APPENDIX F

Geotechnical

GEOTECHNICAL INVESTIGATION
CLASS ENVIRONMENTAL ASSESSMENT
FOR WATERDOWN EAST-WEST BYPASS
HIGHWAY 6 TO BRANT STREET
HAMILTON/BURLINGTON, ONTARIO

for

CITY OF HAMILTON

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PML Ref.: 08HF022
Report: 1
February 26 2009

Peto MacCallum Ltd.
CONSULTING ENGINEERS

February 26, 2009

PML Ref.: 08HF022
Report: 1

Mr. Paul MacLeod
Dillon Consulting Limited
235 Yorkland Boulevard
Suite 800
Toronto, Ontario
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Dear Mr. MacLeod

Geotechnical Investigation
Class Environmental Assessment
for Waterdown East-West Bypass
Highway 6 to Brant Street
Hamilton/Burlington, Ontario

Peto MacCallum Ltd. (PML) is pleased to present the results of the geotechnical investigation recently completed for this project. Authorization to proceed with this assignment was provided by City of Hamilton Purchase Order No. HAMTN-0000043664.

The study corridor for this project is approximately 9 km in length. It extends from Highway 6, about 250 m north of Concession Road 4, easterly on undeveloped land and a short section of Parkside Drive, before turning south through undeveloped land to Dundas Street and then easterly on Dundas Street to Brant Street. Refer to Figure 1 for a plan that shows the overall alignment of the corridor.

The primary objective of this study is to provide information concerning the composition of the soil along the study corridor as well as the depth to bedrock at the structure locations to enable preliminary planning of road grades, site grading and construction work, design of the pavement structure and foundations for structures that may be required, and to identify constraints that may impact detailed design of the alignment of the study corridor.

The objectives of the study were accomplished by:

- Reviewing the preliminary design drawings;
- Reviewing published geologic data for the subject area and reports of geotechnical investigations conducted for other projects along the study corridor;

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BARRIE, BRAMPTON, HAMILTON, KITCHENER, TORONTO

- Conducting a site reconnaissance;
- Drilling widely spaced boreholes along the study corridor;
- Preparing an engineering report to document the findings of the study and provide preliminary geotechnical comments concerning site grading and construction work, pavement structure design and suitable foundations to support structures that may be required.

An Environmental Site Assessment was conducted to assess the potential sources of contamination and present land use along the study corridor to provide recommendations for on site reuse and/or off site disposal of surplus soil that may be generated during construction. The results of this study will be provided under separate cover (PML Ref.: 08HX014).

Document Review

Published geologic maps indicate the overburden soil along the study corridor primarily consists of Halton Till, a layered deposit of silty clay and clayey silt till. The section north of Parkside Drive is near the boundary between deposits of lacustrine and outwash sand and the Halton Till. The drift thickness varies from 9 to 12 m at Highway 6 and decreases towards the east to 6 to 8 m where the alignment joins Dundas Street and is in a bedrock outcrop where it crosses the Niagara Escarpment west of Brant Street. Bedrock along the proposed corridor consists of argillaceous dolostone and shale of the Lockport Formation.

The subsurface stratigraphy revealed in test holes drilled during previous studies near the study corridor generally comprised hard clay till and silt till overlying bedrock as well as silt/sand deposits north of Parkside Drive, consistent with that documented in published reports. Layered clay and silt, sand, sand and silt and silt deposits were also identified locally.

Site Reconnaissance

About 40% of the study corridor follows the alignment of Dundas Street and Parkside Drive. The remaining sections north of Parkside Drive and between Parkside Drive and Dundas Street are undeveloped land primarily used for agricultural purposes.

Land use along Dundas Street and Parkside Drive is a mixture of open space, agricultural, residential and commercial.

The terrain is relatively flat to gently rolling except at the crossings of Borer's Creek west of Centre Road and Grindstone Creek on Parkside Drive, as well as near the east end of the study corridor where Dundas Street descends the Niagara Escarpment west of Brant Street.

The composition and quality of the rock exposed in the rock cut on Dundas Street west of Brant Street varies considerably both vertically and horizontally. The west section of the rock cut is about 1.5 m high and the rock changes from a dolostone/limestone at the west to a shaley limestone at the east of this section. The joint sets are widely spaced and the bedding planes range from close to moderately close.

The eastern section of the rock cut ranges in height from 2 to 10 m with moderately close to wide joint sets and bedding planes. The rock in this zone consists of limestone.

The central portion of the rock cut is about 10 m high and consists of hard dolostone/limestone interbedded with shale/shaley limestone. Both the joints and bedding planes in the dolostone/ limestone are moderately close to wide. The joints in the shale are close to wide; the bedding planes are close to moderately close. Blocky/disturbed sections of rock were also observed.

Topographic features to be considered for this project (from west to east) include:

- Borer's Creek crossing between Centre Road and Highway 6.
- Wood lot crossing east of Centre Road.
- Pedestrian walkway crossing near Station 13+300 east of Centre Road.
- Grindstone Creek crossing on Parkside Drive.
- The culvert under Dundas Street.
- The rock cut west of Brant Street.

Subsurface Investigation

The field work was carried out on October 28 and 29, 2008 and consisted of 13 boreholes. The boreholes were typically advanced to depths of 3.5 m except at the location of the structures to be constructed at the creek crossings and the walkway that were extended to refusal to auger on assumed bedrock. A borehole planned on the east side of Centre Road near Station 13+200 could not be drilled due to access constraints imposed by the heavily wood area, the steeply sloped road embankment and the wet terrain. The locations of the boreholes are shown on Drawings 1 to 8, appended.

The composition of the soil within the wood lot was assessed by probing with a steel rod and correlation with the data revealed in the adjacent boreholes.

The borehole locations were selected and established in the field by PML based on topographic features and landmarks shown on the aerial photographs. The ground surface elevation at the borehole locations was interpolated from the centre line profile shown on the drawings provided by Dillon Consulting (sheets PP-1 to PP-6 dated April 10, 2008).

The boreholes were advanced using continuous flight solid stem augers, powered by a track-mounted CME-75 drill, supplied and operated by a specialist drilling contractor, working under the full time supervision of a member of our engineering staff.

Borehole 7 drilled at the location of the proposed walkway was advanced by power augering without in situ testing/sampling below 6.5 m depth to auger refusal on assumed bedrock at 12.8 m, near elevation 229.7.

Representative samples of the overburden were recovered in all boreholes at frequent depth intervals using a conventional split-spoon sampler during drilling. Standard penetration tests were conducted simultaneously with the sampling operation to assess the strength characteristics of the substrata.

The groundwater conditions in the boreholes were monitored during the course of the field work.

All of the recovered samples were returned to our laboratory for detailed visual examination, classification and routine moisture content determinations.

Summarized Subsurface Conditions

Reference is made to the appended Log of Borehole sheets for details of the subsurface conditions including soil classifications, inferred stratigraphy, standard penetration test N values, groundwater observations and the results of laboratory moisture content determinations.

The subsurface stratigraphy revealed in boreholes drilled along the study corridor was somewhat variable. Sand and/or silty soils overlying/interlayered with silt till or clay till were the predominate soil deposits encountered below the surficial topsoil or fill to a depth of 3.5 m in the holes drilled between Highway 6 and Grindstone Creek. In Borehole 4, drilled near the Borer's Creek crossing, the sand was underlain by silt till; bedrock was encountered at a depth of 6.9 m, near elevation 227.6.

Borehole 7, drilled at the proposed walkway near Station 13+300 encountered silty sand throughout the depth of sampled drilling; bedrock was assumed when auger refusal was met at 12.8 m, near elevation 229.7.

The sand in Borehole 9, drilled at the Grindstone Creek crossing was underlain by silt till; bedrock was inferred at a depth of 8.8 m, near elevation 225.0.

Probing in the wood lot east of Centre Road indicates soft/wet organic rich soil extends to a depth of 300 to 500 mm in this area and this soil is underlain by silt till similar to that revealed in Borehole 6.

East of Grindstone Creek clayey silt/silty clay till was encountered below the surficial topsoil to the maximum depth of drilling. At the culvert extension near Station 9+18 on Dundas Street, bedrock was inferred at a depth of 2.6 m.

Topsoil, 0.2 to 0.7 m in thickness, was identified at the ground surface in five boreholes drilled west of Grindstone Creek and three holes drilled east of Grindstone creek.

Fill, varying in thickness from 0.1 to 2.1 m was contacted surficially in three boreholes drilled at/west of Grindstone Creek and one east of Grindstone Creek. It consisted of sand and gravel in Boreholes 2 and 8, sandy silt in Borehole 9 and clayey silt topsoil fill in Borehole 13. Charcoal and slag were identified below 1.4 m depth within the fill in Borehole 9 while asphalt and concrete pieces were observed within the fill in Borehole 13.

The underlying native soils consisted predominantly of silty sand/sand, clayey silt and clayey silt till. Nine boreholes (Boreholes 1 to 3, 5, 6, 11 to 13) were terminated within the clayey silt till at depths varying from 2.9 to 4.3 m. Boreholes 2 and 9 were terminated in sandy silt till contacted below the clayey silt at 3.5 m depth.

Groundwater was observed in all boreholes except Borehole 9 and 13 during or at the completion of drilling at depths varying from 0.8 to 3 m. All Boreholes except 2, 9 and 13 caved at depths varying from 1.2 to 3.7 m on completion of drilling.

Engineering Discussion and Recommendations

The study corridor for this project is approximately 9 km in length. It extends from Highway 6, about 250 m north of Concession Road 4, easterly on undeveloped land and a short section of Parkside Drive, before turning south through undeveloped land to Dundas Street and then easterly on Dundas Street to Brant Street. Refer to Figure 1 for a plan that shows the overall alignment of the corridor.

The primary objective of the geotechnical component of the Class EA is to provide information concerning the composition of the soil along the study corridor as well as the depth to bedrock at the structure locations for preliminary planning of road grades, site grading and construction work, design of the pavement structure and foundations for structures that may be required, as well as to identify constraints that may impact detailed design of the roadway.

Subsurface Condition Summary

The subsurface stratigraphy along the study corridor is subdivided into three zones for discussion purposes.

From Highway 6 Easterly to the Pedestrian Walkway East of Centre Road (Boreholes 1 to 7)

Silty sand and clayey silt mantled by topsoil is the predominant soil unit in this section of the study corridor. The topsoil thickness varies from 0.2 to 0.7 m, while the silty sand/sand unit extended to 2.1 to 6.5 m. Bedrock was identified at a depth of 6.9 m near Borer's Creek and 12.8 m near the walkway east of Centre Road in this section.

From the Pedestrian Walkway Southeasterly to a Proposed New Road West of Evans Road (Boreholes 8 and 9)

The overburden soil in this zone comprised fill underlain by clayey silt and sandy silt/sand and silt. Refusal to auger on assumed bedrock was encountered at 8.8 m in Borehole 9 at the Grindstone Creek crossing in this section.

Southerly on the Proposed New Road West of Evans Road to Dundas Street (Boreholes 10 to 13)

The overburden along this section of the study corridor consists of topsoil/fill underlain by silt/clayey silt. Bedrock is about 2.6 m below grade near the culvert on Dundas Street.

Site Grading/Excavation

The soil within the anticipated depth of excavation for general site grading and road pavement construction is expected to consist of topsoil and fill underlain by predominantly native silty sand/sand and clayey silt/clayey silt till.

The surficial 300 to 500 mm in the wood lot east of Centre Road consists of soft/wet organic rich soil.

Excavation slopes should be cut at an inclination of 2 horizontal to 1 vertical (2H:1V). A 2 m wide berm with a reverse slope should be provided for earth cuts greater than 6 m high for erosion control and maintenance purposes. Fill slopes should also be inclined at 2H:1V and be provided with a 2 m wide berm with reverse slope if greater than 8 m in height (ref.: OPSD 202.010). An interceptor ditch should be provided at the top of the earth cut (ref.: OPSD 200.020).

Reuse of the native silty sand/clayey silt as bulk fill in other areas of the project is considered to be suitable. Reuse of the organic rich soil in the wood lot is not suitable for bulk fill but should be suitable for use as topsoil during final grading.

The predominant soil type likely to be exposed on earth cuts and fills in the section from Highway 6 to the pedestrian walkway east of Centre Road is likely to comprise silty sand/sand and clayey silt in the remaining section to Brant Street. Based on our visual observations and experience, in general, the Wischmeier Homograph indicates the K factor of the sand/sandy soils is in the order of 0.2 to 0.4 while the K factor for the silt/clayey silt is 0.4 to 0.6; hence they are classified as low and moderately erodible, respectively. Conventional erosion protection systems on exposed slopes should be suitable.

Rock Cut

The preliminary design drawings indicate excavation of bedrock will be required for widening of Dundas Street within the existing rock cut at the escarpment between Stations 10+975 to 11+125.

Excavation of the shaley rock and some of the dolostone/limestone rock by mechanical means (line drilling, hoe ram, jack hammering and/or rock splitting) should be feasible.

It is expected that blasting of the limestone/dolostone with widely spaced joints and bedding planes will be required and implementation of measures to minimize the potential for structural damage to existing underground utilities and nearby buildings implemented. This could involve seismic monitoring during blasting operations as well as a photographic and condition survey of nearby foundations/buildings prior to construction to document existing deficiencies.

Pavement Construction

The subgrade for the pavement structure is expected to consist predominantly of silty sand/clayey silt. Based on the estimated strength and frost susceptibility of the anticipated subgrade and assuming adequate drainage, it is considered that the standard pavement structure for a major arterial road will be suitable.

Pavement Component	Thickness (mm)
Top Course - Asphaltic Concrete HL-1	40
Binder Course - Asphaltic Concrete HL-8 (HS and/or HDBC)	120
Granular A Base Course	150
Granular B Type II Subbase Course	450*

* Can be reduced to 150 mm in rock cut areas. Since a variation in the composition and thickness of the existing pavement structure on Dundas Street east of approximate Station 10+900 may exist and continuous drainage of the granular base to the road side ditch through the road shoulders may be problematic, it is recommended that full depth reconstruction be carried out. It should not be necessary to excavate granular materials that may exist below the design depth of the new pavement structure.

Conventional procedures are considered to be suitable for preparation of the subgrade as well as construction of the pavement structure and associated drainage.

Borer's Creek Overpass Structure

Borehole 4, advanced in the vicinity of Borer's Creek, encountered very loose to loose silty sand with soft to firm clayey silt layers to 2.1 m depth, and compact silty sand and stiff to very stiff clayey silt to 3.7 m depth. Hard clayey silt till was penetrated below this depth to the auger refusal depth of 6.9 m.

Deep foundations consisting of H or pipe pile sections driven to bedrock are the preferred foundation system to support the overpass structure. For preliminary design purposes, an allowable capacity equivalent to 60% of the structural capacity of the pile section selected is considered to be suitable.

Use of spread footings constructed on the hard silt till encountered at a depth of 3.7 m could be considered to support the structure. It should be noted however, that excavations to 3.7 m depth along with implementation of groundwater control methods will be required for this option. Caissons bearing on the hard till at a depth of 4.0 m are also considered to be a suitable

foundation system. It is anticipated however, that basal heave/loss of soil is likely to be experienced when drilling through the silty sand below the water table.

The following bearing resistance is suitable for preliminary design of shallow foundations and caissons.

	Hard Till About 3.7 m Below Grade (kPa)
Factored Bearing Resistance at Ultimate Limit State (ULS)	900
Bearing Resistance at Serviceability Limit State (SLS)	600

Pedestrian Walkway Overpass Structure

Borehole 7, advanced near the pedestrian walkway, penetrated very loose to loose silty sand to the termination of drilling on assumed bedrock at 12.8 m depth.

H or pipe pile sections driven to bedrock encountered at 12.8 m depth are the preferred foundation type for supporting this structure from a geotechnical perspective. An allowable capacity equivalent to 60% of the structural capacity of the pile section selected is considered to be suitable for preliminary design.

Grindstone Creek

Borehole 9 advanced in the vicinity of the Grindstone Creek crossing, identified the presence of loose to compact sandy silt fill to 2.1 m depth. Cobbles and concrete pieces were observed in the upper 1.4 m of this material while charcoal and slag were observed below 1.4 m. A thin layer of firm alluvial silt underlain by a loose sand layer was contacted to 2.9 m depth below the fill. Compact to very dense sandy silt till was encountered below the sand layer to 8.8 m depth, where refusal to the drilling equipment was encountered.

Similar to the Borer's Creek, deep foundations consisting of H or pipe pile sections driven to bedrock are the preferred foundation type for supporting the Grindstone Creek crossing. For preliminary design purposes an allowable pile capacity consisting of 60% of the structural capacity of the pile section selected is considered to be suitable.

Shallow foundations may be considered to support the structure, however, excavation to 2.9 m depth along with groundwater control methods to keep the foundation excavation dry will be required for this option. Alternatively caissons bearing on the compact to dense sandy silt till at 2.9 m depth could be considered.

The following bearing resistance is suitable for preliminary design of shallow foundations and caissons:

	Compact to Dense Till About 2.9 m Below Grade (kPa)
Factored Bearing Resistance at ULS	600
Bearing Resistance at SLS	400

Culvert Extension on Dundas Street

Borehole 13, drilled at the location of the culvert extension on Dundas Street encountered topsoil fill to 1.4 m depth underlain by very stiff to hard silt till to the auger refusal on probable bedrock at a depth of 2.6 m.

The culvert extension should be supported by footings founded on bedrock at 2.6 m depth. A factored bearing resistance of 4000 kPa is recommended for sizing footings bearing on bedrock for preliminary design purposes. Measures will be required to deal with the flow of water during construction of the foundation.

Proposed Retaining Walls – Dundas Street

The preliminary design drawings indicate construction of two retaining walls is planned in this area, one on the south side of Dundas Street from Station 10+975 to 11+125 and one on the north side from Station 11+175 to 11+475.

It is considered that use of spread footings founded on bedrock or the very stiff to hard clay till indigenous to this area is a feasible means of supporting the retaining walls. A factored bearing resistance at ULS of 300 kPa and 200 kPa at SLS is considered to be suitable for preliminary design of footings constructed on the clay till.

We trust the information presented in this report is sufficient for your present purposes. If you have any questions, please do not hesitate to contact our office.

Sincerely

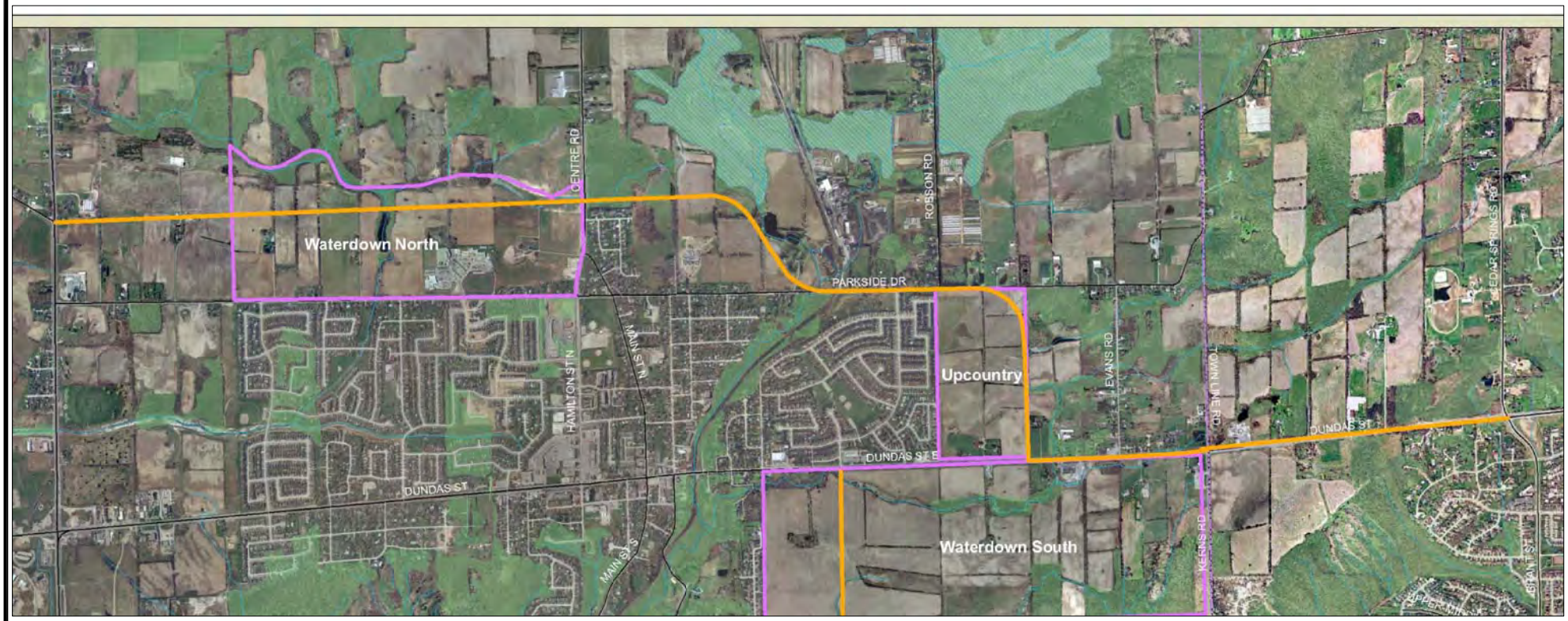
Peto MacCallum Ltd.

Harry Gharegrat, MS, P.Eng.
Senior Engineer

Dennis W. Kerr, MEng., P.Eng.
Principal Consultant
Geotechnical and Geoenvironmental Services

HG/DWK:lad

Enclosures:
Figure 1 – Waterdown East-West Bypass Alignment
List of Abbreviations
Log of Borehole Nos. 1 to 13
Drawings 1 to 8 - Borehole Location Plan



CITY OF HAMILTON

CLASS EA FOR WATERDOWN EAST WEST BYPASS
HAMILTON/BURLINGTON, ONTARIO

ALIGNMENT KEY PLAN

Peto MacCallum Ltd.
CONSULTING ENGINEERS

		DATE	SCALE	PML REF.	FIGURE NO.
DRAWN	MDS	2008–11	N.T.S.	08HF022	1
CHECKED	DWK				
APPROVED	DWK				

LIST OF ABBREVIATIONS

PENETRATION RESISTANCE

Standard Penetration Resistance N: - The number of blows required to advance a standard split spoon sampler 0.3 m into the subsoil. Driven by means of a 63.5 kg hammer falling freely a distance of 0.76 m.

Dynamic Penetration Resistance: - The number of blows required to advance a 51 mm, 60 degree cone, fitted to the end of drill rods, 0.3 m into the subsoil. The driving energy being 475 J per blow.

DESCRIPTION OF SOIL

The consistency of cohesive soils and the relative density or denseness of cohesionless soils are described in the following terms:

CONSISTENCY	N (blows/0.3 m)	c (kPa)	DENSENESS	N (blows/0.3 m)
Very Soft	0 - 2	0 - 12	Very Loose	0 - 4
Soft	2 - 4	12 - 25	Loose	4 - 10
Firm	4 - 8	25 - 50	Compact	10 - 30
Stiff	8 - 15	50 - 100	Dense	30 - 50
Very Stiff	15 - 30	100 - 200	Very Dense	> 50
Hard	> 30	> 200		

WTPL	Wetter Than Plastic Limit
APL	About Plastic Limit
DTPL	Drier Than Plastic Limit

TYPE OF SAMPLE

SS	Split Spoon	TW	Thinwall Open
WS	Washed Sample	TP	Thinwall Piston
SB	Scraper Bucket Sample	OS	Oesterberg Sample
AS	Auger Sample	FS	Foil Sample
CS	Chunk Sample	RC	Rock Core
ST	Slotted Tube Sample		

PH	Sample Advanced Hydraulically
PM	Sample Advanced Manually

SOIL TESTS

Qu	Unconfined Compression	LV	Laboratory Vane
Q	Undrained Triaxial	FV	Field Vane
Qcu	Consolidated Undrained Triaxial	C	Consolidation
Qd	Drained Triaxial		

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LOG OF BOREHOLE NO. 1

METRIC

1 of 1

PROJECT Waterdown East-West Bypass
OUR PROJECT NO. 08HF022
LOCATION Highway 6 to Brant Street, Burlington and Hamilton, Ontario
BORING DATE October 28, 2008
ENGINEER H. Gharegrat
BORING METHOD Continuous Flight Solid Stem Augers
TECHNICIAN M. D. St. Denis

ELEV / DEPTH in meters	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	ELEVATION SCALE
240.5 / 0.0	Ground Surface					
0.0	TOPSOIL: Dark brown sandy clayey silt topsoil		1	SS	0	
239.8 / 0.7	SILTY SAND: Loose to compact, brown silty sand, trace clay, wet		2	SS	9	240
239.1 / 1.4	becoming grey, with partings of brown clayey silt, moist		3	SS	10	239
238.4 / 2.1	becoming saturated		4	SS	11	238
237.6 / 2.9	CLAYEY SILT TILL: Hard, brown clayey silt till, some sand and gravel, low plastic, DTPL		5	SS	31	237
237.0 / 3.5	BOREHOLE TERMINATED AT 3.5 m.					

SHEAR STRENGTH kPa
○ UNCONFINED + FIELD VANE
▲ POCKET PENETROMETER
50 100 150 200
DYNAMIC CONE PENETRATION ×
STANDARD PENETRATION TEST ●
20 40 60 80

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L
WATER CONTENT (%)
10 20 30 40

UNIT WEIGHT γ kg/m^3

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

Upon completion of drilling, free water at 0.9 m, cave at 1.2 m

1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0

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20
15 — 5
10

(%) STRAIN AT FAILURE

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LOG OF BOREHOLE NO. 2

METRIC

1 of 1

PROJECT Waterdown East-West Bypass
OUR PROJECT NO. 08HF022
LOCATION Highway 6 to Brant Street, Burlington and Hamilton, Ontario
BORING DATE October 28, 2008
ENGINEER H. Gharegrat
BORING METHOD Continuous Flight Solid Stem Augers
TECHNICIAN M. D. St. Denis

ELEV / DEPTH in meters	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	ELEVATION SCALE	SHEAR STRENGTH kPa (○ UNCONFINED + FIELD VANE ▲ POCKET PENETROMETER; DYNAMIC CONE PENETRATION STANDARD PENETRATION TEST ×●)	PLASTIC LIMIT w_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT w_L — WATER CONTENT (%)	UNIT WEIGHT γ kg/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
239.4	Ground Surface						50 100 150 200 / 20 40 60 80	10 20 30 40		
0.0	FILL: Compact, brown sand and gravel fill, damp		1	SS	22	239				
238.7										
0.7	CLAYEY SILT: Firm, brown clayey silt, some sand, trace organics, low plastic, WTPL		2	SS	5					
238.0						238				
1.4	CLAYEY SILT TILL: Firm to very stiff, brown to reddish brown clayey silt till, trace sand and gravel, low plastic, WTPL to DTPL, with layers of wet sand, red shale fragments		3	SS	5					Upon completion of drilling, free water at 2.9 m, no cave
			4	SS	16	237				
236.5										
2.9	SANDY SILT TILL: Dense sandy silt till, some gravel, trace clay, damp		5	SS	39					
235.9						236				
3.5	BOREHOLE TERMINATED AT 3.5 m.									

1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0

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(%) STRAIN AT FAILURE

TYPE

	1	5
238.5		
237.8		
	3	
237.1		
	4	
	5	
235.1	6	
234.9		

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CONSULTING ENGINEERS

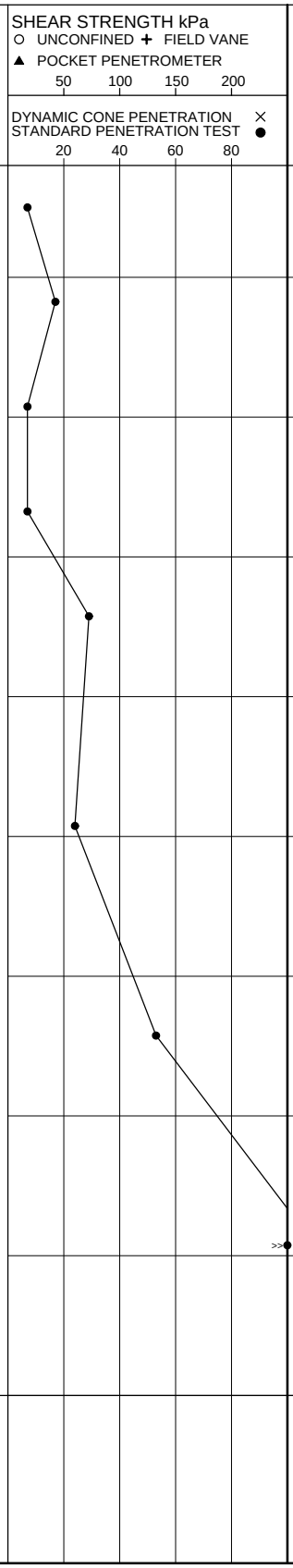
LOG OF BOREHOLE NO. 9

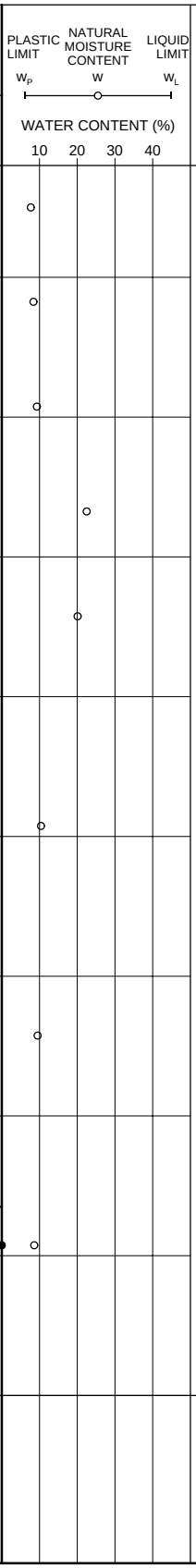
METRIC

1 of 1

PROJECT Waterdown East-West Bypass
OUR PROJECT NO. 08HF022
LOCATION Highway 6 to Brant Street, Burlington and Hamilton, Ontario
BORING DATE October 29, 2008
ENGINEER H. Gharegrat
BORING METHOD Continuous Flight Solid Stem Augers
TECHNICIAN M. D. St. Denis

ELEV / DEPTH in meters	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	ELEVATION SCALE
233.8 / 0.0	Ground Surface					
0.0	FILL: Loose to compact, brown sandy silt fill, some gravel, damp, with cobbles and concrete pieces		1	SS	7	
			2	SS	17	233
232.4 / 1.4	becoming grey with charcoal and slag		3	SS	7	232
231.7 / 2.1	CLAYEY SILT ALLUVIUM: Firm, grey clayey silt alluvium, with organics, WTPL		4	SS	7	
231.2 / 2.6	SILTY SAND: Loose, brown silty sand, wet					231
230.9 / 2.9	SANDY SILT TILL: Compact to very dense, brown sandy silt till, some sand and gravel, trace clay, moist		5	SS	29	230
			6	SS	24	229
			7	SS	53	228
			8	SS	50/75mm	227
225.0 / 8.8	BOREHOLE TERMINATED AT 8.8 m UPON PRACTICAL REFUSAL TO AUGERING. BEDROCK ASSUMED.					226
						225





UNIT WEIGHT γ kg/m^3

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

Upon completion of drilling, free water at 3.0 m, cave at 3.7 m

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+7, ×5 : Numbers refer to Sensitivity

(%) STRAIN AT FAILURE

Peto MacCallum Ltd.
CONSULTING ENGINEERS

LOG OF BOREHOLE NO. 10

METRIC

1 of 1

PROJECT Waterdown East-West Bypass
OUR PROJECT NO. 08HF022
LOCATION Highway 6 to Brant Street, Burlington and Hamilton, Ontario
BORING DATE October 29, 2008
ENGINEER H. Gharegrat
BORING METHOD Continuous Flight Solid Stem Augers
TECHNICIAN M. D. St. Denis

ELEV / DEPTH in meters	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	ELEVATION SCALE
249.4 / 0.0	Ground Surface					
0.0 / 248.9	TOPSOIL: Dark, brown clayey silt topsoil with organics		1	SS	4	249
0.5 / 248.7	CLAYEY SILT: Firm, brown clayey silt, trace sand, DTPL					
0.7	SILT: Loose to compact, brown silt, trace clay and sand, with thin layers of brown silty clay, wet		2	SS	8	
			3	SS	14	248
247.3 / 2.1	CLAYEY SILT: Hard to very stiff, grey clayey silt, some sand and gravel, DTPL		4	SS	64/225mm	247
			5	SS	22	
245.9 / 3.5	BOREHOLE TERMINATED AT 3.5 m.					246

SHEAR STRENGTH kPa
○ UNCONFINED + FIELD VANE
▲ POCKET PENETROMETER
50 100 150 200
DYNAMIC CONE PENETRATION ×
STANDARD PENETRATION TEST ●
20 40 60 80

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L
WATER CONTENT (%)
10 20 30 40

UNIT WEIGHT γ kg/m^3

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

Upon completion of drilling, free water at 1.2 m, cave at 1.5 m

1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0

PML- BH LOG GEO 08HF022 BH LOGS.GPJ ON_MOT.GDT 2/26/2009 3:48:12 PM

+7, ×5 : Numbers refer to Sensitivity

20
15 — 5
10

(%) STRAIN AT FAILURE

Peto MacCallum Ltd.
CONSULTING ENGINEERS

LOG OF BOREHOLE NO. 11

METRIC

1 of 1

PROJECT Waterdown East-West Bypass
OUR PROJECT NO. 08HF022
LOCATION Highway 6 to Brant Street, Burlington and Hamilton, Ontario
BORING DATE October 29, 2008
ENGINEER H. Gharegrat
BORING METHOD Continuous Flight Solid Stem Augers
TECHNICIAN M. D. St. Denis

ELEV / DEPTH in meters	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	ELEVATION SCALE
247.7 / 0.0	Ground Surface					
0.0	TOPSOIL: Dark brown clayey silt topsoil, medium organic		1	SS	5	
247.0 / 0.7	CLAYEY SILT TILL: Stiff to very stiff, brown clayey silt till, trace sand and gravel, low plastic, DTPL, with red shale fragments		2	SS	12	247
			3	SS	19	246
245.5 / 2.3	becoming grey with thin partings of silt		4	SS	12	245
			5	SS	74	
244.2 / 3.5	BOREHOLE TERMINATED AT 3.5 m.					

SHEAR STRENGTH kPa
○ UNCONFINED + FIELD VANE
▲ POCKET PENETROMETER
50 100 150 200
DYNAMIC CONE PENETRATION ×
STANDARD PENETRATION TEST ●
20 40 60 80

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L
WATER CONTENT (%)
10 20 30 40

UNIT WEIGHT γ kg/m^3

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

Upon completion of drilling, free water at 2.4 m, cave at 2.7 m

1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0

+7, ×5 : Numbers refer to Sensitivity

20
15 — 5
10

(%) STRAIN AT FAILURE

Peto MacCallum Ltd.
CONSULTING ENGINEERS

LOG OF BOREHOLE NO. 12

METRIC

PROJECT Waterdown East-West Bypass
OUR PROJECT NO. 08HF022
LOCATION Highway 6 to Brant Street, Burlington and Hamilton, Ontario
BORING DATE October 29, 2008
ENGINEER H. Gharegrat
BORING METHOD Continuous Flight Solid Stem Augers
TECHNICIAN M. D. St. Denis

ELEV / DEPTH in meters	DESCRIPTION	STRAT PLOT	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES "N" VALUES	ELEVATION SCALE
247.6 / 0.0	Ground Surface					
0.2	TOPSOIL: Dark brown clayey silt topsoil		1	SS	4	247
	CLAYEY SILT TILL: Firm to hard, brown clayey silt till, trace sand and gravel, DTPL, with red shale fragments		2	SS	16	
			3	SS	37	246
245.5 / 2.1	some sand and gravel		4	SS	68/200mm	245
244.5 / 3.1	BOREHOLE TERMINATED AT 3.1 m.		5	SS	50/100mm	

SHEAR STRENGTH kPa
○ UNCONFINED + FIELD VANE
▲ POCKET PENETROMETER
50 100 150 200
DYNAMIC CONE PENETRATION ×
STANDARD PENETRATION TEST ●
20 40 60 80

PLASTIC LIMIT w_P | NATURAL MOISTURE CONTENT w | LIQUID LIMIT w_L
WATER CONTENT (%)
10 20 30 40

UNIT WEIGHT γ kg/m^3

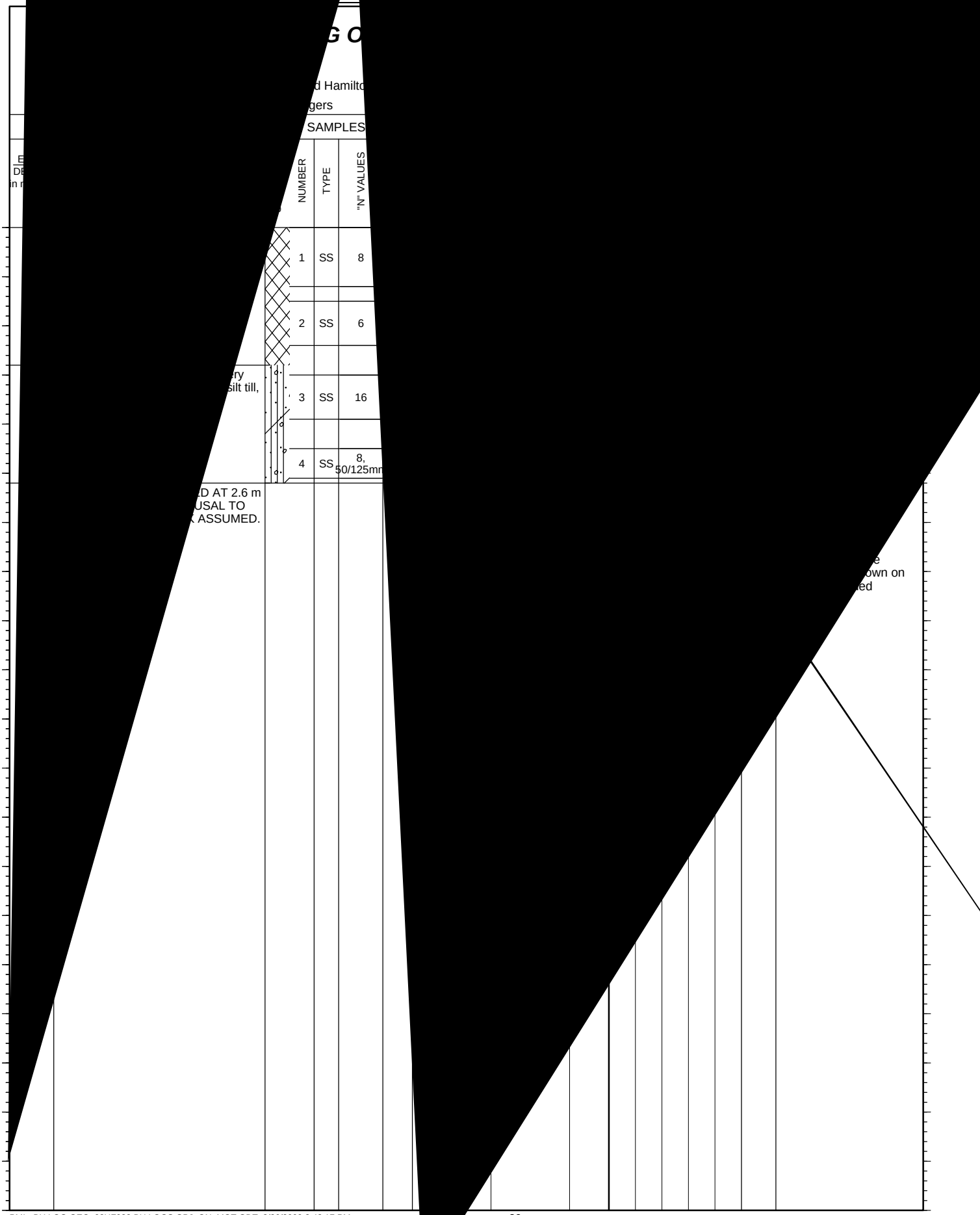
REMARKS & GRAIN SIZE DISTRIBUTION (%)
GR SA SI CL

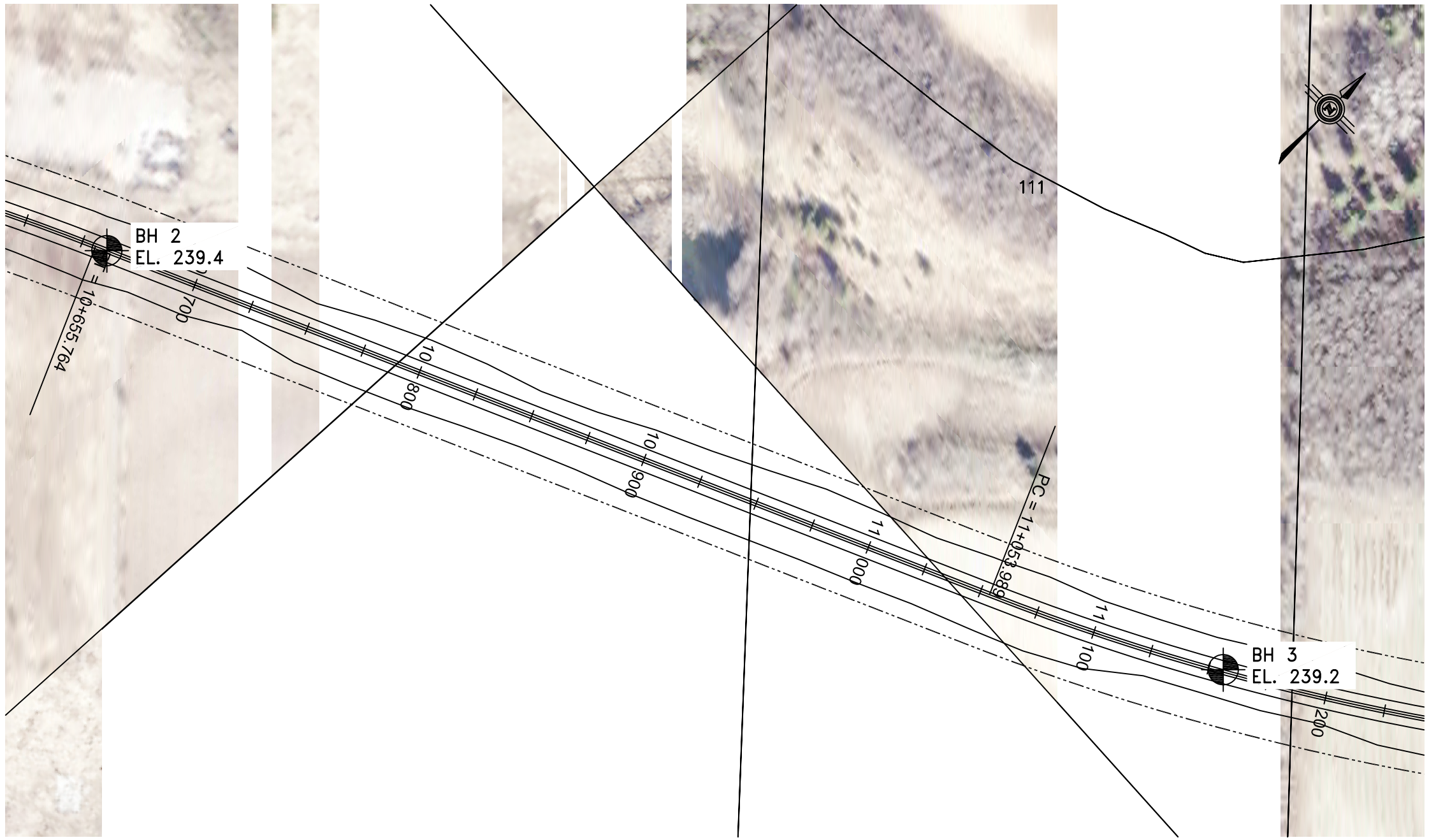
Upon completion of drilling, no free water, no cave

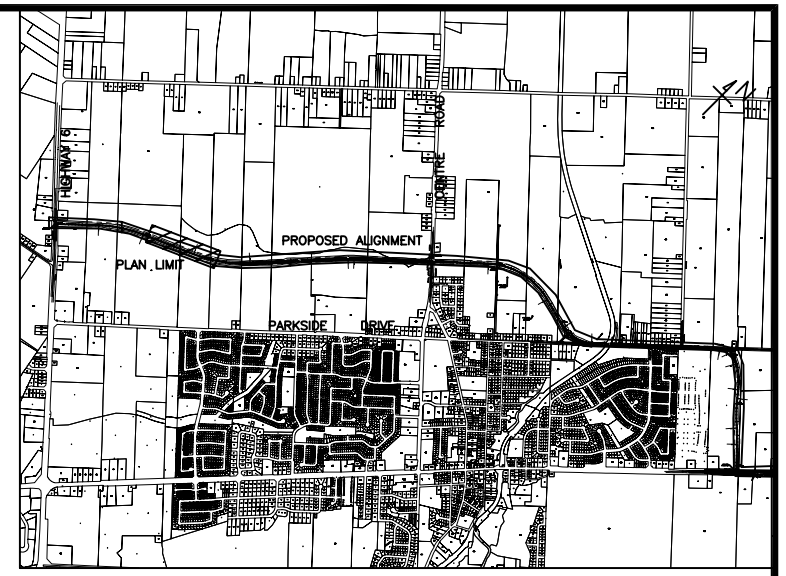
+7, ×5 : Numbers refer to Sensitivity

20
15 — 5
10

(%) STRAIN AT FAILURE


SAMPLES
NUMBER
TYPE
"N" VALUES
1 SS 8
2 SS 6
3 SS 16
4 SS 8, 50/125mm
PML- BH LOG GEO 08HF022 BH LOGS.GPJ ON_MOT.GDT 2/26/2009 3:48:17 PM
(%) STRAIN AT FAILURE





KEY PLAN
HAMILTON AND BURLINGTON, ONTARIO

LEGEND:

⊕ BOREHOLE (BH) LOCATION

REFERENCE:

PLAN PRODUCED FROM UNNAMED DRAWING AND AERIAL PHOTOGRAPHS PROVIDED BY DILLON CONSULTING LTD., MARCH 2009

NOTE:

BOREHOLE ELEVATIONS WERE INTERPOLATED FROM THE CENTRE LINE PROFILE SHOWN ON DRAWINGS PROVIDED BY DILLON CONSULTING (SHEET PP-1 TO PP-6 DATED APRIL 10, 2008)

THE INFERRED STRATIGRAPHY REFERRED TO IN THE REPORT IS BASED ON DATA FROM THESE BOREHOLES, SUPPLEMENTED BY GEOLOGIC EVIDENCE. THE ACTUAL STRATIGRAPHY MAY VARY FROM THAT SHOWN, AT LOCATIONS BETWEEN THE BOREHOLES.

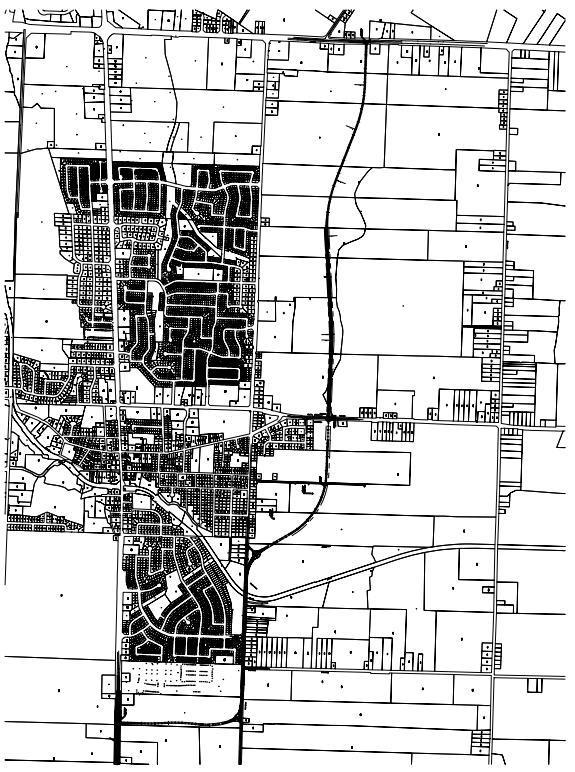
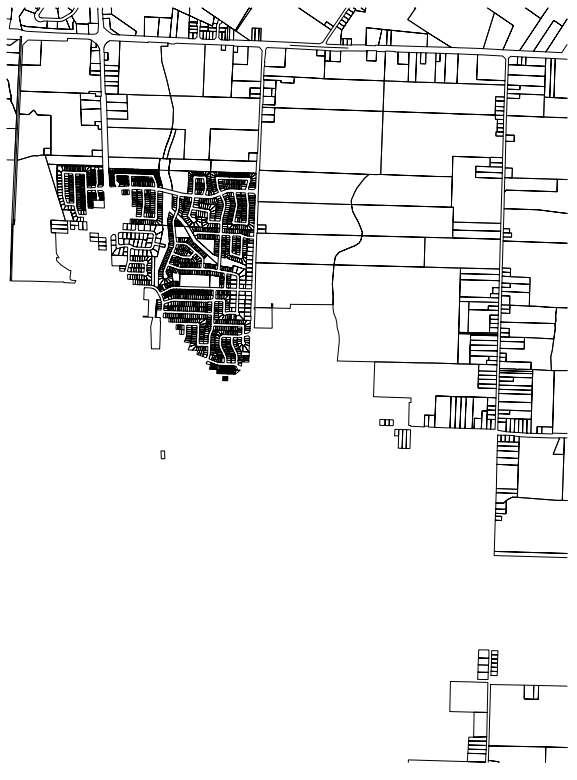
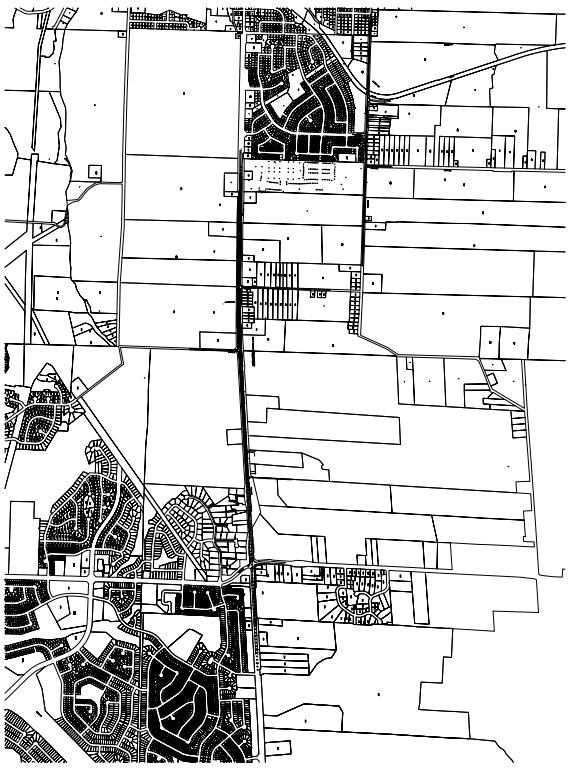
25 0 m 50 100

SCALE

CITY OF HAMILTON

WATERDOWN EAST-WEST BYPASS
HAMILTON / BURLINGTON, ONTARIO

BOREHOLE LOCATION PLAN

Peto MacCallum Ltd.
CONSULTING ENGINEERS

		DATE	SCALE	PML REF.	DRAWING NO.
DRAWN	TC	2009-03	AS SHOWN	08HF022	2
CHECKED	HG				
APPROVED	DWK