LVM

J.H. Cohoon Engineering Limited

Kulmatycky Property
Paris, Ontario

Supplementary Hydrogeology Study Report

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Property and Confidentiality

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REVISION AND PUBLICATION REGISTER		
Revision N°	**Date**	**Modification And/Or Publication Details**
0A	2010-08-09	Draft Report Issued
00	2011-09-29	Final Report Issued

DISTRIBUTION	
11 copies	J.H. Cohoon Engineering Limited
1 original	File

INTRODUCTION

LVM inc. was retained by Stephen Kulmatycky to carry out a supplementary hydrogeology study for the property at Dundas Street West in Paris, Ontario as shown on Drawing 1 (Appendix 3). Authorization to proceed with the work was provided Mr. Kulmatycky following the submission of a proposal. The supplementary hydrogeology study was undertaken in response to comments provided by the Grand River Conservation Authority (GRCA) during their review of the hydrogeological investigation report completed for the property (Naylor Engineering Associates Ltd. Report No. 6190H1.R01, June 2008).

The scope of work for this supplementary study included a review of previous geological and hydrogeological information for the study area, drilling of four boreholes and installation of monitoring wells, and water level measurement in the monitoring wells.

The objectives of this report are to provide a summary of the hydrogeological and geological conditions in proximity to the identified wetland area, to assess the groundwater contribution to the wetland area, to identify the groundwater flow direction and the upgradient lands contributing flow to the groundwater seepage, and to discuss the potential for impacts to the groundwater seepage and wetland area by the proposed development.

1 STUDY METHODOLGY

The study methodology involved a number of tasks, which included:

- a review of topographic, geological, and hydrogeological mapping and reports for the area;
- advancement of four boreholes in proximity to the identified wetland area, completed as monitoring wells;
- collection of soil samples from the boreholes during drilling for moisture analysis and particle size distribution analysis; and,
- measurement of water levels in the monitoring wells.

Previous studies of the area by LVM inc. include a hydrogeological investigation (Naylor Engineering Associates Ltd. Report No 6190H1.R01, June 2008) and a geotechnical investigation (Naylor Engineering Associates Ltd. Report no. 6190G1.R02, October 2008).

A slope stability assessment (LVM inc. Project Number 160-P035259-0100-GE-0001-00) is taking place concurrently with this investigation. This assessment includes the drilling of one borehole in the northwest portion of the property.

1.1 FIELD PROGRAM

The current field program involved the advancement of four boreholes to depths ranging from 2.74 to 3.51 m to identify the subsurface soil and groundwater conditions. The boreholes were advanced on June 28, 2010, by Geo-Environmental Drilling Inc. under the full-time observation of a senior technician from LVM inc. using a CME-75 track-mounted drillrig equipped with continuous flight hollow stem augers, at the locations shown on the appended Site Plan, Drawing 1.

Soil samples were recovered from the boreholes at regular 0.75 and 1.50 m depth intervals using a 50 mm diameter split-spoon sampler in accordance with the Standard Penetration Test (SPT) procedure (ASTM D1586). Soil samples obtained from the boreholes were submitted for moisture content analysis, with selected samples submitted for particle size distribution analysis. The laboratory results for moisture content are presented on the borehole logs included in Appendix 2, while the particle size distribution analysis results are shown on Figure 1 in Appendix 4.

The borehole locations and ground surface elevations were surveyed by J.H. Cohoon Engineering Limited and supplied to LVM inc. in CAD format. It is understood that the elevations are related to a geodetic datum.

1.2 MONITORING WELL INSTALLATIONS

During the borehole drilling program, monitoring wells were installed in all boreholes for measurement of groundwater levels and insitu hydraulic conductivity (slug) testing.

The 50 mm diameter monitoring wells were constructed by inserting slotted, Schedule 40 PVC well screen and riser pipe into the open auger holes. Sand was then added in order to place a filter pack around the screen, until the level of the sand was typically 300 mm above the top of the screen. Bentonite seals were then placed above the sand pack to prevent the infiltration of surface water. The tops of all the well riser pipes were vented to allow accurate measurement of stabilized groundwater levels, and protective steel casings with lockable covers were concreted in place to house each of the monitoring wells.

All of the monitoring wells were constructed in accordance with Ontario Regulation 389/09 (formerly O. Reg. 903) as administered by the Ontario Ministry of the Environment (MOE). Well records were submitted to the MOE based on the cluster system whereby one well record can be submitted on behalf of an entire property. Provincial Site Cluster Tag Identification Number A094892 was placed on the monitoring well at Borehole (BH) 101-10.

Measurements of the stabilized groundwater levels in the monitoring wells were collected on July 13, 2010, with measurement results summarized in the appended Table 1 (Appendix 1). The monitoring well data was used to develop the shallow groundwater contours shown on the appended Drawing 2.

1.3 HYDRAULIC CONDUCTIVITY TESTING

Hydraulic conductivity values of near-surface soil samples were derived empirically using the particle size distribution test and the Hazen Formula:

$$K = 10^{-2} D_{10}^{2}$$

where:

K = hydraulic conductivity of the tested material (m/sec)

D_{10} = effective particle size at 10% passing on the particle size distribution curve (mm)

The calculated conductivity values for samples from BH 101-10 to 103-10 are presented in the appended Table 2.

1.4 LABORATORY SOIL TESTING

All soil samples obtained during borehole drilling were returned to LVM inc.'s laboratory facilities for visual examination and physical testing. The soil moisture content test results obtained from borehole samples are plotted on the appended borehole logs.

2 SUMMARIZED CONDITIONS

2.1 SITE DESCRIPTION

Please refer to Naylor Engineering Associates Ltd. Report No. 6190H1.R01 (June 2008) for a description of the site, and a summary of geological and hydrogeological conditions across the property.

2.2 LOCAL SUBSOIL CONDITIONS

We refer to the appended borehole logs for detailed soil descriptions and stratigraphies, results of SPT testing, moisture content profiles, monitoring well construction, and groundwater measurements and observations.

Subsurface stratigraphy in the area of groundwater seepage consists of topsoil overlying sand and gravel deposits of varying thickness, which are in turn underlain by clay till.

2.3 SURFACE AND GROUNDWATER CONDITIONS

Groundwater levels were measured in the monitoring wells on July 13, 2010, with measurements summarized in the appended Table 1. Elevations of seepage points around the wetland area were also measured. The measurements indicate that groundwater occurs between 0.53 and 1.87 metres below ground surface (mBGS) upgradient of the groundwater seepage/wetland area.

The groundwater contour map shown on the appended Drawing 2 indicates that shallow groundwater in the vicinity of the groundwater seepage/wetland area generally flows north-eastwards. The groundwater contours correlate well with the seepage point elevations.

2.4 HYDRAULIC CONDUCTIVITY – OVERBURDEN SOILS

Hydraulic conductivity estimates from the Hazen Formula Calculations are summarized in the appended Table 2, with the particle size distribution graphs shown on the appended Figure 1.

Within the area of study, granular soils had hydraulic conductivity values ranging from 1.0×10^{-6} m/sec to 2.0×10^{-5} m/sec, with an average value of 8×10^{-6} m/sec, typical of granular deposits.

2.5 CONNECTION BETWEEN SURFACE WATER AND GROUNDWATER

Based on the groundwater contours shown on the appended Drawing 2, groundwater levels are very close to ground surface upgradient of the seepage area. It is concluded that discharge of groundwater to ground surface (i.e. groundwater seepage) is occurring in the wetland area where ground surface levels coincide with the groundwater table.

2.6 UPGRADIENT SOURCE, AND POTENTIAL FOR IMPACT

Based on the groundwater contours shown in the appended Drawing 2, groundwater flows in a north-easterly direction. This indicates that the upgradient source of groundwater seepage in the wetland area is south-west of the seepage area.

The proposed development has the potential to impact the seepage area if a reduction in groundwater levels occurs. However, if the proposed development matches the pre-development site water balance under post-development conditions, the groundwater flow regime would not be expected to change. By maintaining the pre-development infiltration rate, and real distribution of infiltration, south-west of the seepage area, the groundwater discharge rates could be expected to remain constant.

Based on the soil types encountered in the boreholes drilled in proximity to the wetland area, and in the boreholes and test pits (Naylor Engineering Associates Ltd. Report No 6190H1.R01, June 2008) located south-west of the groundwater seepage, an appropriate pre-development infiltration rate for the near-surface sand and gravel deposits is 250 mm/yr*. This infiltration rate is higher than the 156 mm/yr weighted average value for the entire site reported in the Naylor Engineering report, reflecting the high permeability granular soils upgradient of the seepage area.

It is important to consider that if site grading upgradient of the seepage area removes/adds significant volumes of soil, that the post-development infiltration rate will be dependent on the soils exposed at ground surface. Post-grading surficial soils upgradient of the groundwater seepage area should be of similar composition to the sand and gravel deposits that currently exist.

Additionally, it will be important to prevent preferential flow pathways, such as servicing trenches, from diverting groundwater flow. Mitigation measured such as cut-off collars should be implemented.

In order to maintain the volume of groundwater recharge, and the spatial distribution of recharge, the entire development area south-west of the seepage area should employ localized infiltration of precipitation on each lot where possible. Infiltration of precipitation from rooftops using individual soakaway pits or similar structures would allow clean water to recharge into the ground at multiple locations throughout the development. Infiltration along roadways or boulevards should consider the impacts of road salt and the addition of contaminants from the roadway to the water being infiltrated.

During development, soil types that are not conducive to localized infiltration may be encountered in the portion of the property south-west of the wetland area. If significant areas of poor infiltration potential are encountered, additional infiltration in areas with good infiltration potential will be required to match the pre-development water balance.

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* Ontario Ministry of the Environment and Energy. 1995.

Alternately, further study to refine the upgradient area where infiltration is required/appropriate could be undertaken. A review of the development design to confirm the mitigation of impacts will be required prior to the issuance of the final version of the report.

3 SUMMARY

The near surface soils in proximity to the groundwater seepage area are sand and gravel deposits, underlain by clay till.

Shallow groundwater is found within the granular deposits, flowing north-eastwards towards the seepage area. Groundwater is found very close to the ground surface upgradient of the seepage area, and groundwater is discharging to ground surface where ground surface elevations coincide with the groundwater table.

By maintaining the pre-development infiltration rate and spatial distribution of infiltration upgradient of the seepage area (i.e. the entire portion of the development south-west of the seepage area), the groundwater levels and groundwater seepage rates can be maintained, and the wetland can continue to be supported by groundwater discharge.

4 STATEMENT OF LIMITATIONS

It is important to note that this hydrogeology study involved sampling of the site at specific locations, and the conclusions in this report are based on this information gathered.
The subsurface conditions between and beyond the test holes may differ from those encountered at the test holes.

We trust that this report is suitable for your present requirements, and we thank Mr. Stephen Kulmatycky and J.H. Cohoon Engineering Limited for this opportunity to have provided hydrogeological engineering services. If you have any questions or require further hydrogeological or geotechnical consultation, please do not hesitate to contact our office.

REFERENCES

Freeze, R.A. and J.A. Cherry. 1979. *Groundwater*. Englewood Cliffs, New Jersey: Prentice-Hall. 614 pp.

Ontario Ministry of the Environment and Energy. 1995. MOEE Hydrogeological Technical Information Requirements for Land Development Applications.

Appendix 1 Tables

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TABLE 1

MEASURED GROUNDWATER ELEVATIONS

Kulmatycky Property
Dundas Street West
Paris, Ontario

WELL NAME	GROUND SURFACE ELEVATION (mASL)	STICKUP (m)	JUL. 13/10 DEPTH TO WL (mBTOP)	JUL. 13/10 DEPTH TO WL (mBGS)	JUL. 13/10 WL ELEVATION (mASL)
BH01-10-U	242.12	0.71	dry	dry	dry
BH01-10-L	242.12	0.65	16.12	15.47	227.30
BH101-10	242.29	0.73	2.60	1.87	241.15
BH102-10	239.75	0.69	1.68	0.99	239.45
BH103-10	241.23	0.76	2.01	1.25	240.74
BH104-10	243.41	0.88	1.41	0.53	243.76
Seepage Point 1	239.10	--	--	--	--
Seepage Point 2	238.76	--	--	--	--
Seepage Point 3	238.05	--	--	--	--
Seepage Point 4	236.24	--	--	--	--
Seepage Point 5	235.61	--	--	--	--
Seepage Point 6	236.47	--	--	--	--
Seepage Point 7	237.67	--	--	--	--
Seepage Point 8	238.72	--	--	--	--
Seepage Point 9	238.94	--	--	--	--

Notes:
1. mBTOP – metres below top of pipe.
2. mBGS – metres below ground surface.
3. mASL – meters above sea level.
4. WL – water level.

TABLE 2

HYDRAULIC CONDUCTIVITY ESTIMATES

Kulmatycky Property
Dundas Street West
Paris, Ontario

ESTIMATION METHOD	ID/LOCATION	SOIL TYPE	SAMPLE DEPTHS OR DEPTH INTERVAL FOR SCREENED SOIL (mBGS)	HYDRAULIC CONDUCTIVITY ESTIMATE (m/sec)
Hazen Formula Calculation	BH 101-10	Sand and gravel, some silt and clay	0.76 – 1.22	2.3×10^{-6}
	BH 102-10	Sand and gravel, some silt and clay	0.76 – 1.98	2.0×10^{-5}
	BH 103-10	Sand and gravel, some silt and clay	0.76 – 1.22	1.0×10^{-6}

Notes:
1. mBGS – metres below ground surface.

Appendix 2 Boreholes

List of Abbreviations

Borehole 01-10 (Job No. 161-P035259-0100)

Boreholes 101-10 to 104-10

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LIST OF ABBREVIATIONS

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

Sample Types		Soil Tests and Properties	
AS	auger sample	SPT	Standard Penetration Test
CS	chunk sample	UC	unconfined compression
RC	rock core	FV	field vane test
SS	split spoon	ø	angle of internal friction
TW	thin-walled, open	γ	unit weight
WS	wash sample	w_p	plastic limit
		w	water content
		w_l	liquid limit
		I_L	liquidity index
		I_p	plasticity index
		PP	pocket penetrometer

Penetration Resistances	
Dynamic Penetration Resistance	The number of blows by a 63.5 kg (140 lb.) hammer dropped 0.76 m (30 in.) required to drive a 50 mm (2 in.) diameter 60° cone a distance 0.30 m (12 in.). The cone is attached to 'A' size drill rods and casing is not used.
Standard Penetration Resistance, N (ASTM D1586)	The number of blows by a 63.5 kg. (140 lb.) hammer dropped 0.76 m (30 in.) required to drive a standard split spoon sampler 0.30 m (12 in.)
WH	sampler advanced by static weight of hammer
PH	sampler advanced by hydraulic pressure
PM	sampler advanced by manual pressure

Soil Description		
Cohesionless Soils	**SPT N-Value**	**D_r (%)**
Relative Density (D_r)	(blows per 0.30 m)	
Very Loose	0 to 4	0 to 20
Loose	4 to 10	20 to 40
Compact	10 to 30	40 to 60
Dense	30 to 50	60 to 80
Very Dense	over 50	80 to 100
Cohesive Soils	Undrained Shear Strength (C_u)	
Consistency	**kPa**	**psf**
Very Soft	less than 12	less than 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
DTPL	Drier than plastic limit	
APL	About plastic limit	
WTPL	Wetter than plastic limit	

Borehole Number: 01-10

Ground Elevation: *242.07m*

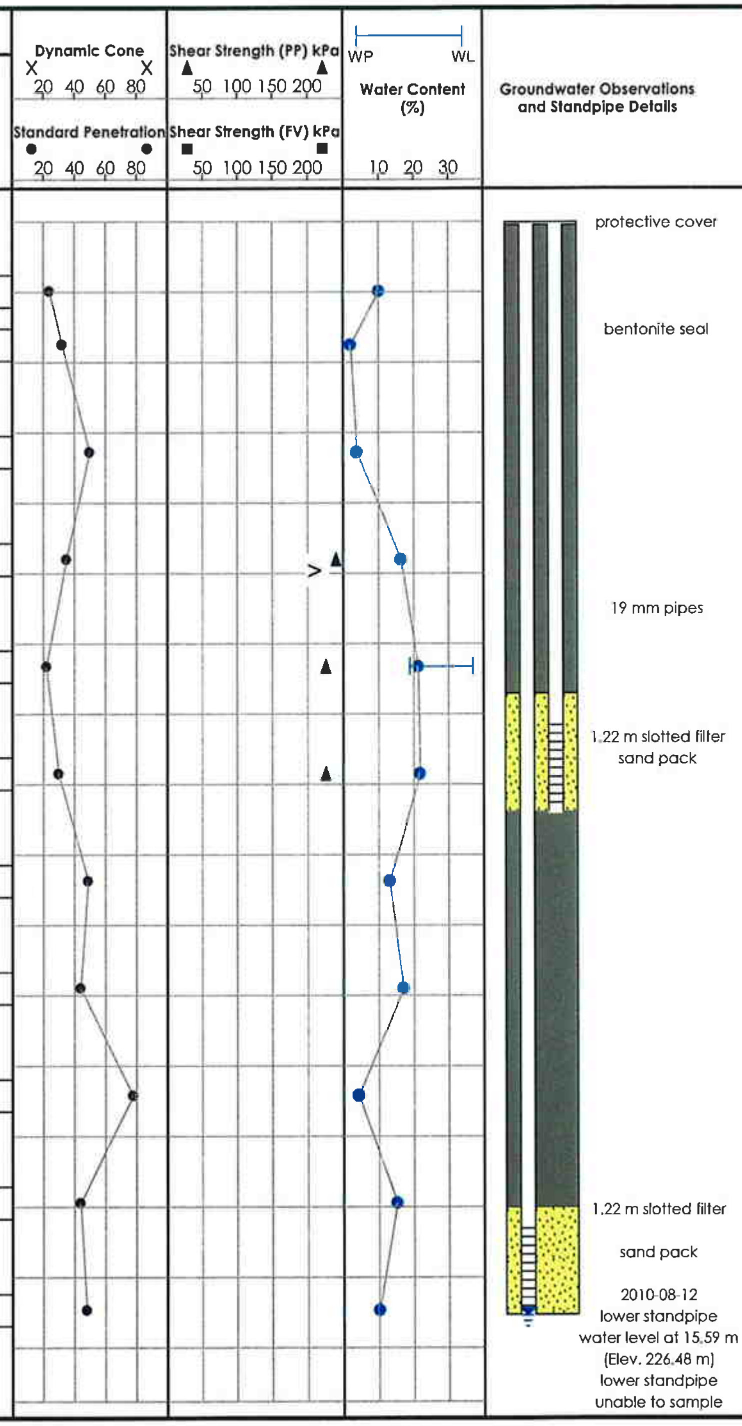
Project: *Kulmatycky Property*

Location: *Dundas Street West, County of Brant, Ontario*

Job No.: *161-P035259-0100*

Drill Date: *2010-06-28*

Depth (m)	Description	Elevation (m)	Number	Type	N-Value
0.00	Ground Elevation	242.07			
0.00	**TOPSOIL:** dark brown silt, moist				
0.85	**SAND AND GRAVEL:** compact brown sand and gravel, some silt, damp	241.00	1	SS	24
			2	SS	32
2.00	trace silt	240.00			
3.00	**SAND:** dense brown fine to coarse sand, some fine gravel, trace silt, damp	239.00	3	SS	50
4.00	**SILT TILL:** hard brown and grey clayey silt, trace sand and fine gravel, DTPL	238.00	4	SS	35
5.50	**CLAY TILL:** hard grey silt and clay, trace sand, and fine gravel, APL	236.00	5	SS	22
7.60	**CLAY:** hard grey silty clay, APL - WTPL; some grey silt layers, very moist to wet	234.00	6	SS	30
9.10	**SILT:** dense brown silt, trace fine sand and clay, moist; some brown clayey silt layers, DTPL	233.00	7	SS	49
10.60	dense brown sandy silt, very moist	231.00	8	SS	44
11.40	**SAND AND GRAVEL:** very dense brown sand and gravel, some silt, damp	230.00	9	SS	78
13.00	**SAND:** dense brown silt and sand, trace gravel, saturated	229.00	10	SS	44
			11	SS	48
15.70	Borehole terminated at 15.70 m	226.00			



Reviewed by: *DK*

Drill Method: *HSR*

Notes:

Field Tech.: *RM*

Sheet: *1 of 1*

Drafted by: *JG*

Borehole Number: 101-10

Ground Elevation: *242.29 m*

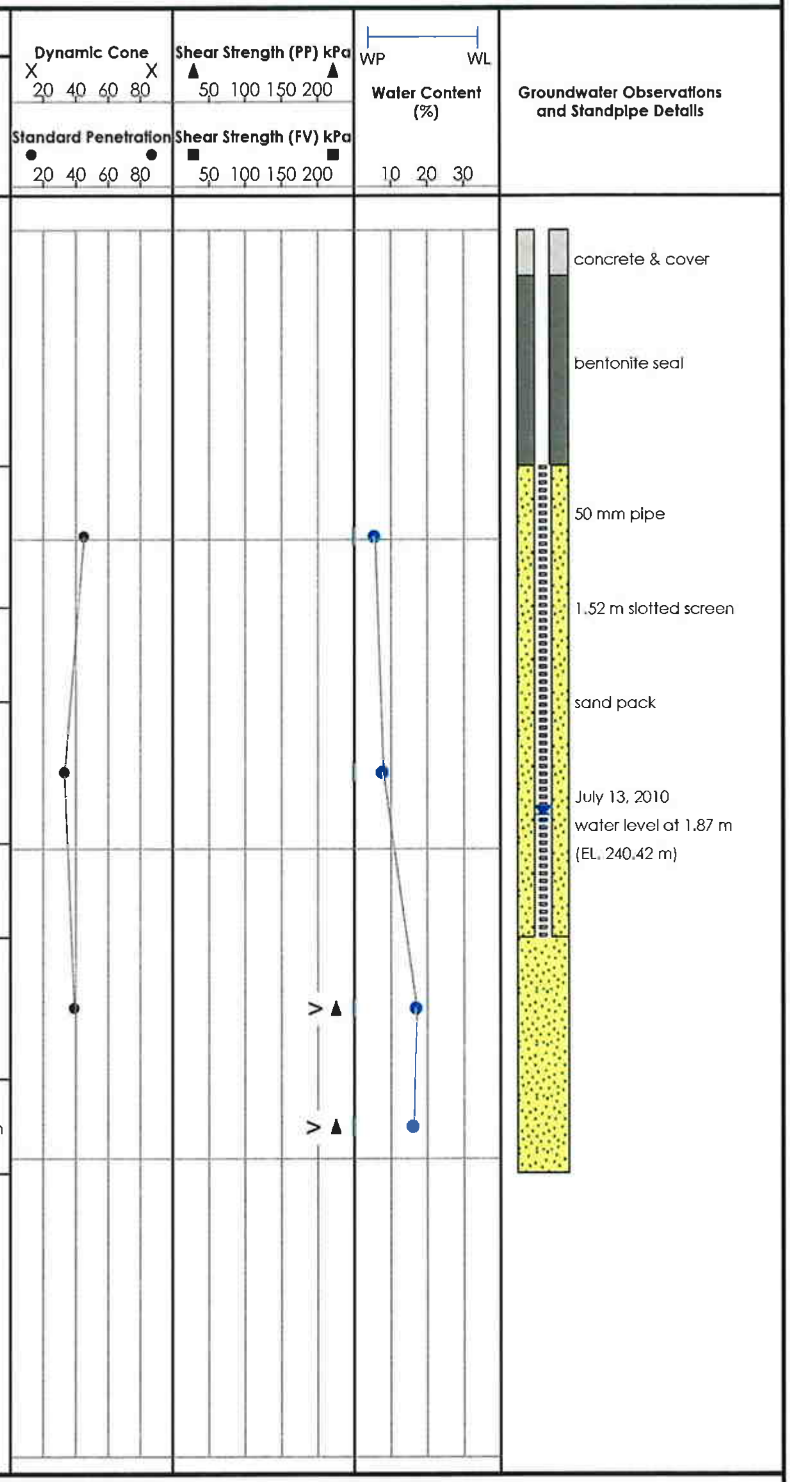
Project: *Supplementary Hydrogeology Study - Kulmatycky Property*

Job No.: *160-P034766-0300*

Location: *Dundas Street West, County of Brant, Ontario*

Drill Date: *2010-06-28*

Depth (m)	Description	Elevation (m)	Sample Number	Type	N-Value
	Ground Elevation	242.29			
0.00	***TOPSOIL:*** dark brown silt, moist				
	SAND AND GRAVEL: dense brown sand and gravel, some silt, damp	242.00			
1.00			1	SS	45
		241.00			
	saturated		2	SS	33
2.00	***CLAY TILL:*** hard grey silty clay, trace sand and fine gravel, DTPL - APL				
		240.00	3	SS	39
			4	SS	32\150mm
3.00	Borehole terminated at 3.05 m				
		239.00			



Reviewed by: *RM*

Drill Method: *Hollow Stem Anger*

Notes: *Well Tag #A094892*

Field Tech.: *RM*

Sheet: *1 of 1*

Drafted by: *JG*

LVM

Borehole Number: 102-10

Ground Elevation: *239.75 m*

Project: *Supplementary Hydrogeology Study - Kulmatycky Property*

Job No.: *160-P034766-0300*

Location: *Dundas Street West, County of Brant, Ontario*

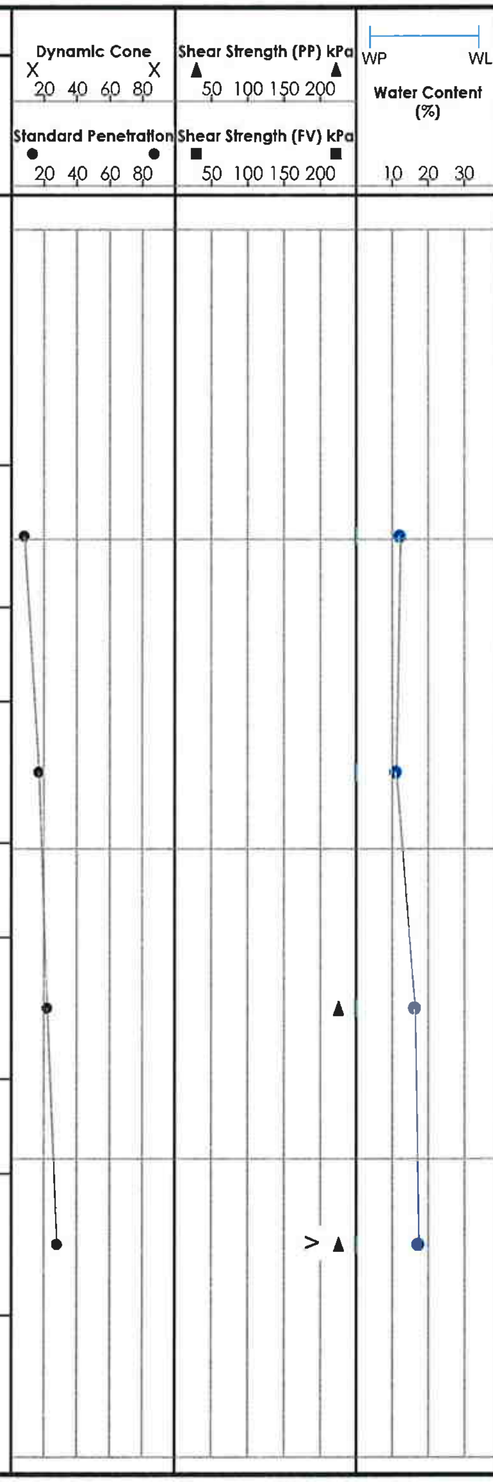
Drill Date: *2010-06-28*

SOIL PROFILE

Depth (m)	Description	Elevation (m)
	Ground Elevation	239.75
0.00	**TOPSOIL:** dark brown silt, moist	
	SAND AND GRAVEL: loose brown silty sand and fine gravel, saturated	239.00
1.00		
		238.00
2.00		
	CLAY TILL: hard grey silty clay and trace sand and fine gravel, APL	237.00
3.00		
	Borehole terminated at 3.51 m	236.00

SAMPLE

Number	Type	N-Value
1	SS	8
2	SS	17
3	SS	22
4	SS	28



Groundwater Observations and Standpipe Details

- concrete & cover
- bentonite seal
- July 13, 2010 water level at 0.99 m (EL. 238.76 m)
- 50 mm pipe
- 1.52 m slotted screen
- sand pack

Reviewed by: *RM*

Drill Method: *Hollow Stem Anger*

Notes:

Field Tech.: *RM*

Sheet: *1 of 1*

Drafted by: *JG*

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Borehole Number: 103-10

Ground Elevation: *241.23 m*

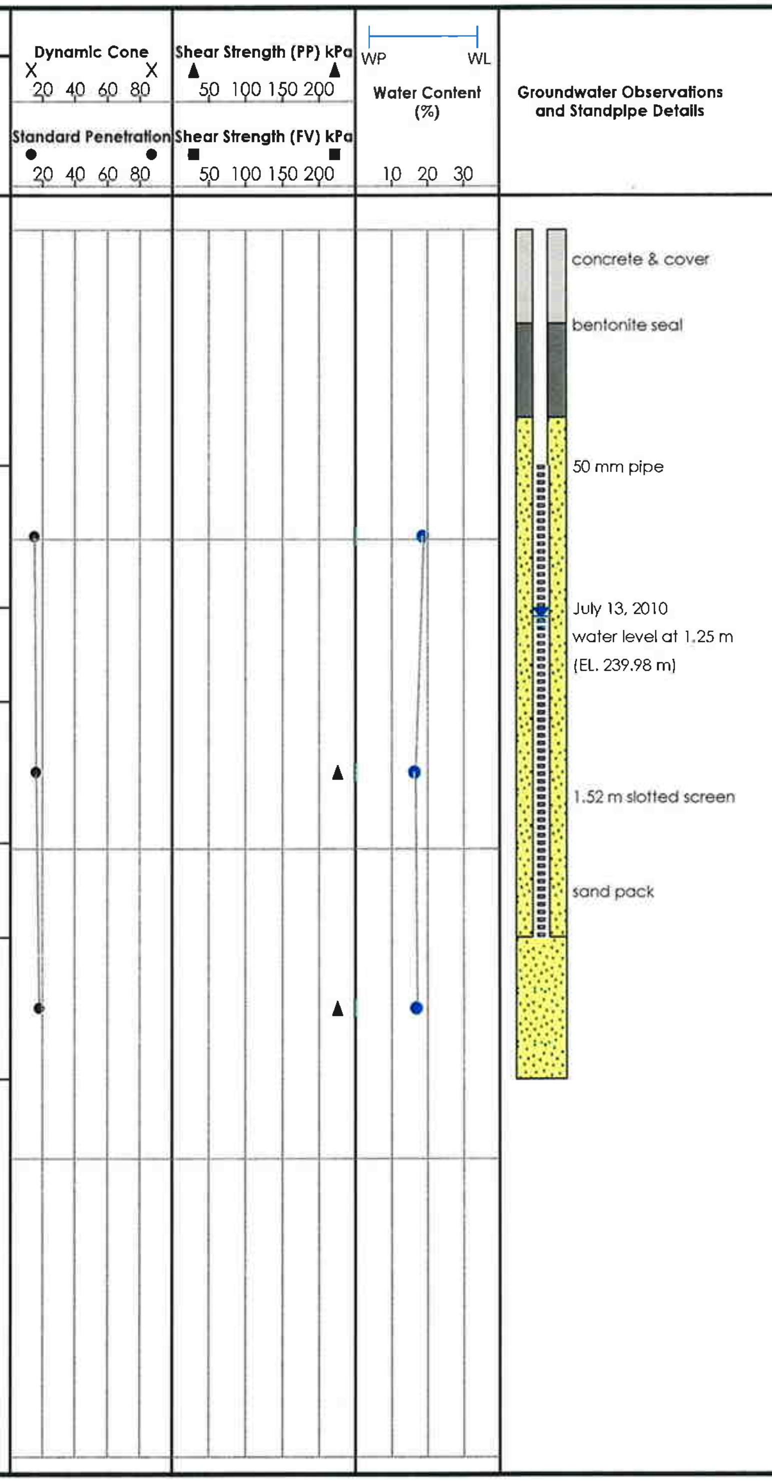
Project: *Supplementary Hydrogeology Study - Kulmatycky Property*

Location: *Dundas Street West, County of Brant, Ontario*

Job No.: *160-P034766-0300*

Drill Date: *2010-06-28*

Depth (m)	Description	Elevation (m)	Sample Number	Type	N-Value
0.00	Ground Elevation	241.23			
0.00	***TOPSOIL:*** dark brown silt, moist	241.00			
	SAND AND GRAVEL: compact brown sand and gravel, some silt, saturated				
1.00			1	SS	15
	CLAY TILL: hard grey silty clay, trace sand and fine gravel, APL	240.00			
			2	SS	16
2.00		239.00			
			3	SS	18
	Borehole terminated at 2.74 m				
3.00		238.00			



Reviewed by: *RM*

Drill Method: *Hollow Stem Anger*

Notes:

Field Tech.: *RM*

Sheet: *1 of 1*

Drafted by: *JG*

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Borehole Number: 104-10

Ground Elevation: *243.41 m*

Project: *Supplementary Hydrogeology Study - Kulmatycky Property*

Location: *Dundas Street West, County of Brant, Ontario*

Job No.: *160-P034766-0300*

Drill Date: *2010-06-28*

Depth (m)	SOIL PROFILE – Description	Elevation (m)	SAMPLE Number	Type	N-Value
	Ground Elevation	243.41			
0.00	***TOPSOIL:*** dark brown silt, moist				
	SAND AND GRAVEL: brown silty sand and gravel, moist	243.00			
1.00	***CLAY TILL:*** very stiff brown silty clay, trace sand and fine gravel, APL		1	SS	13
	grey, some sand layers, saturated, APL	242.00	2	SS	16
2.00		241.00	3	SS	20
3.00	Borehole terminated at 2.90 m	240.00			

Dynamic Cone: X 20 40 60 80 X

Standard Penetration: ● 20 40 60 80 ●

Shear Strength (PP) kPa: ▲ 50 100 150 200 ▲

Shear Strength (FV) kPa: ■ 50 100 150 200 ■

Water Content (%): WP WL 10 20 30

Groundwater Observations and Standpipe Details

- concrete & cover
- bentonite seal
- July 13, 2010 water level at 0.53 m) (EL. 242.88 m)
- 50 mm pipe
- 1.52 m slotted screen
- sand pack

Reviewed by: *RM*

Drill Method: *Hollow Stem Anger*

Notes:

Field Tech.: *RM*

Sheet: *1 of 1*

Drafted by: *JG*

Appendix 3 Drawings

Drawing 1: Site Plan
Drawing 2: Groundwater Contours – Shallow Overburden Soils
Drawing 3: Cross Section A-A'

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