practical refusal in the shaley limestone bedrock at about elevation 151.5 metres. To prevent damage to pile tips and preserve access for installation of rock anchors, it is important that tube piles are not overdriven.

A factored resistance at ULS of 2, 000 kN per pile can be used for piles driven and seated on the bedrock below approximately elevation 152 metres. This value takes into account the structural capacity of the pile. Since the piles will be terminated on bedrock, a SLS value is not provided because the limestone bedrock is considered to be an unyielding medium. Under such conditions, SLS values (for 25 millimetres of settlement) do not govern design since the SLS value will be much higher than the ULS value.

The piles should be equipped with driving shoes as specified in OPSD 3001.100. For vertically driven piles, Type I driving shoes are to be used. Inclined piles require the use of Type II driving shoes. Splices for tube piles should conform to OPSD 3001.150. The tube piles should be installed and monitored in accordance with SP903S01 and OPSD 3001.150.

The pile driving note to be added to the drawings is: "Piles to be driven to bedrock".

### Resistance to Lateral Loads

The lateral loading could be resisted fully or partially by the use of inclined piles. The horizontal reaction to the pile can be estimated using the following equation and ranges in subgrade reaction coefficient where:

$$k_s = \begin{aligned} &\text{coefficient of horizontal subgrade reaction (MPa/m)} \\ &= n_h (z/d) \quad \text{for cohesionless soils} \\ &= \frac{67 S_u}{d} \quad \text{for cohesive soils} \end{aligned}$$

$d$  = pile width or diameter (m)

$n_h$  = constant of horizontal subgrade reaction (MPa/m)

$S_u$  = undrained shear strength of the soil (MPa)

$z$  = depth below ground surface grade (m)

SOIL TYPE	ELEVATION (m)		$n_h$ (MPa/m)	$S_u$ (MPa)
	From	To		
Loose to very dense fill (sand and gravel, silty sand, sandy silt)	Surface	173	2 – 5	-
Soft silty clay	173	169	-	0.020
Soft to stiff clayey silt	169	154	-	0.022
Dense sandy silt till	154	152	10 - 12	-

Group action for lateral loading should be considered when the pile spacing in the direction of the loading is less than six to eight pile diameters. Group action can be evaluated by reducing the coefficient of horizontal subgrade reaction in the direction of loading by a reduction factor  $R$  as follows:

<i>Pile Spacing in Direction of Loading, <math>d</math> = Pile Diameter</i>	<i>Subgrade Reaction Reduction Factor <math>R^2</math></i>
8d	1.00
6d	0.70
4d	0.40
3d	0.25

A maximum lateral resistance of 120 kN at ULS and 35 kN at SLS is recommended for HP310 x 110 piles. For nominal 325 millimetre diameter tube piles, a maximum lateral resistance of 120 kN at ULS and 45 kN at SLS is recommended.

<sup>2</sup> Foundations and Earth Structures – Design Manual 7.2, NAVFAC DM-7.2. Department of the Navy, Naval Facilities Engineering Command (1982).

### Construction Considerations

The surficial fill contains rubble such as concrete and bricks as well as cobbles and boulders. It may be necessary to pre-auger through the fill in order to reduce the possibility of damage to the piles during installation. A NSSP should be included in the Contract Documents to alert the Contractor to the presence of these materials.

Hard driving conditions may be encountered in the dense sandy silt till between elevations 152 and 154 metres.

## **6.5 High Mast Lighting**

A high mast light will be installed in the staging area near the location of borehole 7 as shown in Figure 2. Soil conditions generally consist of 2.6 metres of surficial crushed granular or sandy silt fill which is loose to dense. An upper layer of firm to stiff clayey silt was encountered below elevation 175 metres. Beneath the upper clayey silt was a layer of firm silty clay from elevation 173 metres. The borehole was terminated in a layer of firm to stiff clayey silt which was found at elevation 169 metres. The most recent groundwater level measured indicated the groundwater level at elevation 176 metres.

The high mast light should be designed in accordance with the MTO *Guidelines for the Design of High Mast Pole Foundations*, 4th Edition (2004) and the CHBDC (2006) Section 6.13.

### **6.5.1 Design Parameters**

The following unfactored parameters may be used for the design of the high mast light foundation. It is assumed that the foundation will consist of a drilled, cast-in-place, concrete caisson.

<u>SOIL TYPE</u>	<u>TOTAL UNIT WEIGHT <math>\gamma</math> (KN/m<sup>3</sup>)</u>	<u>COHESION <math>c_u</math> (kPa)</u>	<u>SHAFT ADHESION FACTOR <math>\alpha</math></u>	<u>BEARING CAPACITY FACTOR <math>N_t</math></u>	<u>SHAFT RESISTANCE FACTOR <math>\beta</math></u>	<u><math>K_p</math></u>	<u>FRICTION ANGLE (°)</u>
Fill	21	-	-	20	0.3	3.0	30
Silty Clay	17	25	0.3	-	-	-	-
Clayey Silt	21	30	0.3	-	-	-	-

### **6.5.2 Vertical Loads**

Based on the subsurface conditions encountered in the boreholes, the unfactored unit shaft resistance that may be used in the assessment of the vertical load carrying capacity of the portions of the caisson in the clayey silt or silty clay cohesive soils may be calculated using the following equation:

$$F_s = \alpha c_u d C$$

where  $\alpha$  is a shaft resistance factor and  $d$  is the depth along the caisson,  $C$  is the circumference of the caisson, and  $c_u$  is the average layer undrained shear strength.

Where cohesionless soils are present, the unfactored unit shaft resistance of the caisson may be calculated by:

$$F_s = \Sigma (Cq_s \Delta z)$$

where  $F_s$  = unfactored axial capacity of the caisson (kN)  
 $C$  = circumference of the caisson (m)  
 $\Delta z$  = elemental layer thickness (m)  
 $q_s$  = shear stress along the shaft =  $\beta \sigma_v'$   
 $\beta$  = shaft resistance factor

The shear stress may be calculated using the vertical effective stress, in kPa, adjacent to the caisson. A groundwater level at elevation 176 metres should be assumed for design.

The upper 1.2 metres below the ground surface should be neglected to account for frost action. Any portion of the caisson within fill materials should also be neglected.

The component of vertical load carrying capacity that may be derived from end bearing in the cohesive soils may be calculated using the following equation:

$$Q_b = 6c_u A_b$$

where  $c_u$  is the undrained shear strength of the cohesive founding layer and  $A_b$  is the cross-sectional area of the caisson.

Where cohesionless soils are present, the end bearing resistance of the caisson may be calculated by:

$$Q_b = A_t q_b$$

where  $Q_b$  = unfactored end bearing resistance of the caisson (kN)  
 $q_b$  = bearing capacity of the caisson base =  $N_t \sigma_b'$   
 $N_t$  = bearing capacity factor

The bearing capacity at the base of the caisson may be calculated using the vertical effective stress at the caisson base in kPa. A groundwater level at elevation 176 metres should be assumed for design.

A resistance factor of 0.4 should be applied to obtain the factored axial resistance at ULS. The axial resistance at SLS is greater than at ULS and ULS values will govern design. Assuming a 1 metre diameter caisson, a factored end bearing geotechnical resistance at ULS of 90 kN may be used for the caisson founded in the firm to stiff silty clay/clayey silt material at about elevation 169 metres.

### 6.5.3 Lateral Loads

The lateral loads exerted by the caisson will be resisted primarily by cohesive soils.

The lateral resistance of the cohesive soils along the shaft is represented by a distribution which is limited to  $2c_u$ , where  $c_u$  is the undrained shear strength in kPa at the surface, and increases linearly to  $9c_u$  at a depth of three pile diameters and deeper. The pressure should be converted into a passive resistance by using a bearing width,  $B$  in metres, equivalent to the shaft diameter. The unfactored lateral force resisted by a shaft of length  $L$  metres is given by:

$$\begin{aligned} P &= p B (L - 2.6B) && \text{where } p \text{ ranges from } 2c \text{ to } 9c \text{ above a depth of } 3B \\ &= 9c_u B (L - 2.6B) && \text{below a depth of } 3B \end{aligned}$$

Where the lateral loading exerted by the caisson will be resisted by cohesionless soils, the unfactored passive lateral earth pressure,  $P$ , distributed along the unit length of the caisson foundation may be calculated using the following equations:

$$\begin{aligned} P &= K_p \gamma d && \text{above the groundwater level, and} \\ P &= K_p \gamma d_w + K_p \gamma' (d - d_w) && \text{below the groundwater level;} \end{aligned}$$

where  $K_p$  is the passive earth pressure coefficient;  
 $\gamma$  is the total unit weight ( $\text{kN/m}^3$ );  
 $\gamma'$  is the effective unit weight of soil below the groundwater level ( $\text{kN/m}^3$ ) =  $\gamma - \gamma_w$ ;  
 $\gamma_w$  is the unit weight of water ( $\text{kN/m}^3$ );  
 $d$  is the depth below the ground surface (m); and  
 $d_w$  is the depth to the groundwater level (m).

In cohesionless soils, the lateral earth pressures may be assumed to act over an equivalent width equal to three times the caisson diameter. Also, large deformations (lateral movement) would be required to fully mobilize lateral shaft resistance.

A resistance factor of 0.5 should be applied to this calculated lateral resistance in order to obtain the factored lateral geotechnical resistance.

The passive resistance in front of the caisson within the upper 1.2 metres below the ground surface should also be neglected in the design of the foundation to account for frost action. The design frost depth for this site is 1.2 metres.

#### 6.5.4 Construction Considerations

A temporary liner advanced prior to or during drilling will be required to support the sides of the excavation and permit cleaning and inspection of the base. Occasional obstructions due to cobbles and boulders should be expected in the fill. Careful cleaning of the base of the caisson should be carried out prior to placement of concrete to remove all loosened or disturbed material. Surface water run off should be directed away from the excavations. The appropriate NSSP relating to obstructions should be included in the Contract Documents.

### 6.6 Dredging

The limits of the dredging area are shown on Figure 2. Much of the dredging will occur in the vicinity of the new barge and tug area and along the shoreline immediately to the south. The proposed dredge depths are summarized as follows:

<u>LOCATION</u>	<u>DREDGE DEPTHS</u>	
	<u>Below Datum</u> (m)	<u>Elevation</u> (m)
In front of extension wall (south end)	4.0	170.0
In front of extension wall (north end)	1.5	172.5
In front of ramp wall	4.0	170.0
In front of dock wall	4.0	170.0
In front of return wall	4.0	170.0
General dredge area	3.5	170.5

Three boreholes, 10, 12 and 13, were advanced within the limits of the dredge area. The subsurface conditions consisted of at least 0.3 metres of fill containing organic material, glass and brick. Due to the limitations of the manual drilling method, the full depth of the fill could not be explored at boreholes 10 and 13. However, the depth of fill is variable and should be expected to extend below 171 metres.

The subsurface conditions are summarized on the following table:

<u>BOREHOLE</u>	<u>RIVER WATER LEVEL ELEVATION*</u> (m)	<u>DEPTH OF WATER</u> (m)	<u>ELEVATION OF FILL SURFACE</u> (m)	<u>FILL THICKNESS</u> (m)
10	174.60	1.22	173.38	>0.46
12	174.60	1.68	172.62	0.3
13	174.60	1.52	173.08	>1.53

\* river water level at time of borehole drilling

The presence of larger particles and debris in the materials to be dredged should be expected. Dredging should be designed such that slopes no greater than 10 horizontal to 1 vertical are created.

## **6.7 Truck Ferry Administration Kiosk**

A new kiosk is proposed for the site. The kiosk will measure approximately 2.6 metres by 5.9 metres in plan and will be 3.5 metres high. The closest borehole to the site of the future kiosk is borehole 7. Based on borehole 7, the soil stratigraphy is expected to consist of approximately 0.5 metres of surficial crushed rock fill, underlain by 2 metres of loose to dense sandy silt fill containing concrete. An upper layer of firm to stiff clayey silt was encountered beneath the fill from elevation 175 metres. The clayey silt was underlain by a 4 metre thick layer of firm silty clay from elevation 173 metres. The silty clay was underlain by the firm to stiff lower clayey silt from elevation 169 metres. The groundwater level was measured at elevation 176.1 metres on October 15, 2007.

### **6.7.1 Shallow Foundations**

The kiosk is expected to be a very lightly loaded structure. Therefore, as such, the kiosk can be founded on the upper firm to stiff clayey silt layer at or below about elevation 175 metres. A factored geotechnical resistance of 175 kilopascals at ULS and a geotechnical resistance of 100 kilopascals at SLS can be used for the design of strip or spread footings for the kiosk. The SLS value assumes a maximum settlement of 25 millimetres.

The geotechnical resistances provided are given under the assumption that the loads will be applied perpendicular to the surface of the footings; where the load is not applied perpendicular to the surface of the footing, inclination of the load should be taken into account in accordance with the current Canadian Highway Bridge Design Code (CHBDC).

The above geotechnical resistances assume, however, that appropriate construction procedures are adopted during footing construction to ensure that the founding soils are not softened/disturbed prior to concrete placement.

#### **Frost Protection**

All footings should be provided with a minimum of 1.2 metres of earth cover or equivalent thermal insulation for frost protection purposes.

### Construction Considerations

The founding soils are sensitive to disturbance and loosening due to water seepage and/or ponding. Placement of a working slab will be required at the base of excavation for the footing area. Exposure without protection of the working slab may result in loosening of the founding soils. The cleaned excavation base should be inspected by qualified geotechnical personnel prior to placing the working slab. It is recommended that the footing excavation be carried out such that the final 0.5 metres of excavation is completed with the geotechnical personnel on site and the working slab be placed immediately after footing inspection.

#### **6.7.2 Foundation Excavations and Backfill**

All excavations at the site should be conducted in accordance with the recommendations in Section 6.8. During placement and compaction of the backfill for the foundation walls, care should be taken to maintain equal levels of fill on both sides of the foundation walls. The backfill should consist of free draining, non-frost susceptible material such as Granular B Type III. The granular fill should be placed in lifts with a maximum loose thickness of 200 millimetres and compacted.

The excavated fill material contains debris such as concrete and may be saturated. Therefore, it is unsuitable for reuse as engineered or structural fill.

#### **6.7.3 Slab-on-Grade**

The existing fill materials within the footprint of the proposed kiosk contains concrete debris and varies in density from loose to dense. If post construction settlement cannot be tolerated, all fill materials within a minimum distance of the building footing equal to the depth of the existing fill plus 1 metre should be sub-excavated and replaced with engineered fill comprised of Granular A. The Granular A should be placed in loose lifts no greater than 300 millimetres and compacted. The engineered fill must be constructed on a properly prepared subgrade which has been approved by suitably qualified geotechnical personnel.

If some post construction settlement of the slab can be tolerated then the proposed slab-on-grade area can be subexcavated to a minimum depth of 200 millimetres below the underside of slab to remove any deleterious materials such as organics, debris etc.

The existing subgrade is expected to consist of sandy silt which should be proofrolled in the presence of qualified geotechnical personal. Any low areas can be brought up to grade using Granular A to within 200 millimetres of the underside of slab. Remedial work should be carried out on any loose, disturbed, wet or poorly performing areas as directed by the Contract Administrator.



The slab-on-grade should be constructed on layer of Granular A with a minimum thickness of 200 millimetres and a vapour barrier provided below the slab.

The surface should be graded such that all surface flows are directed away from the structure.

## **6.8 Excavations and Temporary Cut Slopes**

Excavations for the installation of anchor walls and possibly for installation of the tiebacks will be required. The excavations will extend through the existing surficial topsoil and fill and may extend into the underlying native soils which are predominantly cohesive in nature. The fill was noted to contain rubble such as concrete, bricks, wood, glass and cinders. Perched groundwater conditions should be expected in the granular fill. If groundwater is encountered in the fill, the flow should be controlled using properly filtered sumps. It may be necessary to use flatter slopes or blanket the excavation slopes with free draining coarse granular materials to facilitate drainage and enhance slope stability.

All excavations must be carried out in accordance with the latest edition of the Occupational Health and Safety Act and Regulations for Construction Projects.

## **7.0 CLOSURE**

This report was prepared by Ms. Dirka U. Prout, P. Eng. under the direction of the Project Manager, Mr. Philip R. Bedell, P. Eng. This report was reviewed by Mr. Fintan J. Heffernan, P. Eng., the Designated MTO Contact and Quality Control Auditor for this assignment.

### **GOLDER ASSOCIATES LTD.**

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Principal

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Designated MTO Contact

DUP/PRB/FJH/cr  
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## LIST OF ABBREVIATIONS

The abbreviations commonly employed on Records of Boreholes, on figures and in the text of the report are as follows:

### I. SAMPLE TYPE

AS	Auger sample
BS	Block sample
CS	Chunk sample
SS	Split-spoon
DS	Denison type sample
FS	Foil sample
RC	Rock core
SC	Soil core
ST	Slotted tube
TO	Thin-walled, open
TP	Thin-walled, piston
WS	Wash sample

### III. SOIL DESCRIPTION

#### (a) Cohesionless Soils

Density Index (Relative Density)	N Blows/300 mm or Blows/ft.
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

### II. PENETRATION RESISTANCE

#### Standard Penetration Resistance (SPT), N:

The number of blows by a 63.5 kg. (140 lb.) hammer dropped 760 mm (30 in.) required to drive a 50 mm (2 in.) split spoon sampler for a distance of 300 mm (12 in.)

#### (b) Cohesive Soils

Consistency	$c_u, s_u$ kPa	psf
Very soft	0 to 12	0 to 250
Soft	12 to 25	250 to 500
Firm	25 to 50	500 to 1,000
Stiff	50 to 100	1,000 to 2,000
Very stiff	100 to 200	2,000 to 4,000
Hard	over 200	over 4,000

#### Dynamic Cone Penetration Resistance; $N_d$ :

The number of blows by a 63.5 kg. (140 lb.) hammer dropped 760 mm (30 in.) to drive uncased a 50 mm (2 in.) diameter, 60° cone attached to "A" size drill rods for a distance of 300 mm (12 in.).

**PH:** Sampler advanced by hydraulic pressure

**PM:** Sampler advanced by manual pressure

**WH:** Sampler advanced by static weight of hammer

**WR:** Sampler advanced by weight of sampler and rod

#### Piezo-Cone Penetration Test (CPT)

A electronic cone penetrometer with a 60° conical tip and a project end area of 10 cm<sup>2</sup> pushed through ground at a penetration rate of 2 cm/s. Measurements of tip resistance ( $Q_t$ ), porewater pressure (PWP) and friction along a sleeve are recorded electronically at 25 mm penetration intervals.

### IV. SOIL TESTS

w	water content
$w_p$	plastic limit
$w_l$	liquid limit
C	consolidation (oedometer) test
CHEM	chemical analysis (refer to text)
CID	consolidated isotropically drained triaxial test <sup>1</sup>
CIU	consolidated isotropically undrained triaxial test with porewater pressure measurement <sup>1</sup>
$D_R$	relative density (specific gravity, $G_s$ )
DS	direct shear test
M	sieve analysis for particle size
MH	combined sieve and hydrometer (H) analysis
MPC	Modified Proctor compaction test
SPC	Standard Proctor compaction test
OC	organic content test
$SO_4$	concentration of water-soluble sulphates
UC	unconfined compression test
UU	unconsolidated undrained triaxial test
V	field vane (LV-laboratory vane test)
$\gamma$	unit weight

**Note:** 1 Tests which are anisotropically consolidated prior to shear are shown as CAD, CAU.

## LIST OF SYMBOLS

Unless otherwise stated, the symbols employed in the report are as follows:

### I. General

$\pi$	3.1416
$\ln x$ ,	natural logarithm of x
$\log_{10}$	x or log x, logarithm of x to base 10
g	acceleration due to gravity
t	time
F	factor of safety
V	volume
W	weight

### II. STRESS AND STRAIN

$\gamma$	shear strain
$\Delta$	change in, e.g. in stress: $\Delta \sigma$
$\epsilon$	linear strain
$\epsilon_v$	volumetric strain
$\eta$	coefficient of viscosity
$\nu$	poisson's ratio
$\sigma$	total stress
$\sigma'$	effective stress ( $\sigma' = \sigma - u$ )
$\sigma'_{vo}$	initial effective overburden stress
$\sigma_1, \sigma_2, \sigma_3$	principal stress (major, intermediate, minor)
$\sigma_{oct}$	mean stress or octahedral stress $= (\sigma_1 + \sigma_2 + \sigma_3)/3$
$\tau$	shear stress
u	porewater pressure
E	modulus of deformation
G	shear modulus of deformation
K	bulk modulus of compressibility

### III. SOIL PROPERTIES

#### (a) Index Properties

$\rho(\gamma)$	bulk density (bulk unit weight*)
$\rho_d(\gamma_d)$	dry density (dry unit weight)
$\rho_w(\gamma_w)$	density (unit weight) of water
$\rho_s(\gamma_s)$	density (unit weight) of solid particles
$\gamma'$	unit weight of submerged soil ( $\gamma' = \gamma - \gamma_w$ )
$D_R$	relative density (specific gravity) of solid particles ( $D_R = \rho_s / \rho_w$ ) (formerly $G_s$ )
e	void ratio
n	porosity
S	degree of saturation

#### (a) Index Properties (continued)

w	water content
$w_l$	liquid limit
$w_p$	plastic limit
$I_p$	plasticity index $= (w_l - w_p)$
$w_s$	shrinkage limit
$I_L$	liquidity index $= (w - w_p) / I_p$
$I_C$	consistency index $= (w_l - w) / I_p$
$e_{max}$	void ratio in loosest state
$e_{min}$	void ratio in densest state
$I_D$	density index $= (e_{max} - e) / (e_{max} - e_{min})$ (formerly relative density)

#### (b) Hydraulic Properties

h	hydraulic head or potential
q	rate of flow
v	velocity of flow
i	hydraulic gradient
k	hydraulic conductivity (coefficient of permeability)
j	seepage force per unit volume

#### (c) Consolidation (one-dimensional)

$C_c$	compression index (normally consolidated range)
$C_r$	recompression index (over-consolidated range)
$C_s$	swelling index
$C_a$	coefficient of secondary consolidation
$m_v$	coefficient of volume change
$c_v$	coefficient of consolidation
$T_v$	time factor (vertical direction)
U	degree of consolidation
$\sigma'_p$	pre-consolidation pressure
OCR	over-consolidation ratio $= \sigma'_p / \sigma'_{vo}$

#### (d) Shear Strength

$\tau_p, \tau_r$	peak and residual shear strength
$\phi'$	effective angle of internal friction
$\delta$	angle of interface friction
$\mu$	coefficient of friction $= \tan \delta$
$c'$	effective cohesion
$c_u, s_u$	undrained shear strength ( $\phi = 0$ analysis)
p	mean total stress $(\sigma_1 + \sigma_3)/2$
$p'$	mean effective stress $(\sigma'_1 + \sigma'_3)/2$
q	$(\sigma_1 + \sigma_3)/2$ or $(\sigma'_1 + \sigma'_3)/2$
$q_u$	compressive strength $(\sigma_1 + \sigma_3)$
$S_t$	sensitivity

- Notes:**
- 1  $\tau = c' + \sigma' \tan \phi'$
  - 2 shear strength = (compressive strength)/2
  - \* density symbol is  $\rho$ . Unit weight symbol is  $\gamma$  where  $\gamma = \rho g$  (i.e. mass density x acceleration due to gravity)

# LITHOLOGICAL AND GEOTECHNICAL ROCK DESCRIPTION TERMINOLOGY

## WEATHERING STATE

Fresh: no visible sign of weathering.

**Faintly weathered:** weathering limited to the surface of major discontinuities.

Slightly weathered: penetrative weathering developed on open discontinuity surfaces but only slight weathering of rock material.

Moderately weathered: weathering extends throughout the rock mass but the rock material is not friable.

Highly weathered: weathering extends throughout rock mass and the rock material is partly friable.  
Completely weathered: rock is wholly decomposed and in a friable condition but the rock texture and structure are preserved.

## BEDDING THICKNESS

<u>Description</u>	<u>Bedding Plane Spacing-</u>
Very thickly bedded	>2 m
Thickly bedded	0.6 m to 2m
Medium bedded	0.2 m to 0.6m
Thinly bedded	60 m to 0.2 m
Very thinly- bedded	20 mm to 60 mm
Laminated	6 mm to 20 mm
Thinly laminated	< 6 mm

## JOINT OR FOLIATION SPACING

<u>Description</u>	<u>Spacing</u>
Very wide	> 3 m
Wide	1 – 3 m
Moderately close	0.3 – 1 m
Close	50 – 300 mm
Very close	< 50 mm

## GRAIN SIZE

Term	Size*
Very Coarse Grained	> 60 mm
Coarse Grained	2 – 60 mm
Medium Grained	60 microns – 2 mm
Fine Grained	2 – 60 microns
Very Fine Grained	< 2 microns

Note: \*Grains >60 microns diameter are visible to the naked eye.

## CORE CONDITION

### Total Core Recovery (TCR)

The percentage of solid drill core recovered regardless of quality or length, measured relative to the length of the total core run.

### Solid Core Recovery (SCR)

The percentage of solid drill core, regardless of length, recovered at full diameter, measured relative to the length of the total core run.

### Rock Quality Designation (RQD)

The percentage of solid drill core, greater than 100 mm length, recovered at full diameter, measured relative to the length of the total core run. RQD varies from 0% for completely broken core to 100% for core in solid sticks.

## DISCONTINUITY DATA

### Fracture Index

A count of the number of discontinuities (physical separations) in the rock core, including both naturally occurring fractures and mechanically induced breaks caused by drilling.

### Dip with Respect to (W.R.T.) Core Axis

The angle of the discontinuity relative to the axis (length) of the core, In a vertical borehole a discontinuity with a 90° angle is horizontal.

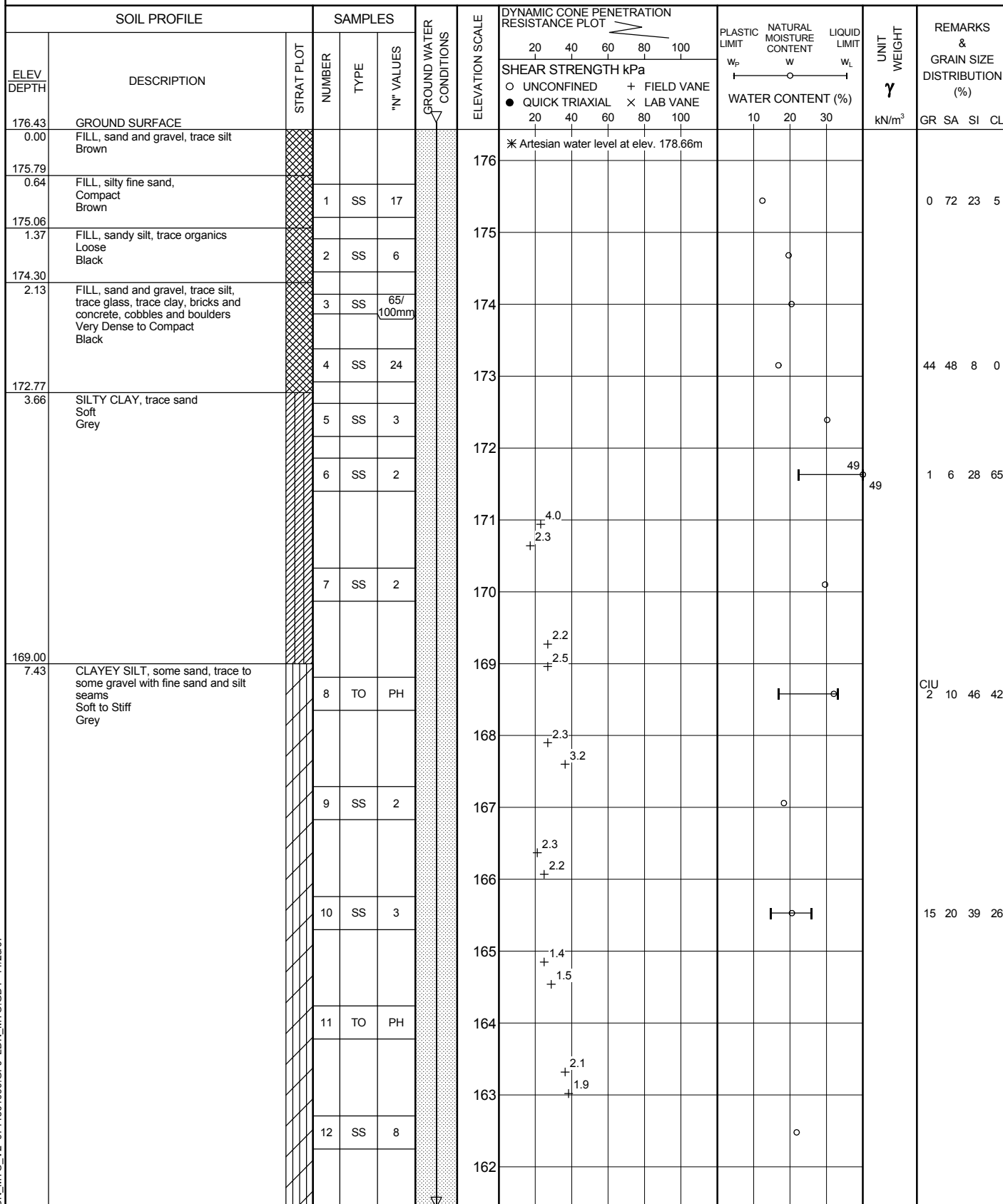
### Description and Notes

An abbreviated description of the discontinuities, whether naturally occurring separations such as fractures, bedding planes and foliation planes or mechanically induced features caused by drilling such as ground or shattered core and mechanically separated bedding or foliation surfaces. Additional information concerning the nature of fracture surfaces

### Abbreviations

B – Bedding	P - Polished
FO - Foliation Schistosity	S - Slickensided
CL - Cleavage	SM - Smooth
SH - Shear Plane Zone	R - Ridged / Rough
VN - Vein	ST - Stepped
F - Fault	PL - Planar
CO - Contact	FL - Flexured
J - Joint	UE - Uneven
FR - Fracture	W - Wavy
M F - Mechanical Fracture	C - Curved
- Parallel To	
⊥ - Perpendicular To	

PROJECT	07-1130-109-0		
G.W.P.	3071-06-00	LOCATION	N 4681695.5 ; E 326636.1
DIST	1	HWY	
		BOREHOLE TYPE	Power Auger (Hollow Stem), Rotary Drilling (NW Casing)
DATUM	GEODETIC	DATE	July 23, 2007 - July 24, 2007
		ORIGINATED BY	DM
		COMPILED BY	BRS/LMK
		CHECKED BY	



Continued Next Page

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+ 3, × 3: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

PROJECT		07-1130-109-0		RECORD OF BOREHOLE No 1		2 OF 3		METRIC	
G.W.P.		3071-06-00		LOCATION		N 4681695.5 ;E 326636.1		ORIGINATED BY	
DIST		1		HWY		BOREHOLE TYPE		Power Auger (Hollow Stem), Rotary Drilling (NW Casing)	
DATALOG		GEODETIC		DATE		July 23, 2007 - July 24, 2007		COMPILED BY	
								BRS/LMK	
								CHECKED BY	

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+ 3, × 3: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

**RECORD OF BOREHOLE No 1**


3 OF 3

**METRIC**

PROJECT 07-1130-109-0 LOCATION N 4681695.5 ; E 326636.1 ORIGINATED BY DM  
G.W.P. 3071-06-00 DIST 1 HWY  BOREHOLE TYPE Power Auger (Hollow Stem), Rotary Drilling (NW Casing) COMPILED BY BRS/LMK  
DATUM GEODETIC DATE July 23, 2007 - July 24, 2007 CHECKED BY

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT $\gamma$	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			"N" VALUES	20	40	60	80	100	W <sub>p</sub>	W		
	Artesian conditions encountered at elev. 150.98m during drilling on July 24, 2007. Estimated elev. head of 178.66m.															

ONL\_MTO\_V2 0711301090.GPJ LDN\_MTO.GDT 11/28/07

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

○ 3% STRAIN AT FAILURE



# RECORD OF BOREHOLE No 2

1 OF 2

**METRIC**

PROJECT 07-1130-109-0

G.W.P. 3071-06-00

LOCATION N 4681717.2 ; E 326635.8

ORIGINATED BY DM

DIST 1 HWY

BOREHOLE TYPE Rotary Drilling (NW Casing)

COMPILED BY BRS/LMK

DATUM GEODETIC

DATE July 25, 2007 - July 26, 2007

CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT   NATURAL MOISTURE CONTENT   LIQUID LIMIT			UNIT WEIGHT  $\gamma$  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)					
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa		W <sub>P</sub>	W	W <sub>L</sub>							
								○ UNCONFINED   + FIELD VANE	WATER CONTENT (%)										
						● QUICK TRIAXIAL   × LAB VANE	20   40   60   80   100	20   40   60   80   100	10   20   30				GR	SA	SI	CL			
174.78 0.00	RIVER WATER LEVEL WATER																		
172.86 1.92	SANDY SILT, with wood Very Loose Grey to black		1	SS	WR								126						
171.88 2.90	SILTY CLAY, trace sand, trace gravel Soft to Firm Grey		2	SS	1								53						
			3	SS	1			2.0						53		2	12	31	55
			4	TO	PH			2.4											
								24.9											
								2.1											
								2.3											
			5	TO	PH									59					
166.55 8.23	CLAYEY SILT, trace to some sand, trace gravel with sand seams Soft to Very Stiff Grey													57		CIU 0	3	19	78
			6	SS	3			2.1											
								2.1											
			7	SS	5			1.6											
								1.5											
			8	SS	8			1.3											
								1.3											
			9	SS	7			1.6											
								1.4											

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+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

**RECORD OF BOREHOLE No 2**

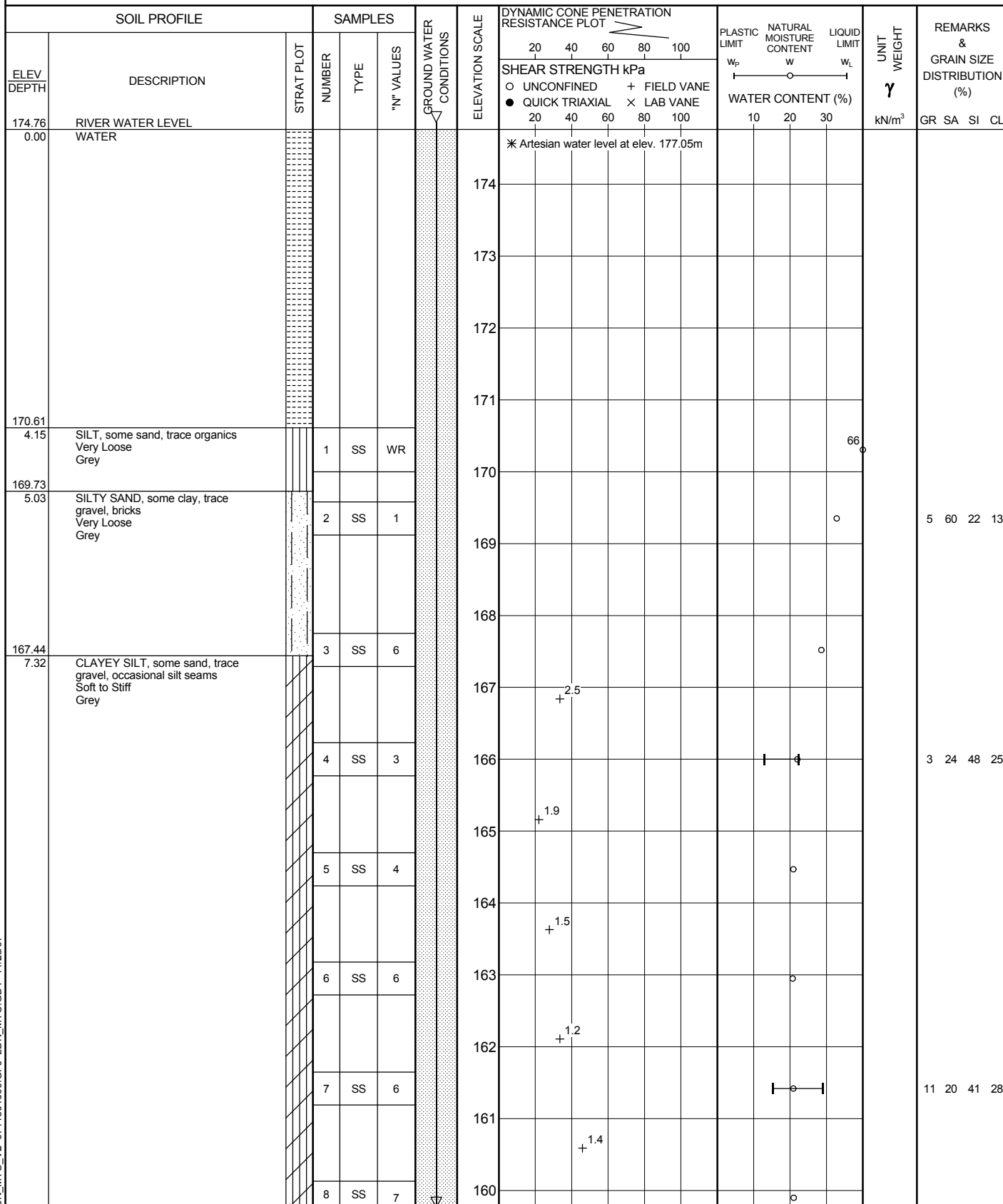
2 OF 2

**METRIC**

PROJECT 07-1130-109-0 G.W.P. 3071-06-00 LOCATION N 4681717.2 ; E 326635.8 ORIGINATED BY DM  
DIST 1 HWY  BOREHOLE TYPE Rotary Drilling (NW Casing) COMPILED BY BRS/LMK  
DATUM GEODETIC DATE July 25, 2007 - July 26, 2007 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT   NATURAL MOISTURE   LIQUID LIMIT LIMIT   CONTENT   LIMIT w <sub>p</sub> w   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 ○ UNCONFINED   + FIELD VANE ● QUICK TRIAXIAL   × LAB VANE		WATER CONTENT (%) 20   40   60   80   100				
			10	SS	16		159							3   34   43   20
							158							
			11	SS	7		157							
							156							
			12	SS	8		155							
							154							
			13	SS	7		153							
			14	SS	10									
152.62														
22.16														
152.22			15	SS	80/									
22.56			16	WS	25mm									
22.71														
	CLAYEY SILT, trace sand, trace gravel (TILL) Grey													
	Pale grey, to brown, laminated SHALEY LIMESTONE with bituminous partings and vuggy bands END OF BOREHOLE													

PROJECT 07-1130-109-0		RECORD OF BOREHOLE No 3		1 OF 2	METRIC
G.W.P. 3071-06-00	LOCATION	N 4681705.2 ;E 326604.2		ORIGINATED BY	DM
DIST 1 HWY	BOREHOLE TYPE	Rotary Drilling (NW Casing)		COMPILED BY	BRS/LMK
DATUM GEODETIC	DATE	July 30, 2007		CHECKED BY	





**RECORD OF BOREHOLE No 4**

1 OF 1

**METRIC**

PROJECT 07-1130-109-0  
G.W.P. 3071-06-00 LOCATION N 4681681.4 ; E 326647.5 ORIGINATED BY DM  
DIST 1 HWY BOREHOLE TYPE Power Auger (Hollow Stem) COMPILED BY BRS/LMK  
DATUM GEODETIC DATE July 31, 2007 CHECKED BY

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							
								○ UNCONFINED	+ FIELD VANE						
176.63	GROUND SURFACE						20	40	60	80	100				
0.00	FILL, sand and gravel with concrete, trace silt Very Dense Brown		1	SS	60/ 150mm										
175.56															
1.07	FILL, sand, trace gravel, some silt, trace clay, concrete Loose Brown to black		2	SS	9										7 75 12 6
			3	SS	9										
173.73															
2.90	FILL, sand and gravel, trace silt, bricks Very Dense to Compact Grey and brown		4	SS	91										60 32 6 2
172.52			5	SS	12										
4.11	SILTY SAND, some gravel, trace organics														
172.21	Loose														
4.42	Brown to black														
171.60	SILTY CLAY, trace sand and gravel		6	SS	5										
5.03	Firm Grey END OF BOREHOLE														
	Groundwater encountered at elev. 173.89m during drilling on July 31, 2007.														

**RECORD OF BOREHOLE No 5**

1 OF 1

**METRIC**

PROJECT 07-1130-109-0  
G.W.P. 3071-06-00 LOCATION N 4681674.5 ; E 326639.4 ORIGINATED BY DM  
DIST 1 HWY BOREHOLE TYPE Power Auger (Hollow Stem) COMPILED BY BRS/LMK  
DATUM GEODETIC DATE July 31, 2007 CHECKED BY

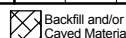
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa									
								○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    × LAB VANE									
								20   40   60   80   100									
						WATER CONTENT (%)											
176.98	GROUND SURFACE																
0.10	FILL, crushed rock  FILL, sand, trace clay, some silt, trace gravel, bricks and glass Loose to Dense Brown to black																
		1	SS	34													
		2	SS	20													
		3	SS	9													
		4	SS	10													
		5	SS	7													
		6	SS	8													
171.80																	
5.18	SILTY CLAY, trace sand Firm Grey																
		7	SS	4													
170.43																	
		8	TO	PH													
6.55	END OF BOREHOLE																
Groundwater encountered at elev. 174.69m during drilling on July 31, 2007.																	
Water level measured in Standpipe at elev. 171.62m following drilling on July 31, 2007																	
Water level measured in Standpipe at elev. 174.63m on August 17, 2007																	



Bentonite Seal



Sand Fill



Backfill and/or  
Caved Material

+ 3, x 3: Numbers refer to  
Sensitivity

○ 3% STRAIN AT FAILURE

**RECORD OF BOREHOLE No 6**

1 OF 1

**METRIC**

PROJECT 07-1130-109-0 LOCATION N 4681640.5 ; E 326616.7 ORIGINATED BY DM  
G.W.P. 3071-06-00 DIST 1 HWY  BOREHOLE TYPE Power Auger (Hollow Stem) COMPILED BY WDF  
DATUM GEODETIC DATE October 9, 2007 CHECKED BY

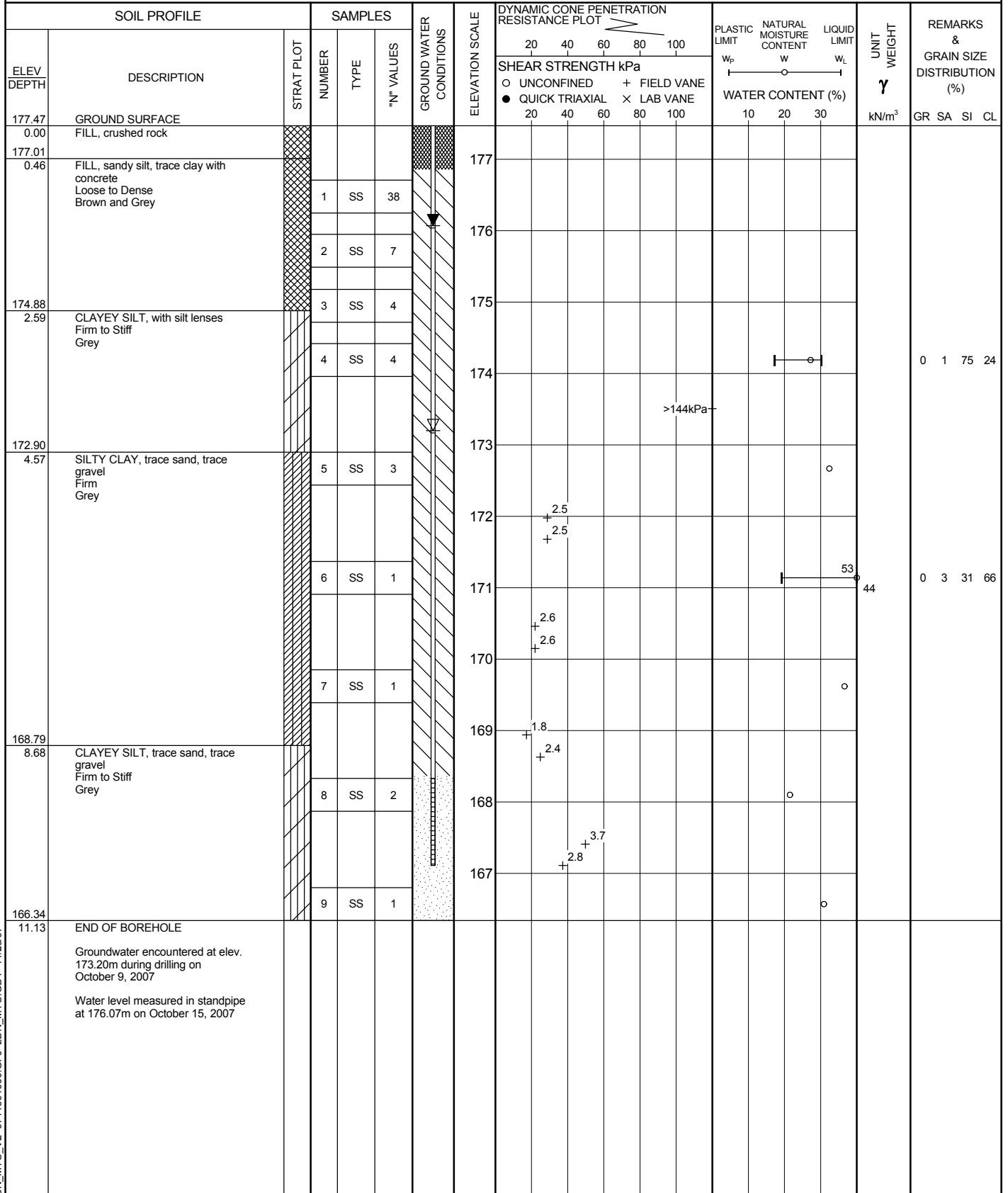
SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT w <sub>p</sub>	NATURAL MOISTURE CONTENT w	LIQUID LIMIT w <sub>L</sub>	UNIT WEIGHT γ  kN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL	
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa ○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    × LAB VANE									WATER CONTENT (%)
177.23	GROUND SURFACE							20	40	60	80	100					
0.00	FILL, crushed sand and gravel Grey						177										
176.83																	
0.40	FILL, silty fine sand Brown																
0.61	FILL, clayey silt, trace sand Firm Black		1	SS	7												
175.86							176										
1.37	FILL, fine to medium sand Loose Brown		2	SS	10												
175.40																	
1.83	FILL, sandy silt, trace clay, with concrete, wood, bricks and topsoil Compact to Dense Black and Grey		3	SS	45		175										
			4	SS	17		174										
173.12			5	SS	6		173										
4.11	SILTY CLAY, trace sand Very Soft to Stiff Grey																
172.20			6	SS	1												
5.03	END OF BOREHOLE																
	Borehole dry during drilling October 9, 2007																

# RECORD OF BOREHOLE No 7

1 OF 1

**METRIC**

PROJECT 07-1130-109-0  
G.W.P. 3071-06-00 LOCATION N 4681677.9 ;E 326691.3 ORIGINATED BY DM  
DIST 1 HWY BOREHOLE TYPE Power Auger (Hollow Stem) COMPILED BY WDF  
DATUM GEODETIC DATE October 9, 2007 CHECKED BY





**RECORD OF BOREHOLE No 8**

1 OF 2

**METRIC**

PROJECT 07-1130-109-0  
G.W.P. 3071-06-00 LOCATION N 4681673.1 ; E 326622.3 ORIGINATED BY DM  
DIST 1 HWY BOREHOLE TYPE Power Auger (Hollow Stem) COMPILED BY WDF  
DATUM GEODETIC DATE October 9, 2007 - October 10, 2007 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT			PLASTIC LIMIT   NATURAL MOISTURE CONTENT   LIQUID LIMIT			UNIT WEIGHT  γ  kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)						
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa			WATER CONTENT (%)										
								○ UNCONFINED ● QUICK TRIAXIAL	+ FIELD VANE × LAB VANE		W <sub>P</sub>	W	W <sub>L</sub>								
176.97	GROUND SURFACE						20	40	60	80	100					GR	SA	SI	CL		
0.00	FILL, sandy silt some gravel Brown		1	AS	-	▽															
176.21	FILL, silty sand, some gravel, trace to some clay, wood, bricks and concrete Loose to Compact Brown and Black		2	SS	9		176														
0.76			3	SS	10		175						○					24	48	16	12
			4	SS	14		174						○					13	56	21	10
			5	SS	8		173														
173.31			6	SS	4		172														
3.66	FILL, silty sand, trace gravel Loose Black		7	SS	2		171														
172.55	CLAYEY SILT, trace sand, trace gravel, with silt seams Very Soft to Soft Grey		8	SS	WH		170														
4.42			9	SS	WH		169														
170.27	SILTY CLAY, trace sand Soft Grey		10	SS	1		168														
6.70			11	SS	2		167														
167.67	CLAYEY SILT, trace sand, trace gravel, with silt seams Firm to Stiff Grey		12	SS	2		166														
9.30			13	SS	3		165														
						164															
						163															

Continued Next Page

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE

**RECORD OF BOREHOLE No 9**

1 OF 3

**METRIC**

PROJECT 07-1130-109-0  
G.W.P. 3071-06-00 LOCATION N 4681658.5 ; E 326615.2 ORIGINATED BY DM  
DIST 1 HWY BOREHOLE TYPE Power Auger (Hollow Stem) - Rotary (Nw Casing) COMPILED BY WDF  
DATUM GEODETIC DATE October 10, 2007 - October 12, 2007 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT NATURAL MOISTURE CONTENT LIQUID LIMIT			UNIT WEIGHT $\gamma$	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			20 40 60 80 100	20 40 60 80 100	W <sub>p</sub>	W	W <sub>L</sub>		
176.99 0.00	GROUND SURFACE		1	AS	-									
176.23 0.76	FILL, fine sand, sandy silt, some fine to coarse gravel Brown		2	SS	7									
			3	SS	6									
			4	SS	36									
			5	SS	50/ 50mm									
			6	SS	50									
172.72 4.27	CLAYEY SILT, trace to some sand, trace gravel, with silt seams Soft to Firm Grey		7	SS	4									
			8	SS	WH									
169.98 7.01	SILTY CLAY, trace sand Firm Grey		9	SS	WH									
168.31 8.68	CLAYEY SILT, trace sand, trace gravel Firm to Stiff Grey		10	SS	1									
			11	SS	2									
			12	SS	1									
			13	SS	1									

Continued Next Page

Grout Filled

+ 3, x 3: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

**RECORD OF BOREHOLE No 9**

2 OF 3

**METRIC**

PROJECT 07-1130-109-0 G.W.P. 3071-06-00 LOCATION N 4681658.5 ; E 326615.2 ORIGINATED BY DM  
DIST 1 HWY  BOREHOLE TYPE Power Auger (Hollow Stem) - Rotary (Nw Casing) COMPILED BY WDF  
DATUM GEODETIC DATE October 10, 2007 - October 12, 2007 CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT	NATURAL MOISTURE CONTENT	LIQUID LIMIT	UNIT WEIGHT  γ  kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)  GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES			SHEAR STRENGTH kPa					W <sub>p</sub>	W	W <sub>L</sub>		
								○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    × LAB VANE						WATER CONTENT (%)			
							20	40	60	80	100						
				14	SS	2											
				15	SS	5											
				16	SS	4											
				17	SS	3											
				18	SS	4											
				19	SS	5											
153.06																	
23.93	CLAYEY SILT, trace sand, trace gravel (TILL) Stiff Grey			20	SS	9											
152.00																	
24.99	Light brown highly weathered SHALEY LIMESTONE																
				21	SS	65											
				22	NQ RC	-											
150.32				23	NQ RC	-											
26.67	Light brown to grey laminated SHALEY LIMESTONE with bituminous partings and vuggy bands			24	NQ RC	-											
147.12																	

Continued Next Page

Grout Filled

+ 3, × 3: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

+<sup>3</sup>, ×<sup>3</sup>: Numbers refer to Sensitivity      ○<sup>3%</sup> STRAIN AT FAILURE

**RECORD OF BOREHOLE No 10**

1 OF 1

**METRIC**

PROJECT 07-1130-109-0 G.W.P. 3071-06-00 LOCATION N 4681672.7 ; E 326611.4 ORIGINATED BY DM  
DIST 1 HWY  BOREHOLE TYPE Manual Drilling COMPILED BY WDF  
DATUM GEODETIC DATE October 15, 2007 CHECKED BY

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 ○ UNCONFINED + FIELD VANE ● QUICK TRIAXIAL × LAB VANE							WATER CONTENT (%)	
174.60 0.00	RIVER WATER LEVEL WATER					▽	174	20	40	60	80	100				
173.38																
1.22	FILL, silty sand with bricks, some gravel		1	SS	36											
172.92	Compact Black and Grey		2	SS	40/ 150mm		173									
1.68	END OF BOREHOLE															

**RECORD OF BOREHOLE No 11**

1 OF 1

**METRIC**

PROJECT 07-1130-109-0  
G.W.P. 3071-06-00 LOCATION N 4681647.4 ; E 326634.3 ORIGINATED BY DM  
DIST 1 HWY  BOREHOLE TYPE Power Auger (Hollow Stem) COMPILED BY WDF  
DATUM GEODETIC DATE October 15, 2007 CHECKED BY

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										WATER CONTENT (%)				
								○ UNCONFINED	+ FIELD VANE	● QUICK TRIAXIAL	× LAB VANE											
177.24	GROUND SURFACE																					
0.00	FILL, crushed sand and gravel, trace silt Brown																					
0.30	FILL, clayey silt, some sand, some gravel Brown  FILL, silty sand and gravel, with clayey silt lumps Compact Brown and Grey		1	SS	15																	
176.63																						
0.61			2	SS	17																	
175.11	FILL, sandy silt, some gravel, with clayey silt layers, concrete Compact Black		3	SS	24																	
2.13			4	SS	50/ 75mm																	
173.43	CLAYEY SILT, trace sand, trace gravel Firm Black and Grey  SILTY CLAY, trace sand Soft to Very Soft Grey		5	SS	4																	
3.81			6	SS	2																	
172.97			7	SS	1																	
4.27																						
171.45	END OF BOREHOLE																					
5.79	Borehole dry during drilling on October 15, 2007																					

# RECORD OF BOREHOLE No 12

1 OF 1

**METRIC**

PROJECT 07-1130-109-0

G.W.P. 3071-06-00

LOCATION N 4681664.7 ; E 326599.9

ORIGINATED BY DM

DIST 1 HWY

BOREHOLE TYPE Manual Drilling

COMPILED BY WDF

DATUM GEODETIC

DATE October 15, 2007

CHECKED BY

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								
								○ UNCONFINED      + FIELD VANE ● QUICK TRIAXIAL    × LAB VANE								
174.60 0.00	RIVER WATER LEVEL WATER						20	40	60	80	100					
172.92 1.68	FILL, sandy silt, trace clay, trace organic material and glass Loose Black		1	SS	6											
1.98	CLAYEY SILT, trace sand Soft Grey															
171.55 3.05	SANDY SILT, some clay, trace gravel Compact Grey		2	SS	22											
3.35	END OF BOREHOLE															



**RECORD OF BOREHOLE No 13**

1 OF 1

**METRIC**

PROJECT 07-1130-109-0  
G.W.P. 3071-06-00 LOCATION N 4681668.1 ; E 326604.9  
DIST 1 HWY BOREHOLE TYPE Manual Drilling  
DATUM GEODETIC DATE October 15, 2007  
ORIGINATED BY DM  
COMPILED BY WDF  
CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT   NATURAL MOISTURE CONTENT   LIQUID LIMIT			UNIT WEIGHT  γ  kN/m³	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								GR   SA   SI   CL
174.60	RIVER WATER LEVEL					▽	174						43	0   15   60   25
0.00	WATER													
173.08														
1.52	FILL, sandy silt, some clay, trace gravel		1	SS	2									
172.77	Very Loose Grey													
1.83	FILL, clayey silt, some sand, trace organic material					172								
	Very soft Grey and black		2	SS	2									
171.70														
2.90	FILL, sandy silt, some clay, with bricks													
3.05	Grey END OF BOREHOLE													



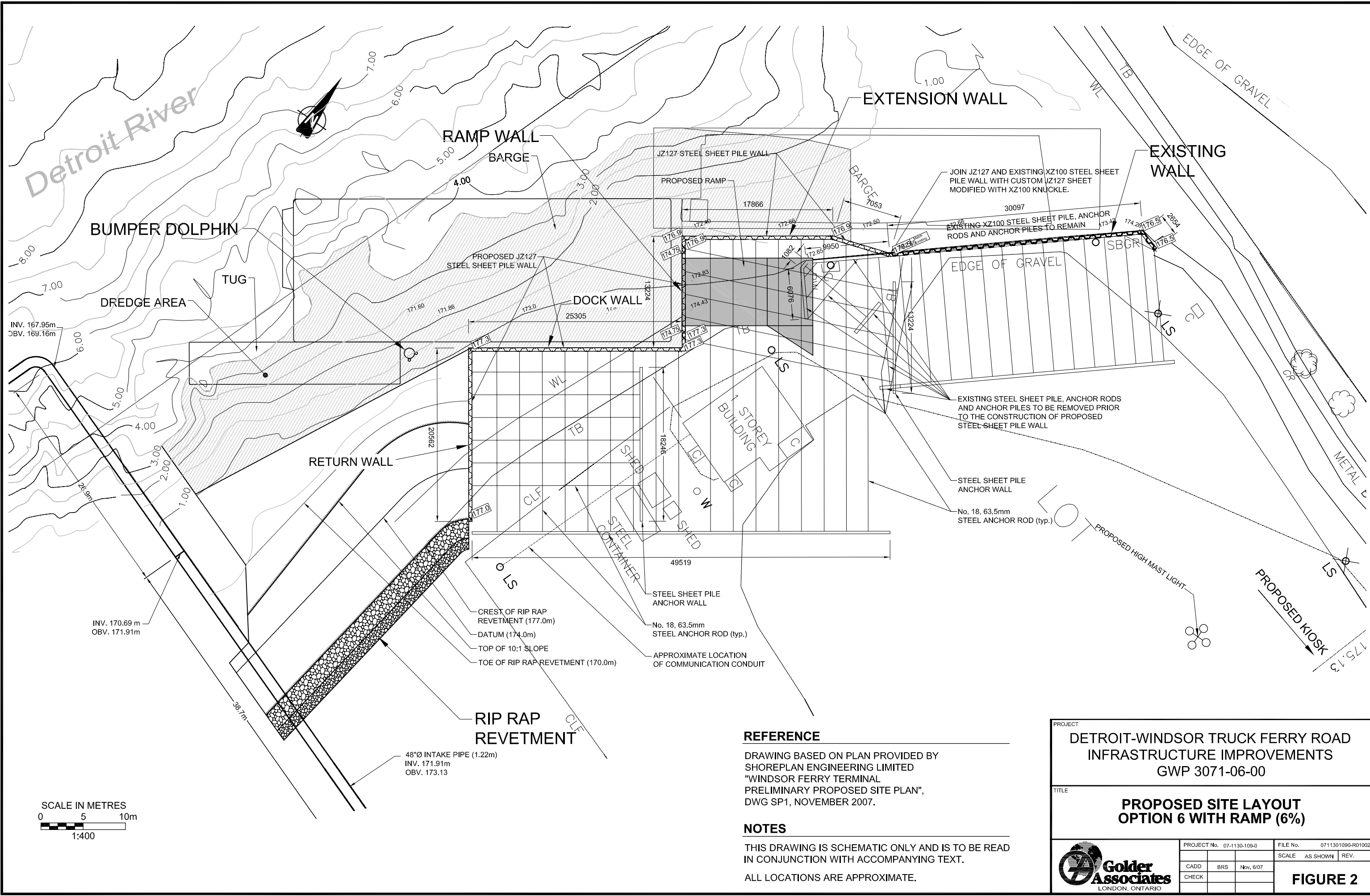
SCALE IN METRES  
0 500 1000m

# **NOTE**

THIS DRAWING IS TO BE READ IN CONJUNCTION WITH  
ACCOMPANYING TEXT.

PROJECT		DETROIT-WINDSOR TRUCK FERRY ROAD INFRASTRUCTURE IMPROVMENTS GWP 3071-06-00			
TITLE		SITE LOCATION MAP			
 <b>Golder Associates</b> LONDON, ONTARIO		PROJECT No. 07-1130-109-0		FILE No. 0711301090-R01001	
		CADD BRS Nov, 6/07		SCALE AS SHOWN REV. 0	
		CHECK		<b>FIGURE 1</b>	

Drawing file: 0711301090-R01002.dwg Nov 28, 2007 - 2:51pm




### REFERENCE

DRAWING BASED ON PLAN PROVIDED BY SHOREPLAN ENGINEERING LIMITED "WINDSOR FERRY TERMINAL PRELIMINARY PROPOSED SITE PLAN", DWG SP1, NOVEMBER 2007.

### NOTES

THIS DRAWING IS SCHEMATIC ONLY AND IS TO BE READ IN CONJUNCTION WITH ACCOMPANYING TEXT.

ALL LOCATIONS ARE APPROXIMATE.

PROJECT				DETROIT-WINDSOR TRUCK FERRY ROAD INFRASTRUCTURE IMPROVEMENTS GWP 3071-06-00			
TITLE				PROPOSED SITE LAYOUT OPTION 6 WITH RAMP (6%)			
 Golder Associates LONDON, ONTARIO		PROJECT No. 07-1130-109-0		FILE No. 0711301090-R01002		SCALE AS SHOWN	
		CADD	BRS	Nov, 6/07		FIGURE 2	
		CHECK					

**METRIC**  
DIMENSIONS ARE IN METRES AND/OR  
MILLIMETRES UNLESS OTHERWISE SHOWN.  
STATIONS IN KILOMETRES + METRES.

CONT No.  
GWP No. 3071-06-00



DETROIT-WINDSOR TRUCK FERRY ROAD  
INFRASTRUCTURE IMPROVMENTS

SHEET

BOREHOLE LOCATION



**Golder Associates Ltd.**  
LONDON, ONTARIO, CANADA



KEY PLAN

SCALE  
1000 0 1000m

### LEGEND

● Borehole - Current Investigation

No.	ELEVATION	CO-ORDINATES (UTM NAD83 ZONE17)	
		NORTHING	EASTING
1	176.43	4 681 695.5	326 636.1
2	174.78	4 681 717.2	326 635.8
3	174.76	4 681 705.2	326 604.2
4	176.63	4 681 681.4	326 647.5
5	176.98	4 681 674.5	326 639.4
6	177.23	4 681 640.5	326 616.7
7	177.47	4 681 677.9	326 691.3
8	176.97	4 681 673.1	326 622.3
9	176.99	4 681 658.5	326 615.2
10	174.60	4 681 672.7	326 611.4
11	177.24	4 681 647.4	326 634.3
12	174.60	4 681 664.7	326 599.9
13	174.60	4 681 668.1	326 604.9

### NOTES

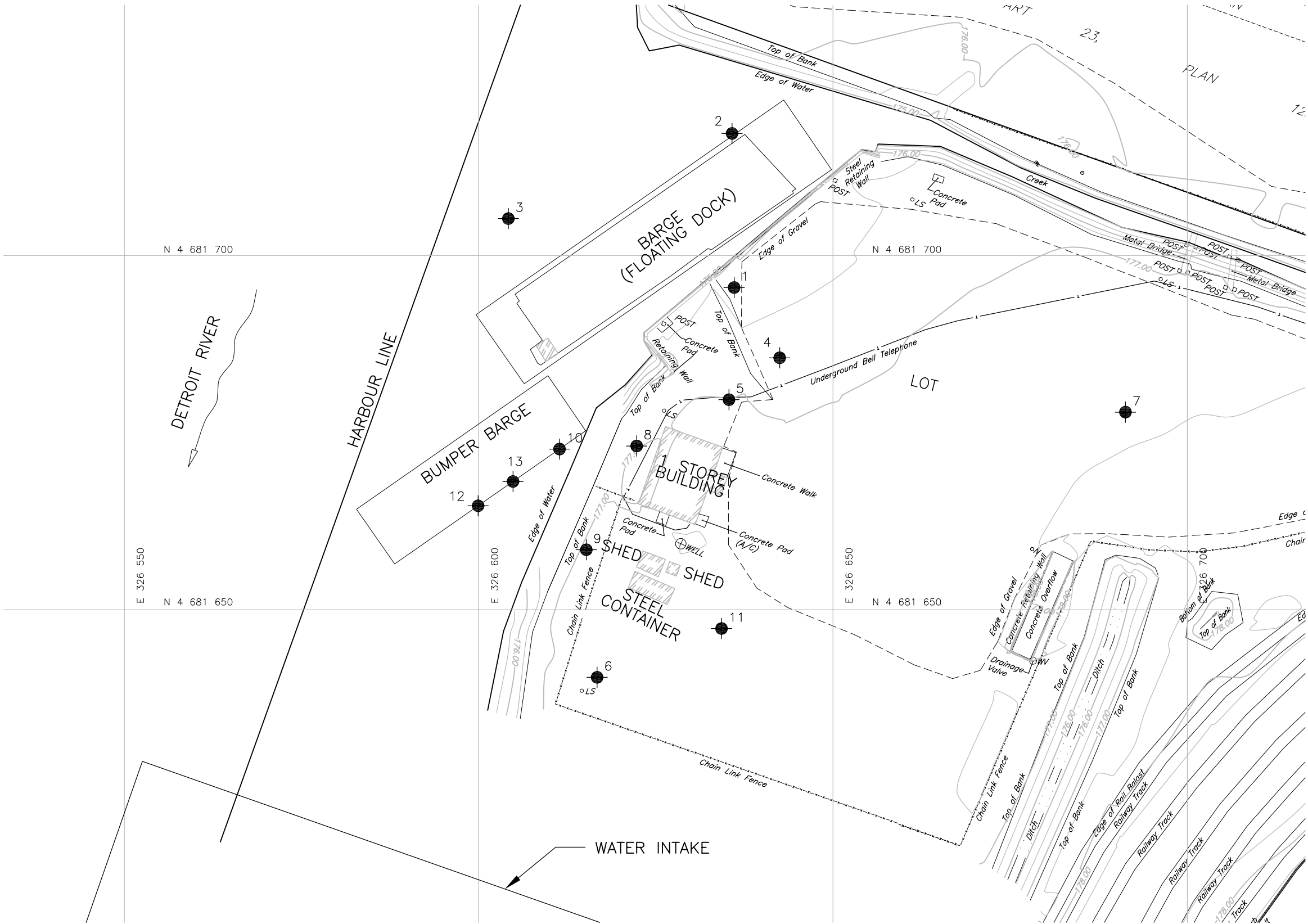
This drawing is for subsurface information only. Surface details and features are for conceptual illustration.

The boundaries between soil strata have been established only at borehole locations. Between Boreholes the boundaries are assumed from geological evidence.

### REFERENCE

Base plans provided in digital format by Stantec consulting limited.

NO.	DATE	BY	REVISION
Geocres No. 40J6-19			
HWY.	N/A	PROJECT NO. 07-1130-109-0	DIST.
SUBM'D.	PRB	CHKD.	DATE: OCT 22/07
DRAWN:	WDF/BRS	CHKD.	APPD.
DWG.			1



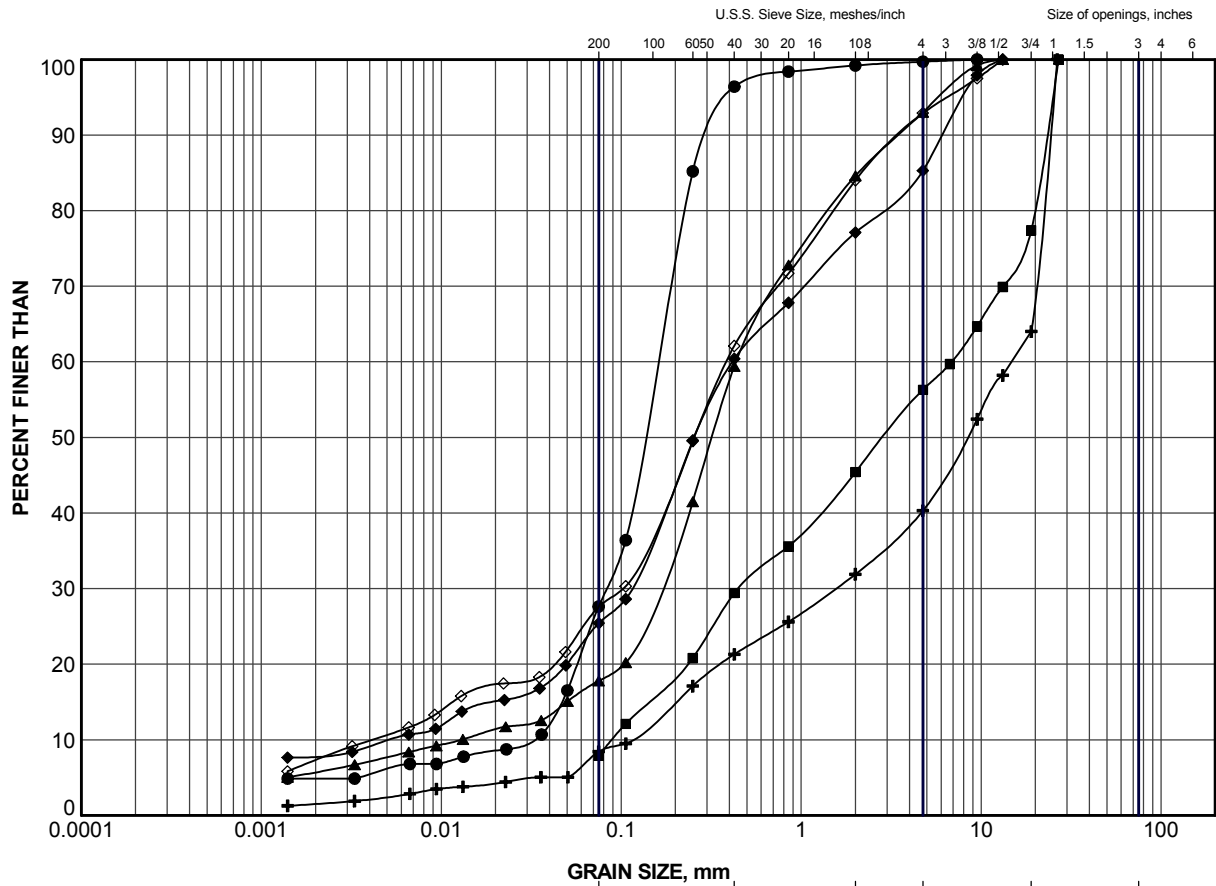
PLAN

SCALE IN METRES

0 10 20m

**APPENDIX A**

**LABORATORY TEST DATA**  
**(FIGURES A1 TO A17)**



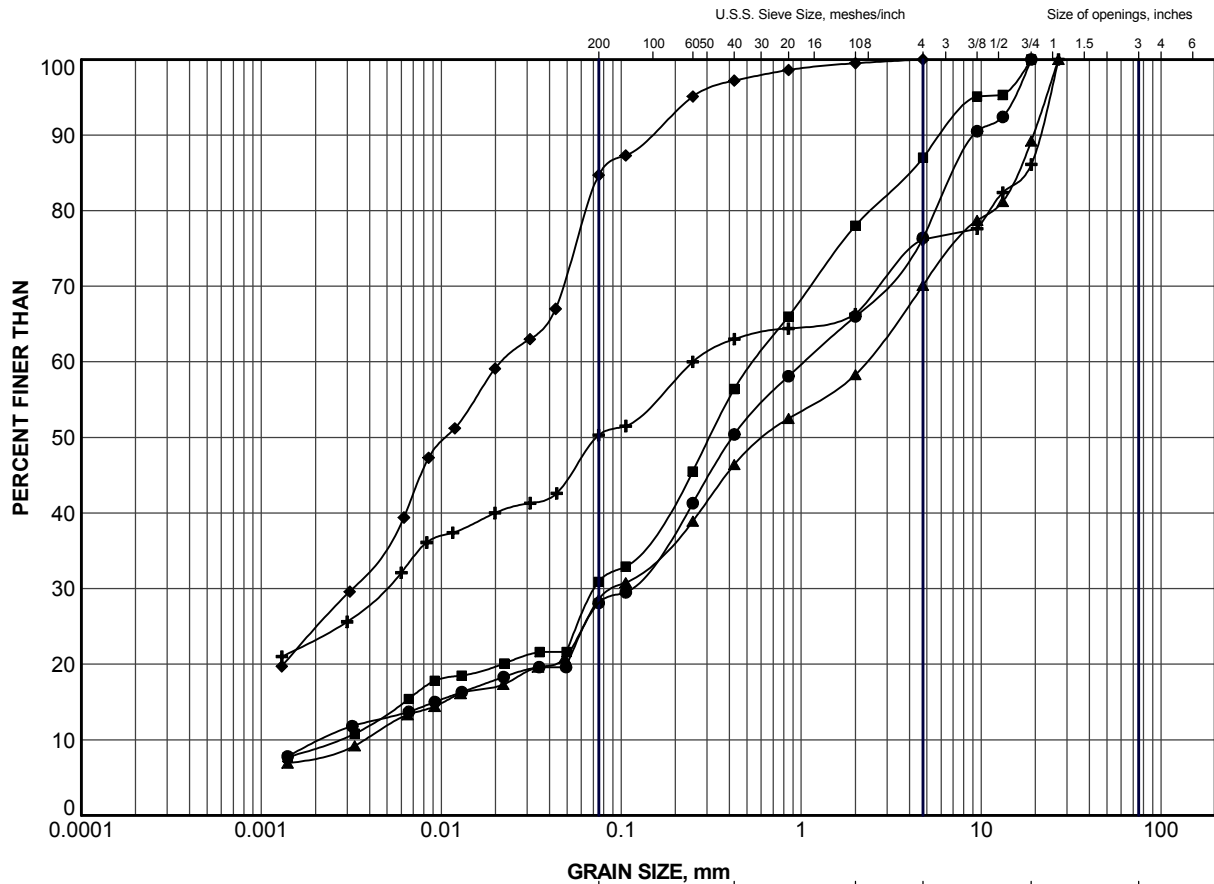
CLAY AND SILT	SAND SIZE, mm			GRAVEL SIZE, mm		Cobble Size
	fine	medium	coarse	fine	coarse	
	SAND SIZE			GRAVEL SIZE		

#### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	1	1	175.4
■	1	4	173.2
▲	4	2	175.0
+	4	4	173.4
◆	5	2	175.4
◇	5	5	172.9


PROJECT				DETROIT-WINDSOR TRUCK FERRY ROAD INFRASTRUCTURE IMPROVEMENTS GWP 3071-06-00			
TITLE				GRAIN SIZE DISTRIBUTION FILL			
PROJECT No.		07-1130-109-0		FILE No.		0711301090.GPJ	
DRAWN		BRS		Nov 06/07		SCALE N/A REV.	
CHECK						FIGURE A-1	

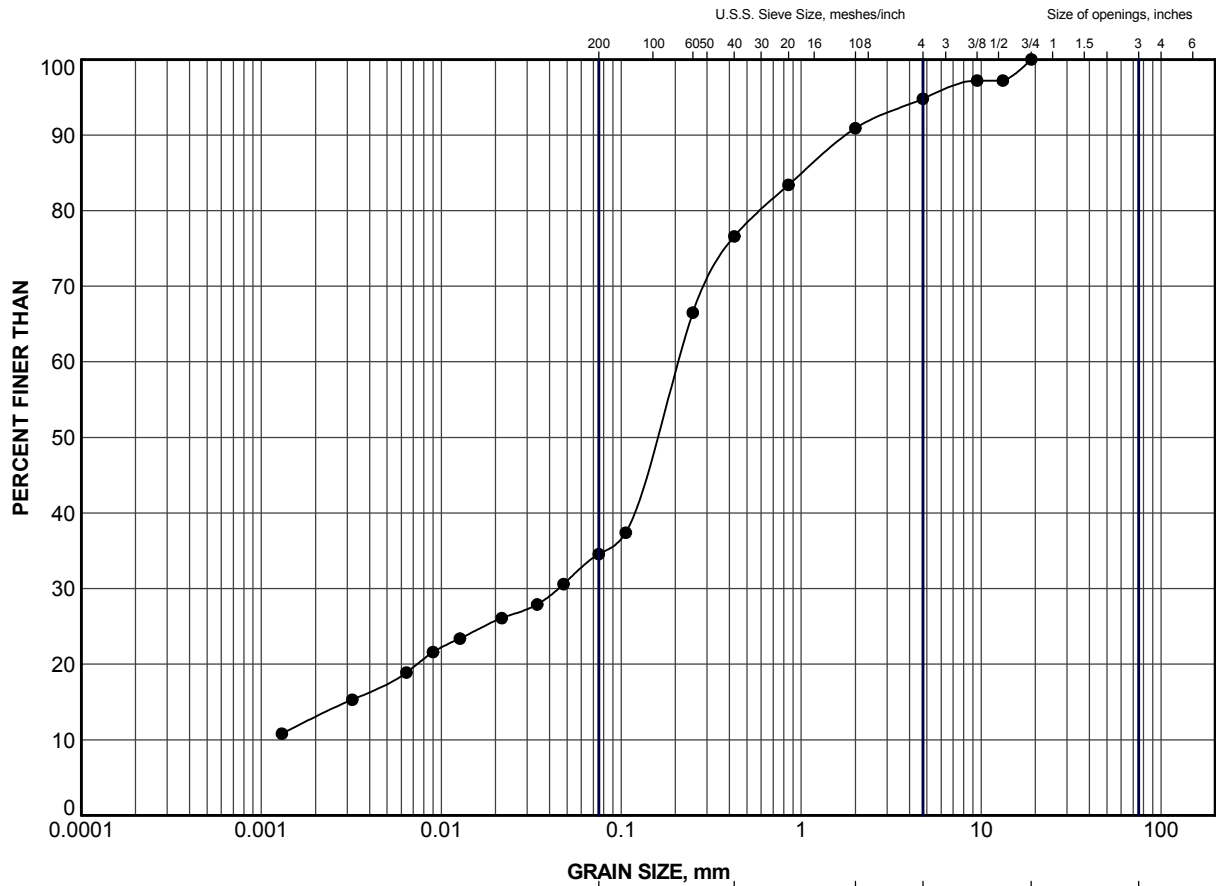




### LEGEND


SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	8	3	175.2
■	8	4	174.5
▲	11	2	175.5
+	11	4	174.0
◆	13	2A	172.1

PROJECT		DETROIT-WINDSOR TRUCK FERRY ROAD INFRASTRUCTURE IMPROVEMENTS GWP 3071-06-00			
TITLE		GRAIN SIZE DISTRIBUTION FILL			
 <b>Golder Associates</b> LONDON, ONTARIO		PROJECT No.		07-1130-109-0	
		FILE No.		0711301090.GPJ	
		SCALE		N/A	
DRAWN		BRS		Nov 06/07	
CHECK					
		<b>FIGURE A-2</b>			

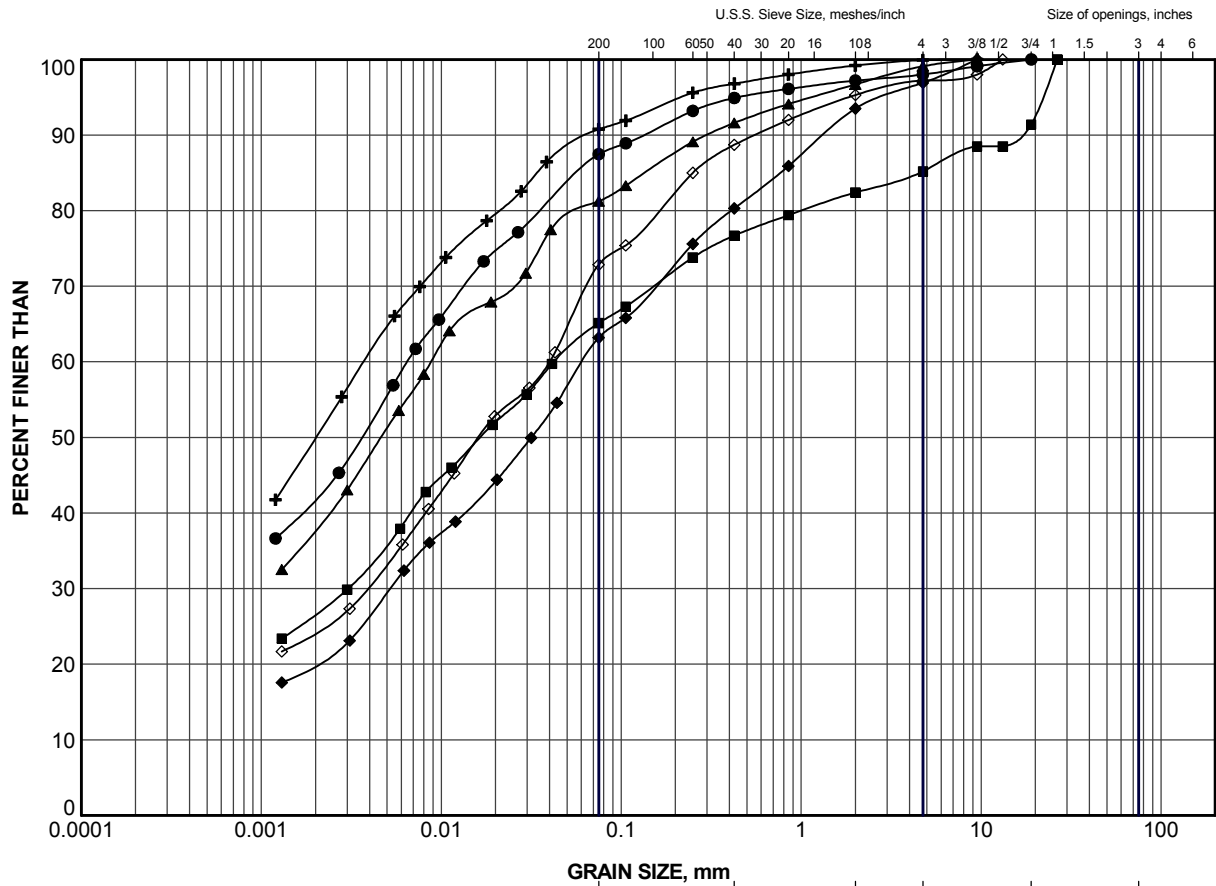


CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

LEGEND			
SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	3	2	169.4

PROJECT				DETROIT-WINDSOR TRUCK FERRY ROAD INFRASTRUCTURE IMPROVEMENTS GWP 3071-06-00									
TITLE				GRAIN SIZE DISTRIBUTION SILTY SAND									
 <b>Golder Associates</b> LONDON, ONTARIO				PROJECT No.		07-1130-109-0		FILE No.		0711301090.GPJ			
								SCALE		N/A		REV.	
				DRAWN		BRS		Nov 06/07		<b>FIGURE A-3</b>			
				CHECK									





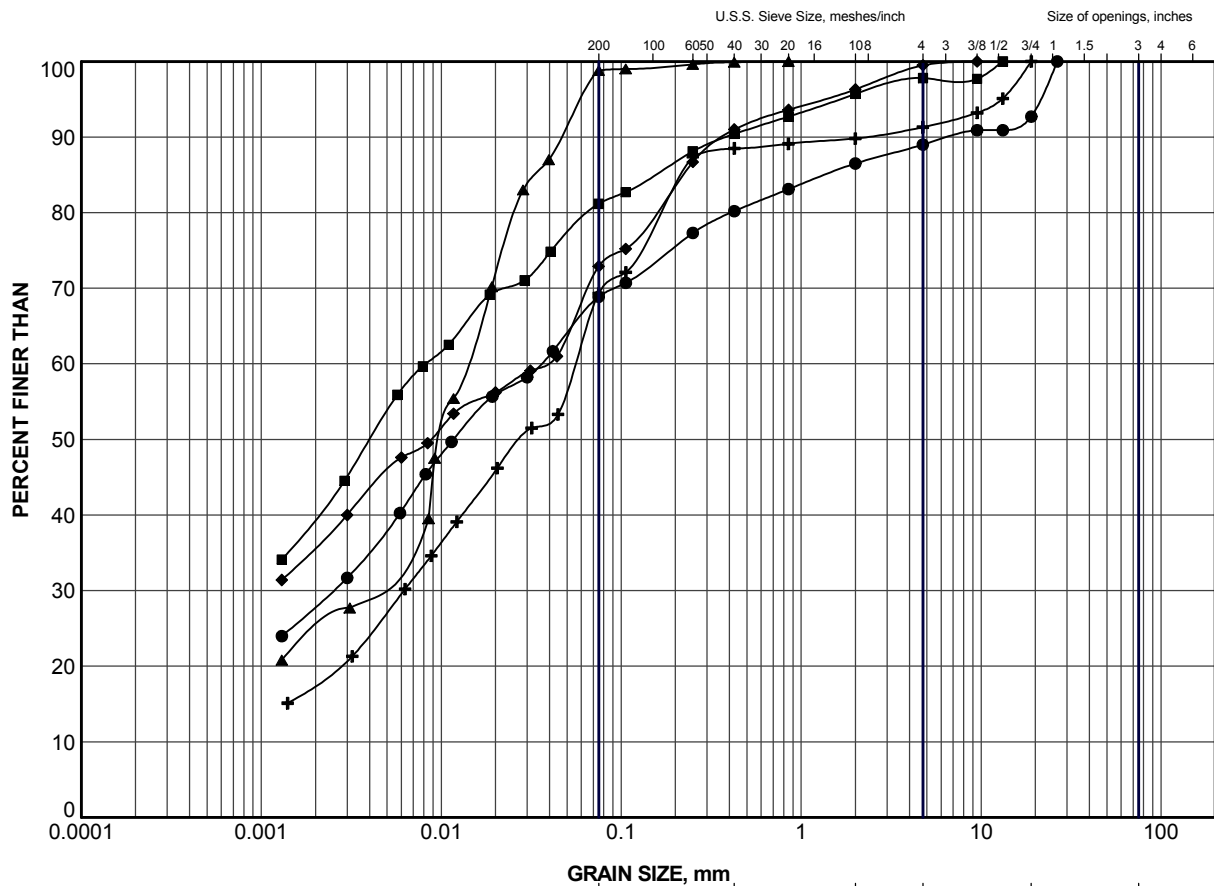
CLAY AND SILT	SAND SIZE, mm			GRAVEL SIZE, mm		Cobble Size
	fine	medium	coarse	fine	coarse	
	SAND SIZE			GRAVEL SIZE		

#### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	1	8	168.6
■	1	10	165.5
▲	1	14	159.4
+	2	6	165.6
◆	2	10	159.5
◇	3	4	166.0

PROJECT				DETROIT-WINDSOR TRUCK FERRY ROAD INFRASTRUCTURE IMPROVEMENTS GWP 3071-06-00			
TITLE				GRAIN SIZE DISTRIBUTION CLAYEY SILT			
PROJECT No.		07-1130-109-0		FILE No.		0711301090.GPJ	
DRAWN		BRS		Nov 06/07		SCALE N/A REV.	
CHECK						FIGURE A-4	





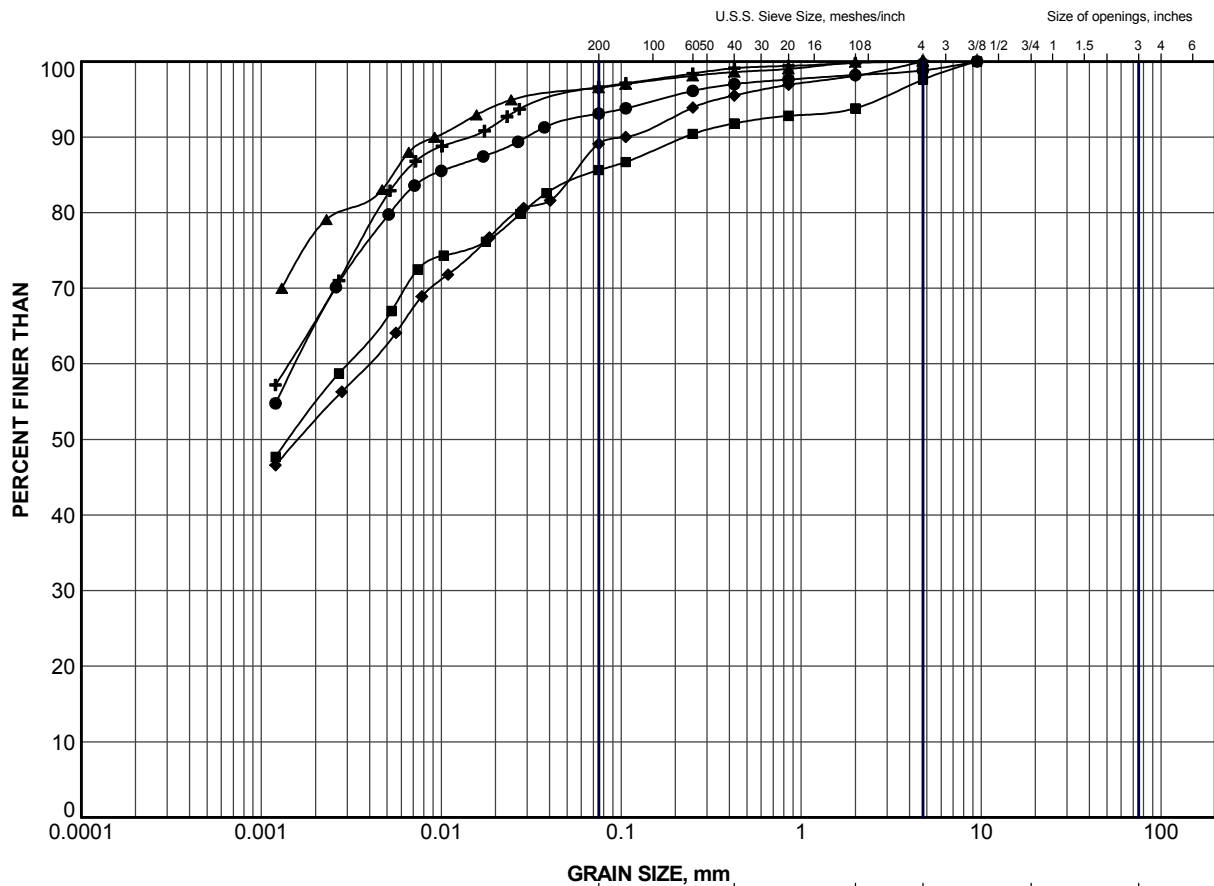
CLAY AND SILT	SAND SIZE, mm			GRAVEL SIZE, mm		Cobble Size
	fine	medium	coarse	fine	coarse	
	SAND SIZE			GRAVEL SIZE		

#### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	3	7	161.4
■	3	10	156.9
▲	7	4	174.2
+	8	7	172.2
◆	9	8	170.7

PROJECT				DETROIT-WINDSOR TRUCK FERRY ROAD INFRASTRUCTURE IMPROVEMENTS GWP 3071-06-00			
TITLE				GRAIN SIZE DISTRIBUTION CLAYEY SILT			
PROJECT No.		07-1130-109-0		FILE No.		0711301090.GPJ	
DRAWN		BRS		Nov 06/07		SCALE N/A REV.	
CHECK						FIGURE A-5	





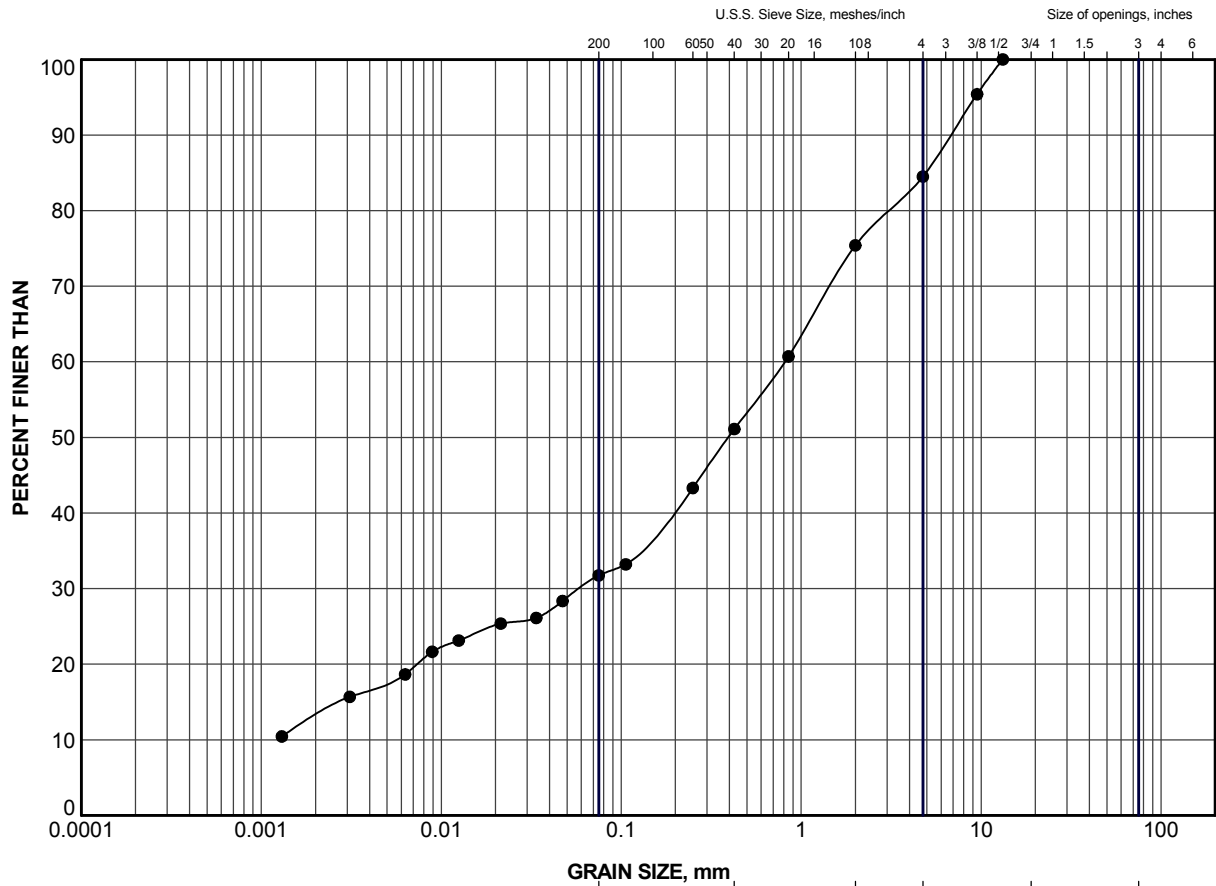
CLAY AND SILT	SAND SIZE, mm			GRAVEL SIZE, mm		Cobble Size
	fine	medium	coarse	fine	coarse	
	SAND SIZE			GRAVEL SIZE		

#### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	1	6	171.6
■	2	3	170.1
▲	2	5	167.1
+	7	6	171.1
◆	8	9	169.1


PROJECT				DETROIT-WINDSOR TRUCK FERRY ROAD INFRASTRUCTURE IMPROVEMENTS GWP 3071-06-00			
TITLE				GRAIN SIZE DISTRIBUTION SILTY CLAY			
PROJECT No.		07-1130-109-0		FILE No.		0711301090.GPJ	
DRAWN		BRS		Nov 12/07		SCALE N/A REV.	
CHECK						FIGURE A-6	

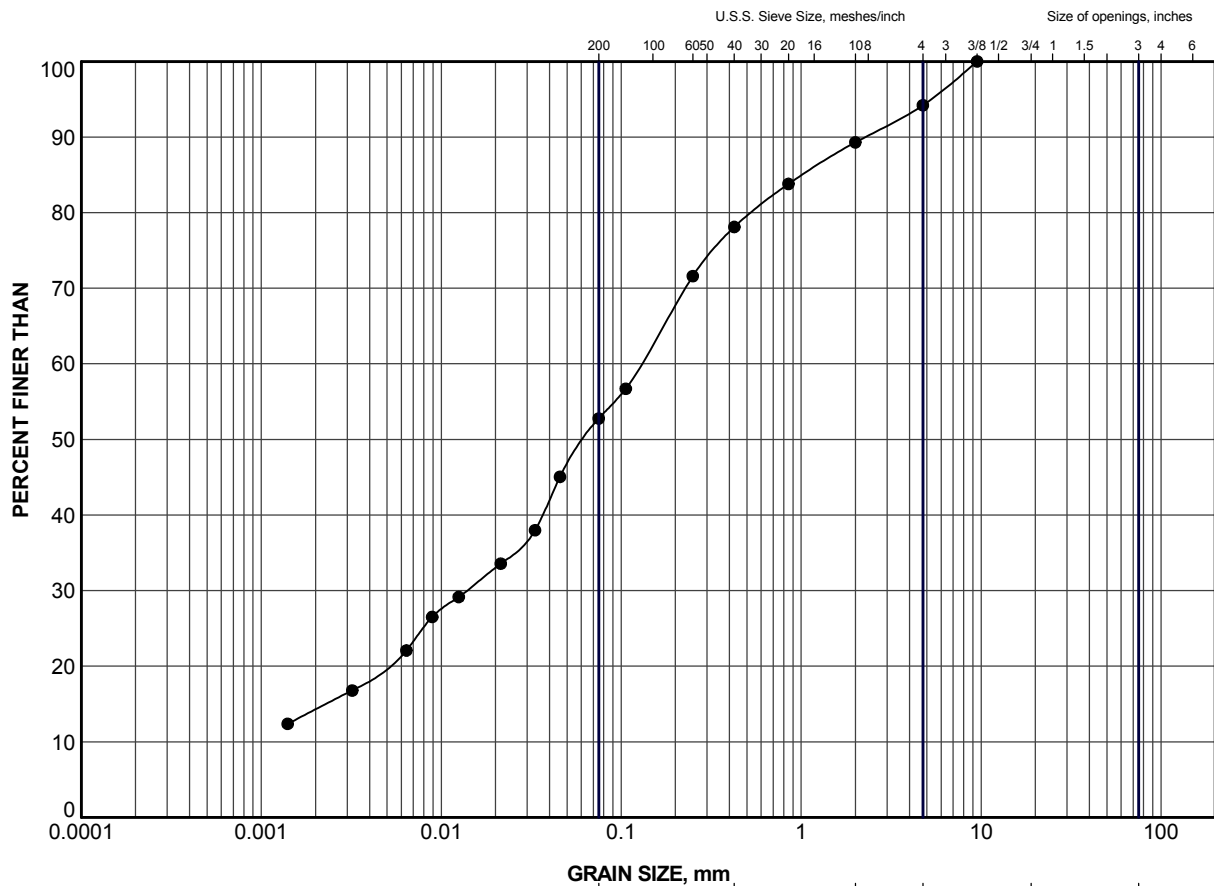




### LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	3	12	152.3


PROJECT				DETROIT-WINDSOR TRUCK FERRY ROAD INFRASTRUCTURE IMPROVEMENTS GWP 3071-06-00			
TITLE				GRAIN SIZE DISTRIBUTION SAND			
PROJECT No.		07-1130-109-0		FILE No.		0711301090.GPJ	
DRAWN		BRS		SCALE		N/A	
CHECK		Nov 06/07		REV.			
 <b>Golder Associates</b> LONDON, ONTARIO				<b>FIGURE A-7</b>			

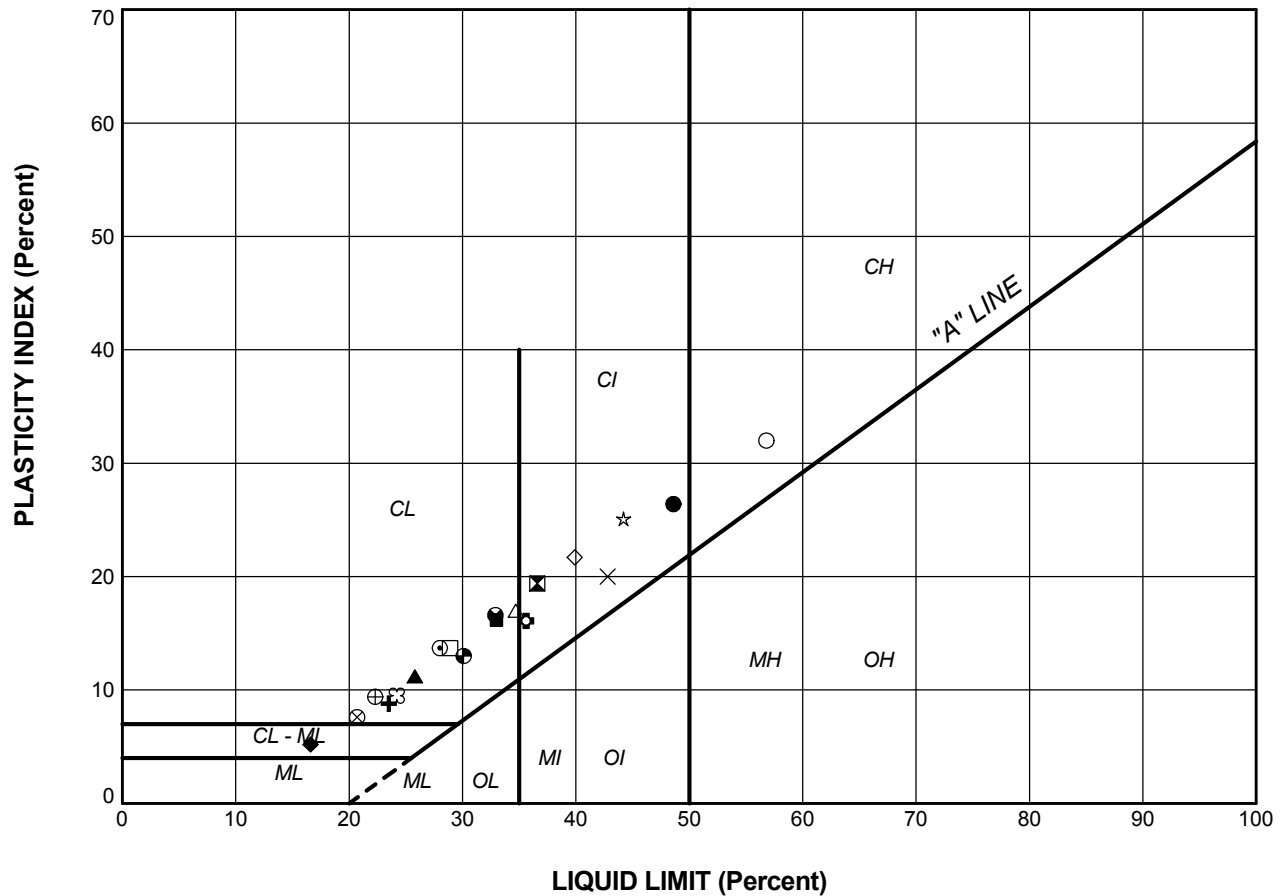


GRAVEL SIZE, mm						
CLAY AND SILT	fine	medium	coarse	fine	coarse	Cobble Size
	SAND SIZE			GRAVEL SIZE		

#### LEGEND


SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	1	18	153.3

PROJECT				DETROIT-WINDSOR TRUCK FERRY ROAD INFRASTRUCTURE IMPROVEMENTS GWP 3071-06-00			
TITLE				GRAIN SIZE DISTRIBUTION SANDY SILT (TILL)			
PROJECT No.		07-1130-109-0		FILE No.		0711301090.GPJ	
DRAWN		BRS		Nov 06/07		SCALE N/A REV.	
CHECK						FIGURE A-8	
 <b>Golder Associates</b> LONDON, ONTARIO							



### LEGEND

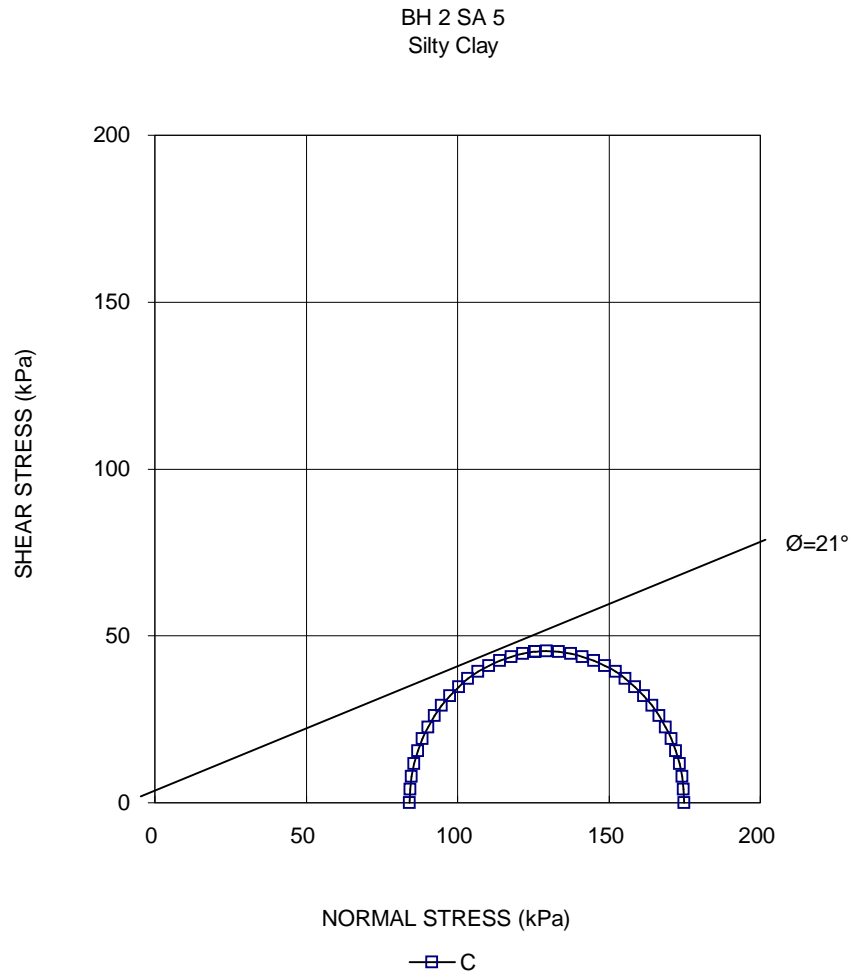
SYMBOL	BOREHOLE	SAMPLE	LL(%)	PL(%)	PI
<u>SILTY CLAY</u>					
●	1	6	48.6	22.2	26.4
◇	2	3	39.9	18.2	21.7
○	2	5	56.8	24.8	32.0
☆	7	6	44.2	19.1	25.1
⊠	8	9	36.6	17.2	19.4
<u>CLAYEY SILT</u>					
■	1	8	33.0	16.8	16.2
▲	1	10	25.8	14.6	11.2
+	1	14	23.5	14.7	8.8
△	2	6	34.7	17.7	17.0
⊗	2	10	20.7	13.1	7.6
⊕	3	4	22.3	12.9	9.4
□	3	7	28.9	15.2	13.7
⊙	3	10	32.9	16.3	16.6
⊗	7	4	30.1	17.1	13.0
⊙	8	7	24.2	14.7	9.5
⊙	8	8	28.0	14.3	13.7
<u>SANDY SILT TILL</u>					
◆	1	18	16.6	11.4	5.2
<u>FILL</u>					
⊕	11	4	35.6	19.5	16.1
×	13	2A	42.8	22.8	20.0

PROJECT				DETROIT-WINDSOR TRUCK FERRY ROAD INFRASTRUCTURE IMPROVEMENTS GWP 3071-06-00			
TITLE				PLASTICITY CHART			
PROJECT No.		07-1130-109-0		FILE No.		0711301090.GPJ	
DRAWN		BRS		SCALE		N/A	
CHECK		Nov 06/07		REV.			
 <b>Golder Associates</b> LONDON, ONTARIO				<b>FIGURE A-9</b>			

<b>CONSOLIDATED UNDRAINED TRIAXIAL WITH PORE PRESSURE MEASUREMENTS</b> <b>SHEET 1 OF 4</b>		<b>FIGURE A-10</b>
TEST STAGE	C	
BOREHOLE NUMBER	2	
SAMPLE	5	
SPECIMEN DIAMETER, cm	0.00	
SPECIMEN HEIGHT, cm	0.00	
WATER CONTENT BEFORE CONSOLIDATION, %	64.2	
CELL PRESSURE, $\sigma_3$ , kPa	0.0	
BACK PRESSURE, kPa	0.0	
PORE PRESSURE PARAMETER "B"	0.97	
CONSOLIDATION PRESSURE, $\sigma_c$ , kPa	0.0	
VOLUMETRIC STRAIN DURING CONSOLIDATION, %	0.0	
WATER CONTENT AFTER CONSOLIDATION, %	51.4	
AVERAGE RATE OF STRAIN, %/hr	0.5	
TIME TO FAILURE, DAYS	1	
WATER CONTENT AFTER TEST, %	53.9	
MAX. DEVIATOR STRESS, $(\sigma_1 - \sigma_3)$ , kPa	17.4	
AXIAL STRAIN AT $(\sigma_1 - \sigma_3)$ MAXIMUM, %	4.5	
MAX EFFECTIVE PRINCIPAL STRESS		
RATIO, $(\sigma_1 / \sigma_3)$ MAXIMUM	75.5	
DEVIATOR STRESS AT $(\sigma_1 / \sigma_3)$ MAXIMUM, kPa	15.7	
AXIAL STRAIN AT $(\sigma_1 / \sigma_3)$ MAXIMUM, %	11.6	
PORE PRESSURE PARAMETER, Af, AT $(\sigma_1 - \sigma_3)$ MAXIMUM	1.28	
PORE PRESSURE PARAMETER, Af, AT $(\sigma_1 / \sigma_3)$ MAXIMUM	1.94	
NATURAL WATER CONTENT, %	59.3	
DRY DENSITY, Mg/m <sup>3</sup>	1.03	
FILTER DRAINS USED, y/n	y	
TEST NOTES:		
CHANGED RATE OF STRAIN, %/hr	-	
AXIAL STRAIN WHERE RATE OF STRAIN WAS CHANGED, %	-	
FAILURE PLANE NUMBER	1.0	
ANGLE OF FAILURE, DEGREES	50.0	
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CONSOLIDATED UNDRAINED TRIAXIAL  
WITH PORE PRESSURE MEASUREMENTS  
SHEET 2 OF 4

FIGURE A-11



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Project No. 07-1130-1090

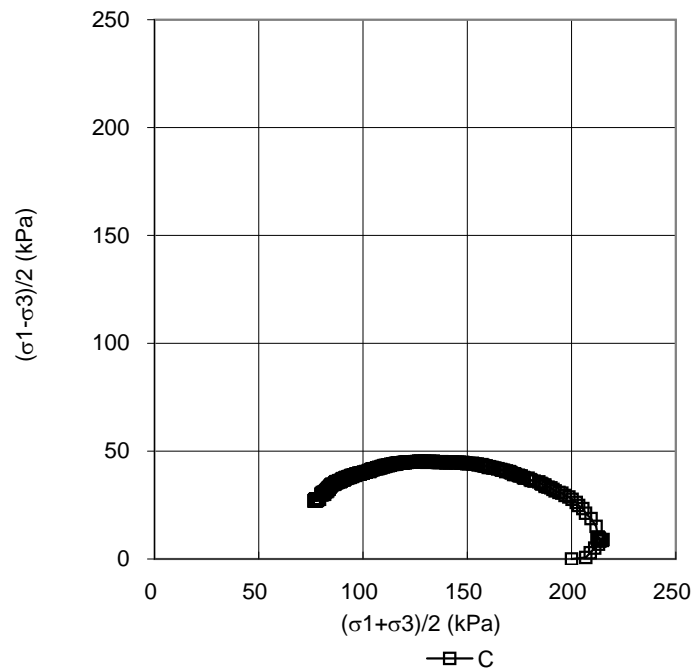
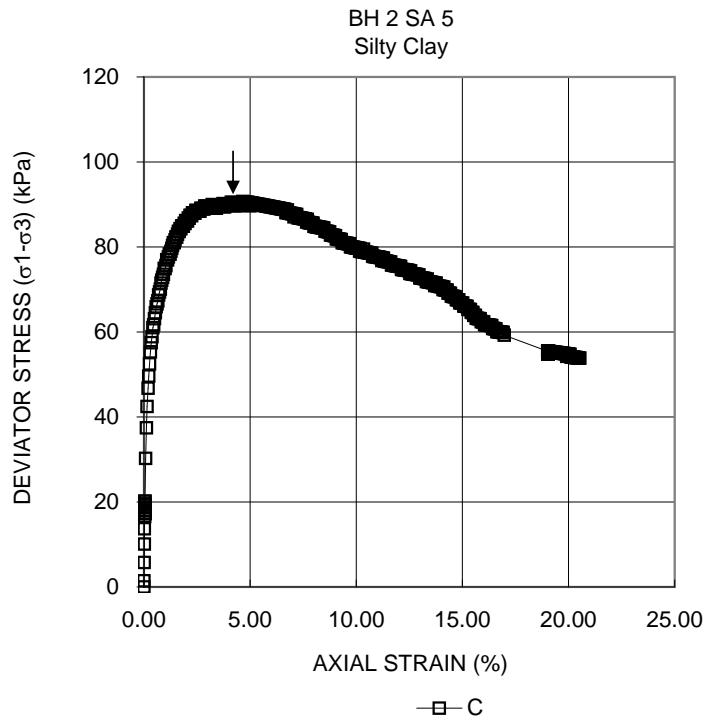
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CONSOLIDATED UNDRAINED TRIAXIAL  
WITH PORE PRESSURE MEASUREMENTS  
SHEET 3 OF 4

FIGURE A-12



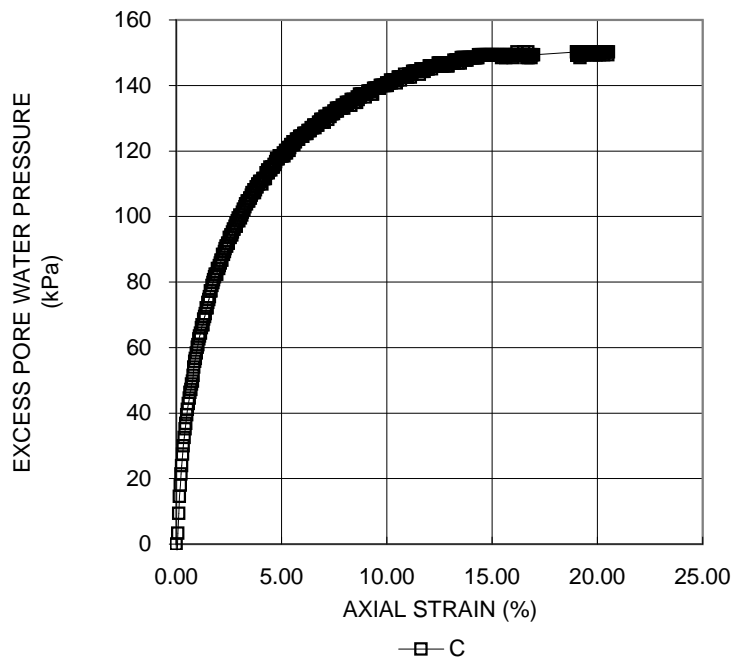
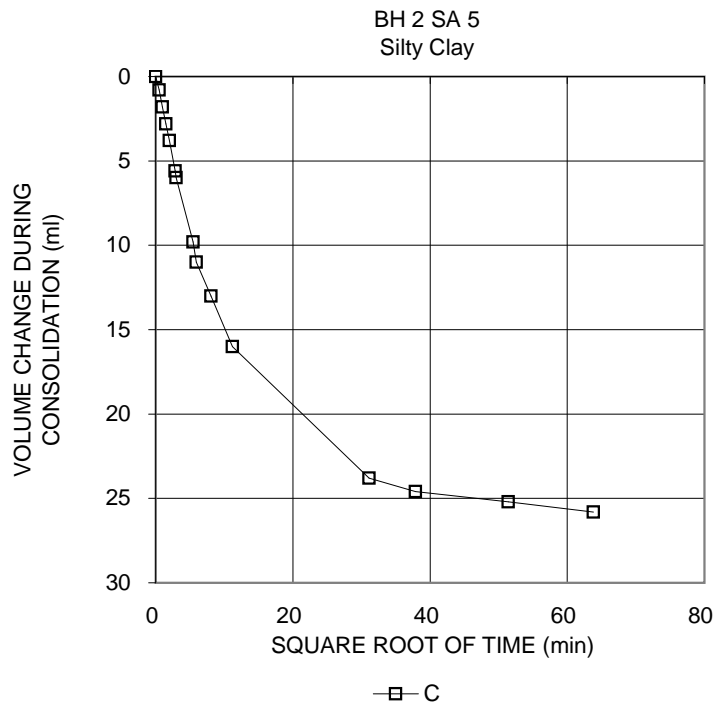
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**CONSOLIDATED UNDRAINED TRIAXIAL  
WITH PORE PRESSURE MEASUREMENTS  
SHEET 4 OF 4**

**FIGURE A-13**



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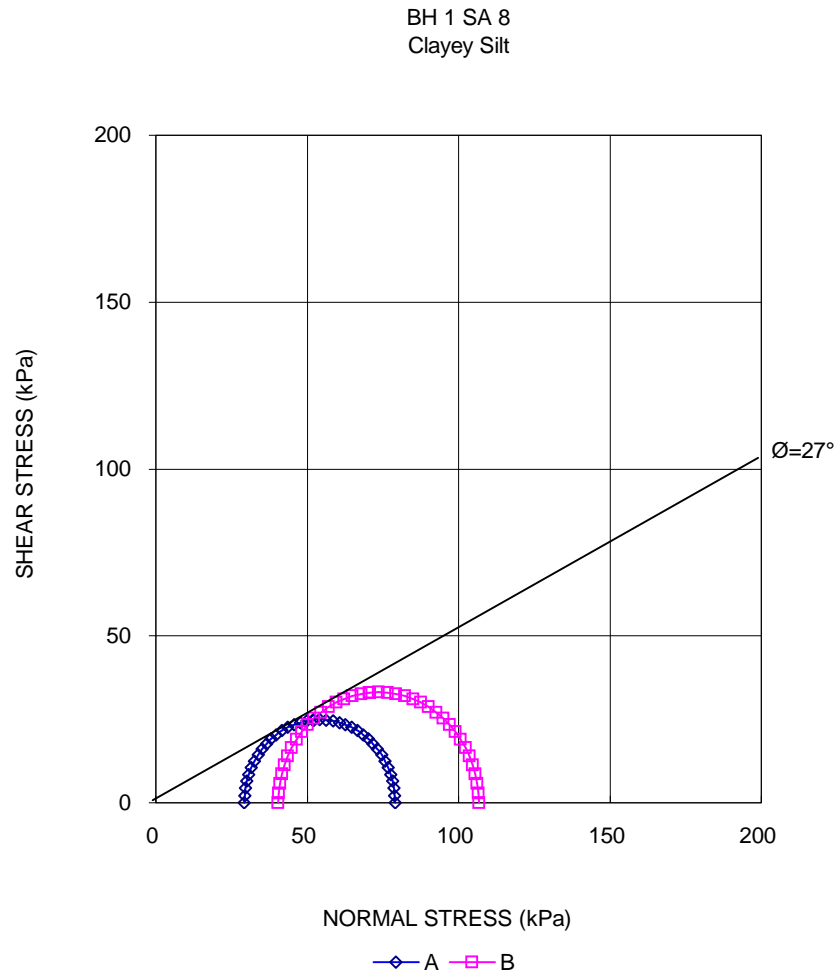
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Checked By: RO

<b>CONSOLIDATED UNDRAINED TRIAXIAL WITH PORE PRESSURE MEASUREMENTS</b>		<b>FIGURE A-14</b>	
<b>SHEET 1 OF 4</b>			
TEST STAGE	A	B	
BOREHOLE NUMBER	1	1	
SAMPLE	8	8	
SPECIMEN DIAMETER, cm	5.18	4.97	
SPECIMEN HEIGHT, cm	9.65	9.81	
WATER CONTENT BEFORE CONSOLIDATION, %	32.2	42.0	
CELL PRESSURE, $\sigma_3$ , kPa	605.0	515.0	
BACK PRESSURE, kPa	555.0	415.0	
PORE PRESSURE PARAMETER "B"	0.96	0.96	
CONSOLIDATION PRESSURE, $\sigma_c$ , kPa	50.0	100.0	
VOLUMETRIC STRAIN DURING CONSOLIDATION, %	4.7	6.8	
WATER CONTENT AFTER CONSOLIDATION, %	29.0	36.7	
AVERAGE RATE OF STRAIN, %/hr	0.5	0.5	
TIME TO FAILURE, DAYS	1	1	
WATER CONTENT AFTER TEST, %	25.5	37.0	
MAX. DEVIATOR STRESS, $(\sigma_1 - \sigma_3)$ , kPa	58.6	66.2	
AXIAL STRAIN AT $(\sigma_1 - \sigma_3)$ MAXIMUM, %	19.9	4.2	
MAX EFFECTIVE PRINCIPAL STRESS			
RATIO, $(\sigma_1 / \sigma_3)$ MAXIMUM	2.7	2.8	
DEVIATOR STRESS AT $(\sigma_1 / \sigma_3)$ MAXIMUM, kPa	49.8	62.7	
AXIAL STRAIN AT $(\sigma_1 / \sigma_3)$ MAXIMUM, %	9.0	7.5	
PORE PRESSURE PARAMETER, $A_f$ , AT $(\sigma_1 - \sigma_3)$ MAXIMUM	0.21	0.90	
PORE PRESSURE PARAMETER, $A_f$ , AT $(\sigma_1 / \sigma_3)$ MAXIMUM	0.42	1.04	
NATURAL WATER CONTENT, %	32.0	39.6	
DRY DENSITY, $Mg/m^3$	1.47	1.30	
FILTER DRAINS USED, y/n	y	y	
TEST NOTES:			
CHANGED RATE OF STRAIN, %/hr	-	-	
AXIAL STRAIN WHERE RATE OF STRAIN WAS CHANGED, %	-	-	
FAILURE PLANE NUMBER	bulged	1.0	
ANGLE OF FAILURE, DEGREES	-	55.0	
<div> <div>Date: 08/16/2007</div> <div>Project No. 07-1130-1090</div> </div> <div> <div>Golder Associates</div> </div> <div> <div>Prepared By: MM</div> <div>Checked By: RO</div> </div>			

CONSOLIDATED UNDRAINED TRIAXIAL  
WITH PORE PRESSURE MEASUREMENTS  
SHEET 2 OF 4

FIGURE A-15



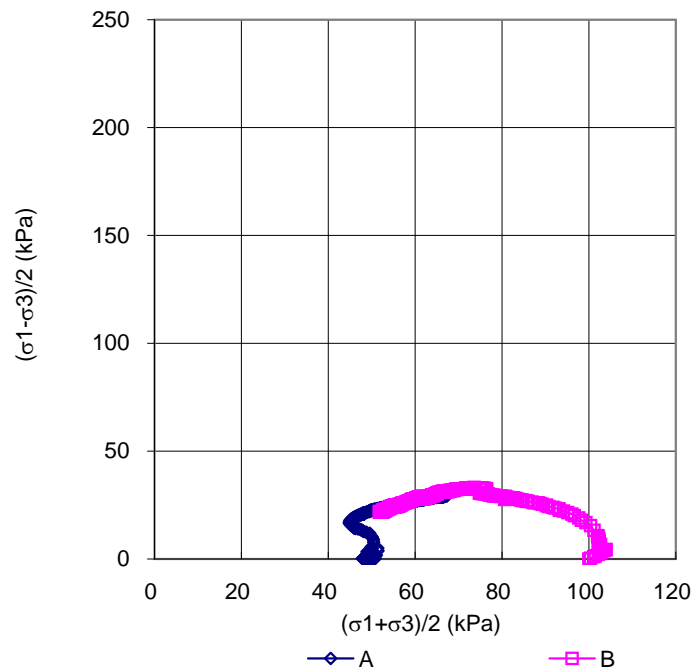
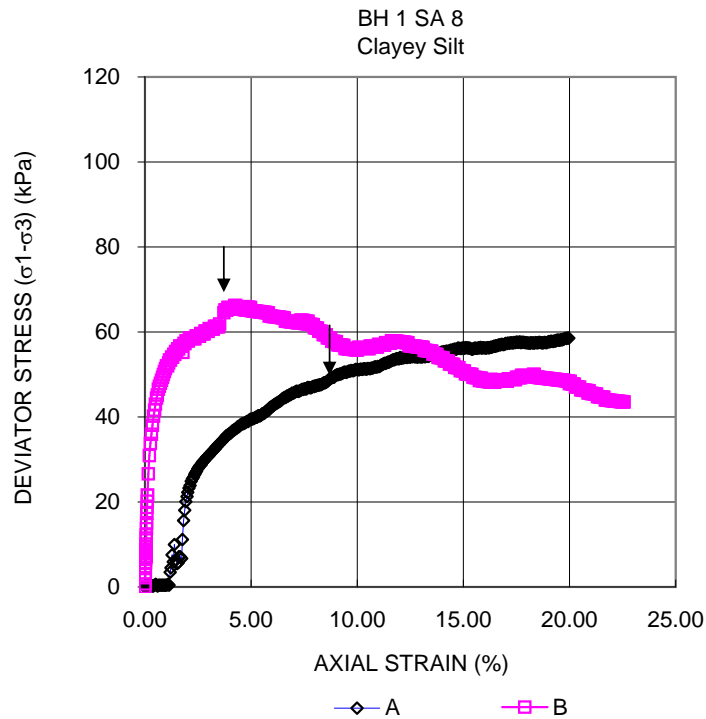
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CONSOLIDATED UNDRAINED TRIAXIAL  
WITH PORE PRESSURE MEASUREMENTS  
SHEET 3 OF 4

FIGURE A-16



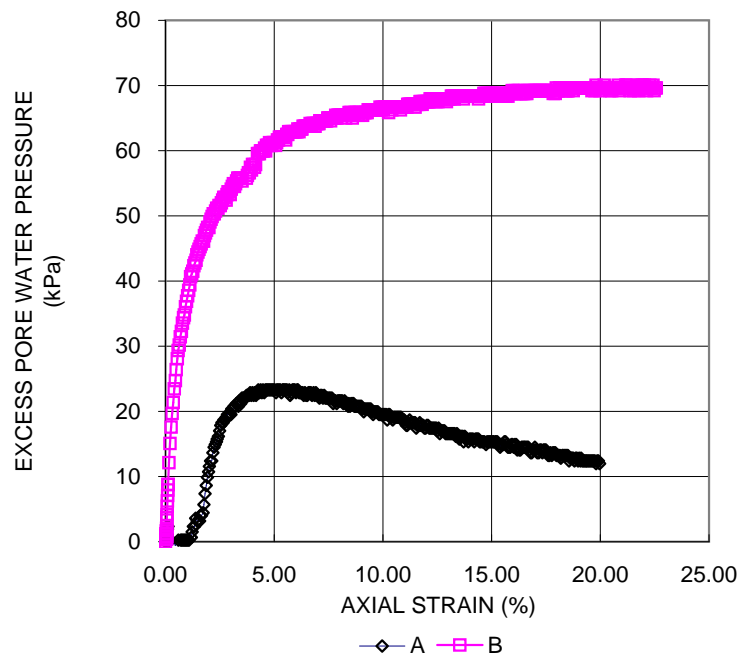
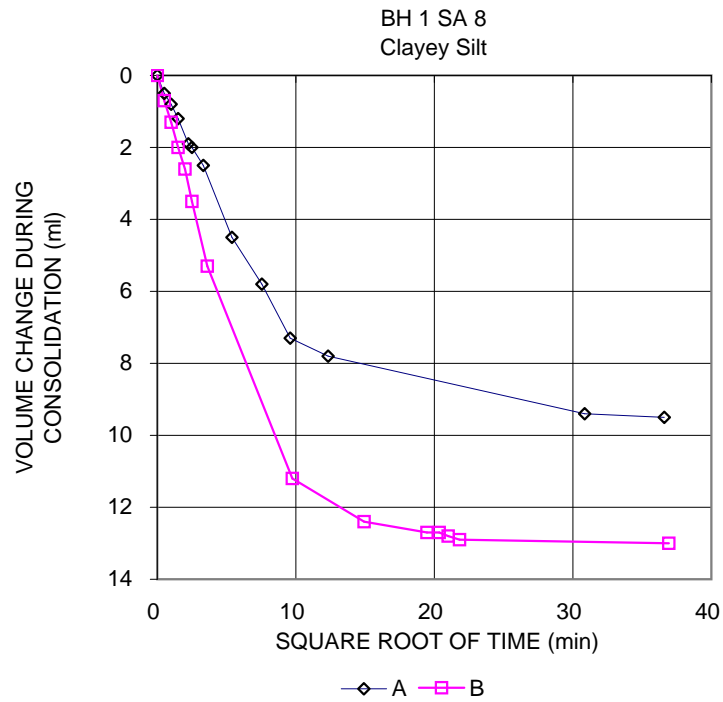
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**CONSOLIDATED UNDRAINED TRIAXIAL  
WITH PORE PRESSURE MEASUREMENTS  
SHEET 4 OF 4**

**FIGURE A-17**



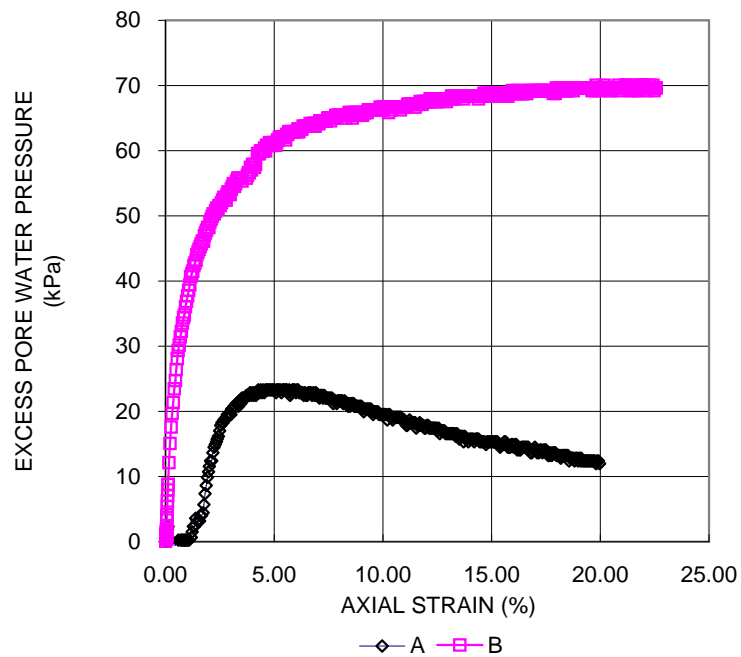
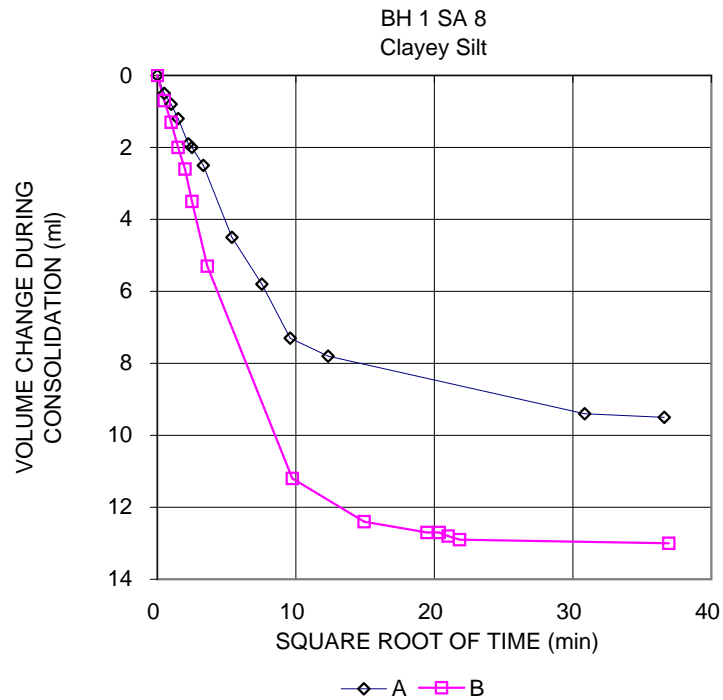
Date: 08/16/2007  
Project No. 07-1130-1090

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**CONSOLIDATED UNDRAINED TRIAXIAL  
WITH PORE PRESSURE MEASUREMENTS  
SHEET 4 OF 4**

**FIGURE A-17**



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Checked By: RO

**APPENDIX B**  
**SITE PHOTOGRAPHS**



November 2007

07-1130-109-0

## **SITE PHOTOGRAPHS**



Photo 1: Ferry getting ready to unload using existing ramp.



Photo 2: View of northwest corner of dock during drilling of borehole 3.

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**SITE PHOTOGRAPHS**



Photo 3: Existing retaining wall and shoreline northwest of custom building.



Photo 4: Existing shoreline near borehole 9.