

## Geotechnical Sampling of Sediment Dredging of Hamilton Harbour Pier 16 Hamilton, Ontario

Prepared for:

Mr. J. Shaw
Chief, Great Lakes 2000 Clean-up Fund
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**Trow Consulting Engineers Ltd.** 



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## 1. Introduction

Trow Consulting Engineers Ltd. (Trow) was retained by the Great Lakes 2000 Clean-up Fund to conduct geotechnical sampling of sediment west of Pier 16 within the Hamilton Harbour for the purpose of assessing dredging operations in Hamilton, Ontario (Drawing No. 1). Authorization to proceed with the investigation was provided by Mr. John Shaw Chief of the Great Lakes 2000 Clean-up Fund.

The project will involve the dredging of an area immediately adjacent to Pier 16 on the west side and north of the mouth of the former Sherman Inlet. This area is also known as The Randel Reef. It is understood that the proposed area to be dredged was previously sampled and analytical testing was conducted by others. The previously sampled boreholes met refusal at depths of up to 2.1 m within or on an unknown material. The purpose of this investigation was to determine the geotechnical engineering properties of the unknown materials where refusal was met during the initial sampling program.



# 2. Terms of Reference

The geotechnical investigation was undertaken to:

- a) establish the sediment and/or soil conditions at the site based on drilling eight (8) boreholes (each to 4 m (13 ft.) depth below harbour bottom) at locations specified by the Client, and
- b) provide geotechnical engineering recommendations regarding dredging operations.

The following modifications to the terms of reference were made:

- a) Nine (9) boreholes were drilled instead of eight (8). The boreholes extended to depths of 2.4 (~7' 10") to 4.9 (~16' 1") m below harbour bottom.
- b) Based on subsequent discussions with the Client, geotechnical engineering recommendations regarding dredging operations are not required at this time. The report should be factual in nature.
- c) The laboratory testing program was to consist of natural moisture content tests on all recovered soil and sediment samples. In addition, grain size analysis, Atterberg Limits and unit weights on selected soil samples was proposed.

Based on subsequent meetings and correspondences with the Client, it was determined that additional laboratory testing was not required at this time and hence, grain size analysis, Atterberg Limit and unit weights were eliminated from the program. The samples will be retained for up to 3 months from the date of sample collection in Trow's laboratory. The samples will be discarded beyond this time period unless a longer retention time is requested by the Client.

Environmental testing was not conducted as part of this sampling program, hence, this report does not reflect the environmental conditions at the site.



# 3. Investigation Program

#### 3.1 Fieldwork

The fieldwork for this investigation was carried out from April 19 to 26, 1999. In accordance with the terms of reference (TOR), and subsequent modifications, nine (9) boreholes were located within the area to be investigated. The borehole locations are shown on Drawing No. 2. The boreholes were advanced by N-casing using equipment owned and operated by a specialized drilling subcontractor, under the full-time monitoring by Trow Consulting Engineers Ltd.

As requested, nine (9) boreholes were drilled at the proposed borehole locations shown on Drawing No. 2. Each borehole was advanced to depths ranging from 2.4 (~7' 10") to 4.9 (~16' 1") m below the harbour bottom, Elevation 61.3 to 65.0 m. The boreholes were advanced by means of a drill rig adapted for soil sampling mounted on the front of a spud barge.

The fieldwork was monitored by a member of Trow's engineering staff who directed the drilling and sampling operations, and documented the stratigraphy encountered at the boreholes.

Soil samples were retrieved on a continuous basis by using the split spoon sampler driven in accordance with the standard penetration test procedures. The undrained shear strength of the cohesive soils was measured using a field vane and pocket penetrometer. Poor sample recovery during the early stages of the fieldwork indicated other sampling equipment such as thin walled tubes (shelby tubes), piston samplers and side samplers were necessary to obtain sufficient sample recovery.

The borehole locations were established in the field by Trow Consulting Engineers Ltd. utilizing a Global Positioning System unit (GPS) supplied by the Canada Centre For Inland Waters (CCIW), Technical Operations Division. Antennae and receivers for the GPS unit were mounted on the top of the drill rig mast. Final borehole position co-ordinates (northing and eastings) were recorded once the spuds from the barge were set in the lake bottom and locations ranged from 0.2 to 5.7 m out of proposed layout centres. Final positions of each borehole are recorded on each borehole log.

The borehole elevations were determined from lake level elevations (on the days the fieldwork was conducted) provided by CCIW.



# 4. Summarized Subsurface Soil Conditions

Details of the fieldwork including soil descriptions, inferred stratigraphy, sampling methods, standard penetration 'N' values, shear strengths, and sampling method in the boreholes during and following completion of drilling are given on the Log of Borehole sheets, (Drawing Nos. 3 to 11). A summary of the borehole information is also presented in tabular form in Appendix A.

It must be noted that the boundaries of soil indicated on the borehole logs are inferred from non-continuous sampling and observations during drilling. These boundaries are intended to reflect transition zones for the purposes of geotechnical assessment and should not be interpreted as exact planes of geological change. It should be noted that the "Notes on Sample Description", preceding the borehole logs, forms an integral part of the report and should be read in conjunction with it.

A brief description of the soils stratigraphy encountered at the borehole locations is summarized, in order of depth, in the following sections.

#### 4.1 Water

The depth of water at each borehole location was determined by CCIW - Technical Operations Division prior to drilling. The lake level elevations were in the order of Elevation 74.7 m. The depth of water varied from approximately 6.0 to 11.0 m below the mean water level of the lake. At the borehole locations, the harbour bottom was contacted at Elevation 63.7 to 68.7 m.

#### 4.2 Fill

A layer of fill was encountered at the surface of each borehole (ie. the harbour bottom) and ranges from approximately 0.8 to 3.4 m depth below harbour bottom, Elevation 62.5 to 66.5 m. The fill was not penetrated in Borehole Nos. 28 and 13. In general, the fill consists of a heterogeneous mixture of sandy silt to silt sediment, dark grey to black in colour with some fragments of coal tar, slag and trace organics (wood, rootlets). Numerous fragments of suspected slag were encountered in the fill within Borehole Nos. 28 and 13. The fill had significant coal tar (hydrocarbon) stains and odours. The compactness condition of the cohesionless portion of the fill based on SPT results of Borehole Nos. 28 and 13 is very loose to compact. The consistency of the cohesive portion based on shear strength measurements (from field vane tests) of 20 to greater than 115 kPa is soft to very stiff. The moisture content of the fill is 13 to 292 percent.



### Sandy Silt to Silty Sand

A layer of sandy silt to silty sand was encountered beneath the fill in Borehole Nos. 11 and 18 and extended to 1.8 and 4.3 m depth below harbour bottom, Elevation 63.9 and 63.4 m. This layer was also encountered in Borehole No. 21 below the clay at 2.2 m depth below harbour bottom, Elevation 61.5 m. In general, this layer is described as a grey to brown sandy silt to silty sand with trace gravel, trace organics (shells, rootlets in Borehole No. 18) with no coal tar (hydrocarbons) stains or odours. Based on SPT N values from Borehole Nos. 11 and 18, the compactness condition of the sandy silt to silty sand is loose to dense and the natural moisture content ranges from 16 to 29 percent.

### Clay

Beneath the fill in Borehole Nos. 154, 6, 22 and 21 and beneath a layer of sandy silt to silty sand in Borehole No. 11 exists a grey clay layer. The clay was penetrated in Borehole No. 21 at 2.2 m depth below harbour bottom, Elevation 61.5 m. In general, the clay is described as grey with trace silt and sand having no stains or odours and becoming till-like with trace to some sand and gravel in Boreholes No. 22 and 21. The undrained shear strength of the clay, based on field vane and pocket penetrometer tests was up to 115 kPa which indicates a very soft to very stiff consistency. The sensitivity of the clay was 1.0 to 9.2 indicating a low to highly sensitive clay. The natural moisture content of the clay ranges from 23 to 37 percent.

### Organic Silt

Beneath the layer of fill within Borehole No. 14 and beneath a layer of silty sand within Borehole No. 18, a layer of organic silt was encountered at depths of 2.5 and 4.3 m below harbour bottom, Elevation 63.4 and 65.2 m. Both boreholes terminated within this layer. In general, this layer is described as a greeenish grey to grey organic silt with trace to some sand and gravel, trace organics (wood, rootlets). The silt has a spongy texture with organic stains, slight coal tar (hydrocarbon) stains and odours. Based on field vane tests from Borehole No. 14, the measured shear strength of the organic silt is 70 to 110 kPa indicating a consistency of stiff to very stiff. The natural moisture content of the silt is 69 to 87 percent.



## 5. Environmental Considerations

The disposal of any excess material is regulated by the current provincial government environmental regulations. If any of the excess material is disposed of off-site, the material should be tested so that the disposal of such material will be carried out in compliance with the environmental guidelines. Ontario Regulation 347 (O.Reg. 347) would apply. Trow will composite and retain the excess samples collected during this investigation and submit composite samples for O.Reg. 347 testing (leachate chemistry) to assess disposal options.

We trust this information is satisfactory for your purposes. Should you have any questions, please do not hesitate to contact this office.

Yours very truly,

Trow Consulting Engineers Ltd.

Todd Barlow, P.Eng.

Field Engineer

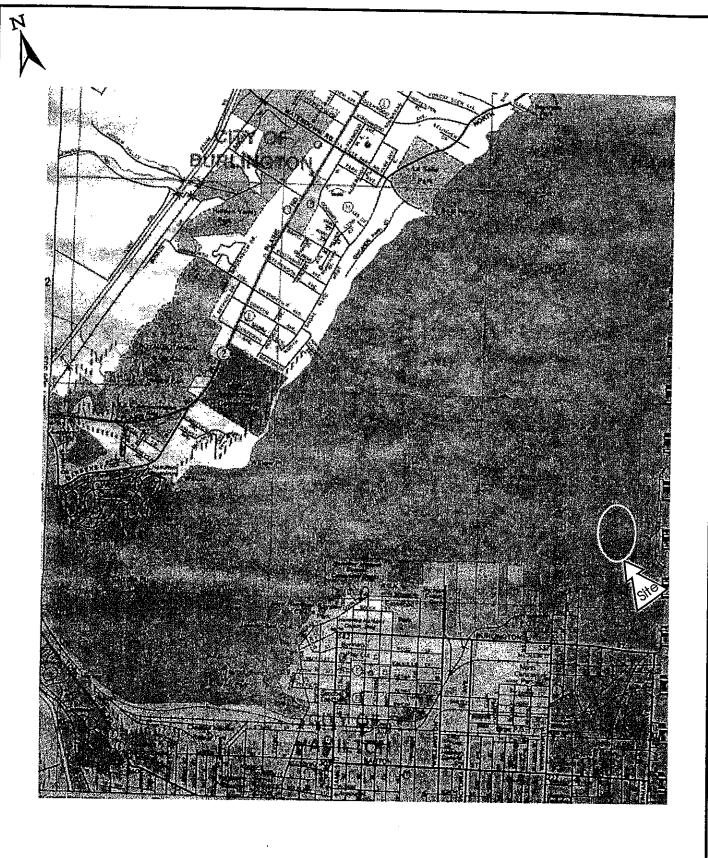
Geotechnical Services Group

S. M. Potyondy, P.Eng.

Head, Geotechnical Services Group



# Drawings:



Geotechnical Sampling of Sediment Derdging of Hamilton Harbour, Pier 16, Hamilton, Ontario HAGE-0053319-A/E

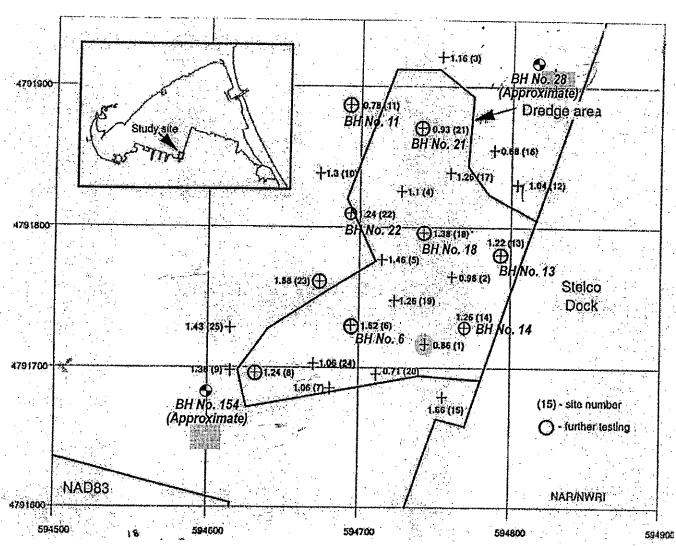
# Location Plan

Drawing No. 1 August, 1999



TROW CONSULTING ENGINEERS LTD.





#### Note:

Site Plan Modified as supplied to Trow by CCIW via the Great Lakes 2000 Clean-Up Fund.

#### LEGEND

- Borehole Location Corresponding to CCIW Site No.
- \* All Dimensions are Approximate as Shown.

#### Notes:

Boundaries and soil types have been established only at Borchole locations.

Between Borcholes they are assumed and may be subject to considerable error.

Soil Samples will be retained in storage for 3 months and then destroyed unless the client advises otherwise.

- 3) Topsoil quantities should not be established from the information provided at the Borehole locations.
- Borehole elevations should not be used to design building(s), or floor slab(s), or parking lot(s) grades.

Geotechnical Sampling of Sediment Dredging of Hamilton Harbour, Pier 16, Hamilton, Ontario HAEN-0053319-A/E

# Site Plan

Drawing No. 2 August, 1999 N.T.S.



TROW CONSULTING ENGINEERS LTD.

# NOTES ON SAMPLE DESCRIPTIONS



1. All sample descriptions included in this report follow the Canadian Foundation Engineering Manual soil classification system. This system follows the standard proposed by the International Society for Soil Mechanics and Foundation Engineering. Laboratory grain size analyses provided by Trow also follow the same system. Different classification systems may be used by others; one such system is the Unified Soil Classification. Please note that, with the exception of those samples where a grain size analysis has been made, all samples are classified visually. Visual classification is not sufficiently accurate to provide exact grain sizing or precise differentiation between size classification systems.

### ISSMFE SOIL CLASSIFICATION

							10711014			
	SILT			SAND			GRAVEL			
Fine	Medium	Medium Coarse		Medium	Coarse	Fine	Medium	Coarse	COBBLES	BOULDERS
0.00	06 o	0.02	0.06	0.2 0	2.6 2.	0 6.	0 20	 0	50 200	
	l,	<u></u>	EQUIV	ALENT G	RAIN DIA	METER	IN MILL	MTERE	<u> </u> s	· · · · · · · · · · · · · · · · · · ·
Plastic) to	F	INE	<del></del>	<del></del>	<del></del>		<del></del>		<del></del>	F
n Plastic)	1		S	AND		-				<del>-</del>
	2 0.0	Fine Medium 2 0.006 0 Plastic) to F	Fine Medium Coarse 2 0.006 0.02  Plastic) to FINE	Fine         Medium         Coarse         Fine           2         0.006         0.02         0.06           EQUIV           lastic) to         FINE         ME	SILT   SAND	SILT   SAND	SILT   SAND	SILT   SAND   GRAVEL	Fine   Medium   Coarse   Fine   Medium   Coarse   Fine   Medium   Coarse    2	SILT   SAND   GRAVEL   COBBLES

UNIFIED SOIL CLASSIFICATION

- 2. Fill: Where fill is designated on the borehole log it is defined as indicated by the sample recovered during the boring process. The reader is cautioned that fills are heterogeneous in nature and variable in density or degree of compaction. The borehole description may therefore not be applicable as a general description of site fill materials. All fills should be expected to contain obstructions such as wood, large concrete pieces or subsurface basements, floors, tanks, etc., none of these may have been encountered in the boreholes. Since boreholes cannot accurately define the contents of the fill, test pits are recommended to provide supplementary information. Despite the use of test pits, the heterogeneous nature of fill will leave some ambiguity as to the exact composition of the fill. Most fills contain pockets, seams, or layers of organically contaminated soil. This organic material can result in the generation of methane gas and/or significant ongoing and future settlements. Fill at this site may have been monitored for the presence of methane gas and, if so, the results are given on the borehole logs. The monitoring process does not indicate the volume of gas that can be potentially generated nor does it pinpoint the source of the gas. These readings are to advise of the presence of gas only, and a detailed study is recommended for sites where any explosive gas/methane is detected. Some fill material may be contaminated by toxic/hazardous waste that renders it unacceptable for deposition in any but designated land fill sites; unless specifically stated the fill on this site has not been tested for contaminants that may be considered toxic or hazardous. This testing and a potential hazard study can be undertaken if requested. In most residential/commercial areas undergoing reconstruction, buried oil tanks are common and are generally not detected in a conventional geotechnical site investigation.
- 3. Till: The term till on the borehole logs indicates that the material originates from a geological process associated with glaciation. Because of this geological process the till must be considered heterogeneous in composition and as such may contain pockets and/or seams of material such as sand, gravel, silt or clay. Till often contains cobbles (60 to 200 mm) or boulders (over 200 mm). Contractors may therefore encounter cobbles and boulders during excavation, even if they are not indicated by the borings. It should be appreciated that normal sampling equipment cannot differentiate the size or type of any obstruction. Because of the horizontal and vertical variability of till, the sample description may be applicable to a very limited zone; caution is therefore essential when dealing with sensitive excavations or dewatering programs in till materials.

Trow

Piston Sample
Side Sampler
SPT(N) Value
Dynamic Cone Test
Shelby or BenthosTube
Field Vane Test
Natural Moisture
Plastic and Liquid Limit

Penetrometer

Project: Geotechnical Sampling of Sediment, Dredging of Hamilton Harbour, Pier 16, Hamilton, Ontario

Dwg. No: 3 Project No: HAGE0053319-A

Ground Elevation: N/A Supervised By: T.B.

Borehole Location : E 594 856.0 m N 4 791 976.7 m

Water Level	Elev. Scale (m)	Soil Description	1	epth cale	Value	6	<u>2</u> 0 4		0 80		tural N % i	loistur Ory We	e Conten	Sample
>	74.66	Approximate Depth of Water = 10.0 m	m 	ft	z	She	ar Stre	ength 00	kPa 200	-	10	20	30	Sai
	64.7	(as reported by CCIW - Tech Ops.)	10	<u>3</u> 2			,							
	~64.7 ~(10.0)	FILL: Sandy Silt to Silt Sediment and coal tar sludge, black, numerous fragments of slag, trace fragments of coal tar, (sand to cobble size), coal tar (hydrocarbon) stains and odours very loose to compact, wet.	Γ	_ 34	6	0						X	= 130%	5 <u>6-5-3</u>
		Iimited sample recovery due to suspected presence of slag throughout, based on drilling and sampling observations in the field.	- 11	_ <u>3</u> 6	8	0						*		
			-	_			;				i			
	-		-	<u>3</u> 8	23		0				X			
į		oxidized and coal tar stains and odours and numerous fragments of slag from 11.7	<u>12</u>	40	2	o						×		
	~62.3 ~(12.4)	to 12.4 m depth.  BOREHOLE TERMINATED							ļ					
			- 13	<u>4</u> 2		•								
			-	- 44					3	:				
			_											
			14	<u>4</u> 6	į		ļ			:				
l				-										

- Borehole advanced using N-Casing to a termination depth of 2.4 m below the Lake bottom or at 12.4 m depth from top of water level in lake on April 19, 1999.
- Borehole advanced by means of wash-boring techniques (where applicable).

¥ Trow

Piston Sample
Side Sampler

SPT(N) Value

Dynamic Cone Test
Shelby or BenthosTube
Field Vane Test

# \$

Project: Geotechnical Sampling of Sediment, Dredging of Hamilton Harbour, Pier 16, Hamilton, Ontario

Dwg. No: 4

Project No: HAGE0053319-A

Ground Elevation: N/A

Supervised By: T.B.

Plastic and Liquid Limit
Penetrometer

X

Natural Moisture

Borehole Location : E 594 792,9 m N 4 791 783.1 m

Water Level	Elev. Scale (m)	Soil Description	De Se	epth cale	Value		20 4		60	30	Nat	ural M % D	oisture ry We	Conten	t gumes
ڎڎ	74.66		m	ft	z	Sh	ear Str	engti 00		kPa 00	4	10	20	30	a a
:		Approximate Depth of Water = 9.0 m (as reported by CCIW - Tech Ops.)	_	<u>2</u> 8							·		T	<u> </u>	0.
	~65.7		9	-								Benthos CCIW -	s Sample Tech Op	e Retrieved os. from 0 t	i rom
	~(9.0)	FILL: Sandy Silt to Clayey Silt Sediment and coal tar sludge, black, numerous fragments of slag, trace fragments of coal tar, (sand to	Ţ	<u>3</u> 0			ļ					depth be 9.0 to 9. level in	'qre	e Retrieved os. from 0 t e bottom o oth from top	
		cobble size), coal tar (hydrocarbon) stains and odours, loose to compact, stiff to very stiff, wet.		F	-								2	X = 68%	
		- limited sample recovery due to suspected presence of slag throughout, based on drilling	-	32											
		and sampling observations in the field.  -mixed with trace to some organics (wood)	10	F	23		b		115 25				,	X = 73%	ó
		and organic silt from 9.6 to 11.4 m depth.	-	34				+ '	15 kF	a				<u>:</u>  -	
			-	  -  -	15	0	s = 2	2	•				,	X = 58%	
			11	<u>3</u> 6											
			-	_	5	0	+ <sub>s</sub>	= 9.	2				)	<= 51%	$\geq$
		-heterogenous mixture of silty sand, dark	-	<u>3</u> 8							i				
		brown to black, with coal tar stains and odours and numerous fragments of slag from 11.4 to 12.7 m depth.	  - 		13	0							>	(= 59%	
			12	<u>4</u> 0											
					8	0						X = N Moiste	o sar	nple for ontent	$\geq$
	~62.0 ~(12.7)	BOREHOLE TERMINATED	_	42							1	Retair	ed - i	arge f Slag	
			<u>1</u> 3												
			-	44											
			_												

- Borehole advanced using N-Casing to a termination depth of 3.7 m below the Lake bottom or 12.7 m depth from top of water level in lake on April 19 and 20, 1999.
- 2. Borehole advanced by means of wash-boring techniques (where applicable).

Trow

Piston Sample
Side Sampler

SPT(N) Value

Dynamic Cone Test
Shelby or BenthosTube
Field Vane Test
Natural Moisture

Plastic and Liquid Limit

Penetrometer

Project: Geotechnical Sampling of Sediment, Dredging of Hamilton Harbour, Pier 16, Hamilton, Ontario

Dwg. No: 5

Project No: HAGE0053319-A

Ground Elevation: N/A Supervised By: T.B.

Borehole Location : E 594 778.6 m N 4 791 724.3 m

Level	Elev. Scale (m)	Soil Description	De So	epth cale	를	She	N Valu 20 40 6 ar Strength	0 80	Natural Moisture Content © Content % Dry Weight E W
	~67.7 ~(7.0)	Approximate Depth of Water = 7.0 m (as reported by CCIW - Tech Ops.)  FILL: Sandy Silt to Clayey Silt Sediment and coal tar sludge, black, trace fragments of slag, and coal tar (sand size), trace organics (wood pieces), coal tar (hydrocarbon) stains and odours, firm to stiff, wet.	7	<u>2</u> 2	<del> </del>		100	200	Benthos Sample Retrieved from CCIW - Tech Ops. from 0 to 0.6 m depth below lake bottomor approx. 7.0 to 7.6 m depth from top of wate level in lake.  X = No Sample for Moisture Content
		-heavy coal tar sludge (thick) from 7.6 to 9.5 m depth below lake bottom.	8	 <u>2</u> 6 _ _ _ _		+s	= 2.5		Retained  X = 90%  X = 63.5%
		ORGANIC CLAYEY SILT: Greenish-grey to grey, trace to some sand, trace gravel, trace organics (wood, rootlets), spongy texture, organic stains, slight coal tar odour, stiff to very stiff, moist to wet.	<u>1</u> 0	30 - 32 - 34		O d spo	+s = 9.4 +s = 3.0 +s = 3.1 +s = 1.8		X = 56% X = 98%
	~64.0 ~(10.7) ~63.7 ~(11.0)	- soil type from 10.7 to 11.0 m depth assumed to be organic clayey silt.  BOREHOLE TERMINATED	-	<u>3</u> 6		•	s = 1.5 ts = 1.		

- Borehole advanced using N-Casing to a termination depth of 4.0 m below the Lake bottom or 11.0 depth from top of water level in lake on April 20 and 21, 1999
- 2. Borehole advanced by means of tricone and wash-boring techniques (where applicable).
- 3. Vane Profile Hole conducted approximately 0.3 m to the south of existing hole.

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Plastic and Liquid Limit

Penetrometer

Project: Geotechnical Sampling of Sediment, Dredging of Hamilton Harbour, Pier 16, Hamilton, Ontario

Project No: HAGE0053319-A
Ground Elevation: N/A

Supervised By: T.B.

Dwg. No: 6

Borehole Location : E 594 604.1 m N 4 791 677.5 m

Water Level	Elev. Scale (m) 74.66	Soil Description	De Se m	epth cale ft	- 40	N Value 20 40 60 80 Shear Strength kPa 100 200	Natural Moisture Content % Dry Weight E 80 00 00 00 00 00 00 00 00 00 00 00 00
	~68.7 ~(6.0)	Approximate Depth of Water = 6.0 m (as reported by CCIW - Tech Ops.)  FILL: Sandy Silt to Silt Sediment and coal tar sludge, black, trace fragments of coal tar (sand size), trace organics (wood pieces), coal tar (hydrocarbon) stains and odours, wet.	6	20			Benthos Sample Petrived from CCIW - Tech Ops. from 0 to 0.6 m depth below lake tottom or approx. 6.0 to 6.6 m depth from top of water level in lake.
			7	<u>-</u> 22 -	-		X = 135% X = 129%
	~66.5	-heavy coal tar sludge (thick) from 6.6 to 8.2 m depth.	  -  -	<u>2</u> 4			X = 123%
	~(8.2)	CLAY: Grey, trace silt and sand, no stains or odours, firm, moist to wet.	-	<u>2</u> 8	-	<sup>+</sup> s = 1.5	X
	~65.0 ~(9.7)	BOREHOLE TERMINATED	-	<u>3</u> 0 - <u>3</u> 2	•	+ s = 1.5	x
			10	_ <u>3</u> 4			

- 1. Borehole advanced using N-Casing to a termination depth of 3.7 m below the Lake bottom or 9.7 m from top of water level in lake on April 22, 1999.
- 2. Borehole advanced by means of tricone and wash-boring techniques (where applicable).

Trow

Piston Sample
Side Sampler

SPT(N) Value

Dynamic Cone Test

Dynamic Cone Test

Shelby or BenthosTube

Field Vane Test

+ s

Natural Moisture

Natural Moisture
Plastic and Liquid Limit
Penetrometer

Project: Geotechnical Sampling of Sediment, Dredging of Hamilton Harbour, Pier 16, Hamilton, Ontario

Dwg. No: 7 Project No:

Project No: HAGE0053319-A

Ground Elevation: N/A Supervised By: T.B.

Borehole Location : E 594 692.1 m N 4 791 733.6 m

Water Level	Elev. Scale (m)	Soil Description	Di Si	epth cale	N Value			N Va 40		80	Nat	tural M % E	oisture	Conten	t ed
ڎۜۛۨڐ	74.67		m	ft	Z	She	ar St	engt 00	h	kPa 00	•		20	30	Sample
:	~67.7 ~(7.0)	Approximate Depth of Water = 7.0 m (as reported by CCIW - Tech Ops.)  FILL: Sandy Silt to Clayey Silt Sediment and	7	22									s Sampi Tech O elow lak	le Retrived ps. from 0 (e pottom o pth from to	
		FILL: Sandy Silt to Clayey Silt Sediment and coal tar sludge, black, trace fragments of coal tar (sand size), trace organics (wood pieces), coal tar (hydrocarbon) stains and odours, soft to firm, wet.	-	<u>2</u> 4	-							X = I Mois Reta	ture (	mple fo Content	Г
			8	<u>2</u> 6	-								X	129%	( <u>\</u>
			}			+ <sub>s</sub> =	1.0								
			-	<u>2</u> 8	-	+s=	1.2					:	,	K = 88%	
			9	-		+ <sub>s</sub>	1.6								
			-	<u>3</u> 0	-	+s=	9.2						X	156%	
			-	-		+ <sub>s=</sub>	9.2								
		-becoming coal tar sludge mixed with dark grey to grey clay from 9.4 to 10.2 m depth.	10	<u>3</u> 2	-	+ <sub>s</sub> ≈	0.8						x	135%	X
İ	~64.5 ~(10.2)		Γ	$\vdash$ $ $		+,	= 3.2								
	-(10.2)	CLAY: Grey, trace silt and sand, no stains or odours, stiff, moist to wet.	<u> </u>	<u>3</u> 4	-		+ s = -	.6					x		
			-	-			ts = 1	.7							
	·		11	<u>3</u> 6	-		+ <sub>s ≈</sub>	1.6					X		
			-	-			+ <sub>s</sub> :	- 1.3							
].	~63.1 ~(11.6)	BOREHOLE TERMINATED	-	<u>3</u> 8			+	s=	1.3		į				

- Borehole advanced using N-Casing to a termination depth of 4.3 m below the Lake bottom or 11.6 m depth from top of water level in lake on April 22 and 23, 1999.
- 2. Borehole advanced by means of tricone and wash-boring techniques (where applicable).
- 3. Vane Profile Hole conducted approximately 0.3 m south of the existing hole.

\*Trow

Shelby or BenthosTube
Field Vane Test

Natural Moisture
Plastic and Liquid Limit
Penetrometer

Project: Geotechnical Sampling of Sediment, Dredging of Hamilton Harbour, Pier 16, Hamilton, Ontario

Dwg. No: 8

Project No: HAGE0053319-A

Ground Elevation: N/A Supervised By: T.B.

Borehole Location : E 594 750.1 m N 4 791 792.3 m

Water Level	Elev. Scale (m)	Soil Description	De Sc	epth cale	N Value	N Value 20 40 60 80	Natural Moisture Content % Dry Weight	Sample
Ľ.Ķ	74.67		m	ft	$\frac{2}{z}$	Shear Strength kPa	10 20 30	Sam
	~67.7 ~(7.0)	Approximate Depth of Water = 7.0 m (as reported by CCIW - Tech Ops.)  FILL: Sandy Silt to Silt Sediment and coal	7	22			Benthos Sample Retrieved from CCIW - Tech Ops from 0 to 0.0 depth below lake bottom or app 7.0 to 7.4 m depth from top of v level in lake.	
		tar sludge, black, trace fragments of coal tar (sand size), trace organics (wood pieces), coal tar (hydrocarbon) stains and odours, wet.		<u>2</u> 4	-			
	~66.5		8	<u>2</u> 6	-		X = 88%	X
	~(8.2)	FILL: Sand mixed with coal tar sludge, black, trace fragments of coal tar (sand size), trace organics (wood pieces), coal tar (hydrocarbon) stains and odours, wet.	<u></u>	<u>2</u> 8	-		X = 227%	$\overline{\times}$
			9	<u>3</u> 0	-		X = 292%	Z
			  -    -	_ <u>3</u> 2	-		X = 85%	Z
		-becoming thicker coal tar sludge from 9.9 to 10.4 m depth.	- 10	-				
	~64.3 ~(10.4)	SILTY SAND: Grey to brown, trace gravel, trace organics (shells, rootlets), no stains or odours, loose, moist to wet.		<u>3</u> 4 _	-		X	
	~63 4		11	<u>3</u> 6	4	0	×	
•	~63.4 ~(11.3)	ORGANIC SILT: Grey, trace sand and gravel, spongy texture, no stains or odours, wet.	_	_ <u>3</u> 8	-		X= 87%	
	~62.8 ~(11.9)	BOREHOLE TERMINATED	12	_				

- Borehole advanced using N-Casing to a termination depth of 4.9 m below the Lake bottom or 11.9 m depth from top pf water level in lake on April 23, 1999.
- 2. Borehole advanced by means of tricone and wash-boring techniques (where applicable).

\*\*Trow

Piston Sample
Side Sampler

SPT(N) Value

OO

Dynamic Cone Test Shelby or BenthosTube

Field Vane Test Natural Moisture Plastic and Liquid Limit

Penetrometer

+ s

X

Project: Geotechnical Sampling of Sediment, Dredging of Hamilton Harbour, Pier 16, Hamilton, Ontario

Dwg. No: 9

Project No: HAGE0053319-A

Ground Elevation: N/A

Supervised By: T.B.

Borehole Location : E 594 691.6 m N 4 791 887.2 m

Water Level	Elev. Scale (m)	Soil Description	D S	epth cale	N Value		N Va 20 40	60 80	Natural M % D	oisture ry Weig	Content tht	Sample
٣٩	74.67	<b>'</b>	m	ft	>   z	She	ar Strengt	th kPa 200	10	20 (	30	Sam
		Approximate Depth of Water = 9.0 m (as reported by CCIW - Tech Ops.)	9	28					Rentho	Sample	Retrieved of from 0 to of pottom or p	
	~65.7 ~(9.0)	FILL: Sandy Silt to Silt Sediment and coal tar sludge, black, trace fragments of coal tar (sand size), coal tar (hydrocarbon) stains and odours, wet.	-	<u>3</u> 0	-				evel in		128%	f wate
	~64.9 ~(9.8)	SANDY SILT to SILTY SAND: Brown, no stains or odours, dilatent, compact to dense,	-	<u>3</u> 2	39							41
		moist to wet.	10	-					X			
		-increasing silt content from 10.4 to 10.8 m depth.	-	34	16	0			x			
	~63.9 ~(10.8)	CLAY: Grey, trace to some silt and sand, no stains or odours, stiff, moist.	11	<u>3</u> 6								<u>* </u>
	~63.3 ~(11.4)		<u> </u>	-	-		+s=1.6	5		Х	į	
	<b>,</b>	BOREHOLE TERMINATED	-	<u>3</u> 8								
			12	- 40			ļ					
			-  -			}				i		
				<u>4</u> 2								
			13	-								
			_	44		ļ						
			-	-								

- Borehole advanced using N-Casing to a termination depth of 2.4 m below the Lake bottomor 11.4 m from top of water level in lake on April 26, 1999.
- 2. Borehole advanced by means of tricone and wash-boring techniques (where applicable).

\*Trow

Piston Sample
Side Sampler
SPT(N) Value

X

SPT(N) Value

Dynamic Cone Test

Shelby or BenthosTube Field Vane Test

Natural Moisture
Plastic and Liquid Limit
Penetrometer

Project: Geotechnical Sampling of Sediment, Dredging of Hamilton Harbour, Pier 16, Hamilton, Ontario

Dwg. No: 10

Project No: HAGE0053319-A

Ground Elevation: N/A Supervised By: T.B.

Borehole Location : E 594 694.0 m N 4 791 811.8 m

Γ	Elev.		Τ'n	epth		,	1 811.8 m N Value	I New York
Water Level	Scale (m) 74.67	Soil Description	S	cale I	N Value	Sī	20 40 60 80 hear Strength kPa	Natural Moisture Content % Dry Weight 10 20 30
	~65.7	Approximate Depth of Water = 9.0 m (as reported by CCIW - Tech Ops.)	9	<u>2</u> 8				Benthos Sample Retrieved for CCIW - tech Ops, from 0 to 0.0 depth below lake bottomor app 9.0 to 9.6 m depth from top of v level in lake.
	~(9.0)	FILL: Sandy Silt to Silt Sediment and coal tar sludge, black, trace fragments of coal tar (sand size), trace organics (wood pieces), coal tar (hydrocarbon) stains and odours, wet.		<u>3</u> 0	-			kevel in lake.  X = 102%
			10	<u>3</u> 2	-			X = 183%
	~63.9		<u> -</u>	<u>3</u> 4 _	-			X = 119%
	~(10.8)	CLAY: Grey, trace to some silt and sand, trace gravel (Till-Like), no stains or odours, stiff to very stiff, wet.	- 11 -	<u>3</u> 6	-		s = 2.8	x
			-	<u>3</u> 8	-		>115 kPa	x
	~62.6 ~(12.1)	BOREHOLE TERMINATED	12	<u>4</u> 0				
			- 13	<u>4</u> 2				
			-	- 44				
			- 14	-				

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

1. Borehole advanced using N-Casing to a termination depth of 3.1 m below the Lake bottom or 12.1 m depth from top of water level in lake on April 26, 1999.

Borehole advanced by means of tricone and wash-boring techniques (where applicable).

Y Trow

Piston Sample
Side Sampler
SPT(N) Value
Dynamic Cone Test
Shelby or BenthosTube
Field Vane Test
Natural Moisture
Plastic and Liquid Limit

Penetrometer

Project: Geotechnical Sampling of Sediment, Dredging of Hamilton Harbour, Pier 16, Hamilton, Ontario

Dwg. No: 11
Project No: HA

Project No: HAGE0053319-A

Ground Elevation: N/A Supervised By: T.B.

Borehole Location : E 594 745.7 m N 4 791 875.1 m

Depth Value N Value Natural Moisture Content Scale Sample Water Level Scale 80 20 40 60 (m) Soil Description % Dry Weight Shear Strength ft m kPa 200 74.67 Z. 10 20 30 100 Approximate Depth of Water = 11.0 m (as reported by CCIW - Tech Ops.) Benthos Sample Retrieved from CCIW - tech Ops from 0 to 0.6 m depth below lake pottom or approx. 11.0 to 1.6 m depth from top of water level in lake <u>3</u>6 11 ~63.7 FILL: Sandy Silt to Silt Sediment and coal tar sludge, black, trace fragments of coal tar (sand size), coal tar (hydrocarbon) stains ~(11.0) and odours, wet. X = 167% <u>3</u>8 12 X ± 46% ~62.5 40 ~(12.2) CLAY: Grey, trace to some silt and sand, trace grave! (Till-Like), no stains or odours, very stiff, moist to wet. 115 kPa <u>4</u>2 <u>1</u>3 ~61.5 ~(13.2) 3.6 s Х SILTY SAND: Brown, trace gravel, no stains or odours, moist to wet. 44 ~61.3 ~(13.4) **BOREHOLE TERMINATED** 14 46 <u>4</u>8 15 <u>5</u>0

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

 Borehole advanced using N-Casing to a termination depth of 2.4 m below the Lake bottom or 13.4 m depth from top of water level in lake on April 26, 1999.

2. Borehole advanced by means of tricone and wash-boring techniques (where applicable).



# Appendix A:

Summary Table of Sampling Parameters



Table No. 1
Summary of Sampling Parameters

			Shear	1613	1 -
Borehole No. (Site No.)	Sample No. *	Sampler Type	Strength (kPa)	SPT N-Value	% Moisture Content
28	1	Split Spoon		6	130.0
28	2	Split Spoon		8	20.0
28	3	Split Spoon		23	14.1
28	4	Split Spoon		2	23.4
		·			
13	1	Side Sampler			68.0
13	2	Split Spoon	>115	23	73.0
13	3	Side Sampler	50	15	58.0
13	4	Side Sampler	78	5	51.0
13	5	Side Sampler		13	59.0
13	6	Side Sampler		8	
14	1	Piston Sampler			
14	2	Piston Sampler	***		90.0
14	3	Side Sampler	23		63.5
14	4	Side Sampler	65		56.0
14	5	Side Sampler	65	5	98.0
14	6	Split Spoon	78	push	69.0
154	1	Side Sampler			135.0
154	2	Side Sampler		<u></u>	129.0
154	3	Side Sampler		•	123.0
154	4	Shelby Tube			38.0
154	5	Shelby Tube	41		26.1
154	. 6	Shelby Tube	46		28.9
6	1	Benthos Tube			
6	2	Side Sampler			129.0
6	3	Side Sampler	14		88.0
6	4	Side Sampler	9		156.0
6	5	Side Sampler	9		135.0
6	6	Shelby Tube	55		27.0
6	7	Shelby Tube	65		28.0



# Table No. 1 (cont'd) Summary of Sampling Parameters

Borehole No. (Site No.)	Sample No. *	Sampler Type	Shear Strength (kPa)	SPT N-Value	% Moisture Content
18	1	Benthos Tube			
18	2	Side Sampler			88.0
18	3	Side Sampler	74		227.0
18	4	Side Sampler			292.0
18	5	Side Sampler	***		85.0
18	6	Shelby Tube			26.4
18	7	Split Spoon		4	29.3
18	8	Shelby Tube			87.0
	<u> </u>		-	<del></del>	
11	1	Benthos Tube		***	128.0
11	2	Split Spoon		39	17.6
11	3	Split Spoon		16	18.3
11	4	Shelby Tube	83		23.4
	· ·				
22	1	Benthos Tube		<del></del>	102.0
22	2	Side Sampler			183.0
22	3	Side Sampler			119.0
22	4	Shelby Tube	97	***	36.0
22	5	Shelby Tube	>115		36.0
	· · ·				
21	1	Benthos Tube			167.0
21	2	Side Sampler			46.0
21	3	Shelby Tube	>115		21.0
21	4	Shelby Tube	115		27.7

<sup>\*</sup> Samples attempted at 0.6 m (2 ft.) depth intervals, therefore Sample No. 1 = 0' to 2', Sample No. 2 = 2' to 4', Sample No. 3 = 4' to 6' .....etc.