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FOUNDATION INVESTIGATION AND DESIGN REPORT

MTO FERRY DOCKS AT LEAMINGTON
DISTRICT #31 CHATHAM, SOUTHWESTERN REGION
WORK ORDER NUMBER 01-33-001
PURCHASE ORDER NUMBER 3005-A-000218

Submitted to:

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1.0 INTRODUCTION

Golder Associates Ltd. (Golder) has been retained by Morrison Hershfield Limited (Morrison Hershfield) on behalf of the Ministry of Transportation, Ontario (MTO) to carry out additional preliminary foundation investigations for the MTO ferry docks at Leamington, Kingsville and Pelee Island in conjunction with Work Order Number 01-33-001. This report addresses the additional investigation at the Leamington docks site.

The purpose of this foundation investigation is to determine the subsurface conditions in front of the sheet pile walls and to obtain the soil parameters and lake information necessary to revise and complete stability calculations for the existing sheet pile walls. The work includes drilling three additional boreholes at each site as well as utilizing existing borehole, lake level and scour/dredging data. The terms of reference for the scope of work are outlined in Golder's proposal for additional preliminary foundations engineering services dated August 18, 2004. The work was carried out in accordance with our Quality Control Plan dated October 30, 2002.

The report is provided as part of the planning phase of the project. Morrison Hershfield provided Golder with drawings for the existing docks and scour profiles.

The results of previous foundation investigations carried out at the site were reviewed during the preparation of this report and the relevant borehole records from those reports are provided in Appendix A in their original format. The previous reports are:

- Golder Associates Preliminary Foundation Investigation Report, Geocres No. 40J2-57 entitled "MTO Ferry Docks at Leamington, Kingsville and Pelee Island, Townships of Mersea, Gosfield South and Pelee Island, District 31, Chatham, Work Order Number: 01-33-001, Purchase Order Number: 3005-A-000218", dated February 26, 2003.

- Trow Consulting Engineers Ltd. report prepared for Public Works Canada entitled “Geotechnical Investigation, Proposed Ferry Terminal, Leamington, Ontario”, dated January 1993.

- Trow Ontario Ltd. report prepared for Public Works Canada entitled “Geotechnical Investigation, Proposed Leamington Harbour Improvements, Leamington, Ontario”, dated December 14, 1988.

2.0 SITE DESCRIPTION

The Leamington ferry docks site is located along the southerly extension of Erie Street South in the Town of Leamington, Ontario. The present ferry docks were constructed in 1993/1994 when the original wharf (which includes the access road, restaurant/warehouse, timber crib and armour stone breakwall to the north) was widened to the east. The expanded docking facilities were created to improve the shipping operations to Pelee Island. The present docking complex extends approximately 300 metres into Lake Erie and comprises an asphalt pavement surface and, at the waters edge, is enclosed by steel sheet piling with a concrete cap. Pelee Island Transportation Services currently operates the dock facilities.

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

Based on information provided by Morrison Hershfield, the existing docks are at elevation 176 metres (all elevations are referenced to International Great Lakes Datum, IGLD), the lake water level is at about elevation 174 metres, the dredge line is at elevation 169.0 to 170.5 metres and the design sheet pile tip is at elevation 162.3 metres.

3.0 INVESTIGATION PROCEDURES

The field work for this investigation was carried out between August 30 and September 3, 2004. At that time, three boreholes were put down in front of the steel sheet pile walls about 0.4 to 0.9 metres from the docks using a timber platform with safety rails cantilevered over the walls. The boreholes were drilled and sampled to depths of 17.3 to 23.0 metres below the dock surface. The borehole locations are shown in plan on Drawing 1 together with boreholes put down during previous investigations (1988, 1993 and 2002).

The investigation was carried out using an all terrain vehicle mounted CME-750 drill rig fitted with a drilling platform and was supplied and operated by Lantech Drilling Services Inc. The boreholes were advanced using a combination of rotary drilling techniques in NW size casing. The bedrock was cored in NQ size. In the boreholes, samples of the overburden and rock were obtained at regular intervals of depth using 50 millimetre outside diameter split-spoon samplers in accordance with the Standard Penetration Test (SPT) procedures. In situ vane shear testing and cone penetration testing were also carried out in the surficial materials. In addition, thin walled tube samples were obtained from the silty clay soil at each borehole location. The boreholes were backfilled using Ministry of Transportation, Ontario (MTO) recommended procedures and as required by Ontario Regulation 903 (amended by Ontario Regulation 128/03).

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 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 and thin walled tube samples were transported to our laboratory in Mississauga, Ontario. Triaxial testing was carried out on a thin walled tube sample from borehole 102 at our Mississauga laboratory. The results of the field and laboratory testing are given on the Record of Borehole sheets and in Appendix C.

The as-drilled borehole locations and elevations were referenced to a temporary benchmark and stations provided by Callon Dietz Inc. The bench mark elevation is understood to be referenced to International Great Lakes Datum (IGLD).

4.0 GENERAL SITE GEOLOGY AND STRATIGRAPHY

4.1 Geology

The Town of Leamington is located in the physiographic region of southwestern Ontario known as the St. Clair Clay Plain. The continuity of the clay plain is broken west of Leamington by a small morainic hill with sands and gravels deposited by beaches from former Lakes Whittlesey and Warren deposited east of the moraine and fine sands and silt deposited down the slope towards Lake Erie.

The Leamington docks have been constructed into Lake Erie about 300 metres south of the current shoreline. This has been accomplished by mass filling to raise the grade in the Lake Erie bed.

The bedrock is Devonian age limestone of the Lucas Formation belonging to the Detroit River Group. The limestone is light brown and fine to medium grained.

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 C. The records of relevant boreholes previously drilled at the site are provided 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 in front of the sheet pile walls at the site generally consist of silty fine sand, sandy silt and variable thicknesses of silts and sands to about elevation 166 metres which are underlain by a silty clay deposit about 2 to 3 metres thick. The silty clay deposit is underlain by layers of clayey silt till, sandy silt till, sand and sand and gravel materials, which extend to a depth of about 19 metres where the limestone bedrock was encountered at elevation 156.6 metres.

The locations and elevations of the borings, together with the interpreted stratigraphical profiles, are shown on the attached Drawings 1 and 2. A detailed description of the subsurface conditions encountered in the boreholes for this investigation is provided on the Record of Borehole sheets. The results of dynamic cone penetration testing carried out in the surficial deposits are shown on the Record of Borehole sheets and a summary of the soil stratigraphy is provided in the following paragraphs.

4.2.1 Surficial Silt, Sandy Silt and Sand

Boreholes 101, 102 and 103 encountered very loose to compact surficial lake bed deposits consisting of silt, sandy silt and sand beneath some 4.8 to 7.0 metres of water. Shells and organics were noted in the upper layers of the deposits. The surficial deposits were about 0.6 to 2.7 metres thick and extended between elevation 169.6 and 165.4 metres.

In boreholes 101 and 102, the fine grained granular materials had standard penetration test N values of 2 to 5 blows per 0.3 metres. In borehole 103, the N values were 5 to 19 blows per 0.3 metres. The dynamic cone penetration tests confirmed these values and indicated the generally very loose to loose relative density in boreholes 101 and 102 and loose to compact relative density in borehole 103. The water contents in this surficial material ranged from 25 to 111 per cent, reflecting the organic content.

Beneath the silt in borehole 103 and the sandy silt in borehole 101, a 1.1 to 2.7 metre thick deposit of fine sand was encountered. The sand had standard penetration test N values of 3 to 19 blows per 0.3 metres penetration and water contents of about 25 to 34 per cent. The results of grain size analyses carried out on samples of sand, some silt from boreholes 101 and 103 are shown on Figure C-1 in Appendix C following the text of this report.

4.2.2 Silty Clay

The boreholes encountered a layer of silty clay with traces of sand and gravel beneath the surficial silts and sands. The silty clay deposit was 2.2 to 3.2 metres thick and extended to between elevation 165.9 and 162.7 metres. The silty clay had standard penetration test N values of 4 to 10 blows per 0.3 metres penetration. The results of dynamic cone penetration testing and in situ vane testing are also shown on the Record of Borehole sheets. The in situ vane testing indicated undrained shear strengths ranging from 54 to 115 kilopascals with an average undrained shear strength of about 85 kilopascals. The in situ vane sensitivities ranged from 2.0 to 3.7. The testing indicated that the silty clay materials have a stiff to very stiff consistency.

The results of consolidated, undrained triaxial laboratory testing carried out on a sample of the silty clay materials collected from borehole 102 are provided on Figures C-2 to C-5 in Appendix C. The laboratory testing indicated that the sample had an effective angle of internal friction of 32 degrees and an effective cohesion of zero.

The water contents of the silty clay samples ranged from about 17 to 27 per cent with an average water content of 23 per cent. The silty clay deposits had average plastic and liquid limits of about 18 and 25 per cent, respectively, with an average plasticity index of 16. The results are shown on the Plasticity Chart, Figure C-6 in Appendix C.

4.2.3 Clayey Silt Till

Beneath the silty clay deposit, all of the boreholes encountered a 0.3 to 1.3 metre thick layer of clayey silt till. A 2.2 metre thick clayey silt till deposit was also encountered above the bedrock in borehole 103. The upper and lower clayey silt till layers were encountered at elevations of about 163 and 159 metres, respectively, and extended to the bedrock surface at about elevation 156.6 metres. A boulder was encountered at the bottom of the till deposit at elevation 162.6 metres in borehole 101.

The clayey silt till layers had standard penetration test N values of 66 blows per 0.3 metres penetration to 100 blows per 100 millimetres penetration, indicating a hard consistency. The clayey silt till samples had measured water contents between about 8 and 12 per cent.

4.2.4 Sand and Silty Fine Sand

Layers of sand and silty fine sand were encountered beneath the clayey silt till in borehole 102. In boreholes 101 and 103, the sands were interlayered with sandy silt materials beneath the clayey silt till. The individual layers of sand and silty fine sand were 0.5 to 1.8 metres thick where fully penetrated. Borehole 101 was terminated in a layer of fine sand at elevation 158.7 metres after exploring the layer for some 0.9 metres. The sand and silty fine sand layers had standard penetration test N values of 41 to 100 blows per 0.3 metres penetration, indicating dense to very dense materials. Water contents of the fine sand layers in borehole 101 were about 19 per cent.

The results of a grain size analysis carried out on a sample of sand with some silt from borehole 101 are shown on Figure C-1 in Appendix C.

4.2.5 Sandy Silt

Beneath the clayey silt till in borehole 103 and interlayered with the sands in boreholes 101 and 102, sandy silt layers 0.8 to 1.4 metres thick were encountered. The sandy silt layers had standard penetration test N values of 69 to 110 blows per 0.3 metres penetration, indicating very dense deposits with measured water contents of about 13 and 18 per cent.

4.2.6 Sand and Gravel

Beneath the sands in borehole 102, a 1.5 metre thick layer of very dense sand and gravel was encountered at elevation 160.2 metres. The very dense sand and gravel layer had a single standard penetration test N value of 64 blows per 0.3 metres penetration.

4.2.7 Sandy Silt Till

Beneath the sand and gravel, borehole 102 encountered a 2.1 metre thick deposit of sandy silt till at elevation 158.7 metres. The sandy silt till was noted to contain cobbles and had a single standard penetration test N value of 64 blows per 0.3 metres penetration, indicating a very dense deposit. The measured water content of the sandy silt till sample was about 8 per cent.

4.2.8 Bedrock

The bedrock surface was encountered some 19.4 metres below the dock surface, or at elevation 156.6 metres, in boreholes 102 and 103. The top 3.5 to 3.6 metres of the bedrock was cored in NQ size in the boreholes and it was identified to be brownish grey, medium strong, argillaceous limestone of the Lucas formation. The total rock core recoveries (TCR) recorded were 53 to 100 per cent, with measured solid core recoveries (SCR) of 5 to 100 per cent and rock quality designations (RQD) of zero to 100 per cent. The lower TCR, SCR and RQD values were typically indicated in the upper metre of the bedrock surface.

4.3 Water Conditions and Lake Bed Elevations

Lake Erie water levels were noted at the three borehole locations during drilling and are reported to about 1.6 to 1.7 metres below the dock, or at about elevation 174.3 metres. No artesian water levels were noted in the borehole casings. These measured water levels and lake bed elevations are shown on the attached Record of Borehole sheets and are summarized below:

BOREHOLE NUMBER	LAKE WATER ELEVATION (m)	LAKE BED ELEVATION (m)
101	174.28	168.57
102	174.25	167.26
103	174.33	169.55

Based on the profile drawings provided, it is understood that the design dredge elevations at the Pelee Islander and the Jiimaan ferry docks are at elevations 170.5 and 169.0 metres, respectively, with about 0.6 to 1.4 metres of scour measured in 2003. The measured lake surface and bottom levels are shown in profile and section on Drawing 2 together with the subsurface stratigraphy encountered in the boreholes. The lake bed at the docks was at elevation 167.3 metres at borehole 102 drilled at the southern end, at elevation 169.6 metres at borehole 103 drilled at the north end, and at elevation 168.6 metres at borehole 101 in the central area. The lake bed at the borehole locations is underlain by 2.0 to 2.8 metres of very loose sands and silts.

Lake level data collected since 1918 by the Canadian Hydrographic Service indicate that the minimum and maximum recorded water levels for Lake Erie are 173.18 and 175.04 metres, respectively. It should be noted that the lake level is subject to seasonal fluctuations and the mean level for the month of August is reported to be 174.94 metres.

5.0 ENGINEERING RECOMMENDATIONS

5.1 General

This section of the report provides our recommendations on the foundation aspects of the existing sheet pile walls for the MTO ferry docks at Leamington. Similar foundation investigations were undertaken for this project at the ferry docks in Kingsville and Pelee Island.

Our recommendations are based on our interpretation of the factual information obtained during the investigation and the results of field and laboratory testing. It should be noted that the interpretation and recommendations are intended for use 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.

5.2 Existing Sheet Pile Walls

Based on information provided by Morrison Hershfield, the existing docks are at elevation 176.0 metres (all elevations are referenced to International Great Lakes Datum, IGLD) and the lake water level is at elevation 174.3 metres. Lake level data collected since 1918 by the Canadian Hydrographic Service indicate that the minimum and maximum recorded water levels for Lake Erie are 173.18 and 175.04 metres, respectively. Based on the information provided, it is understood that the design dredge elevations at the Pelee Islander and the Jiimaan ferry docks are at elevations 170.5 and 169.0 metres, respectively. The current lake bed survey data provided indicate about 0.6 to 1.4 metres of scour below the design level being measured in 2003. The design sheet pile tips are at elevation 162.3 metres.

It is understood that soil parameters are required to analyze the stability of the existing sheet pile walls at the docks. The subsurface conditions encountered in the three boreholes drilled in Lake Erie adjacent to the retaining wall during this investigation typically consisted of thin surficial very loose to compact fine grained granular deposits below some 4.8 to 7.0 metres of water. These deposits extended to about elevation 166 metres and were underlain by a 2.2 to 3.2 metre thick layer of stiff to very stiff silty clay. Below elevation 162.7 to 163.2 metres, the silty clay deposit is underlain by layers of hard clayey silt till, very dense sandy silt till, and dense to very dense sand, silty fine sand, sandy silt and sand and gravel materials, which extend to depths of about 19 metres where limestone bedrock was encountered at elevation 156.6 metres. Cobbles and boulders are indicated in the till deposits. The stratigraphy encountered in the boreholes is detailed on the Record of Borehole sheets, Drawing 2, and is summarized in the following table:

BOREHOLE	DOCK SURFACE ELEVATION (m)	BOTTOM OF DOCK FILL* (m)	LAKE WATER ELEVATION^ (m)	LAKE BED ELEVATION (m)	TILL SURFACE ELEVATION (m)	ROCK SURFACE ELEVATION (m)
101	175.98	170.85	174.28	168.57	163.00	-
102	175.98	170.12	174.25	167.26	163.18	156.56
103	175.95	172.26	174.33	169.55	162.69	156.56

*Elevations obtained from previous boreholes drilled on the dock by Golder Associates (Geocres No. 40J2-57) as shown on Drawings 1 and 2.

^Lake water level at time of drilling.

Based on the high N values obtained in the clayey silt till and the results of the dynamic cone penetration tests that were advanced to refusal just below the surface of the till, it is anticipated that the existing sheet pile walls only extend to just below the top of the clayey silt till deposit or to about elevation 162.5 to 163.0 metres. However, if the sheet piles were driven their full 13.7 metre design lengths and into the till deposit, the sheet pile tips would be at about elevation 162.0 metres and about 4 to 7 metres of embedment is indicated at the borehole locations.

5.2.1 Geotechnical Parameters

Based on the subsurface conditions encountered in the boreholes, the following parameters are recommended for the analysis and design of the sheet pile walls to check the stability of the existing conditions in accordance with the Canadian Highway Bridge Design Code (CHBDC):

	TOTAL	SUBMERGED
Unit weight of granular backfill:	21 kN/m^3	11 kN/m^3
Unit weight of native soils:		
Surficial granular soils	17 kN/m^3	0.7
Silty clay	17 kN/m^3	0.7
Till deposits	22 kN/m^3	1.2
Lower granular soils	22 kN/m^3	1.2
Undrained shear strength of cohesive soils:		
Silty clay	85 kPa	
Clayey silt till	200 kPa	

MATERIAL	ANGLE OF FRICTION		COEFFICIENTS OF LATERAL EARTH PRESSURE			
			No Wall Friction		With 10° Wall Friction	
	Internal	Soil/Steel	'active',K_a	'passive', K_p	K_a	K_p
Compact to dense rock fill	40°	25°	0.22	4.60	0.21	7.0
Very loose to loose surficial granular soils	28°	17°	0.36	2.77	0.34	3.7
Stiff to very stiff silty clay	32°	21°	0.31	3.20	0.29	4.6
Hard clayey silt till deposit	34°	22°	0.25	4.00	0.23	6.0
Dense to very dense lower granular soils and sandy silt till	35°	22°	0.25	4.00	0.23	6.0

The inclusion of soil/wall friction in the analyses will depend upon the amount of relative movement which has or can occur or would be required to develop these forces. Further, the wall friction coefficient has been limited to 10° since larger values would necessitate substantial wall deformation, particularly to develop passive resistance.

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.

Section A-A¹, as shown on Drawing 2, should be used for the analytical model.

5.2.2 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 below the soil and steel sheeting can be mobilized will be dependent upon the amount of relative movement which has or can occur.

We understand that if the stability of the sheet pile walls is found to be marginally acceptable, consideration would be given to replacing the loose surficial sands and silts in the lake bed adjacent to the docks with less erodible and heavier fill. In addition, consideration could be given to replacing the rock fill below the deck of the dock with lighter weight fill. It should be noted that expanded polystyrene fill is not considered suitable at this site due to the high water level.

In addition to these geotechnical considerations, a number of structural options could be considered such as a pile supported relieving platform constructed behind the wall or steel pipes inserted into the hard clayey silt till to effectively increase the toe resistance. The table on the following page provides a summary of the various stabilization alternatives, their advantages, disadvantages, relative costs and risks.

	ALTERNATIVE	ADVANTAGES	DISADVANTAGES	COSTS	RISKS
1	Relieving Platform (piles driven to bedrock for support of backfill)	Decreases active pressures	Complete disturbance of dock area Interference with ferry operations Long construction period Extensive	Expensive construction	Interference with removal of existing services below dock
2	Light Weight Fill Above the Water Level	Decreases active pressures	Disturbance of dock area, installation below water level less effective No increase in passive pressure or scour resistance Interference with ferry operations	Expensive construction	Interference with existing services below dock
3	Drilled Pile/Grouted Toe Restraint	Increases passive pressures	Installation below water	Less expensive	Buckling of existing sheeting Lower water may be required
4	Rock Anchors Connected to Waler	Increases stability	Minimal impact on dock Installation from marine equipment Long construction period Interference with ferry operations	Moderately expensive	Substantial below water operations
5	Addition of Lake Bed Fill	Reduces scour and increases passive pressures	Requires careful placement Conflict with additional requirements	Less expensive	Below water operations Damage to ferry

Based on foundations engineering consultations, alternative 3 is the recommended solution.

If the analyses indicate that the stability of the wall is not acceptable, a monitoring program should be implemented to assess the magnitude and rate of wall deformation and related effects.

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LIST OF ABBREVIATIONS

The abbreviations commonly employed on each "Record of Borehole", on the figures and in the text of the report, are as follows:

I. SAMPLE TYPES

AS auger sample
CS chunk sample
DO drive open
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
SS split spoon

II. PENETRATION RESISTANCES

Dynamic Penetration Resistance:
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 0.3 m (12 in.).

Standard Penetration Resistance, 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.) drive open sampler for a distance of 0.3 m (12 in.).

WH sampler advanced by static weight-weight, hammer

PH sampler advanced by hydraulic force

PM sampler advanced by manual force

III. SOIL DESCRIPTION

(a) *Cohesionless Soils*

Relative Density	"N" Blows/0.3 m or Blow/ft.
Very loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very dense	over 50

(b) *Cohesive Soils*

Consistency	"Cu" = "Su" kPa	psf.
Very soft	0 to 12	0 to 250
Soft	12 to 25	250 to 500
Firm	25 to 50	500 to 1000
Stiff	50 to 100	1000 to 2000
Very stiff	100 to 200	2000 to 4000
Hard	over 200	over 4000

IV. SOIL TESTS

C consolidation test
H hydrometer analysis
M sieve analysis
MH combined analysis, sieve and hydrometer [1]
Q undrained triaxial [2]
R consolidated undrained triaxial [2]
S drained triaxial
U unconfined compression
V field vane test
Chem chemical analysis

NOTES:

1. Combined analyses when 5 to 95 per cent of the material passes the No. 200 sieve.
2. Undrained triaxial tests in which pore pressures are measured are shown as Q or R.

LIST OF SYMBOLS

I. GENERAL

$\pi = 3.1416$
e = base of natural logarithms 2.7183
$\log_e$ a or ln a, natural logarithm of a
$\log_{10}$ a or log a, logarithm of a to base 10
t time
g acceleration due to gravity
V volume
W weight
m mass
M moment
F factor of safety

II. STRESS AND STRAIN

u pore pressure
σ normal stress
σ' normal effective stress (σ is also used)
τ shear stress
ε linear strain
ε_{sy} shear strain
υ Poisson's ration (μ is also used)
E modulus of linear deformation (Young's modulus)
G modulus of shear deformation
K modulus of compressibility
η coefficient of viscosity

III. SOIL PROPERTIES

(a) *Unit weight*

γ unit weight of soil (bulk density)
γ_s unit weight of solid particles
γ_w unit weight of water
γ_d unit dry weight of soil (dry density)
γ' unit weight of submerged soil
G_s specific gravity of solid particles $G_s = \gamma_s/\gamma_w$
e void ratio
n porosity
w water content
S_r degree of saturation

(b) *Consistency*

w_L liquid limit
w_P plastic limit
I_P plasticity index
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
D_r relative density = $(e_{max} - e)/(e_{max} - e_{min})$

(c) *Permeability*

h hydraulic head or potential
q rate of discharge
v velocity of flow
i hydraulic gradient
κ coefficient of permeability
j seepage force per unit volume

(d) *Consolidation (one-dimensional)*

m_v coefficient of volume change = $-\Delta e/(1+e)\Delta\sigma'$
C_c compression index = $-\Delta e/\Delta\log_{10}\sigma'$
c_v coefficient of consolidation
T_F time factor = $c_v t/d^2$ (d, drainage path)
U degree of consolidation

(e) *Shear strength*

τ_f shear strength
c' effective cohesion intercept
ϕ' effective angle of shearing resistance, or friction

(in terms of effective stress: $\tau_f = c' + \sigma' \tan\phi$)

S_u apparent cohesion*
ϕ_u apparent angle of shearing resistance, or friction

(in terms of total stress: $\tau_f = cu + \sigma \tan\phi_u$)

μ coefficient of friction
S_t sensitivity

*For the case of a saturated cohesive soil, $\phi_u = 0$ and the undrained shear strength $\tau_f = S_u$ is taken as half the undrained compressive strength.

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

Description	Bedding Plane Spacing-
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

Description	Spacing
Very wide	> 3 m
Wide	I – 3 m
Moderately close	0.3 – I 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 front 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
FO - Foliation Schistosity
CL - Cleavage
SH - Shear Plane Zone
VN - Vein
F - Fault
CO - Contact
J - Joint
FR - Fracture
M F - Mechanical Fracture
II - Parallel To
⊥ - Perpendicular To

P - Polished
S - Slickensided
SM - Smooth
R - Ridged / Rough
ST - Stepped
PL - Planar
FL - Flexured
UE - Uneven
W - Wavy
C - Curved

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RECORD OF BOREHOLE No 101

1 OF 2

METRIC

PROJECT 021-4216-1-1 | G.W.P. (WO No. 01-33-001) | LOCATION N 4653697.3 ;E 367325.2 | ORIGINATED BY MA

DIST 31 | HWY N/A | BOREHOLE TYPE ROTARY DRILLING (NW CASING) TO 11.13m, NQ TRI-CONE TO END | COMPILED BY BG

DATUM I.G.L.D. | DATE August 30, 2004 - August 31, 2004 | CHECKED BY

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE
175.98	DOCK SURFACE						
0.00							
174.28						▽	
1.70	WATER						
168.57							
7.41	SILT, trace sand, Very loose, Grey						
167.72			1	SS	2		
8.26	SAND & SANDY SILT, layered, trace organics, Very loose, Grey						
166.80			2	SS	3		
9.18	SAND, fine, trace to some silt, Very loose, Grey		3	SS	3		
165.74							
10.24	SILTY CLAY, trace sand, trace gravel, Stiff to very stiff, Grey		4	SS	10		
			5	TO	PH		
163.00							
12.98	CLAYEY SILT, trace sand, gravel (TILL), Hard, Grey		6	SS	82		
162.63			7	SS	40/0mm		
13.35			8	SS			
162.11	BOULDER						
13.87	SAND, fine, trace to some silt, Very dense, Grey		9	SS	100		
161.01							

DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100)

SHEAR STRENGTH kPa (20 40 60 80 100)
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L

WATER CONTENT (%) (10 20 30)

UNIT WEIGHT γ kN/m³

REMARKS & GRAIN SIZE DISTRIBUTION (%)

GR SA SI CL

110.6
56.2
40.8
3.2
2.0

DYNAMIC CONE PENETRATION TEST (100 blows/last 0.2m)

0 60 32 8

0 60 32 3

Continued Next Page

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

ON_MTO 021-4216-L.GPJ ON_MOT.GDT 10/6/04

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RECORD OF BOREHOLE No 101

2 OF 2

METRIC

PROJECT 021-4216-1-1

G.W.P. (WO No. 01-33-001)

LOCATION N 4653697.3 ;E 367325.2

ORIGINATED BY MA

DIST 31 HWY N/A

BOREHOLE TYPE ROTARY DRILLING (NW CASING) TO 11.13m, NQ TRI-CONE TO END

COMPILED BY BG

DATUM I.G.L.D.

DATE August 30, 2004 - August 31, 2004

CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (20 40 60 80 100): ○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES						GR SA SI CL
14.97	SANDY SILT, trace clay, Very dense, Grey		10	SS	110		160		○		
159.64											
16.34	SAND, fine, trace to some silt, Very dense, Grey		11	SS	106		159		○		
158.73											
17.25	END OF BOREHOLE Water level at elev. 174.28m during drilling Aug. 30&31, 2004										

+ 3, × 3: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

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London, Ontario

RECORD OF BOREHOLE No 102

1 OF 2

METRIC

PROJECT 021-4216-1-1
G.W.P. (WO No. 01-33-001)
LOCATION N 4653665.9 ;E 367316.7
ORIGINATED BY MA
DIST 31 HWY N/A
BOREHOLE TYPE ROTARY DRILLING (NW CASING), N TRI-CONE
COMPILED BY BG
DATUM I.G.L.D.
DATE August 31, 2004 - September 1, 2004
CHECKED BY

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS
175.98	DOCK SURFACE					
0.00						
174.25						▽
1.73	WATER					
167.26						
8.72	SAND, silty fine, trace shells, organics, Very loose, Grey					
166.62						
9.36	SANDY SILT and FINE SAND, layered, Very loose, Grey		1	SS	3	
			2	SS	4	
165.40						
10.58	SILTY CLAY, trace sand, trace gravel, Stiff, Grey		3	SS	5	
			4	TO	PH	
163.18						
12.80	CLAYEY SILT, trace sand, gravel, (TILL), with cobbles, Hard, Grey		5	SS	110	
161.90						
14.08	SAND, fine to coarse, some gravel, trace silt, Dense, Grey		6	SS	41	

ELEVATION SCALE: 175, 174, 173, 172, 171, 170, 169, 168, 167, 166, 165, 164, 163, 162

DYNAMIC CONE PENETRATION RESISTANCE PLOT
20 40 60 80 100

SHEAR STRENGTH kPa
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE
20 40 60 80 100

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L
WATER CONTENT (%)
10 20 30

60.5
3.5
(>96kPa)+
DYNAMIC CONE PENETRATION TEST
(100 blows/last 0.2m)

UNIT WEIGHT γ kN/m³

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

R

Continued Next Page

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

ON_MTO 021-4216-L.GPJ ON_MOT.GDT 10/6/04

Golder Associates
London, Ontario

RECORD OF BOREHOLE No 102

2 OF 2

METRIC

PROJECT 021-4216-1-1

G.W.P. (WO No. 01-33-001)

LOCATION N 4653665.9 ;E 367316.7

ORIGINATED BY MA

DIST 31 HWY N/A

BOREHOLE TYPE ROTARY DRILLING (NW CASING), N TRI-CONE

COMPILED BY BG

DATUM I.G.L.D.

DATE August 31, 2004 - September 1, 2004

CHECKED BY

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
160.74			6	SS	41				○		
15.24 / 160.22	SAND, fine, trace silt, Dense, Grey										
15.76	SAND AND GRAVEL, trace to some silt, with cobbles, Very dense, Grey		7	SS	112		160				
158.70							159				
17.28	SANDY SILT, with cobbles, (TILL) Very dense, Grey		8	SS	64		158		○		
156.56							157				
19.42	Fresh, fine grained, thinly bedded, moderately porous, brownish grey, medium strong, argillaceous LIMESTONE, with a styolite texture and occasional fossils (LUCAS FORMATION)		9	SS	150/150mm						
			10	NQ RC			156	T.C.R. (%): 65 / S.C.R. (%): 35 / R.Q.D. (%): 25			
			11	NQ RC			155	T.C.R. (%): 100 / S.C.R. (%): 51 / R.Q.D. (%): 49			
			12	NQ RC			154	T.C.R. (%): 95 / S.C.R. (%): 85 / R.Q.D. (%): 80			
152.94							153				
23.04	END OF BOREHOLE Water level at elev. 174.25m during drilling drilling Aug. 31, 2004										

+ 3, × 3: Numbers refer to Sensitivity

○ 3% STRAIN AT FAILURE

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RECORD OF BOREHOLE No 103

1 OF 2

METRIC

PROJECT 021-4216-1-1
G.W.P. (WO No. 01-33-001)
LOCATION N 4653740.4 ;E 367365.5
ORIGINATED BY MA
DIST 31 HWY N/A
BOREHOLE TYPE ROTARY DRILLING (NW CASING), N TRI-CONE
COMPILED BY BG
DATUM I.G.L.D.
DATE September 2, 2004 - September 3, 2004
CHECKED BY

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS
175.95	DOCK SURFACE					
0.00						
174.33						▽
1.62	WATER					
169.55						
6.40	SILT, trace sand, shells, organics, Very loose, Grey					
168.63			1	SS	5	
7.32	SAND, fine, trace to some silt, Loose to compact, Grey		2	SS	19	
			3	SS	11	
165.89						
10.06	SILTY CLAY, trace sand, trace gravel, Stiff, Grey		4	SS	6	
			5	SS	5	
			6	TO	PH	
162.69						
13.26	CLAYEY SILT, trace sand, gravel, (TILL), Hard, Grey		7	SS	101	
162.39						
13.56	SANDY SILT, Very dense, Grey					
161.62						
14.33	SILTY FINE SAND, Dense, Grey		8	SS	91	

ELEVATION SCALE: 175, 174, 173, 172, 171, 170, 169, 168, 167, 166, 165, 164, 163, 162

DYNAMIC CONE PENETRATION RESISTANCE PLOT
20 40 60 80 100

SHEAR STRENGTH kPa
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE
20 40 60 80 100

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L
WATER CONTENT (%)
10 20 30

UNIT WEIGHT γ kN/m³

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

76.1
3.7
2.9
2.6
DYNAMIC CONE PENETRATION TEST (100 blows/last 0.2m)

0 55 41 4

Continued Next Page

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

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London, Ontario

PROJECT 021-4216-1-1

RECORD OF BOREHOLE No 103

2 OF 2

METRIC

G.W.P. (WO No. 01-33-001) LOCATION N 4653740.4 ;E 367365.5 ORIGINATED BY MA

DIST 31 HWY N/A BOREHOLE TYPE ROTARY DRILLING (NW CASING), N TRI-CONE COMPILED BY BG

DATUM I.G.L.D. DATE September 2, 2004 - September 3, 2004 CHECKED BY

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	SILTY FINE SAND, Dense, Grey		8	SS	91						
159.80							160				
16.15	SANDY SILT, Very dense, Grey		9	SS	69						
158.73							159				
17.22	CLAYEY SILT, trace sand, trace gravel (TILL) Hard, Grey		10	SS	66		158		○		
156.56			11	SS	100/100mm		157				
19.39	Fresh, fine grained, thinly bedded, moderately porous, brownish grey, medium strong, argillaceous LIMESTONE, with a styolite texture and occasional fossils (LUCAS FORMATION)		12	SS	100/50mm						
			13	NQ RC			156	T.C.R. (%): 53			
			14	NQ RC			155	T.C.R. (%): 98; S.C.R. (%): 5; R.Q.D. (%): 0			
			15	NQ RC			154	T.C.R. (%): 100; S.C.R. (%): 90; R.Q.D. (%): 90			
153.06								T.C.R. (%): 100; R.Q.D. (%): 100			
22.89	END OF BOREHOLE Water level at elev. 174.33m during drilling drilling Sept 2&3, 2004										

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

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RECORD OF BOREHOLE No L1

1 OF 1

METRIC

PROJECT 021-4216 | G.W.P. 01-33-001 | DIST #31 HWY N/A | DATUM Geodetic

LOCATION 4653751N, 367367E | BOREHOLE TYPE POWER AUGER (SOLID STEM, HOLLOW STEM) | DATE September 13, 2002

ORIGINATED BY C.C. | COMPILED BY T.M. | CHECKED BY H.D.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (20 40 60 80 100): ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
175.95	GROUND SURFACE										
0.00	FILL, granular base, with filter fabric Loose to compact Grey Brown to Brown		1	AS	-				○		
			2	SS	8		175				
			3	SS	26	▽					
173.82							174				
2.13	FILL, rock (cobble size), some sand layers/ inclusions Compact Grey to Brown		4	SS	16						
173.05							173		○		
2.90	FILL, silty sand, some rock fragments, occ. grey to black organic inclusions		5	SS	59						
172.60											
3.35	Very dense Grey Brown to grey										
172.14							172				
3.81	FILL, rock (cobble size), some sand Very Dense Grey to Brown		6	SS	5						0 85 10 5
	FINE SAND to SILTY FINE SAND, trace gravel Loose to compact Brown Grey to Grey		7	SS	10						
							171				
			8	SS	4						
							170				
							169				
			9	SS	11				○		
							168				
							167				
			10	SS	23						
							166				
164.92			11	SS	4		165		○		
11.13	SILTY CLAY, some sand Soft Grey Brown End of Borehole										

NOTES:
Water level in Borehole at about elev. 173.97m upon completion of drilling on Sept. 13, 2002.

Borehole drilled in repaired area.

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

ON_MTO 021-4216.GPJ ON_MOT.GDT 9/29/04

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RECORD OF BOREHOLE No L2

1 OF 1

METRIC

PROJECT 021-4216 | G.W.P. 01-33-001 | LOCATION 4653738N, 367361E | ORIGINATED BY C.C.

DIST #31 | HWY N/A | BOREHOLE TYPE POWER AUGER (HOLLOW STEM and WASH BORING) | COMPILED BY T.M.

DATUM Geodetic | DATE September 13, 2002 - September 16, 2002 | CHECKED BY H.D.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (20 40 60 80 100): ○ UNCONFINED, ● QUICK TRIAXIAL, + FIELD VANE, × LAB VANE	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
175.92	PAVEMENT SURFACE										
0.00	ASPHALT										
0.14	FILL, granular base										
0.33	FILL, fine sand, trace silt, some crushed rock at depth Loose Brown		1	AS	-				○		
174.85			2	SS	5		175				
1.07	FILL, crushed rock (clear stone), some sand Loose to dense Grey										
173.82			3	SS	31		174				
2.10	FILL, fine sand, trace silt, cobbles in sand layers, with some black organic inclusions Very dense to dense Brown		4	SS	52	▽			○		38 48 14 0
172.72							173				
3.20	FILL, rock (cobble size), wth silty sand layers Dense Grey		5	SS	39						
172.26							172				
3.66	FINE SAND to SILTY FINE SAND, occ. black organic inclusions, trace gravel, occ. shells Loose to very loose Grey Brown to Grey		6	SS	9						
			7	SS	3		171		○		
			8	SS	9		170				
			9	SS	6		169		○		
			10	SS	8		168		○		
166.16							167				
9.75	End of Borehole										

NOTES:
Water seepage into borehole encountered at about elev. 173.63m during drilling on Sept. 16, 2002.

Borehole drilled in existing settled pavement area.

Encountered buried electrical wires at a depth of about 1.5m during drilling.

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

$\bigcirc^{3\%}$ STRAIN AT FAILURE

ON_MTO 021-4216.GPJ ON_MOT.GDT 9/29/04

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RECORD OF BOREHOLE No L3

1 OF 1

METRIC

PROJECT 021-4216
G.W.P. 01-33-001
LOCATION 4653721N, 367353E
ORIGINATED BY C.C.
DIST #31 HWY N/A
BOREHOLE TYPE POWER AUGER (HOLLOW STEM and WASH BORING)
COMPILED BY T.M.
DATUM Geodetic
DATE September 16, 2002
CHECKED BY H.D.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
175.96	PAVEMENT SURFACE										
0.00	ASPHALT										
0.14 / 175.53	FILL, granular base		1	AS	-						
0.43	FILL, fine sand, trace silt, occ. gravel										
0.61	Brown		2	SS	4		175				
	FILL, crushed rock (clear stone), with some sand layers/ intermixing Loose										
174.59	Brown										
1.37	FILL, rock (cobble size), with some sand layers/ inclusions Compact to dense Grey Brown to Grey		3	SS	>30	▽	174				
			4	SS	21						
							173				
			5	SS	32						53 39 8 0
172.15											
3.81	FILL, fine sand to silty fine sand, with rock fragments, occ. black organic inclusions		6	SS	9		172				
171.63	Loose										
4.33	Black to Grey		7	SS	11						
	FINE SAND to SILTY FINE SAND, occ. black organic pockets/ staining Loose to compact Grey to Black						171				
							170				
			8	SS	5						
							169				
			9	SS	6						
							168				
							167				
			10	SS	8						
							166				
164.84			11	SS	5		165				
11.13	End of Borehole										

NOTES:
Water level in borehole at about elev. 174.00m upon completion of drilling on Sept. 16, 2002.

Borehole drilled in (sound) existing pavement area.

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

ON_MTO 021-4216.GPJ ON_MOT.GDT 9/29/04

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RECORD OF BOREHOLE No L4

1 OF 1

METRIC

PROJECT 021-4216
G.W.P. 01-33-001
LOCATION 4653725N, 367338E
ORIGINATED BY C.C.
DIST #31 HWY N/A
BOREHOLE TYPE POWER AUGER (HOLLOW STEM and WASH BORING)
COMPILED BY T.M.
DATUM Geodetic
DATE September 11, 2002 - September 16, 2002
CHECKED BY H.D.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS
175.86	PAVEMENT SURFACE					
0.00	ASPHALT					
0.15	FILL, granular base		1	AS	-	
0.33	FILL, fine sand, trace silt, some rock fragments Compact Brown		2	SS	20	
174.70						
1.16	FILL, rock (cobble size) Compact					
174.34						
1.52	Grey Brown		3	SS	23	▽
1.68	FILL, fine sand, trace silt, some rock fragments Compact Brown					
	FILL, rock (cobble size), some sand layers, occ. grey black organic pockets/ staining Compact Grey to Brown		4	SS	25	
			5	SS	20	
171.44						
4.42	FINE SAND to SILTY FINE SAND, trace silt, some rock fragments near surface, occ. black organic inclusions/ pockets Very loose to compact Grey brown to grey		6	SS	7	
			7	SS	7	
			8	SS	10	
			9	SS	3	
166.11						
9.75	End of Borehole					

NOTES:
Initial Borehole L4 terminated at about elevation 173.9m upon encountering buried electrical conduit.

Water seepage into borehole encountered at about elev. 175.16m during drilling on Sept. 16, 2002.

ELEVATION SCALE: 175, 174, 173, 172, 171, 170, 169, 168, 167

DYNAMIC CONE PENETRATION RESISTANCE PLOT
20 40 60 80 100

SHEAR STRENGTH kPa
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE
20 40 60 80 100

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L
WATER CONTENT (%)
10 20 30

UNIT WEIGHT γ kN/m³

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

$+^3, \times^3$: Numbers refer to Sensitivity
○ 3% STRAIN AT FAILURE

ON_MTO 021-4216.GPJ ON_MOT.GDT 9/29/04

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London, Ontario

RECORD OF BOREHOLE No L5

1 OF 1

METRIC

PROJECT 021-4216 | G.W.P. 01-33-001 | LOCATION 4653709N, 367327E | ORIGINATED BY C.C.

DIST #31 | HWY N/A | BOREHOLE TYPE POWER AUGER (HOLLOW STEM and WASH BORING) | COMPILED BY T.M.

DATUM Geodetic | DATE September 16, 2002 | CHECKED BY H.D.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: "N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa: ○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
175.95	PAVEMENT SURFACE										
0.00	ASPHALT										
0.13 / 175.52	FILL, granular base		1	AS	-				○		
0.43 / 175.19	FILL, fine sand, trace silt, some gravel/ rock fragments										
0.76	Brown		2	SS	9		175				80 17 3 0
174.58	FILL, crushed rock (clear stone) some sand										
1.37	Loose Grey Brown FILL, rock (cobble size), some sand layers/ inclusions Compact to loose Grey to Brown		3	SS	20	▽	174		○		
			4	SS	15						
							173				
			5	SS	9						
			6	SS	13		172				
171.53											
4.42	FINE SAND to SILTY FINE SAND, some rock fragments near surface, occ. black peat/ organic silt seams/ layers Compact to loose Grey to Brown Grey		7	SS	16		171		○		
			8	SS	4		170				
			9	SS	3		169				
			10	SS	5		168				
							167				
			11	SS	3		166				
164.82							165		○		
11.13	End of Borehole										

NOTES:
Water level in borehole at about elev. 174.02m upon completion of drilling on Sept. 16, 2002.

Borehole drilled in paved, repaired area.

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

ON_MTO 021-4216.GPJ ON_MOT.GDT 9/29/04

Golder Associates
London, Ontario

RECORD OF BOREHOLE No L6

1 OF 1

METRIC

PROJECT 021-4216 | G.W.P. 01-33-001 | LOCATION 4653698N, 367320E | ORIGINATED BY C.C.

DIST #31 | HWY N/A | BOREHOLE TYPE POWER AUGER (HOLLOW STEM and WASH BORING) | COMPILED BY T.M.

DATUM Geodetic | DATE September 17, 2002 | CHECKED BY H.D.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
175.88	PAVEMENT SURFACE										
0.00	ASPHALT										
0.18	FILL, granular base										
175.40	Grey		1	AS	-				○		
0.48	FILL, fine sand and gravel										
0.61	Brown		2	SS	17		175		○		
174.72	FILL,fine sand , trace silt, occ. gravel										
1.16	Compact Brown										
1.37	FILL, crushed rock (clear stone), some sand		3	SS	30	▽	174				
	Compact Grey Brown										
	FILL, rock (cobble size), some sand layers/ inclusions Compact to dense Grey Brown to Grey		4	SS	10						
							173				
			5	SS	16						
			6	SS	20		172				91 7 2 0
170.85			7	SS	16				○		
5.03	FINE SAND to SILTY FINE SAND, trace silt, some rock fragments near surface, occ. grey black organic pockets/ zones Very loose to compact Grey to Grey Brown						171				
			8	SS	5		170				
							169				
			9	SS	2		168				
							167				
166.13			10	SS	4				○		
9.75	End of Borehole										

NOTES:
Water level in borehole at about elev. 173.95m upon completion of drilling on Sept. 17, 2002.

Borehole drilled in existing pavement area (nonrepaired).

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

ON_MTO 021-4216.GPJ ON_MOT.GDT 9/29/04

Golder Associates
London, Ontario

RECORD OF BOREHOLE No L7

1 OF 1

METRIC

PROJECT 021-4216 | G.W.P. 01-33-001 | DIST #31 HWY N/A | DATUM Geodetic

LOCATION 4653669N, 367314E | BOREHOLE TYPE POWER AUGER (HOLLOW STEM and WASH BORING) | DATE September 17, 2002

ORIGINATED BY C.C. | COMPILED BY T.M. | CHECKED BY H.D.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH kPa (○ UNCONFINED ● QUICK TRIAXIAL + FIELD VANE × LAB VANE) (20 40 60 80 100)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%) (10 20 30)	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
175.91	PAVEMENT SURFACE										
0.07	ASPHALT										
175.43	FILL, granular base		1	AS	-				○		
0.48	FILL, fine sand, mixed with clear stone and gravel Loose Brown		2	SS	8		175		○		
174.72											
1.19	FILL, sand and gravel, with asphalt fragments Grey and Black Loose		3	SS	10	▽	174				
1.37	FILL, rock (cobble size), some sand layers/ inclusions Compact to dense Grey Brown to Grey		4	SS	14		173				
			5	SS	13						
			6	SS	10		172		○		
			7	SS	>30		171				
170.12											
5.79	FINE SAND to SANDY SILT, trace clay, occ. grey black organic zones/ inclusions Loose to very loose Grey		8	SS	7		170				
			9	SS	3		169				
			10	SS	5		168				
165.12							167				
10.79	SILTY CLAY, trace sand Soft Brown		11	SS	4		166				
164.78							165				
11.13	End of Borehole										

NOTES:
Water seepage into borehole encountered at about elev. 173.96m during drilling on Sept. 17, 2002.

Borehole drilled in existing settled pavement area.

$+^3, \times^3$: Numbers refer to Sensitivity ○ 3% STRAIN AT FAILURE

ON_MTO 021-4216.GPJ ON_MOT.GDT 9/29/04

Golder Associates
London, Ontario

RECORD OF BOREHOLE No L8

1 OF 1

METRIC

PROJECT 021-4216 | G.W.P. 01-33-001 | LOCATION 4653654N, 367310E | ORIGINATED BY C.C.

DIST #31 | HWY N/A | BOREHOLE TYPE POWER AUGER (HOLLOW STEM and WASH BORING) | COMPILED BY T.M.

DATUM Geodetic | DATE September 12, 2002 | CHECKED BY H.D.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	GROUND WATER CONDITIONS
175.93	GROUND SURFACE					
0.00	FILL, granular base, with filter fabric Loose to compact Grey Brown to Brown		1	AS	-	
			2	SS	10	
			3	SS	22	▽
173.80						
2.13	FILL, rock (cobble size), some sand layers/ inclusions Loose to compact Grey Brown to grey		4	SS	5	
			5	SS	10	
			6	SS	10	
			7	SS	24	
170.44						
5.49	SILTY FINE SAND, with some rock fragments, occ. grey black organic zones/ inclusions Loose Grey Brown		8	SS	6	
169.38						
6.55	End of Soil Sampling					
168.00						
7.93	Start of Dynamic Cone Test					
165.26						
10.67	End of Borehole					

NOTES:
Water seepage into borehole encountered at about elev. 173.90m during drilling on Sept. 12, 2002.

Borehole drilled in repaired area.

ELEVATION SCALE: 175, 174, 173, 172, 171, 170, 169, 168, 167, 166

DYNAMIC CONE PENETRATION RESISTANCE PLOT
20 40 60 80 100

SHEAR STRENGTH kPa
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE
20 40 60 80 100

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L

WATER CONTENT (%)
10 20 30

UNIT WEIGHT γ kN/m^3

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

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

○ 3% STRAIN AT FAILURE

ON_MTO 021-4216.GPJ ON_MOT.GDT 9/29/04

Golder Associates
London, Ontario

RECORD OF BOREHOLE No L9

1 OF 1

METRIC

PROJECT 021-4216
G.W.P. 01-33-001
LOCATION 4653637N, 367296E
ORIGINATED BY C.C.
DIST #31 HWY N/A
BOREHOLE TYPE POWER AUGER (HOLLOW STEM and WASH BORING)
COMPILED BY T.M.
DATUM Geodetic
DATE September 11, 2002 - September 18, 2002
CHECKED BY H.D.

ELEV / DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	ELEVATION SCALE	UNIT WEIGHT γ kN/m^3	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
175.97	GROUND SURFACE								
0.00 175.54	FILL, granular base		1	AS	-				
0.43 175.21	FILL, fine sand, trace silt, occ. gravel Brown								
0.76 174.90	FILL, granular subbase Loose		2	SS	8		175		
1.07 174.51	Brown FILL, fine sand, occ. gravel/ rock								
1.46	fragments Loose Brown		3	SS	30	▽	174		
	FILL, crushed rock (cobble size), some sand layeres/ inclusions Dense to loose Grey Brown to Grey		4	SS	10				
			5	SS	24		173		
			6	SS	9		172		
			7	SS	21		171		
170.48									
5.49	FINE SAND to SILTY FINE SAND, trace silt, occ. grey black organic zones/ inclusions Compact to very loose Grey Brown to Brown		8	SS	11		170		0 79 14 7
			9	SS	8		169		
			10	SS	2		168		
166.22							167		
9.75	End of Borehole								

NOTES:
Water level in borehole at about elev. 174.01m during drilling on Sept. 18, 2002.

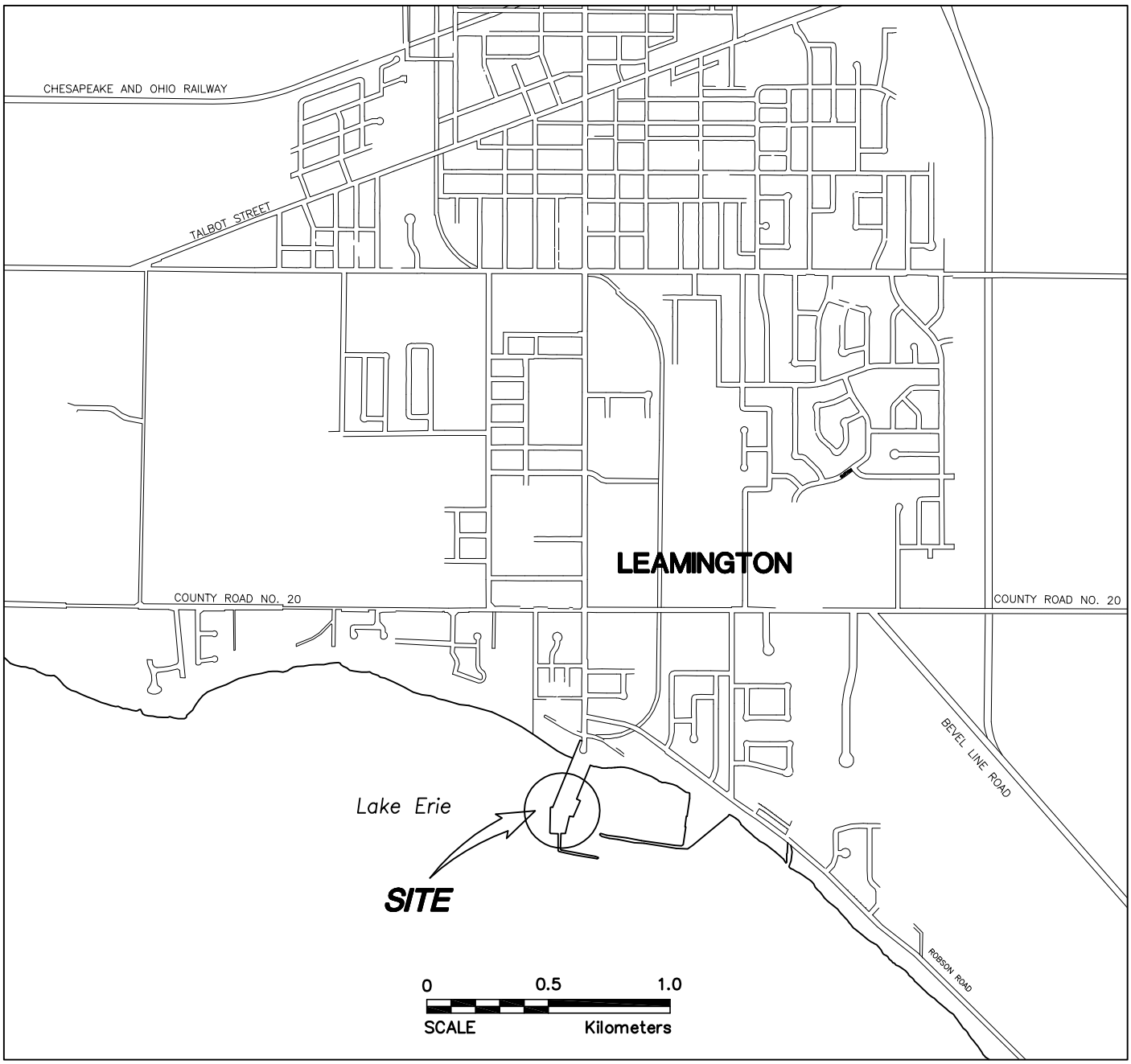
Borehole drilled in repaired area.

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100

SHEAR STRENGTH kPa
○ UNCONFINED + FIELD VANE
● QUICK TRIAXIAL × LAB VANE
20 40 60 80 100

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L
WATER CONTENT (%)
10 20 30

$+^3, \times^3$: Numbers refer to Sensitivity
○ 3% STRAIN AT FAILURE



PROJECT

FERRY WHARF
LEAMINGTON, ONTARIO

TITLE

SITE LOCATION PLAN

Golder Associates
LONDON, ONTARIO

PROJECT No. 021-4216-1-1			FILE No.	0214216-1-L-000
			SCALE AS SHOWN	REV. 0
CADD	WDF	Sept 2004		
CHECK				

FIGURE 1

Drawing file: 0214216-1-L-000.DWG Sep 29, 2004 - 3:05pm

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

DIST	31
W.O. No.	01-33-001
P.O. No.	3005-A-000218

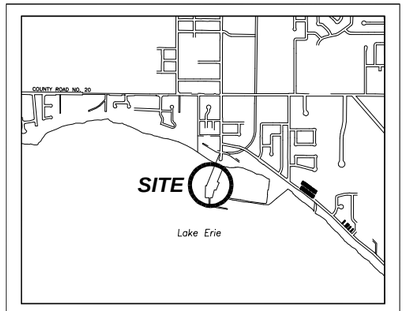
MTO FERRY DOCKS LEAMINGTON, ONTARIO

BOREHOLE LOCATIONS

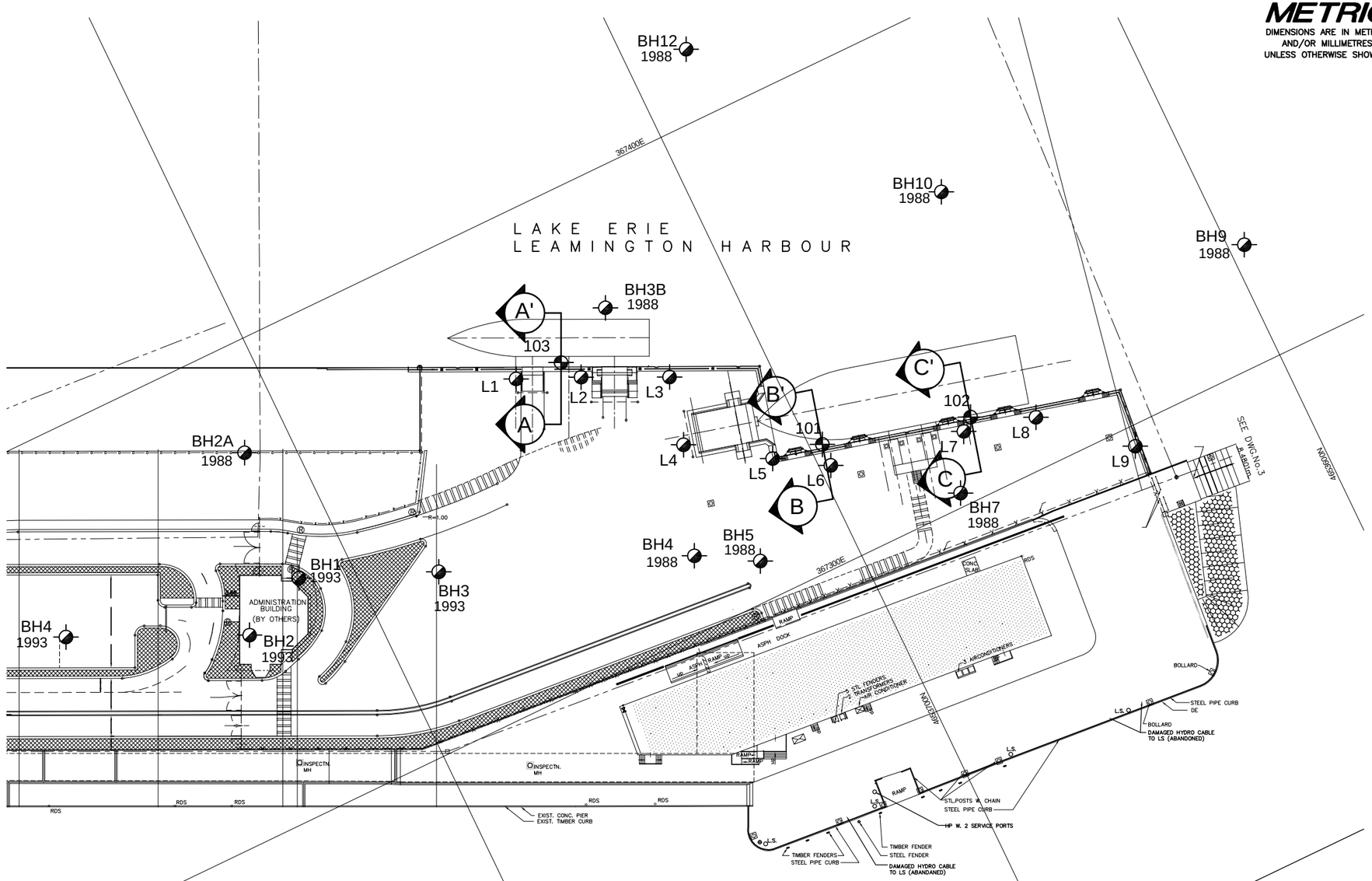
SHEET

Golder Associates Ltd.
LONDON, ONTARIO, CANADA

REFERENCE
DRAWING SUPPLIED BY PUBLIC WORKS CANADA
ARCHITECHURAL AND ENGINEERING SERVICES, ONTARIO REGION
SITE SERVICES AND PAVING
LEAMINGTON, ONTARIO FERRY WHARF
PROJECT No. 670702 DRAWING No. C001
DATED 1993-10-25



KEY PLAN



PLAN

LEGEND

- Borehole Current Investigation
- Borehole Previous Investigations (Boreholes by others indicated by 1988 and 1993)
- Seal
- Piezometer
- N — Blows/0.3m (Std. Pen. Test, 475 j/blow)
- WL in piezometer
- WL during drilling

No.	ELEVATION (metres)	CO-ORDINATES NORTH	CO-ORDINATES EAST
101	175.98	4 653 697.3	367 325.2
102	175.98	4 653 665.9	367 316.7
103	175.95	4 653 740.4	367 365.5
L1	175.95	4 653 751	367 367
L2	175.92	4 653 738	367 361
L3	175.96	4 653 721	367 353
L4	175.86	4 653 725	367 338
L5	175.95	4 653 709	367 327
L6	175.88	4 653 698	367 320
L7	175.91	4 653 669	367 314
L8	175.93	4 653 654	367 310
L9	175.97	4 653 637	367 296

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

BOREHOLE BY OTHERS – 1988

No.	ELEVATION (metres)	CO-ORDINATES NORTH	CO-ORDINATES EAST
BH1	174.5	4 653 883	367 350
BH2A	175.5	4 653 810	367 378
BH3B	174.0	4 653 727	367 372
BH4	173.9	4 653 733	367 316
BH5	174.0	4 653 720	367 308
BH7	173.9	4 653 675	367 303
BH9	174.0	4 653 597	367 325
BH10	174.0	4 653 650	367 363
BH12	173.9	4 653 687	367 415

BOREHOLE BY OTHERS – 1993

No.	ELEVATION (metres)	CO-ORDINATES NORTH	CO-ORDINATES EAST
BH1	175.2	4 653 811	367 348
BH2	174.8	4 653 826	367 341
BH3	175.2	4 653 784	367 336
BH4	175.8	4 653 862	367 358

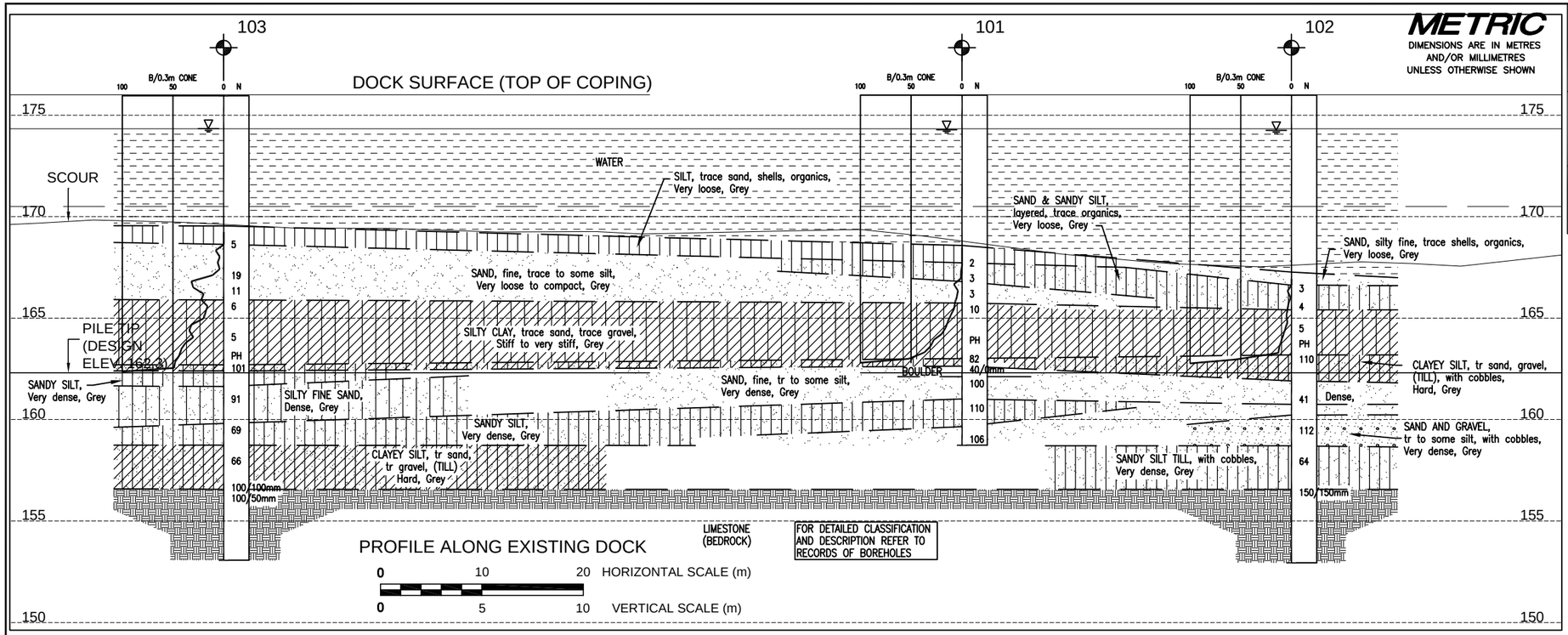
NO.	DATE	BY	REVISION

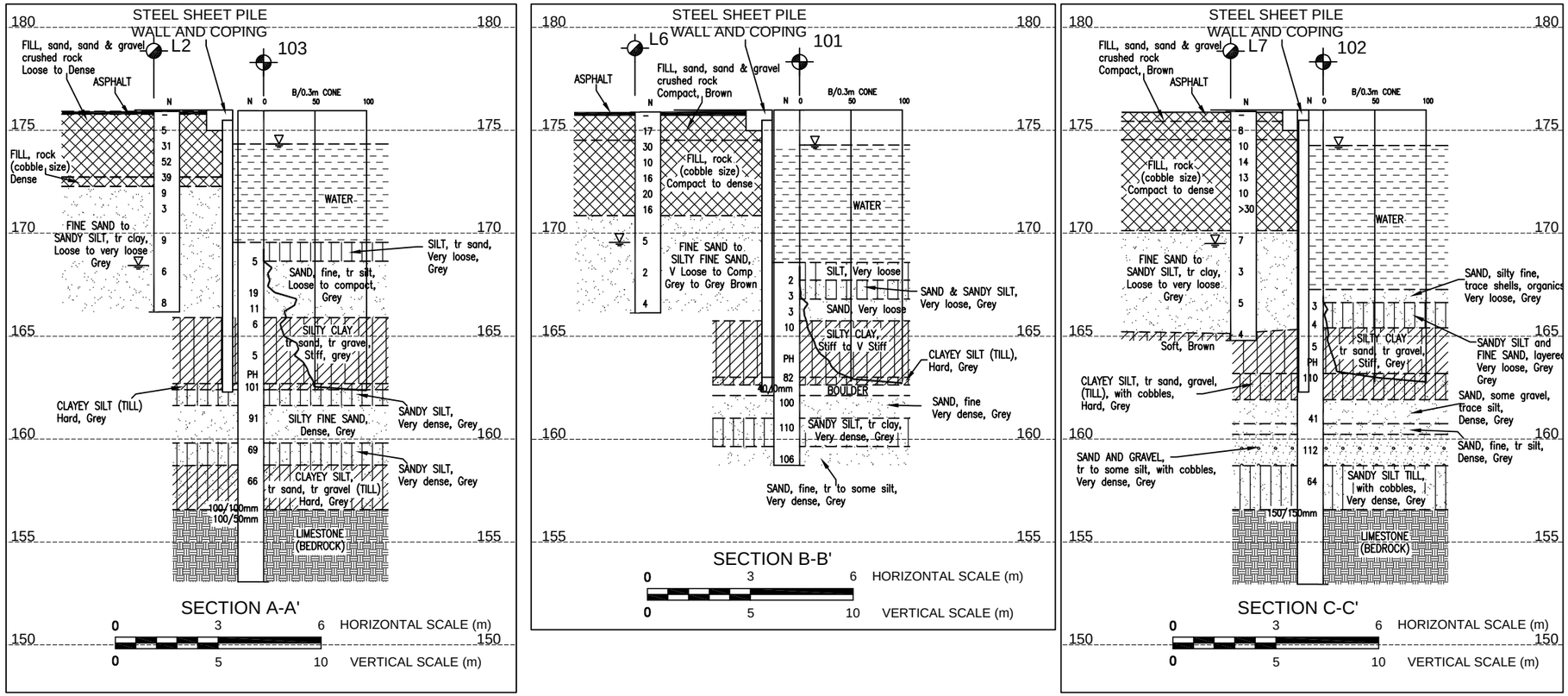
Geocres No.

HWY. No. N/A		PROJECT NO.: 021-4216-1-1	
SUBM'D. –	CHKD: –	DATE: SEPT 2004	
DRAWN: WDF	CHKD.	APPD.	DWG. 1

Drawing file: 0214216-1-L-001.DWG

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





DIST	31
W.O. No.	01-33-001
P.O. No.	3005-A-000218

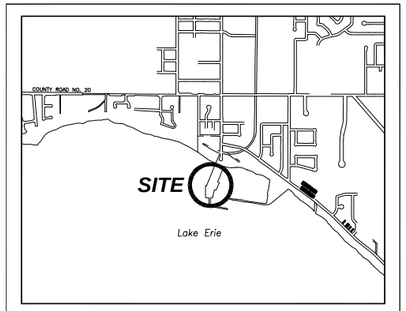
SHEET

MTO FERRY DOCKS
LEAMINGTON, ONTARIO

SOIL STRATA

Golder Associates Ltd.
LONDON, ONTARIO, CANADA

REFERENCE
DRAWING SUPPLIED BY PUBLIC WORKS CANADA
ARCHITECHURAL AND ENGINEERING SERVICES, ONTARIO REGION
SITE SERVICES AND PAVING
LEAMINGTON, ONTARIO FERRY WHARF
PROJECT No. 670702 DRAWING No. C001
DATED 1993-10-25



KEY PLAN

LEGEND

- Borehole Current Investigation
- Borehole Previous Investigations
- Seal
- Piezometer
- N Blows/0.3m (Std. Pen. Test, 475 j/blow)
- WL in piezometer
- WL during drilling

No.	ELEVATION (metres)	CO-ORDINATES NORTH	EAST
101	175.98	4 653 697.3	367 325.2
102	175.98	4 653 665.9	367 316.7
103	175.95	4 653 740.4	367 365.5
L2	175.92	4 653 738	367 361
L6	175.88	4 653 698	367 320
L7	175.91	4 653 669	367 314

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

NO.	DATE	BY	REVISION

Geocres No.

HWY. No. N/A	PROJECT NO.: 021-4216-1-1		
SUBM'D. –	CHKD: –	DATE: SEPT 2004	
DRAWN: WDF	CHKD.	APPD.	DWG. 2

Drawing file: 0214216-1-L-002.DWG

APPENDIX A

RECORDS OF PREVIOUS BOREHOLES

Trow

LOG OF BOREHOLE 1

Auger Sample ⊠
SPT (N) Value ○○▨
Dynamic Cone Test ——
Natural Moisture ×
Penetrometer ▲

Project **Proposed Ferry Terminal** Dwg. No. 2

Leamington, Ontario

Project No. **L03473BGI**

Hole location and datum see drawing No. 1

Elev. Scale m (ft)	Water Level	Soil Description	Depth Scale m	Depth Scale ft	N Value	N Value 20 40 60 80 / Shear Strength MPa 0.1 0.2	Natural Moisture Content % Dry Weight 10 20 30	Sample	Natural Unit Weight kN/m³
175.2		**FILL - Sand and Gravel intermixed with asphalt and concrete rubble, wet below 0.6 m depth**	1	2					
				4	36	o	x		
173.7		**SAND - hydraulic placed dredge in upper levels, layered, fine grained, trace gravel and silt, brown, wet, compact**	2	6	21	o	x		
				8					
			3	10	11	o	x		
				12	8	o	x		
			4	14					
			5	16	9	o			
				18					
		shell fragments at 6 m depth	6	20					
				22	12	o	x		
			7	24					
			8	26	21	o			
167		**END OF BOREHOLE**							

NOTE: BOREHOLE DATA REQUIRES INTERPRETATION ASSISTANCE FROM TROW BEFORE USE BY OTHERS.

1. Borehole advanced by hollow stem auger equipment to termination on January 25, 1993.
2. Water Level Records:

Elapsed Time	Depth to Water	Hole Open To
Completion	0.6 m	1.8 m

Trow

LOG OF BOREHOLE 2

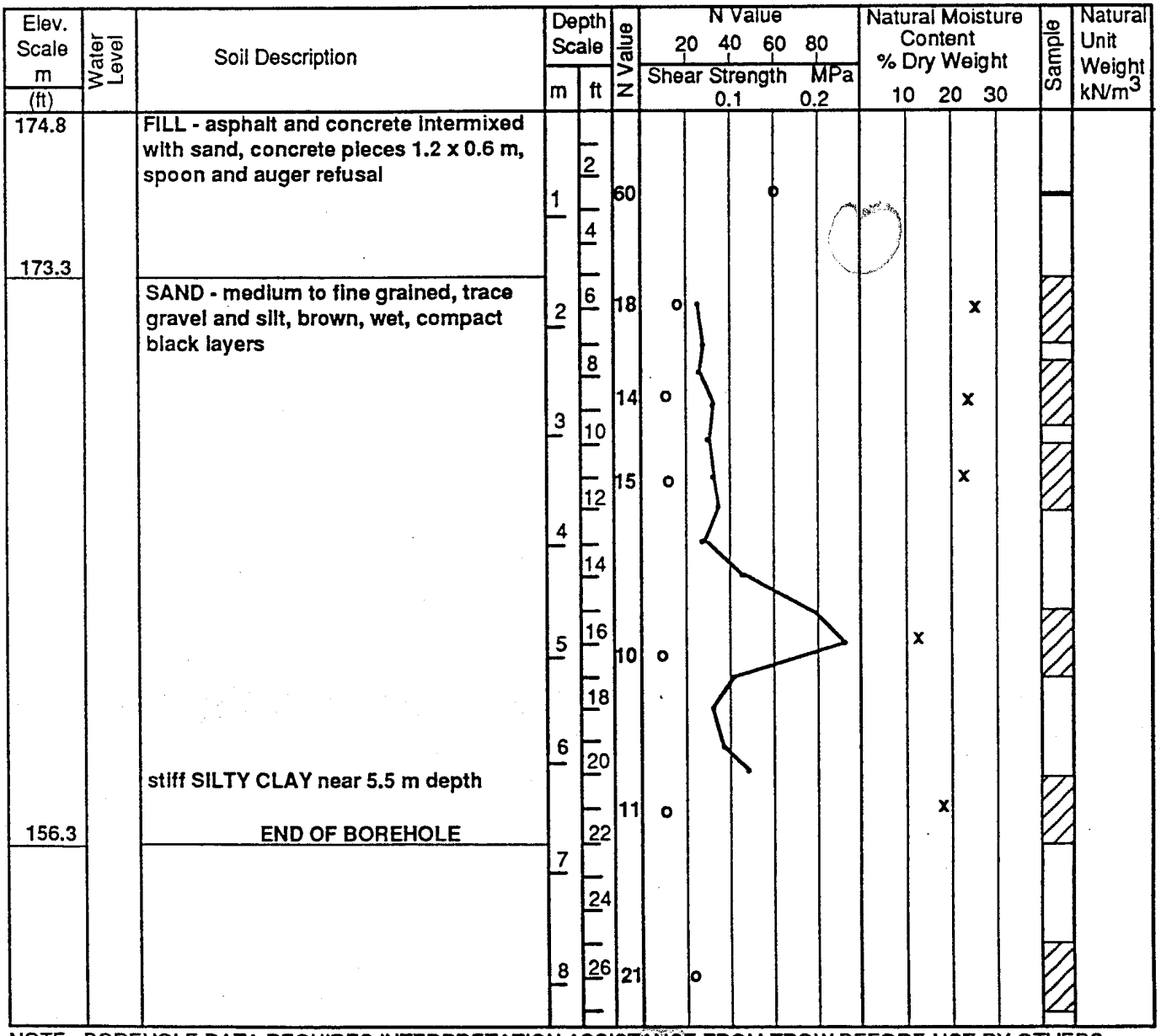
Auger Sample ⊠
SPT (N) Value o o ▨
Dynamic Cone Test ——•
Natural Moisture ×
Penetrometer ▲

Project **Proposed Ferry Terminal** Dwg. No. 3

Leamington, Ontario

Project No. **L03473BGI**

Hole location and datum see drawing No. 1



NOTE: BOREHOLE DATA REQUIRES INTERPRETATION ASSISTANCE FROM TROW BEFORE USE BY OTHERS.

1. Borehole advanced by hollow stem auger equipment to termination on January 25, 1993.
2. Water Level Records:

Elapsed Time	Depth to Water	Hole Open To
Completion	0.6 m	1.2 m

3. Dynamic cone test driven at location shown on Drawing No. 1.

Trow

LOG OF BOREHOLE 3

Auger Sample ⊠
SPT (N) Value OO▨
Dynamic Cone Test ——
Natural Moisture ×
Penetrometer ▲

Project **Proposed Ferry Terminal** Dwg. No. **4**

Leamington, Ontario

Project No. **L03473BGI**

Hole location and datum see drawing No. 1

Elev. Scale m (ft)	Water Level	Soil Description	Depth Scale m	Depth Scale ft	N Value	N Value 20 40 60 80 / Shear Strength MPa 0.1 0.2	Natural Moisture Content % Dry Weight 10 20 30	Sample	Natural Unit Weight kN/m³
175.2		**FILL - concrete and asphalt obstructions 4 attempts to complete hole, sandy silt some gravel and topsoil intermixed, moist**		1					
				2					
			1	3	79	o			
		auger refusal at 1.2 m depth		4					
		END OF BOREHOLE		5					
				6					
			2	7					
				8					
				9					
			3	10					
				11					

NOTE: BOREHOLE DATA REQUIRES INTERPRETATION ASSISTANCE FROM TROW BEFORE USE BY OTHERS.

1. Borehole advanced by hollow stem auger equipment to termination on January 25, 1993.

Trow

LOG OF BOREHOLE 4

Auger Sample ⊠
SPT (N) Value 0 0 ▨
Dynamic Cone Test ——
Natural Moisture ×
Penetrometer ▲

Project **Proposed Ferry Terminal**
Leamington, Ontario

Dwg. No. 5

Project No. **L03473BGI**

Hole location and datum see drawing No. 1

Elev. Scale m (ft)	Water Level	Soil Description	Depth Scale m	Depth Scale ft	N Value	N Value 20 40 60 80 / Shear Strength MPa 0.1 0.2	Natural Moisture Content % Dry Weight 10 20 30	Sample	Natural Unit Weight kN/m³
175.8		**FILL - sandy silt intermixed with asphalt and concrete rubble, some brick chunks, brown, moist**		1					
				2					
		augered through concrete from 1 to 1.2 m depth	1	3	36	o			
174.6				4					
		SAND - medium grained, brown, wet, compact		5	20	o			
174		**END OF BOREHOLE**		6					
			2	7					
				8					
				9					
			3	10					
				11					

NOTE: BOREHOLE DATA REQUIRES INTERPRETATION ASSISTANCE FROM TROW BEFORE USE BY OTHERS.

1. Borehole advanced by hollow stem auger equipment to termination on January 25, 1993.

Trow

LOG OF BOREHOLE 5

Auger Sample ⊠
SPT (N) Value ○○▨
Dynamic Cone Test ——
Natural Moisture ×
Penetrometer ▲

Project **Proposed Ferry Terminal** Dwg. No. 6

Leamington, Ontario

Project No. **L03473BGI**

Hole location and datum see drawing No. 1

Elev. Scale m (ft)	Water Level	Soil Description	Depth Scale m	Depth Scale ft	N Value	N Value 20 40 60 80 / Shear Strength MPa 0.1 0.2	Natural Moisture Content % Dry Weight 10 20 30	Sample	Natural Unit Weight kN/m³
175.7		**FILL - concrete and asphalt pieces (5 attempts to advance borehole) intermixed with sandy silt some topsoil, brown, moist**		1					
				2					
			1	3	8	o			
				4					
174.3				5					
		SAND - medium grained, trace gravel, brown, wet, compact			21	o			
				6					
			2						
173.7		**END OF BOREHOLE**		7					
				8					
				9					
			3	10					
				11					

NOTE: BOREHOLE DATA REQUIRES INTERPRETATION ASSISTANCE FROM TROW BEFORE USE BY OTHERS.

1. Borehole advanced by hollow stem auger equipment to termination on January 25, 1993.

2. Borehole 6 abandonned. Concrete pieces up to 0.9 x 0.9 m.

Log of Borehole 1

Trow

Auger Sample
SPT (N) Value
Dynamic Cone Test
Shelby Tube
Field Vane Test

Natural Moisture
Plastic and Liquid Limit
Undrained Triaxial at Overburden Pressure
% Strain at Failure
Penetrometer

Project Leamington Harbour Improvement Dwg. No. 2

Leamington, Ontario

Project No. L02534AGI

Hole location and datum see drawing No. 1

GWL	SYMBOL	Soil Description	I.G.L.D. ELEV. m	DEPTH
		SAND- fine to medium some silt (probable fill), grey brown, compact to loose	174.5	0
		SILTY CLAY-traces of sand and gravel, grey, stiff	169.5	6
		SILT TILL-clayey, very dense	162	12
		SAND-silty, fine to medium, silt layers dense to very dense.	161.5	14
		Boulder near 16 m depth	158.3	16
		SILT TILL-clayey, traces of sand and gravel, very dense	155.3	18
		End of Borehole (Auger Refusal on assumed limestone bedrock)		20

N Value: 20 40 60 80
Shear Strength: 0.1 0.2 MPa
Natural Moisture Content and Atterberg Limits % Dry Weight: 10 20 30

+23
+22
Bouncing No Core
@150mm

Natural Unit Weight kN/m³: 19.8

Log of Borehole 2A

Trow

Auger Sample
SPT (N) Value
Dynamic Cone Test
Shelby Tube
Field Vane Test

Natural Moisture
Plastic and Liquid Limit
Undrained Triaxial at Overburden Pressure
% Strain at Failure
Penetrometer

Project: Learnington Harbour Improvement
Learnington, Ontario

Dwg. No. 3

Project No. L02534AGI

Hole location and datum see drawing No. 1

G W L	S Y M B O L	Soil Description	I.G.L.D. ELEV. m	DEPTH
		GRAVEL FILL of about 1.5 m depth	175.5	0
		SAND-fine to medium grained, trace shells, grey brown, compact. Water Level Lake Bottom		2
		trace to some fine gravel, dense at 4.5 m depth	170	4
		SILTY CLAY-trace sand and gravel, grey, firm		6
				8
				10
			163	12
		SILT (TILL)-trace gravel, grey	162.3	
		SILTY FINE SAND-grey, very dense		14
		SANDY SILT TILL-trace gravel, grey, very dense	160.6	16
		coarse sand fine gravel pocket near 16.7 m depth		
		End of Borehole	158.3	18

N Value: 20 40 60 80

Shear Strength MPa: 0.1 0.2

Natural Moisture Content and Atterberg Limits % Dry Weight: 10 20 30

Natural Unit Weight kN/m³: 20.6

Log of Borehole 3B

Trow

Auger Sample ⊠ | Natural Moisture X
SPT (N) Value O O ▨ | Plastic and Liquid Limit ⊢—○
Dynamic Cone Test —— | Undrained Triaxial at Overburden Pressure, % Strain at Failure 0 / 15 ⊕ 5 / 10
Shelby Tube ● ● ■
Field Vane Test + s | Penetrometer ▲

Project Leamington Harbour Improvement Dwg. No. 4

Leamington, Ontario

Project No. L02534AGI

Hole location and datum see drawing No. 1

GWL	SYMBOL	Soil Description	I.G.L.D. ELEV. m	DEPTH	N Value 20 40 60 80 / Shear Strength 0.1 0.2 MPa	Natural Moisture Content and Atterberg Limits % Dry Weight 10 20 30	Natural Unit Weight kN/m³
		Water Level- September 28, 1988	174	0			
		(Gauge Level +0.7 m)					
		Lake Bottom (0.8 m below chart datum)	172.5				
		SAND-fine to medium grained, trace gravel and shells, grey brown, compact to very loose		2			
				4			
		SILTY SAND to SANDY SILT-with organic inclusions near 6 m depth		6			
			166.7				
		SILTY CLAY-trace sand and gravel, grey, stiff		8			20.3
				10			
			162.7				
		SILTY FINE SAND-grey, very dense to dense		12			
				14			
			158.2	16			
		SANDY SILT TILL-trace gravel, grey, very dense	158				
		End of Borehole		18			
				20			

Log of Borehole 4

Trow

Auger Sample ☒
SPT (N) Value ○ ○ ▨
Dynamic Cone Test ——
Shelby Tube ● ● ■
Field Vane Test + s

Natural Moisture X
Plastic and Liquid Limit ⊢—○
Undrained Triaxial at Overburden Pressure 0 15 5 10
% Strain at Failure
Penetrometer ▲

Project Leamington Harbour Improvement Dwg. No. 5
Leamington, Ontario
Project No. L02534AGI
Hole location and datum see drawing No. 1

GWL	SYMBOL	Soil Description	I.G.L.D. ELEV. m	DEPTH
		Water Level September 21, 1988	173.9	0
		(Gauge +0.6 m)		
		Lake Bottom 0.9 m below chart datum	172.4	
		SAND-fine to medium, some silt, trace organics, shells, compact to loose		2
		becoming more silty with more organic inclusions near 7 m depth, loose		6
			165.4	8
		SILTY CLAY-traces of sand and gravel, grey, stiff		10
			161.7	12
		SANDY SILT to SILTY FINE SAND-grey dense		
			159.9	14
		SILT TILL-clayey, traces of sand and gravel, occasional cobbles and boulders, grey, very dense.		16
		600 mm Boulder at 17.4 m depth		
			155.6	18
		BEDROCK- limestone		
			154.1	20
		End of Borehole (Casing bent, 1 run cored)		

N Value: 20 40 60 80
Shear Strength: 0.1 0.2 MPa
Natural Moisture Content and Atterberg Limits % Dry Weight: 10 20 30
Natural Unit Weight kN/m³: 20.2

CORE LOG

Trow

Project PROPOSED HARBOUR IMPROVEMENTS	**Orientation** Vertical	**Collar Elevation**	**Datum** I.G.L.D.	**Borehole No.** 4
Location LEAMINGTON, ONTARIO	**Date Started** Sept. 21/88	**Completed** Sept. 22/88	**Logged By** H. Lohse	**Sheet** 1 of 1
Client PUBLIC WORKS CANADA	**Drilling Agency** Malone	**Drill Type** CME 55	**Core Barrel & Bit Design** NQ	**Project No.** L02534AGI

ELEVATION (M)	DEPTH (M)	SYMBOL	GENERAL DESCRIPTION	Joint Characteristics: No. OF SETS	JOINT TYPE	ORIENTATION	SPACING	ROUGHNESS	FILLING	APERTURE	WEATHERING	STRENGTH	FRACTURE FREQUENCY	RUN No. CORE RECOVERY %	R Q D %	CORE SIZE/CASING	WATER RECOVERY, LEVEL & TESTS	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
	18																	
155.6			Assumed lost core in upper part of run.											1				
	19		Limestone (100%), calcisiltite to calcarenite, occasional shaley seam at 19.7 m, grey to buff colour, slightly weathered to 19.3 m, medium strength.	I	B	F	C	SP						47	37	NQ		
				I	C	D	VC	RP	T	O								
154.1			END OF BOREHOLE															
	20																	
	21																	
	22																	

Remarks

Log of Borehole 5

Trow

Auger Sample ☒
SPT (N) Value ○ ○ ▨
Dynamic Cone Test ——
Shelby Tube • • ■
Field Vane Test + s

Natural Moisture X
Plastic and Liquid Limit ⊢—○
Undrained Triaxial at Overburden Pressure 0 / 15 ⊕ 5 / 10
% Strain at Failure
Penetrometer ▲

Project Leamington Harbour Improvement Dwg. No. 6
Leamington, Ontario
Project No. L02534AGI
Hole location and datum see drawing No. 1

GWL	SYMBOL	Soil Description	I.G.L.D. ELEV. m	DEPTH
		Water Level September 22, 1988	174	0
		0.7 m above chart datum		
		Lake bottom 1.6 m below chart datum	171.7	2
		SAND-silty, fine to medium, trace shells, organic stained seams loose.		4
		ORGANIC SILT-wood pieces near 7.5 m depth		6
			165.2	8
		SILTY CLAY-traces of sand and gravel, grey, stiff.		10
		poor recovery near 11 m depth (wood piece in samples)		
		End of Borehole	162.7	12
		(Borehole aborted due to poor weather)		14
				16
				18
				20

N Value: 20 40 60 80
Shear Strength: 0.1 0.2 MPa
Natural Moisture Content and Atterberg Limits % Dry Weight: 10 20 30
Natural Unit Weight kN/m³

Log of Borehole 7

Trow

Auger Sample ☒ | Natural Moisture X
SPT (N) Value ○ ○ ▨ | Plastic and Liquid Limit ⊢—○
Dynamic Cone Test ——— | Undrained Triaxial at Overburden Pressure (C, 15, 5, 10)
Shelby Tube • • ■ | % Strain at Failure
Field Vane Test + s | Penetrometer ▲

Project: Leamington Harbour Improvement, Leamington, Ontario — Dwg. No. 7
Project No. L02534AGI
Hole location and datum see drawing No. 1

GWL	SYMBOL	Soil Description	I.G.L.D. ELEV. m	DEPTH
		Water Level - September 30, 1988	173.9	0
		(Gauge +0.6 m)		
		(2.9 m below chart datum)		2
		Lake Bottom	170.4	
		SAND-fine to medium grained, trace shells and organics, grey-brown, compact to very loose, trace to some silt		4
		becoming silty with depth		6
		SILTY FINE SAND to SANDY SILT-trace shells, organic inclusion near 7.6 m depth		
			165.9	8
		SILTY CLAY-trace sand and gravel, grey, stiff		10
			162.5	
		SILT TILL-sandy, occasional clayey zones, grey, very dense		12
			160.4	
		very dense to dense SILTY FINE SAND between 13.5 and 16.5 m depth		14
			157.4	16
		boulders between 17 to 17.8 m depth		
			155.3	18
		BEDROCK		20

N Value: 20 40 60 80
Shear Strength MPa: 0.1 0.2
Natural Moisture Content and Atterberg Limits % Dry Weight: 10 20 30
Natural Unit Weight kN/m³: 20

CORE LOG

Trow

Project PROPOSED HARBOUR IMPROVEMENTS	**Orientation** Vertical	**Collar Elevation**	**Datum** I.G.L.D.	**Borehole No.** 7	
Location LEAMINGTON, ONTARIO	**Date Started** Oct. 1/88	**Completed** Oct. 1/88	**Logged By** H. Lohse	**Sheet** 1 of 1	
Client PUBLIC WORKS CANADA	**Drilling Agency** Malone	**Drill Type** CME 55	**Core Barrel & Bit Design** NQ	**Project No.** L02534AGI	

ELEVATION (M)	DEPTH (M)	SYMBOL	GENERAL DESCRIPTION	Joint Characteristics: No. OF SETS	JOINT TYPE	ORIENTATION	SPACING	ROUGHNESS	FILLING	APERTURE	WEATHERING	STRENGTH	FRACTURE FREQUENCY	RUN No. CORE RECOVERY %	R Q D %	CORE SIZE/CASING	WATER RECOVERY, LEVEL & TESTS
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
	18																
			Boulders and Till											1			
155.2	19		Limestone (100%), calcisiltite to calcarenite, occasional shale seams, fossiliferous seam from 21.3 to 21.7, buff colour, slightly weathered to 19.5 m medium strength, bedding joints and smooth planar, rough planar and rough undulating and at very close to moderate intervals, cross joints noted above 19.6 m and at 20.5 m.	1	B	F	VC	SP RP RU	T	O				2	60		Est. 80% water recovery
				2	B C	F D	C										
				1	C	D											
				1	B	F	M										
				1	C	D	C							90			
	20			1	B	F	M										
							C										
				1	C	V	VC										
	21						M							3	86		Est. 80% water recovery
				1	B	F	C VC							97			
							M										
152.2			END OF BOREHOLE														
	22																

Remarks Point Load Test for rock sample from Elev. 152.6 m I.G.L.D.
Mean Point Load Strength = 2.4 MPa (3 tests)
Uniaxial Compressive Strength = 49 MPa

Log of Borehole 9

Trow

Auger Sample ⊠
SPT (N) Value ○ ○ ▨
Dynamic Cone Test ——
Shelby Tube • • ■
Field Vane Test + s

Natural Moisture X
Plastic and Liquid Limit ——○
Undrained Triaxial at Overburden Pressure 0 / 15 ⊕ 5 / 10
% Strain at Failure
Penetrometer ▲

Project Learnington Harbour Improvement Dwg. No. 8
Learnington, Ontario
Project No. L02534AGI
Hole location and datum see drawing No. 1

G W L	SYMBOL	Soil Description	I.G.L.D. ELEV. m	DEPTH
		Water Level - September 24, 1988	174	0
		(Gauge +0.7 m)		
		Lake Bottom (4.3 m below chart datum)	169	2
		(Casing sunk 1.5 m) (very loose sandy deposit)		4
		SILTY FINE SAND to SANDY SILT-occasional shells and organics, grey, very loose		6
			165.6	8
		SILTY CLAY-traces of sand and gravel, grey, stiff		
		boulder at 11.5 m depth		10
			161.3	12
		SAND-silty, fine grained, grey, very dense to compact		
			158.3	14
		SANDY SILT (TILL)-some gravel, grey, very dense (sand back up in casing; artesian condition) boulders near 17 m depth		16
			156	18
		SILT-layer over weathered rock or boulder	155.3	
		End of Borehole Borehole ended on assumed bedrock (Casing broke and jammed) No core recovered		20

N Value: 20 40 60 80
Shear Strength MPa: 0.1 0.2
Natural Moisture Content and Atterberg Limits % Dry Weight: 10 20 30
Natural Unit Weight kN/m³: 20.1

Log of Borehole 10

Trow

Auger Sample ⊠
SPT (N) Value ○ ○ ▨
Dynamic Cone Test ——
Shelby Tube • • ■
Field Vane Test + s

Natural Moisture X
Plastic and Liquid Limit ⊢—○
Undrained Triaxial at Overburden Pressure (C, 15, 5, 10)
% Strain at Failure
Penetrometer ▲

Project **Leamington Harbour Improvement** Dwg. No. 9
Leamington, Ontario
Project No. **L02534AGI**
Hole location and datum see drawing No. 1

GWL	SYMBOL	Soil Description	I.G.L.D. ELEV. m	DEPTH
		Water Level	174	0
		(September 29, 1988) (Gauge +0.7 m)		
		Lake Bottom (3.9 m below chart datum)	~169.4	4
		SAND-fine to medium grained, trace shells and organic inclusions (i.e. wood pieces), grey brown, very loose	~167.8	6
		SANDY SILT-organics, slightly cohesive, wood fibre and pieces, grey, very loose	~166.1	8
		SILTY CLAY-trace sand and gravel, grey, stiff to firm	~162.4	12
		SANDY SILT (TILL)-grey, very dense.	161.4	
		End of Borehole		16

N Value: 20 40 60 80
Shear Strength: 0.1 0.2 MPa
Natural Moisture Content and Atterberg Limits % Dry Weight: 10 20 30
Natural Unit Weight kN/m³

Log of Borehole 12

Trow

Auger Sample ⊠
SPT (N) Value ○ ○ ▨
Dynamic Cone Test ——
Shelby Tube ● ● ■
Field Vane Test + s

Natural Moisture X
Plastic and Liquid Limit ⊢—○
Undrained Triaxial at Overburden Pressure ⊕ 0 15 5 10
% Strain at Failure
Penetrometer ▲

Project Leamington Harbour Improvement Dwg. No. 10
Leamington, Ontario
Project No. L02534AGI
Hole location and datum see drawing No. 1

G.W.L.	SYMBOL	Soil Description	I.G.L.D. ELEV. m	DEPTH	N Value 20 40 60 80 / Shear Strength MPa 0.1 0.2	Natural Moisture Content and Atterberg Limits % Dry Weight 10 20 30	Natural Unit Weight kN/m³
		Water Level - September 26, 1988	173.9	0			
		(Gauge +0.6 m)		2			
		Lake Bottom (2.7 m below chart datum)	170.6	4			
		SAND-fine to medium, trace organics, shells, loose					
		becomes more silty with organic inclusions near 6 m depth		6			
			166.8				
		SILTY CLAY-traces of sand and gravel, grey, stiff		8			
		600 mm boulder at 11.5 m depth		10			19.9
			162.4				20.4
		SILT TILL-clayey in upper level, traces of sand and gravel, grey, very dense to dense (hard)		12			
			158.8	14			
		SAND-silty, fine, sandy silt zones, grey, dense, (slight artesian condition, water flowing 1.5 m above lake level)		16			
			157.2				
		SILT TILL-traces to some sand and gravel, cohesive, very dense, Boulder near 18.5 m depth		18			
			154.3				
		BEDROCK-limestone		20			

CORE LOG

Trow

Project PROPOSED HARBOUR IMPROVEMENTS	**Orientation** Vertical	**Collar Elevation**	**Datum** I.G.L.D.	**Borehole No.** 12	
Location LEAMINGTON, ONTARIO	**Date Started**	**Completed**	**Logged By** H. Lohse	**Sheet** 1 of 1	
Client PUBLIC WORKS CANADA	**Drilling Agency** Malone	**Drill Type** CME 55	**Core Barrel & Bit Design** NQ	**Project No.** L02534AGI	

ELEVATION (M)	DEPTH (M)	SYMBOL	GENERAL DESCRIPTION	Joint Characteristics: No. OF SETS	JOINT TYPE	ORIENTATION	SPACING	ROUGHNESS	FILLING	APERTURE	WEATHERING	STRENGTH	FRACTURE FREQUENCY	RUN No. CORE RECOVERY %	R Q D %	CORE SIZE/CASING	WATER RECOVERY, LEVEL & TESTS
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
	19																
154.3	20		Limestone (100%), calcisiltite to calcarenite, shaley, laminae throughout, stylolites at 22.7 m, fossiliferous calurudite from 21.5 to 21.8 m, light grey to buff colour, unweathered, medium strength, bedding joints are smooth planar and at very close to moderate intervals.	1	B	F	C VC	SP RP	T	O				1 100%	61	NQ	Est. 50% water recovery
	21																
	22						C M							2 100%	97	NQ	
151.2	23		END OF BOREHOLE														

Remarks

Log of Borehole 14

Trow

Auger Sample ☒
SPT (N) Value ○ ○ ▨
Dynamic Cone Test ——
Shelby Tube • • ■
Field Vane Test + s

Natural Moisture X
Plastic and Liquid Limit ——○
Undrained Triaxial at Overburden Pressure 0 15 5 10
% Strain at Failure
Penetrometer ▲

Project Leamington Harbour Improvement Dwg. No. 11
Leamington, Ontario
Project No. L02534AGI
Hole location and datum see drawing No. 1

GWL	SYMBOL	Soil Description	I.G.L.D. ELEV. m	DEPTH
		Water Level September 24, 1988	174	0
		(Gauge +0.7 m)		
		(4.7 m below chart datum)		4
		Lake Bottom	168.6	
		SILTY CLAY traces of sand and gravel, grey, firm to stiff		6
				8
				10
			163	
		SAND-silty, fine to medium, grey, very dense		12
				14
			159	
		SILTY TILL-clayey, traces of sand and gravel, very dense	158.3	16
		End of Borehole (Auger Refusal on Boulder or rock)		
				18
				20

N Value: 20 40 60 80
Shear Strength MPa: 0.1 0.2
Natural Moisture Content and Atterberg Limits % Dry Weight: 10 20 30
Natural Unit Weight kN/m³: 19.8

APPENDIX B

SITE PHOTOGRAPHS

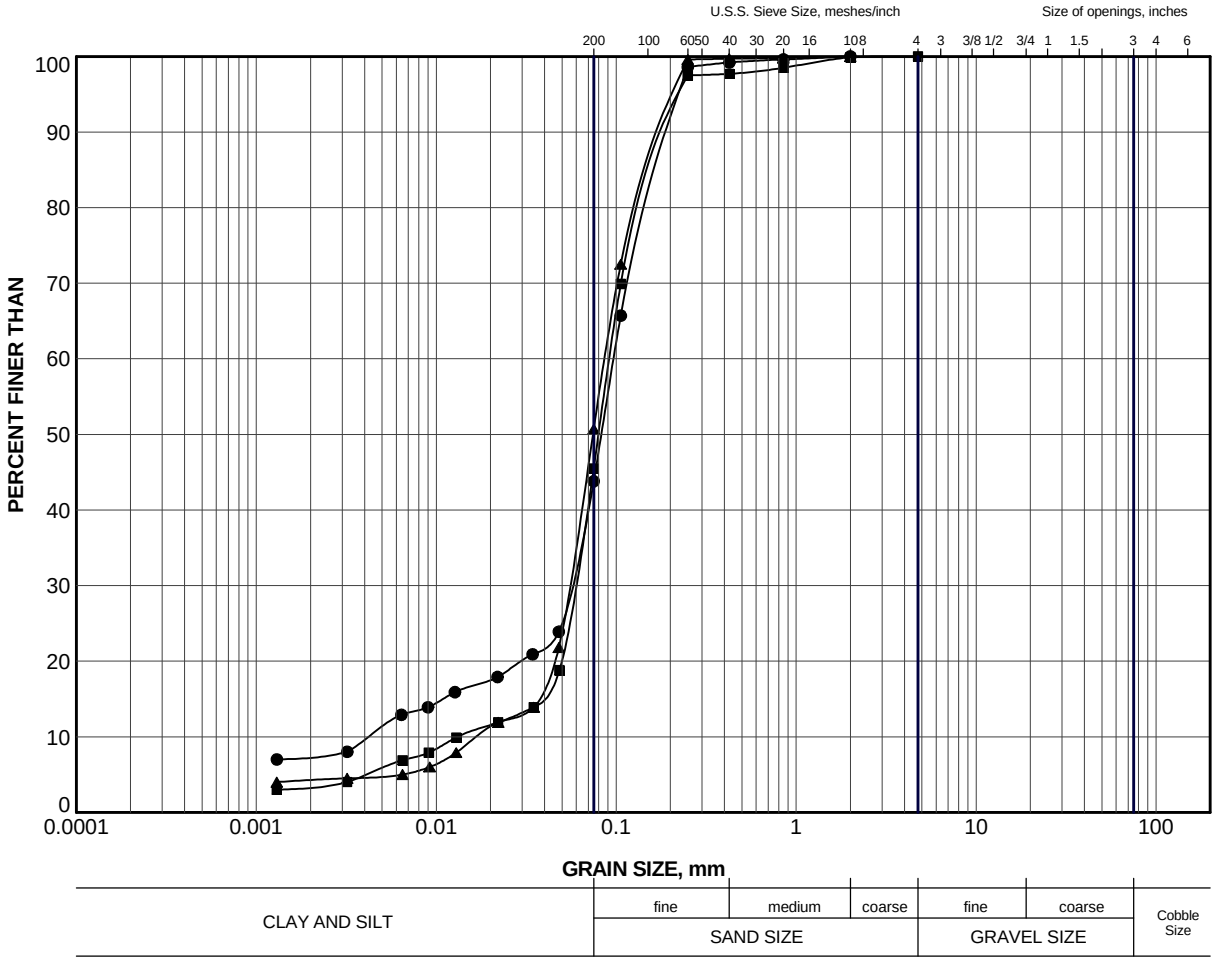
SITE PHOTOGRAPHS

Photo 1: General view of drilling platform at Leamington dock.

Photo 2: Rock core from borehole 103.

APPENDIX C

LABORATORY TEST DATA



LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)
●	101	3	166.1
■	101	9	161.7
▲	103	2	167.0

PROJECT

MTO FERRY DOCKS
LEAMINGTON, ONTARIO

TITLE

GRAIN SIZE DISTRIBUTION

SAND, some silt

Golder Associates
LONDON, ONTARIO

PROJECT No.		021-4216-1-1	FILE No.	021-4216-L.GPJ
			SCALE N/A	REV.
DRAWN	WDF	Sep 28/04		
CHECK	AMH	Oct 05/04	**FIGURE C-1**	

LDN_MTO_NEW GLDR_LDN.GDT

CONSOLIDATED UNDRAINED TRIAXIAL WITH PORE PRESSURE MEASUREMENTS SHEET 1 OF 4			FIGURE C-2
SPECIMEN	A	B	C
BOREHOLE NUMBER	102	102	102
SAMPLE NUMBER	4	4	4
SPECIMEN DIAMETER, cm	4.82	5.00	5.01
SPECIMEN HEIGHT, cm	10.01	10.06	10.02
WATER CONTENT BEFORE CONSOLIDATION, %	27.7	27.1	29.0
CELL PRESSURE, σ_3, kPa	170.0	205.0	285.0
BACK PRESSURE, kPa	135.0	135.0	135.0
PORE PRESSURE PARAMETER "B"	0.96	0.98	0.99
CONSOLIDATION PRESSURE, σc, kPa	35.0	70.0	150.0
VOLUMETRIC STRAIN DURING CONSOLIDATION, %	2.7	4.1	5.5
WATER CONTENT AFTER CONSOLIDATION, %	26.1	24.5	25.5
AVERAGE RATE OF STRAIN, %/hr	0.5	0.5	0.5
TIME TO FAILURE, DAYS	1	1	1
WATER CONTENT AFTER TEST, %	24.8	24.6	25.7
MAX. DEVIATOR STRESS, $(\sigma_1-\sigma_3)$, kPa	82.4	103.1	137.8
AXIAL STRAIN AT $(\sigma_1-\sigma_3)$ MAXIMUM, %	23.4	15.0	10.8
MAX EFFECTIVE PRINCIPAL STRESS RATIO, (σ_1/σ_3) MAXIMUM	3.6	3.4	2.9
DEVIATOR STRESS AT (σ_1/σ_3) MAXIMUM, kPa	48.9	93.1	137.8
AXIAL STRAIN AT (σ_1/σ_3) MAXIMUM, %	5.3	7.9	10.8
PORE PRESSURE PARAMETER, Af, AT $(\sigma_1-\sigma_3)$ MAXIMUM	-0.06	0.27	0.57
PORE PRESSURE PARAMETER, Af, AT (σ_1/σ_3) MAXIMUM	0.33	0.34	0.57
NATURAL WATER CONTENT, %	26.2	26.5	27.8
DRY DENSITY, Mg/m^3	1.73	1.60	1.56
FILTER DRAINS USED, y/n	y	y	y
TEST NOTES:			
CHANGED RATE OF STRAIN, %/hr	-	-	-
AXIAL STRAIN WHERE RATE OF STRAIN WAS CHANGED, %	-	-	-
FAILURE PLANE NUMBER	-	-	-
ANGLE OF FAILURE, DEGREES	-	-	-

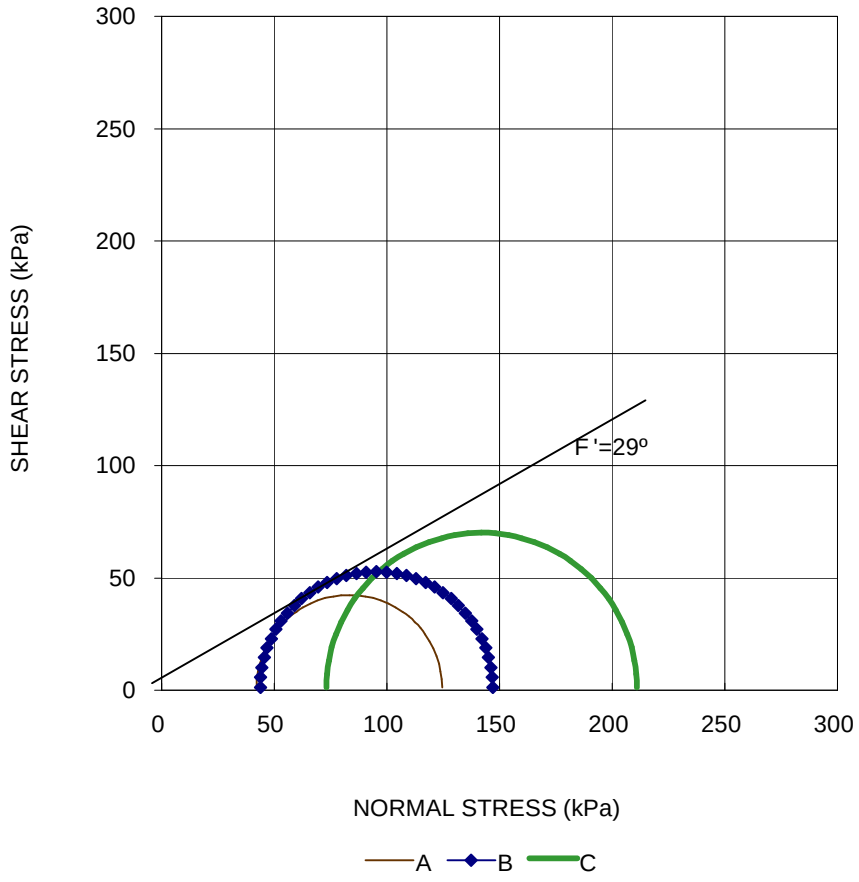
Date: September, 2004 Prepared By: LFG

Project No. 021-4216-1 **Golder Associates** Checked By: MM

CONSOLIDATED UNDRAINED TRIAXIAL
WITH PORE PRESSURE MEASUREMENTS
SHEET 2 OF 4

FIGURE C-3

BH 102 SA 4



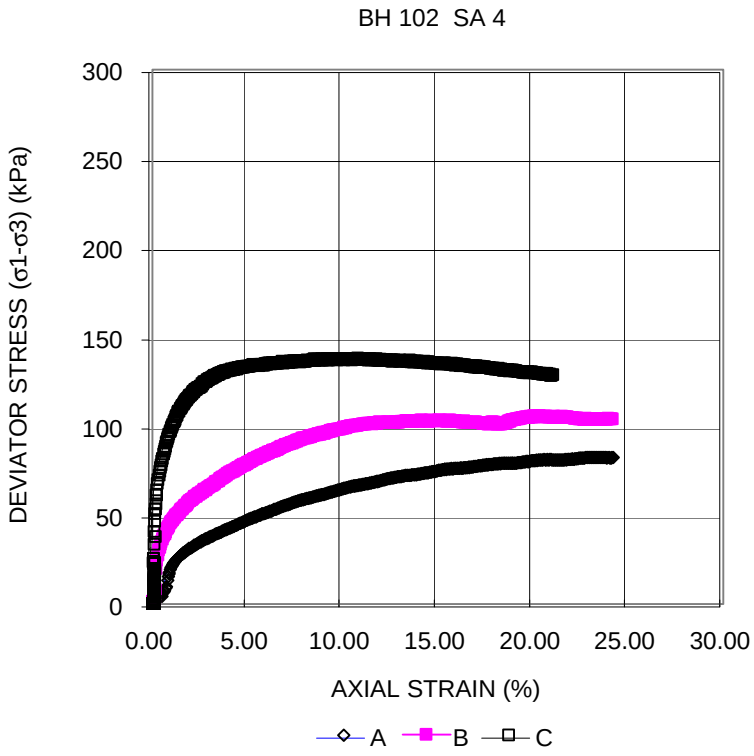
Date: September, 2004
Project No. 021-4216-1

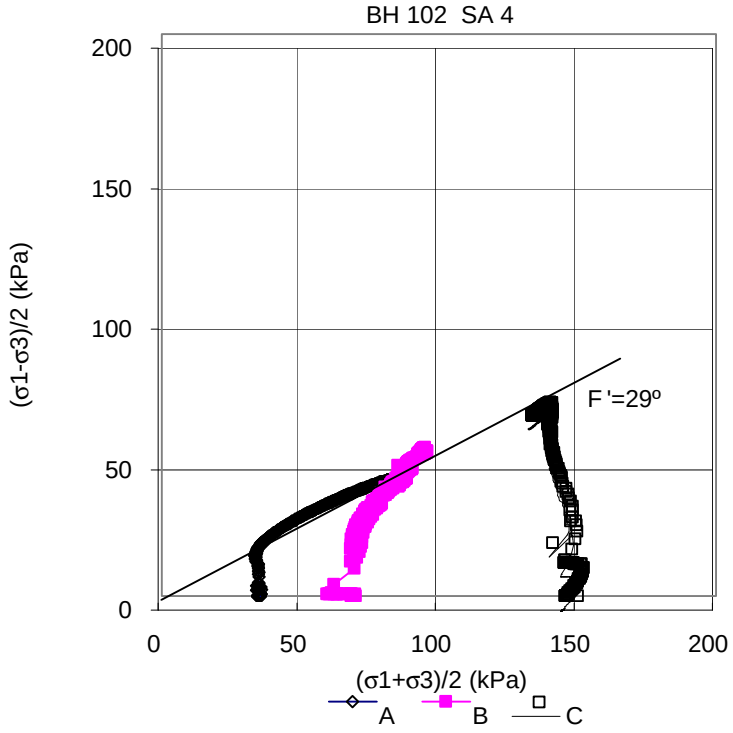
Golder Associates

Prepared By: LFG
Checked By: MM

CONSOLIDATED UNDRAINED TRIAXIAL
WITH PORE PRESSURE MEASUREMENTS
SHEET 3 OF 4

FIGURE C-4





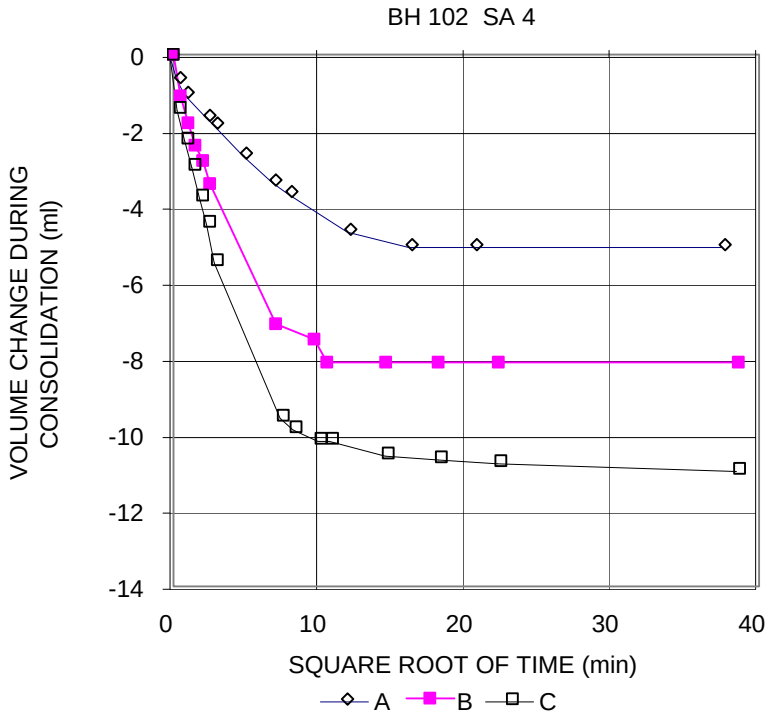
Date: September, 2004
Project No. 021-4216-1

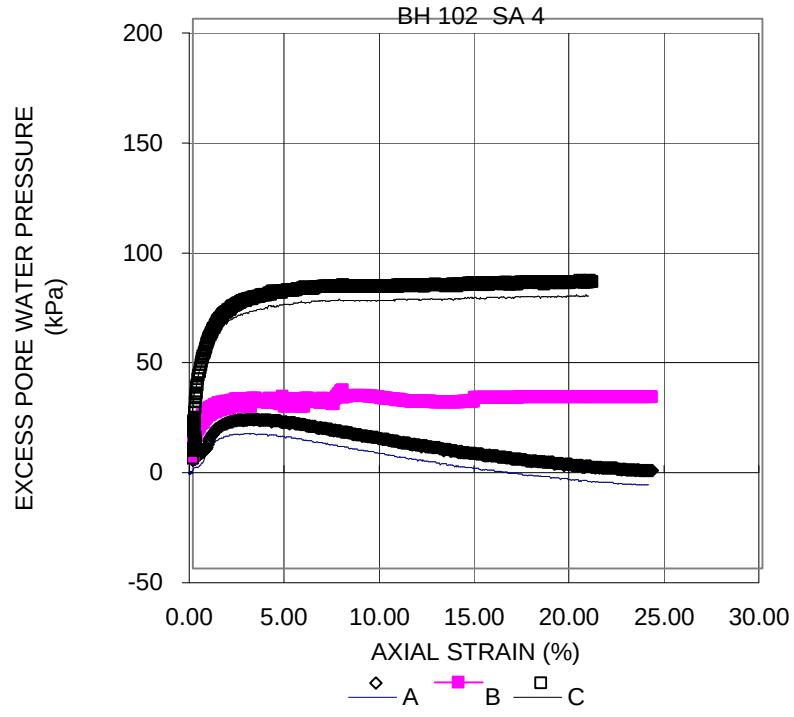
Golder Associates

Prepared By: LFG
Checked By: MM

CONSOLIDATED UNDRAINED TRIAXIAL
WITH PORE PRESSURE MEASUREMENTS
SHEET 4 OF 4

FIGURE C-5

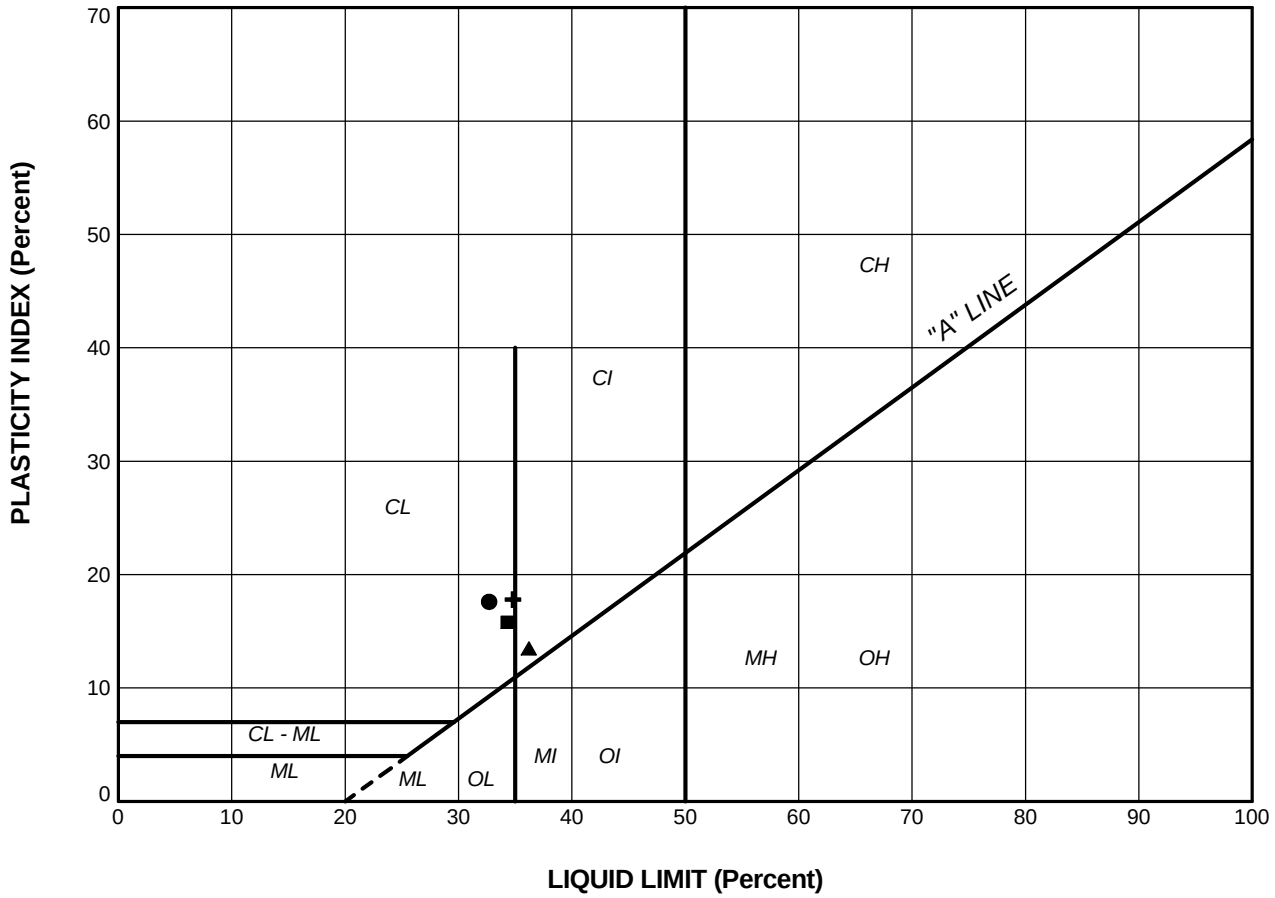




Date: September, 2004
Project No. 021-4216-1

Golder Associates

Prepared By: LFG
Checked By: MM



SOIL TYPE	PLASTICITY
C = Clay	L = Low
M = Silt	I = Intermediate
O = Organic	H = High

LEGEND

SYMBOL	BOREHOLE	SAMPLE	ELEV (m)	LL(%)	PL(%)	PI
●	101	5	164.1	32.7	15.1	17.6
■	102	4	163.9	34.3	18.5	15.8
▲	103	4	165.7	36.2	22.7	13.5
✚	103	6	163.3	34.8	17.0	17.8

PROJECT

MTO FERRY DOCKS
LEAMINGTON, ONTARIO

TITLE

PLASTICITY CHART

Golder Associates
LONDON, ONTARIO

PROJECT No.		021-4216-1-1	FILE No.	021-4216-L.GPJ	
			SCALE	N/A	REV.
DRAWN	WDF	Oct 04/04	FIGURE C-6		
CHECK	AMH	Oct 05/04			

MTO_PI GLDR_LDN.GDT