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# SOIL-MAT ENGINEERS & CONSULTANTS LTD.

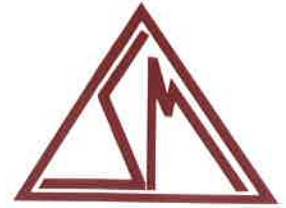
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PROJECT NO.: SM 166999-G

November 28, 2016

ROYAL LEPAGE NIAGARA REAL ESTATE CENTRE  
39 Queen Street – Suite 203  
St. Catharines, Ontario  
L2R 5G4

Attention: Leo DiFabio  
Sales Representative

**PRELIMINARY HYDROGEOLOGICAL ASSESSMENT  
PROPOSED RESIDENTIAL DEVELOPMENT  
FIRELANE 13B ROAD  
NIAGARA-ON-THE-LAKE, ONTARIO**

Dear Mr. DiFabio,

Further to your authorisation, SOIL-MAT ENGINEERS & CONSULTANTS LTD. has completed the fieldwork, laboratory testing, and report preparation in connection with the above noted project. The fieldwork was conducted in general accordance with our proposal P6321, dated August 15, 2016, revised August 18, 2016. Our comments and recommendations, based on our findings at the three [3] borehole locations are presented herein.

## **1. INTRODUCTION**

We understand that the project will involve the redevelopment of the existing single family properties adjacent Firelane 13B Road in St. Catharines, Ontario. The redevelopment is expected to include a number of new single family lots on a single paved roadway. The lots are also expected to have private water services [well or cistern] and on-site private septic systems, or possibly a communal septic system. The purpose of this investigation is to assess the existing soil, bedrock and shallow groundwater conditions, as well as review available water well records and other information, and to interpret this information with respect to supply of domestic water for the proposed dwellings, on-site sewage treatment, and general earthworks for the development.

Additionally, our scope of investigation included a slope stability assessment to determine the top of stable slope location for the slope bordering Lake Ontario, which included the measurement of two [2] representative slope profiles. The slope assessment work was conducted in general accordance with the guideline policies of the Niagara Peninsula Conservation Authority [NPCA], including the Natural Hazards Technical Guide by the Ministry of Natural Resources [MNR] and the supporting document "Geotechnical Principles for Stable Slopes".

This report is based on the above summarised project description, and on the assumption that the design and construction will be performed in accordance with applicable codes and standards. Any significant deviations from the proposed project design may void the recommendations given in this report. If significant changes are made to the proposed design, this office must be consulted to review the new design with respect to the results of this investigation. The information contained in this report does not reflect upon the environmental aspects of the site and therefore does not address them in this document.

## 2. PROCEDURE

A total of three [3] sampled boreholes were advanced at the locations illustrated in the attached Drawing No. 1, Slope Profile and Borehole Location Plan. The boreholes were advanced using solid stem continuous flight auger equipment on October 11, 2016, under the direction and supervision of a staff member of SOIL-MAT ENGINEERS & CONSULTANTS LTD. The boreholes were advanced to depths of between approximately 8.1 to 12.2 metres beneath the existing ground surface. Upon completion of drilling, Borehole Nos. 1 and 3 were fitted with a monitoring well to allow for measurement of the static groundwater level, while Borehole No. 2 was backfilled in general accordance with Ontario Regulation 903. The monitoring wells consisted of 50-millimetre diameter PVC pipe, screened in the lower 3 metres, backfilled with filter sand to approximately 0.3 metres above the screened portion, and with bentonite clay 'hole plug' medium to ground surface. Each monitoring well was outfitted with a 'monument' protective steel casing, flush with the existing ground surface.

Representative samples of the subsoils were recovered from the boreholes at selected depth intervals. After undergoing a general field examination, the soil samples were preserved and transported to the SOIL-MAT laboratory for visual, tactile, and olfactory classifications. Routine moisture content tests were performed on all soil samples recovered from the borings. Hand penetrometer testing and unit weight determinations were conducted on selected samples. In addition, four [4] selected samples were subjected to grain size analysis. The results of these analyses have been presented on the attached Grain Size Analysis Nos. 1 to 4.

The boreholes were located in the field by a representative of SOIL-MAT ENGINEERS & CONSULTANTS LTD. The ground surface elevation at the borehole locations was surveyed to a site specific benchmark, described as the top of the catch basin in front of 9 Firelane 13B Road. This temporary benchmark was assigned an elevation of 100.00 metres for convenience.

A second site visit was conducted on October 28, 2016 by a representative of SOIL-MAT ENGINEERS. During this site visit, two [2] representative slope profiles were measured along the face of the subject slope at the locations illustrated in the attached Drawing No. 1, Slope Profile and Borehole Location Plan, while the slope profiles can be found on Drawing Nos. 2 and 3, Slope Profiles A-A. and B-B. At this time, a Slope Stability Rating Chart was completed and indicated a Rating Value of 34 corresponding to a slight potential for slope instability. A copy of the Slope Stability Rating Chart has been appended to the end of this report.

Details of the conditions encountered in the boreholes, together with the results of the field and laboratory tests are presented in Borehole Log Nos. 1 to 3, inclusive, following the text of this report. It is noted that the boundaries of soil types indicated on the logs are inferred from non-continuous soil sampling and observations made during drilling. These boundaries are intended to reflect transition zones for the purpose of geotechnical design and therefore should not be construed as the exact planes of geological change

### **3. SITE DESCRIPTION AND SUBSURFACE CONDITIONS**

The subject site consists of the residential properties along Firelane 13B Road in Niagara-on-the-Lake, Ontario. The lots are currently occupied by thirteen single family dwellings with associated driveways, eleven of which are within the subject parcel. The project area is relatively flat and even, and slopes down to the north toward Lake Ontario, its northern boundary. The site is bound to the south and east by vacant agricultural lands, and to the west by existing residential properties.

The subsurface conditions encountered at the borehole locations are summarised as follows:

#### **Topsoil**

A surficial veneer of approximately 75 millimetres of topsoil was encountered at the borehole locations. It is noted that the depth of topsoil may vary across the site and from the borehole locations. It is also noted that the term 'topsoil' has been used from a geotechnical point of view, and does not necessarily reflect its nutrient content or ability to support plant life.



### Sandy Silt

A deposit of brown sandy silt was encountered beneath the topsoil at all borehole locations. This fine grained granular soil contains trace clay, with occasional organic inclusions in the upper level, and is generally in a compact to dense state. The sandy silt soils encountered were proven to depths of approximately 3.8 to 3.9 metres below grade.

As noted above four [4] selected samples of the subsurface soils were subjected to laboratory grain size analyses. The results of this testing are summarised in Table A below. The grain size analyses confirm the material as a sandy silt, with silt content in the range of approximately 59 to 80 per cent, and traces of clay. One sample, BH2-SS1, was noted to have a clay content of 16 per cent, however the clay content was shown to reduce with depth in sample BH2-SS4. These fine grained granular soils would afford a moderately permeable overburden.

**TABLE A**  
**SUMMARY OF GRAIN SIZE ANALYSES**

Sample ID	Depth [m]	%Gravel	%Sand	%Silt	%Clay	D <sub>10</sub> [mm]	K [cm/sec]
BH1-SS2	1.75	0	13	80	7	0.005	10 <sup>-5</sup>
BH2-SS1	1.0	0	25	59	16	<0.001	10 <sup>-7</sup>
BH2-SS4	3.3	0	27	70	3	0.009	10 <sup>-5</sup>
BH3-SS2	1.75	0	22	77	1	0.015	10 <sup>-4</sup>

### Clayey Silt/Silty Clay

Clayey silt/silty clay was encountered beneath the sandy silt at all borehole locations. This native cohesive material is grey, contains trace to some sand, and is generally firm to stiff in consistency. The clayey silt/silty clay encountered was proven to depths of approximately 7.8 to 8.6 metres at all borehole locations. These cohesive soils would be generally characterised as low permeable material.

### Queenston Shale

Queenston shale bedrock was encountered beneath the clayey silt/silty clay at depths of approximately 7.8 to 8.6 metres beneath the existing ground surface at all borehole locations. The shale is red, and highly weathered in the upper levels, exhibiting the properties of very stiff to hard silty clay, becoming sounder with depth. The bedrock was not cored as part of this investigation.

## Groundwater Observations

As noted above, groundwater monitoring wells were installed in Borehole Nos. 1 and 3. Water levels recorded from these wells are summarised in Table B.

**TABLE B**  
**GROUND WATER LEVEL MEASUREMENTS**

Monitoring Well No.		1	3
Surface Elevation [m]		100.13	100.08
MW	Depth [m]	9.1	7.6
Details	Elev. [m]	91.03	92.48
Oct 28/16	Depth [m]	5.1	2.05
	Elev. [m]	95.03	98.03

Based on these readings, as well as our observations during drill, the static groundwater level is estimated at a depth of approximately 3 to 5 metres below the existing ground surface, near to slightly above the water level of Lake Ontario. It is noted that the shallower level measured in Monitoring Well No. 3 may be influenced by recent rainfall events, and so may not be indicative of the static groundwater level.

## 4. SLOPE CONDITIONS AND STABILITY ASSESSMENT

### SLOPE CONDITIONS

As noted above, two [2] representative slope profiles were measured from the existing roadway down to the water level of Lake Ontario. The subject slope was noted to be approximately 5 to 6 metres in height, and to be as steep as approximately 1.5 to 1.9 horizontal to 1 vertical, with overall inclinations of approximately 2.4 to 2.9 horizontal to 1 vertical. The slope consisted of large irregular armour stone, with a terrace at roughly the mid-height of the slope. The large armour stone appeared to be in sound condition with no evidence of slope instability or previous failures. Evidently the existing armour stone shoreline protection have been performing adequately to protect the slope from ongoing erosion.

As with all slopes, there is a reduction in surficial shearing resistance attributed to the effects of freezing and thawing, wetting and drying, burrowing animals, etc. With time, the surface of the slope will degenerate and tend to reach equilibrium within its stress



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and ambient environment, including vegetative cover. It should be noted that this type of degeneration is a very slow process, and would be further slowed by the stabilising effect of the armour stone, as is evident by the observed stable condition of the existing slope.

STABILITY ASSESSMENT

Stability analyses of the subject slope were performed with a computerized modeling program [SLOPE/W 2007] considering appropriate material parameters and multiple potential failure planes. Conservative soil parameters were assigned to the soil strata encountered based on our finding in the borehole, and have been summarised as follows:

Soil	Unit weight, $\gamma$	Friction angle, $\phi$	Cohesion, c
Sandy Silt	19.5 kN/m <sup>3</sup>	36°	0 kPa
Clayey Silt/Silty Clay	19.0 kN/m <sup>3</sup>	34°	5 kPa
Queenston Shale	20.0 kN/m <sup>3</sup>	40°	10kPa

Stability analyses yielded minimum factors of safety on the order of approximately 1.51 and 1.57 with respect to global stability, for the two profiles measured, profiles A-A and B-B respectively, and in excess of 3.1 with respect to the long-term top of stable slope location for both slope profiles. It is noted that these stability analyses do not account for the stabilising effect of the existing armour stone, and would suggest the stability of the slope to be higher than that calculated. Sample results of these analyses are appended to this report.

Table 7.2 of the Geotechnical Principles for Stable Slopes [Ministry of Natural Resources] lists a Design Minimum Factor of Safety of between 1.3 and 1.5 for 'Active' land use properties [habitable or unoccupied structures near slope]. As the calculated factors of safety are found to be exceeding this range, the existing slope is considered to be stable in both the short and long term.

TOP OF STABLE SLOPE

The top of stable slope location is determined by the application of an erosion allowance at the toe and a stable slope inclination through the slope. In this case, considering the existing shore protection, a conservative erosion allowance of 20 metres has been applied at the toe. It is noted that an engineering review by an experienced coastal engineer of the existing shoreline protection should be conducted to confirm its condition, and would possibly allow for a reduction in this erosion allowance. Table 4.3 of the Ministry of Natural Resources publication "Geotechnical Principles for Stable

Slopes" indicates stable slope inclinations through sands and gravels from 1.5 to 2.0 horizontal to 1.0 vertical, and through the clays and silts as steep as 2.0 to 4.0 horizontal to 1.0 vertical. In this case, given the borehole information indicating compact to dense sandy silt and stiff cohesive soil conditions, a conservative stable slope inclination of 2.0 horizontal to 1 vertical has been applied through both the sandy silt and clayey silt soils. Applying the appropriate erosion and stable slope inclinations as outlined above results in a top of stable slope location at each profile. For Profiles A-A and B-B, the determined top of stable slope is approximately 36.7 and 38.3 metres from the existing roadway, respectively. An interpolated line of the top of stable slope has been illustrated on Drawing No. 1.

#### DESIGN AND CONSTRUCTION CONSIDERATIONS

As the slope has been established as stable in the short and long-term, with factors of safety exceeding the acceptable range of 1.3 to 1.5, structures associated with the proposed new residential development may be constructed uphill of the top of stable slope without negatively impacting the stability of the slope, from a geotechnical engineering point of view. Depending on the nature of any proposed new structures, applicable development setbacks from the top of stable slope line may be required by NPCA.

The following recommendations should be incorporated into the design and construction of any such addition:

1. Heavy construction equipment, such as excavators, should not come any closer to the slope than the top of stable slope. A temporary silt fence should be erected along, or just uphill of the top of stable slope to delineate the work area and prevent sediment runoff during construction.
2. Excavated soil or other fill should not be placed near or over the top of stable slope.
3. Foundations for any new structures should conform to the requirements of the Ontario Building Code and the project design drawings. For any significantly loaded structures the founding level should be lowered such that it extends below a line drawn up from the toe of the slope at 3 horizontal to 1 vertical. This will minimise, or eliminate, potential load transfer from new foundations to the face of the slope.
4. Drainage and/or surface runoff should be directed away from the slope where possible. Any drainage towards the slope should be in a controlled fashion, such as sheet flow through well-established grass or vegetation, so as to not alter the natural drainage over the slope or create concentrated flows onto the slope.



## 5. PRIVATE SEWAGE TREATMENT CONSIDERATIONS

### ON-SITE SOIL AND GROUNDWATER CONDITIONS

The subsurface soil condition have been characterised, as described above, based on three [3] boreholes advanced across the site. The upper approximately 4 metres consist of a sandy silt deposit, underlain by a clayey silt/silty clay cohesive deposit, transitioning to weathered Queenston Shale bedrock at a depth of approximately 8 metres. Given these conditions private septic systems would be anticipated to be constructed within the moderately permeable sandy silt deposit.

As noted above, four representative samples of the subsurface soils were subjected to laboratory grain size analyses (sieve and hydrometer). The results of this testing were interpreted with respect to the design percolation rate for the proposed septic systems. The results of the grain size analyses are presented as follows:

Sample ID	Depth (m)	Clay (%)	Silt (%)	Sand (%)	Gravel (%)	Estimated Hydraulic Conductivity [k, cm/s]	Estimated Percolation Time [min/cm]
BH1 SS2	1.5	7	80	13	0	$10^{-5}$	18 to 20
BH2 SS1	1.0	16	59	25	0	$10^{-7}$	> 50
BH2 SS4	3.1	3	70	27	0	$10^{-5}$	14 to 18
BH3 SS2	1.5	1	77	22	0	$10^{-4}$	10 to 12

The results outlined above indicate relatively consistent conditions of sandy silt with trace clay, with occasionally more clayey areas in the upper levels. As shown in the table above, the results of this laboratory testing indicate the estimated hydraulic conductivity of the subsurface soils at a depth of 1.5 metres or more to be on the order of  $10^{-4}$  to  $10^{-5}$  cm/s. Based on the permeability as outlined above, the percolation time is estimated to range from 10 to 20 min/cm.

The values for the percolation time were determined assuming the following conditions:

- a) relatively uniform soil conditions,
- b) the soil sample tested is representative of in-situ conditions, and
- c) in-situ degree of compaction corresponds to low to medium densities.



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Since percolation rates vary with gradation, segregation, compaction, etc., we would recommend the use of conservative T values, i.e. 20 min/cm for the purposes of preliminary design. Additional sampling and testing should be conducted at each septic bed location, in order to estimate a more precise t-time for each design. If more exact value are required, in situ testing at each septic bed location may be required.

As presented above the groundwater level over the site has been preliminarily established at approximately 3 to 5 metres below the existing grade. As noted the shallower level measured in Monitoring Well No. 3 may be influenced by recent rainfall events, and so may not be indicative of the static groundwater level. In any event, based on the existing grades it would be reasonably expected that septic beds within the moderately permeable sandy silt deposit will be sufficiently above the static groundwater level to operate as designed.

#### BUILDING CONSIDERATIONS FOR PRIVATE SEWAGE SYSTEMS

The site conditions pertinent to determining if the Site area is suitable for a private sewage system include:

- Available area
- Percolation rate
- Depth to impermeable soil
- Depth to high water table
- Slope
- Horizontal clearances and easements
- Groundwater background quality and potential nitrate loading

#### AVAILABLE AREA

Based on a conceptual site plan for the proposed development, the proposed development Site has a total of approximately 13,000 m<sup>2</sup> [1.3 hectares, or ~3.2 acres] of land available for development, up to the existing physical top of slope, including approximately 3,000 m<sup>2</sup> [0.3 hectares, ~ 0.74 acres] for the existing roadway. This provides approximately 10,000 m<sup>2</sup> [1.0 hectare, or ~2.47 acres] for development.

#### HORIZONTAL CLEARANCES

The applicable minimum required clearances for distribution piping are established in Ontario Building Code Table 8.2.1.6.B, and include:

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Structure: 5 metres  
Well with a watertight casing to a depth of 6 metres: 15 metres  
Any other well: 30 metres  
Lake: 15 metres  
Pond: 15 metres  
Reservoir: 15 metres  
River: 15 metres  
A spring not used as a source of *potable* water: 15 metres  
Stream: 15 metres  
Property Line: 3 metres

#### SEWAGE SYSTEM LEACHING BED MINIMUM SPECIFICATIONS

The basic system specifications, as per the Provincial Building Code, for a three bedroom dwelling include:

- Daily effluent flow:  $Q = 1,600$  litres/day for a four bedroom dwelling
- Minimum size of septic tank, the greater of 3,600 litres or  $= 2 \times$  daily flow  
 $2 \times 1,600$  litres = 3,200 litres, use 3,600 litres
- $T = 20$  min/cm
- Length of tile:  $L = QT/200 = [1,600 \times 20] \div 200 = 160$  m.

The trench length of  $Q/50$  [as per Table 8.7.3.1 of the Provincial Building Code] would be  $1,600/50$  equalling 32 metres. The number of trenches required for 160 metres of total tile length would be  $160/32$  equalling 5 rows. The total area required for the leaching bed, based on 5 rows and a spacing of 1.6 metres by 32 metres in length would be approximately 300 square metres plus a 100 percent reserve area of 300 square metres totalling 600 square metres [0.06 ha or ~0.15 acres].

#### GROUNDWATER BACKGROUND QUALITY AND NITRATE LOADING

Nitrate loading calculations require a reduction of Nitrates to 10 mg/l at the property limits. The standard nitrate loading,  $L$ , would be 40 mg/l for 1,000 litres per day for a typical dwelling. With an annual recharge of 0.150 metres per year for sandy silt, and impervious area of  $S = 25\%$ , the on-site recharge is:

$$R = A (1-S) I \quad \text{where } A = \text{required lot area}$$
$$S = 25\%$$
$$I = 0.150 \text{ m/yr}$$

The nitrate loading is then calculated as:

$$10.0 \text{ mg/l} = \underline{L/R}$$

This results in a required area of  $A = 13,000 \text{ m}^2$  to achieve a nitrate concentration of  $9.98 \text{ mg/l}$ . This correlates to roughly 1 privately serviced lot on the subject lands, based on a standard tile bed private sewage treatment system, in order to satisfy the theoretical boundary nitrate concentration requirement. Proprietary treatment systems are available that can reduce the nitrate loading prior to discharge to establish lower nitrate concentrations and thus smaller required area in to accommodate additional lots. Consultation with the designers of such systems, along with further study of the site would be required to establish the feasibility of such systems. Alternatively a communal private sewage treatment system could be considered in order to support additional lots on the subject lands. This approach would require further study and consultation.

## **6. POTABLE WATER SUPPLY CONSIDERATIONS**

The existing conditions in the area of the subject site were reviewed and evaluated with respect to the feasibility of supply of potable water for the proposed residential dwellings. In particular a review of existing water well information for the area was undertaken.

Information for this well survey was compiled mainly from geological maps and well records for wells drilled in the study area from 1951 to 1982. Water well locations are approximated in well records using the UTM coordinate system and in some instances may be in error by more than 50 metres. Potential for mapping error therefore exists in correlation of well registration numbers with street addresses. Soils and bedrock descriptions in the well records are limited and generalized regarding formation lithology. Stratigraphic interpretation in this report is based on information from water well records, topographic maps, Paleozoic Geology maps of the area, and geotechnical investigations performed by SOIL-MAT ENGINEERS in the general area.

The term aquifer here generally refers to a geologic unit[s] or formation permeable enough to yield economic quantities of groundwater to the wells. The term aquitard refers to a geologic unit[s] or formation with insufficient permeability to supply production wells. Aquifers and aquitards are interpreted here based on statistical observation of data contained in the MOEE water well records. Hydrographs of water levels are normally not kept for private wells, therefore historical fluctuations in water levels are not known.

### **MOE WATER WELL RECORDS**

An inventory of well locations, distance, and usage, compiled from MOEE Water Well Records are presented below in Table 1.

**TABLE 1: DISTANCE TO EXISTING WATER WELLS**

Lot	Con	Water Use	UTM [E]	UTM [N]	Distance from Site [Km]
					[UTM 647930E/ 4788620N]
3	1	DO	647896	4788280	0.34
4	1	DO	647710	4788163	0.51
4	1	DO	647800	4788300	0.35
4	1	DO	647848	4788066	0.56
4	1	ST	647890	4788195	0.43
4	1	DO	647901	4788180	0.44
4	1	DO	647906	4788243	0.38
4	1	DO	648018	4788281	0.35

Site Plan Drawing No.: 3, in Appendix 'A', illustrates the approximate location of the above referenced ground water wells. The MOE water well records obtained from "<https://www.ontario.ca/environment-and-energy/map-well-records>".

It is noted that there are no records for water wells for any of the existing dwellings on the subject lands, suggesting that they are presently serviced with cisterns and trucked in municipal potable water.

#### HYDROGEOLOGICAL SETTING

Data contained in MOEE Water Well Records for 7 wells [as one well was recorded as dry] from Part of Lots 3 and 4, Concession 1, Grantham Township, are presented for statistical observations in Table 2. Observations include:

- Groundwater was most frequently found at depths of 12.2 to 22.9 metres [avg. 17.6m] below ground surface [bgs], at a mean elevation of 80.2 metres above sea level [masl].
- Static water levels at time of well drilling vary from 2.4 to 9.5 metres [avg. 5.5] bgs, corresponding to static elevations of 70.7 to 79.3 masl [avg.=74.7, sd=2.6]
- Pressure head [hydraulic head above aquifer] ranged from 6.7 to 15.9 metres [avg=12.2m].
- The water bearing formation lithology reported in all the wells was shale.

The aquifer exhibited a positive pressure head [i.e. static water level is above the elevation where water was found] in each well record, indicating the aquifer was under confined artesian conditions with respect to its confining layer, although the confining layer is expected to be leaking to a certain extent.

The water well record data, considered statistically and viewed in scatter plots of depth water found and static elevation, suggest that one predominant aquifer is in use in the study area, as illustrated below:



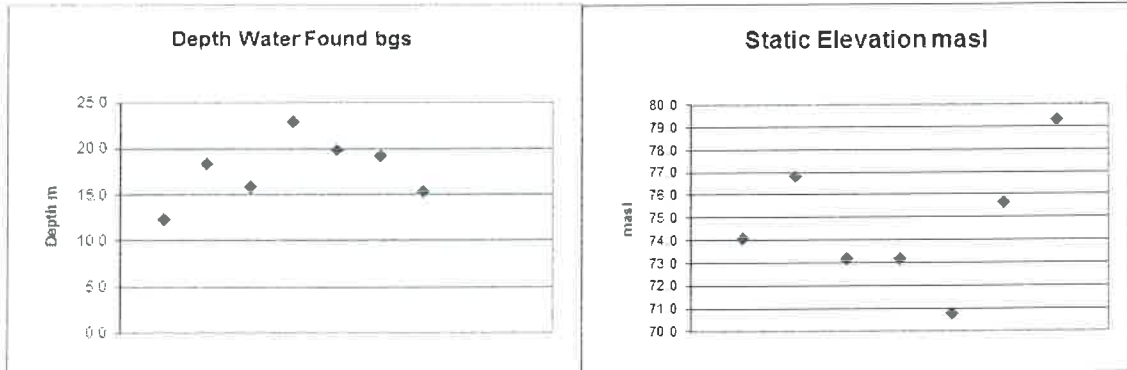
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**Table 2: Water Well Records - Statistical Observations**

Surface Elevation		Depth found bgs		Elevation found		Static depth bgs		Static Elevation		Pressure Head
fasl	masl	fasl	masl	fasl	masl	ft	m	fasl	masl	m
261	79.6	40	12.2	221	67.4	18	5.5	243	74.1	6.7
264	80.5	60	18.3	204	62.2	12	3.7	252	76.8	14.6
260	79.3	52	15.9	208	63.4	20	6.1	240	73.2	9.8
263	80.2	75	22.9	188	57.3	23	7.0	240	73.2	15.9
263	80.2	65	19.8	198	60.4	31	9.5	232	70.7	10.4
262	79.9	63	19.2	199	60.7	14	4.3	248	75.6	14.9
268	81.7	50	15.2	218	66.5	8	2.4	260	79.3	12.8
		Avg.=	17.6	Avg.=	62.5	Avg.=	5.5	Avg.=	74.7	12.2
		SDevP=	3.2	SDevP=	3.3	SDevP=	2.2	SDevP=	2.6	3.1

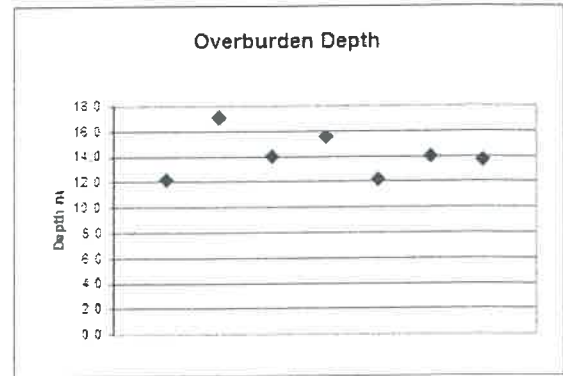
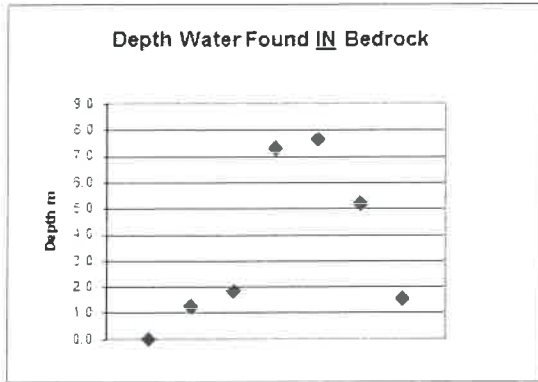
**Water bearing formation**

Formation	#	%
Overburden	0	0
Bedrock	7	100



ft	m
0	0.0
4	1.2
6	1.8
24	7.3
25	7.6
17	5.2
5	1.5
Avg.=	3.5
SDevP=	2.9

ft	m
40	12.2
56	17.1
46	14.0
51	15.5
40	12.2
46	14.0
45	13.7
Avg.=	14.1
SDevP=	1.6



The apparent dominant aquifer in use in the study area is situated an estimated 20 metres below the surface elevation of the study area.

Review and interpretation of available data indicates:

- The bedrock geology of the study area presents a complex sequence of stratified sedimentary rocks, including; dolostones, limestones, sandstones, and shales.
- It appears that there is one dominant aquifer in the study area, being an estimated 20 metres bgs of the study area.
- Interpretation of MOE Water Well Records suggests that the wells in the study area are obtaining groundwater from a leaky-confined artesian aquifer.
- Static depths at the time of well drilling range from 2.4 to 9.5 metres bgs, with an average depth of 5.5 metres bgs.

#### POTABLE WATER SUPPLY

The existing water well record information indicates few existing water wells within the study area. In particular the existing dwellings on the subject site do not have record of water wells for potable supply. The available water well records indicate limited yields from the shale bedrock aquifer, generally well less than the typically required minimum rate of 5 gpm for domestic potable water supply. As such it would not be considered feasible to supply the proposed dwellings by on-site private supply wells.

## **7. HOUSE AND BUILDING CONSTRUCTION**

The undisturbed sandy silt soils encountered in the boreholes are generally considered suitable for support of typical residential single family dwellings on conventional spread footings. The support conditions afforded by the native soils and/or engineered fill are generally not uniform across the building footprint, nor are the loads on the various foundation elements. As such, the provision of nominal steel reinforcement should be considered in the concrete foundations. Such reinforcement will act to reduce the potential for cracking in the foundation walls due to minor settlements, heaving, shrinkage, etc. and will assist in resisting the earth pressures generated against the foundation walls by the backfill. This nominal reinforcement is an economical approach to the reduction or prevention of costly foundation repairs after completion and later in the life of the buildings. Such nominal reinforcement would typically consist of two continuous 15M steel rods placed in the footings [directly below the foundation wall] and a similar two steel rods placed approximately 300 millimetres from the top of the foundation walls. The reinforcing bars should be bent to reinforce all corners and under basement windows, and be provided with sufficient overlap at staggered splice locations. At 'steps' in the foundations and at window locations, the reinforcing steel should be bent to follow the step diagonally, rather than at 90 degrees, to maintain the continuous tensile capacity of the reinforcement. Where footings are founded on or partially on engineered fill, the above provision for nominal reinforcement would be a requirement.

All footings exposed to the environment must be provided with a minimum of 1.2 metres of earth cover or equivalent insulation to protect against frost penetration. This frost protection, or equivalent, would also be required if construction were undertaken during the winter months. All footings must be proportioned to satisfy the requirements of the 2012 Ontario Building Code.

All basement walls should be suitably damp-proofed, including a 'dimple type' drainage boarding leading to a perimeter drainage tile system. The perimeter weeping tile should consist of a perforated plastic pipe with a geofabric sock, surrounded with a minimum of 200 millimetres [top and sides] of 20-millimetre clear stone, in turn encased in a heavy geofabric. The perimeter drainage system should outlet to a gravity storm sewer connection, fitted with a suitable back-flow prevention valve. In the event that sump pit systems are required, consideration should be given to constructing the sump pump system with an 'oversized' reservoir so that the sump pump will not cycle repeatedly within short time periods.

It is imperative that a soils engineer be retained from this office to provide geotechnical engineering services during the excavation and foundation construction phases of the project. This is to observe compliance with the design concepts and recommendations of this geotechnical investigation report, and to allow changes to be made in the event that subsurface conditions differ from the conditions identified at the borehole locations.

## 8. GENERAL COMMENTS

The comments provided in this document are intended only for the guidance of the design team. The subsoil descriptions and borehole information are only intended to describe conditions at the borehole locations. Contractors placing bids or undertaking this project should carry out due diligence in order to verify the results of this investigation and to determine how the subsurface conditions will effect their operations.

We trust that this geotechnical report is sufficient for your present requirements. Should you require any additional information or clarification as to the contents of this document, please do not hesitate to contact the undersigned.

Yours very truly,  
SOIL-MAT ENGINEERS & CONSULTANTS LTD.



Matt LiVecchi, B.Eng, EIT



Kyle Richardson, P.Eng.  
Project Engineer



Ian Shaw, P.Eng.  
Senior Engineer







Enclosures: Drawing No.1, Slope Profile and Borehole Location Plan  
Borehole Log Nos. 1 to 3, inclusive  
Drawing Nos. 2 and 3, Slope Profiles A-A and B-B  
Grain Size Analysis Nos. 1 to 4, inclusive  
Slope Stability Rating Chart  
Slope/W analyses results

Distribution: Leo DiFabio [2, plus pdf]



## LEGEND

-  Slope Profile Location
-  <sup>BH-#</sup> Borehole Location
-  Top of Stable Slope
-  Temporary Benchmark  
TBM [Catch Basin in front of #9 Firelane 13B, with assumed elevation of 100.00 metres.]

## NOTES:

1. This drawing should be read in conjunction with Soil-Mat Engineers & Consultants Ltd. report number SM 166999-G.
2. Borehole and slope profile locations are approximate.
3. Soil samples will be discarded after 3 months unless directed otherwise by client.

# Soil-Mat

Engineers & Consultants Ltd.

### CLIENT

John Perry

### PROJECT TITLE

Preliminary Geotechnical and Hydrogeological Investigation  
Proposed Residential Development  
Firelane 13B Road  
St. Catharines, Ontario

### DRAWING TITLE

Slope Profile and Borehole Location Plan

**PROJECT No.** SM 166999-G

**SCALE** N.T.S.

**DATE** November 2016

**CHECKED** ML

**DRAWN** AS

### FILENAME

SM 166999-G Slope Profile and Borehole Location Plan.kcw

# DRAWING No. 1



**LEGEND**

★ = Proposed Development Site

**NOTES:**

1. This drawing should be read in conjunction with Soil-Mat Engineers & Consultants Ltd. Report No. SM 166999-E.
2. Base map provided by Image © 2016 DigitalGlobe [Google Earth]

**Soil-Mat**  
Engineers & Consultants Ltd.

**CLIENT**  
Royal LePage Niagara Real Estate Centre

**PROJECT TITLE**  
Water Well Records  
Firelane 13B  
Niagara-on-the-Lake, Ontario

**DRAWING TITLE**  
Ministry of the Environment  
Water Well Records Plots

**PROJECT No.** SM 166999-E  
**SCALE** N.T.S.  
**DATE** November 2016  
**CHECKED** IS  
**DRAWN** PM  
**FILENAME** 166999 Well Records.kcw

**DRAWING 1**

Project No: SM 166999-G

Project: Firelane 13B Road

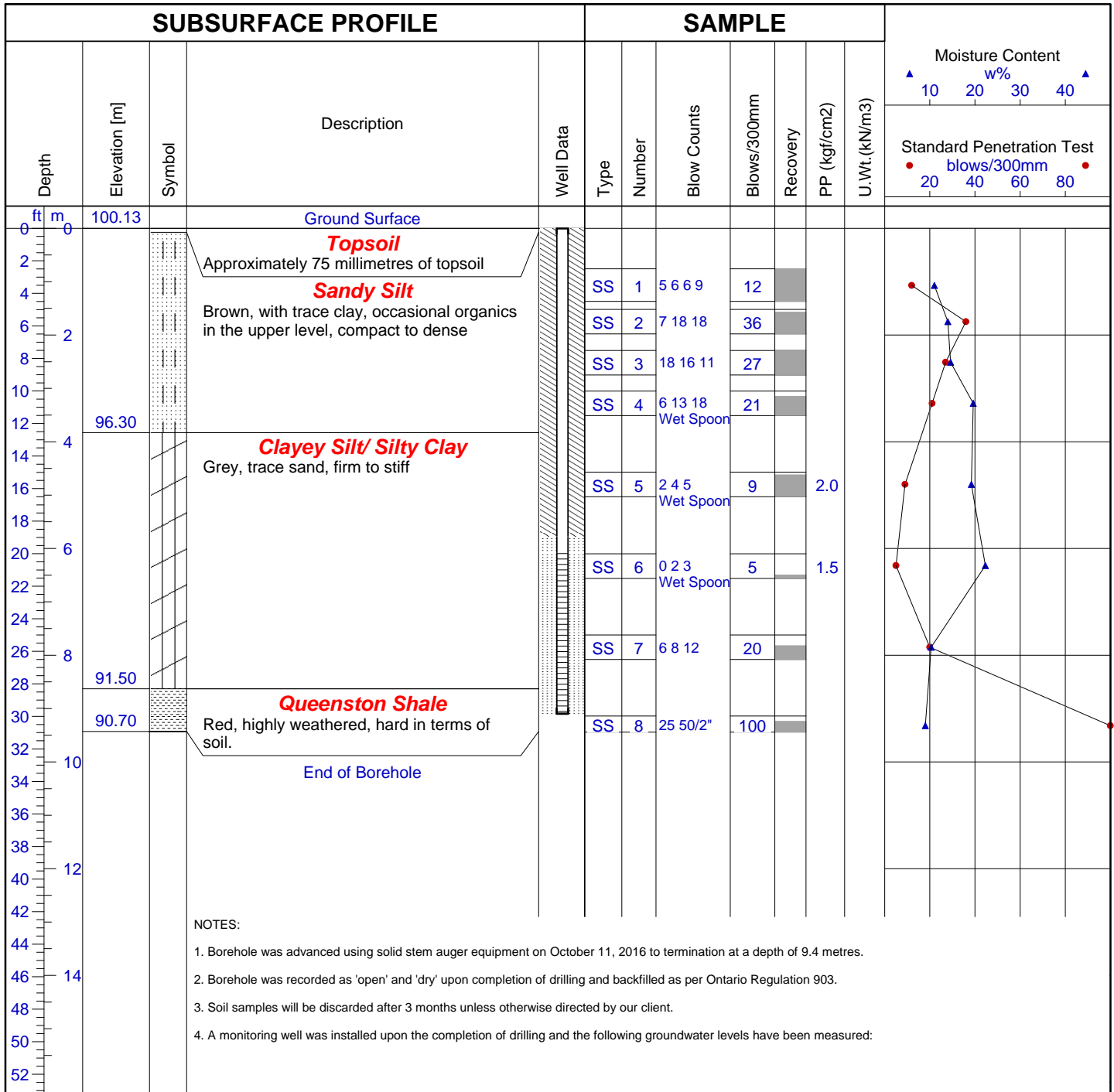
Location: Niagara-on-the-Lake, Ontario

Client: John Perry

## Log of Borehole No. 1

Project Manager: Ian Shaw, P.Eng

Borehole Location: See Drawing No. 1



Drill Method: **Solid Stem Augers**  
 Drill Date: **October 11, 2016**  
 Hole Size: **150 mm**  
 Drill Contractor: **Elite Drilling**

SOIL-MAT ENGINEERS & CONSULTANTS LTD.  
 130 Lancing Drive, Hamilton, ON L8W 3A1  
 Phone: (905) 318-7440 Fax: (905) 318-7455  
 e-mail: info@soil-mat.on.ca

Datum: **Temporary Benchmark**  
 Field Logged by: **AS**  
 Checked by: **ML**  
 Sheet: **1 of 1**

Project No: SM 166999-G

Project: Firelane 13B Road

Location: Niagara-on-the-Lake, Ontario

Client: John Perry

## Log of Borehole No. 2

Project Manager: Ian Shaw, P.Eng

Borehole Location: See Drawing No. 1



SUBSURFACE PROFILE					SAMPLE					Moisture Content w%			
Depth	Elevation [m]	Symbol	Description	Well Data	Type	Number	Blow Counts	Blows/300mm	Recovery	PP (kgf/cm2)	U.Wt. (kN/m3)	▲	●
0	99.96		Ground Surface										
0			<b>Topsoil</b> Approximately 75 millimetres of topsoil										
2			<b>Silty Sand</b> Brown, mottled appearance, trace organics in upper level, compact to dense		SS	1	5 8 8 7	16					
4					SS	2	3 6 10	16					
6					SS	3	7 9 13	22					
8					SS	4	6 14 18	32					
10													
12	96.10		<b>Clayey Silt/ Silty Clay</b> Grey, trace sand, stiff		SS	5	1 3 6 Wet Spoon	9		1.0			
14					SS	6	1 3 6 Wet Spoon	9		1.0			
16													
18													
20													
22													
24													
26	91.90		<b>Queenston Shale</b> Red, highly weathered in upper levels, becoming more sound with depth, hard in terms of soil.		SS	7	17 15 15	30					
28													
30													
32													
34													
36													
38													
40	87.80		End of Borehole										
42													
44			NOTES:										
46			1. Borehole was advanced using solid stem auger equipment on October 11, 2016 to termination at a depth of 12.2 metres.										
48			2. Borehole was recorded as 'open' and 'dry' upon completion of drilling and backfilled as per Ontario Regulation 903.										
50			3. Soil samples will be discarded after 3 months unless otherwise directed by our client.										
52													

Drill Method: **Solid Stem Augers**  
 Drill Date: **October 11, 2016**  
 Hole Size: **150 mm**  
 Drill Contractor: **Elite Drilling**

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 130 Lancing Drive, Hamilton, ON L8W 3A1  
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 e-mail: info@soil-mat.on.ca

Datum: **Temporary Benchmark**  
 Field Logged by: **AS**  
 Checked by: **ML**  
 Sheet: **1 of 1**

Project No: SM 166999-G

Project: Firelane 13B Road

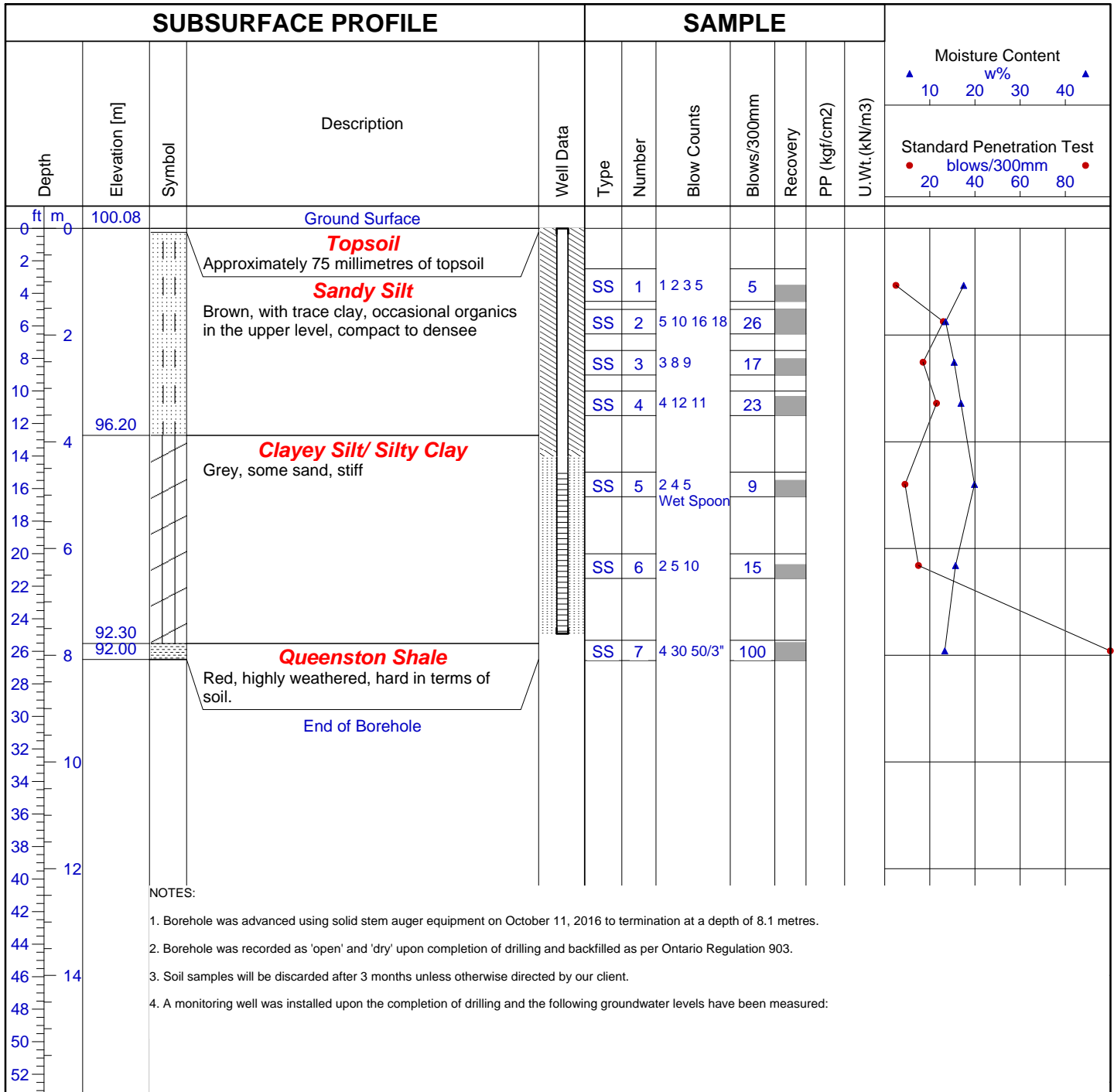
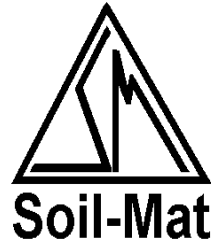
Location: Niagara-on-the-Lake, Ontario

Client: John Perry

## Log of Borehole No. 3

Project Manager: Ian Shaw, P.Eng

Borehole Location: See Drawing No. 1

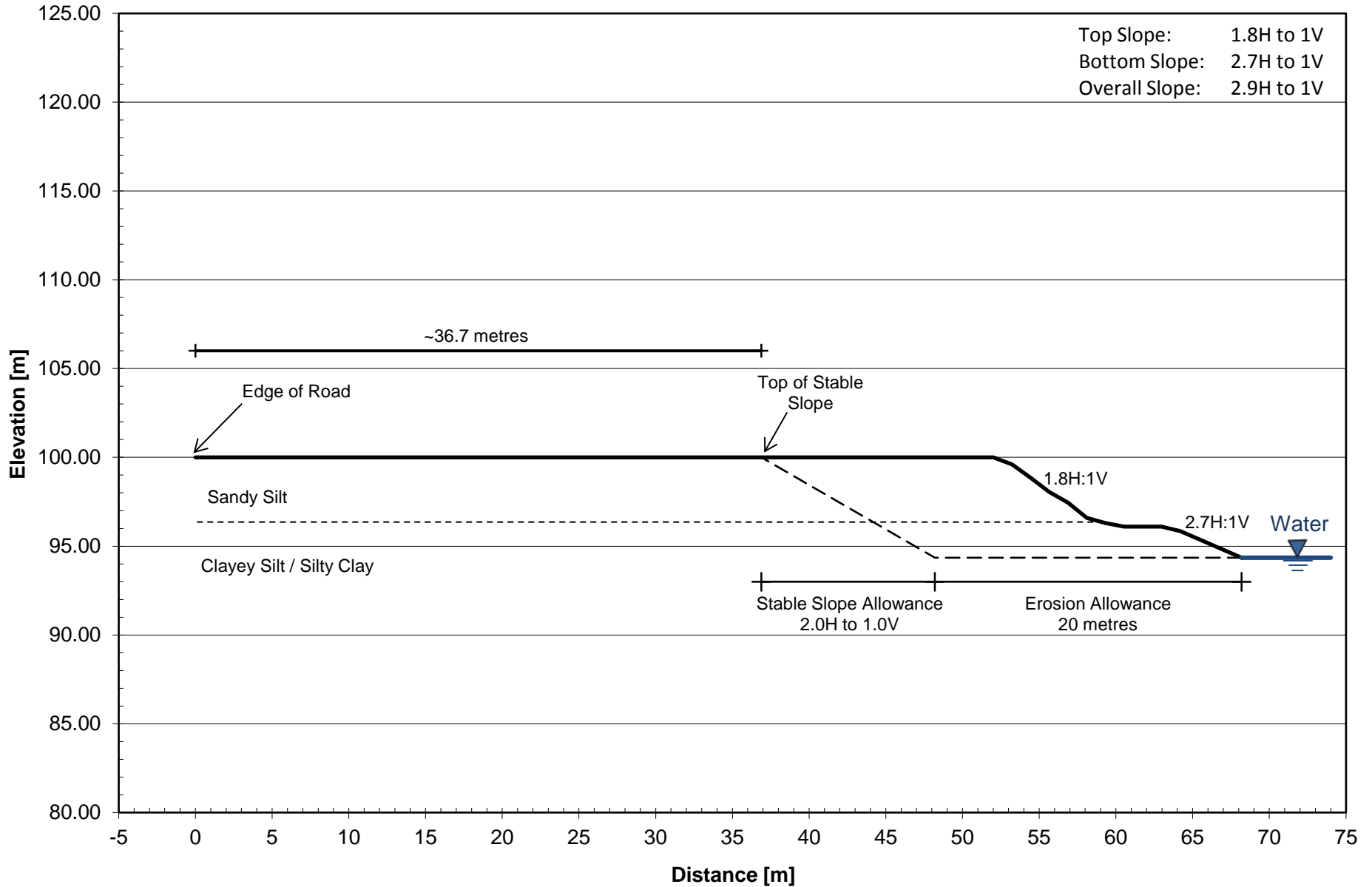


Drill Method: **Solid Stem Augers**  
 Drill Date: **October 11, 2016**  
 Hole Size: **150 mm**  
 Drill Contractor: **Elite Drilling**

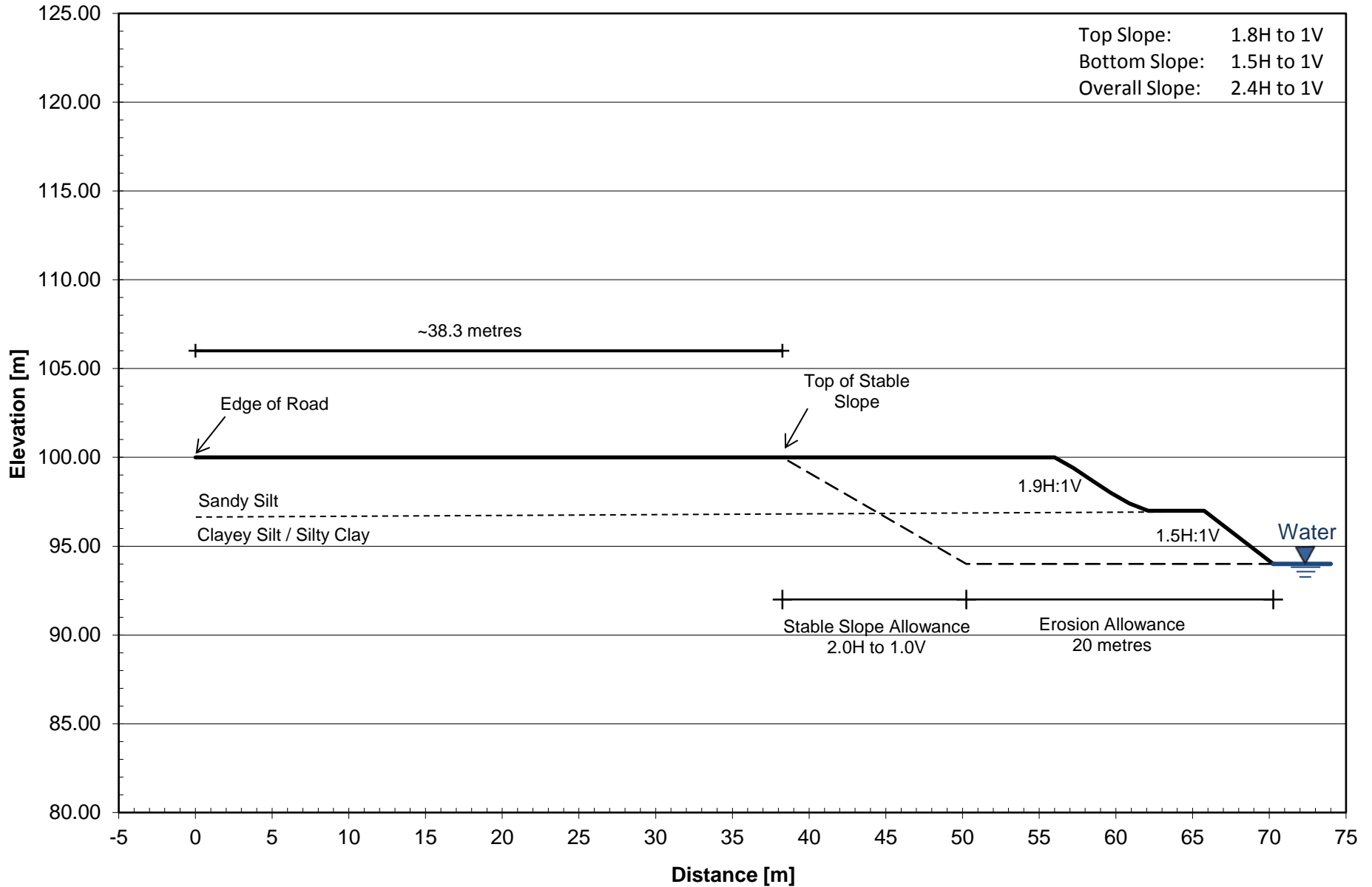
SOIL-MAT ENGINEERS & CONSULTANTS LTD.  
 130 Lancing Drive, Hamilton, ON L8W 3A1  
 Phone: (905) 318-7440 Fax: (905) 318-7455  
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Datum: **Temporary Benchmark**  
 Field Logged by: **AS**  
 Checked by: **ML**  
 Sheet: **1 of 1**

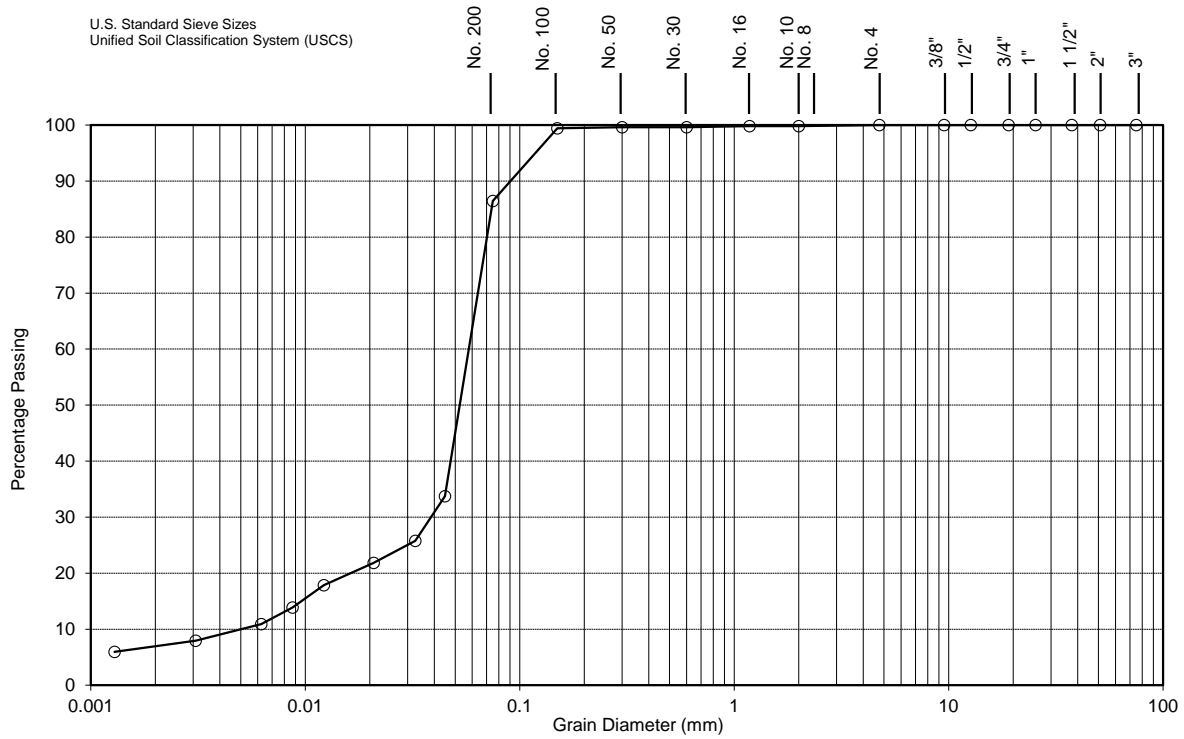
**Slope Profile Section A-A  
Firelane 13B Road  
St. Catharines, Ontario**



**Slope Profile Section B-B  
Firelane 13B Road  
St. Catharines, Ontario**



## Mechanical & Hydrometer Analyses



Lab No.	<b>107-16</b>	Notes: Sample retrieved by Soil-Mat Engineers & Consultants Ltd. laboratory on October 11, 2016.					
Borehole No.:	1	Soil Description: <b>Brown SILT with some Sand and trace Clay</b> <b>ML - Inorganic silts and very fine sands</b>					
Sample No.:	2						
CLAY [%]:	<b>7</b>	Estimated <i>T</i> Time [min/cm] :		<b>18 to 20</b>	Estimated Permeability, <i>k</i> [cm/s]	<b>10<sup>-5</sup></b>	
SILT [%]:	<b>80</b>	Coefficient of Uniformity <i>C<sub>u</sub></i> :		<b>12.0</b>	Coefficient of Curvature <i>C<sub>c</sub></i> :		<b>5.3</b>
SAND [%]:	<b>13</b>						
GRAVEL [%]:	<b>0</b>	D <sub>10</sub> (Effective Diam. in mm):		<b>0.005</b>			

**SOIL-MAT ENGINEERS & CONSULTANTS LTD.**

**Firelane 13B Road, Niagara-on-the-Lake**

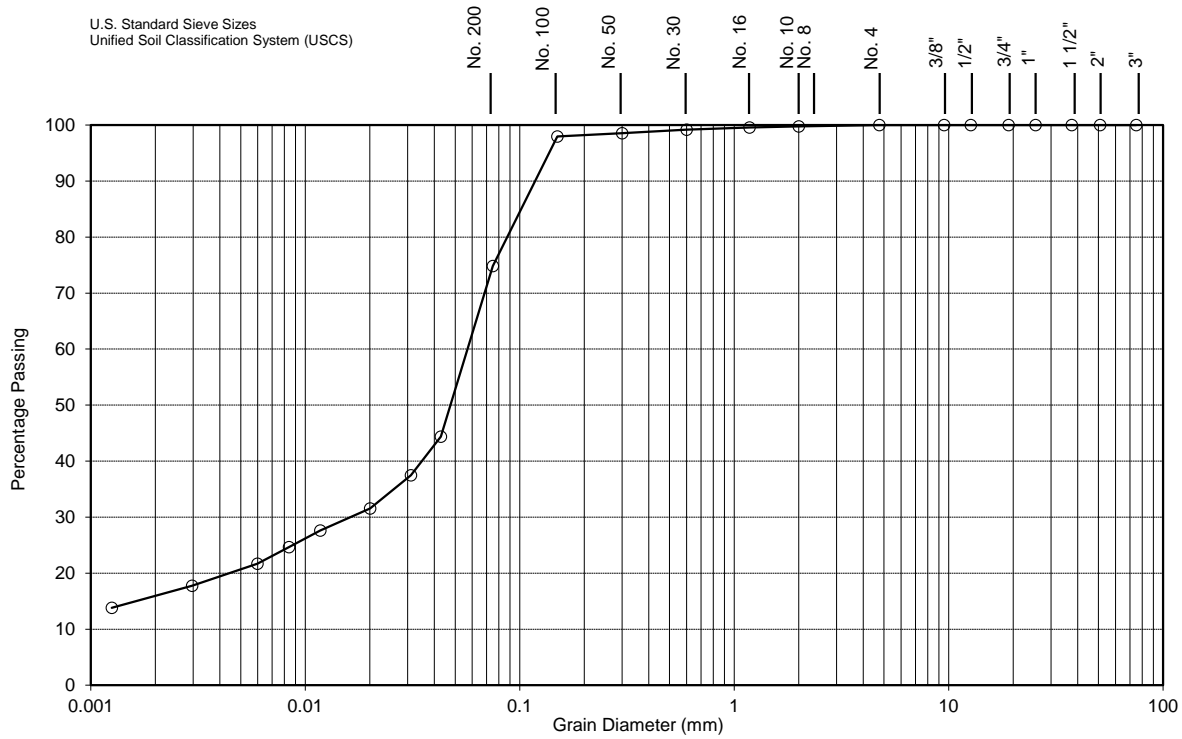


October 19, 2016

Grain Size Analysis No. 1

Project No.: SM 166999-G

## Mechanical & Hydrometer Analyses



<b>CLAY</b>	<b>SILT</b>	FINE	MEDIUM	COARSE	FINE	COARSE
		<b>SAND</b>			<b>GRAVEL</b>	

Lab No.	<b>108-16</b>	Notes: Sample retrieved by Soil-Mat Engineers & Consultants Ltd. laboratory on October 11, 2016.			
Borehole No.:	2				
Sample No.:	1				
CLAY [%]:	<b>16</b>	Soil Description: <b>Brown Sandy SILT with some Clay</b> <b>ML - Inorganic silts and very fine sands, clayey silts with slight plasticity</b>			
SILT [%]:	<b>59</b>				
SAND [%]:	<b>25</b>	Estimated T Time [min/cm] : <b>Greater than 50</b>			
GRAVEL [%]:	<b>0</b>	Estimated Permeability, k [cm/s]		<b>10<sup>-7</sup></b>	
D <sub>10</sub> (Effective Diam. in mm):	<b>&lt;0.001</b>	Coefficient of Uniformity C <sub>u</sub> :		<b>68.8</b>	
		Coefficient of Curvature C <sub>c</sub> :		<b>5.1</b>	

**SOIL-MAT ENGINEERS & CONSULTANTS LTD.**

**Firelane 13B Road, Niagara-on-the-Lake**

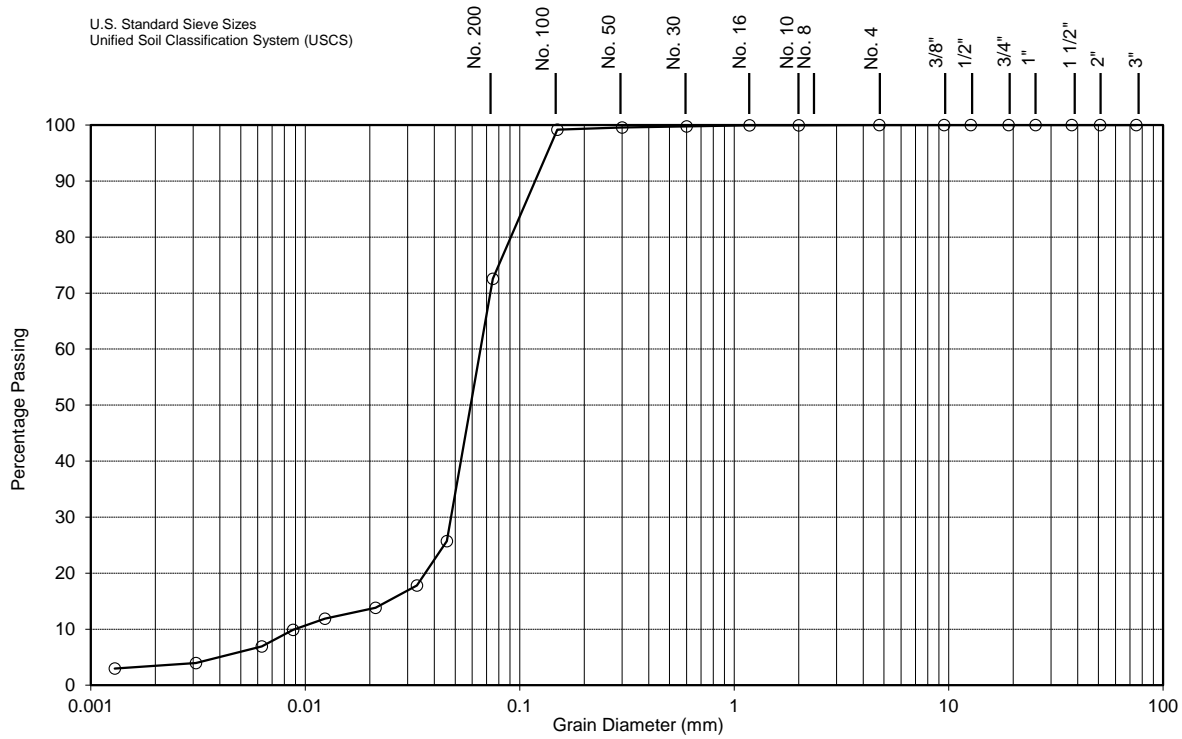


October 19, 2016

Grain Size Analysis No. 2

Project No.: SM 166999-G

## Mechanical & Hydrometer Analyses



<b>CLAY</b>	<b>SILT</b>	FINE	MEDIUM	COARSE	FINE	COARSE
		<b>SAND</b>			<b>GRAVEL</b>	

Lab No.	<b>109-16</b>	Notes: Sample retrieved by Soil-Mat Engineers & Consultants Ltd. laboratory on October 11, 2016.			
Borehole No.:	2	Soil Description: <b>Brown Sandy SILT with trace Clay</b> ML - Inorganic silts and very fine sands, to; SM - silty sands, sand-silt mixtures			
Sample No.:	4				
CLAY [%]:	<b>3</b>	Estimated T Time [min/cm] :		Estimated Permeability, k [cm/s]	
SILT [%]:	<b>70</b>	14 to 18		10 <sup>-5</sup>	
SAND [%]:	<b>27</b>	Coefficient of Curvature C <sub>c</sub> : <b>3.5</b>			
GRAVEL [%]:	<b>0</b>				
D <sub>10</sub> (Effective Diam. in mm):	<b>0.009</b>	Coefficient of Uniformity C <sub>u</sub> : <b>7.2</b>			

**SOIL-MAT ENGINEERS & CONSULTANTS LTD.**

**Firelane 13B Road, Niagara-on-the-Lake**

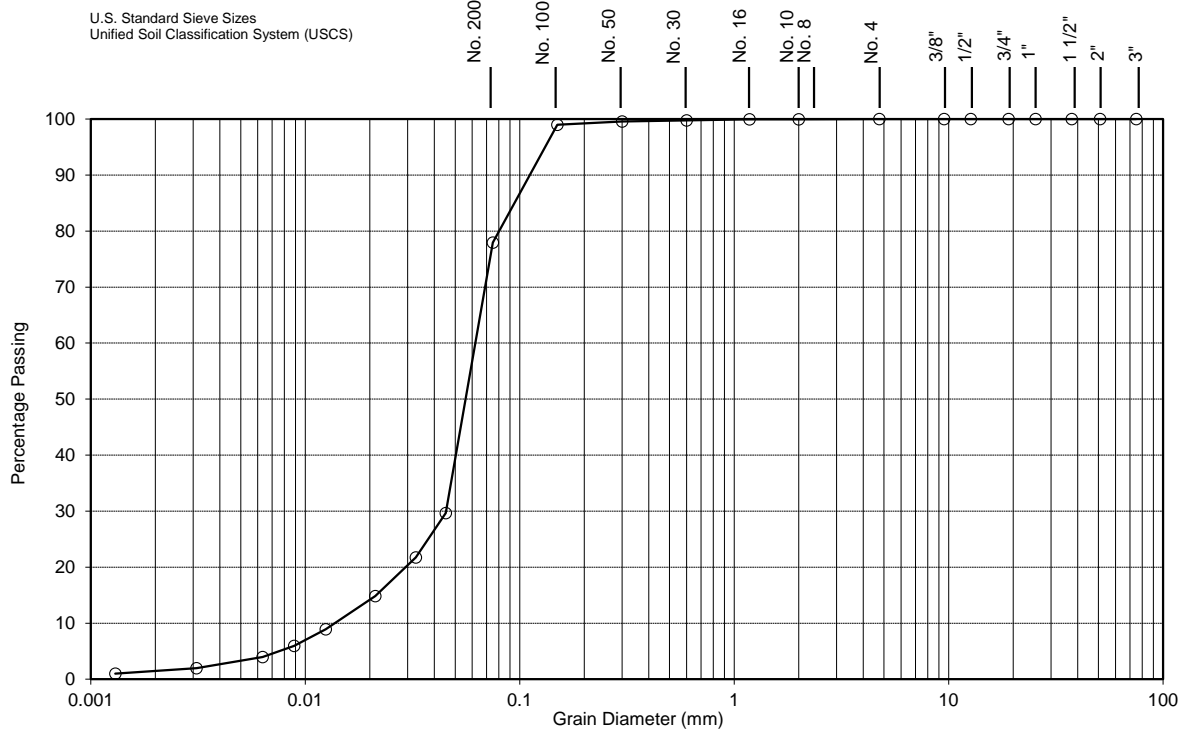


October 19, 2016

Grain Size Analysis No. 3

Project No.: SM 166999-G

## Mechanical & Hydrometer Analyses



<b>CLAY</b>	<b>SILT</b>	FINE	MEDIUM	COARSE	FINE	COARSE
		<b>SAND</b>			<b>GRAVEL</b>	

Lab No.	<b>110-16</b>	Notes: Sample retrieved by Soil-Mat Engineers & Consultants Ltd. laboratory on October 11, 2016.			
Borehole No.:	3	Soil Description: <b>Brown Sandy SILT with trace Clay</b> ML - Inorganic silts and very fine sands, to; SM - silty sands, sand-silt mixtures			
Sample No.:	2				
CLAY [%]:	<b>1</b>	Estimated T Time [min/cm] : <b>10 to 12</b>			
SILT [%]:	<b>77</b>	Estimated Permeability, k [cm/s] <b>10<sup>-4</sup></b>			
SAND [%]:	<b>22</b>	Coefficient of Uniformity C <sub>u</sub> : <b>4.0</b>			
GRAVEL [%]:	<b>0</b>				
D <sub>10</sub> (Effective Diam. in mm):	<b>0.015</b>	Coefficient of Curvature C <sub>c</sub> : <b>2.3</b>			

**SOIL-MAT ENGINEERS & CONSULTANTS LTD.**

**Firelane 13B Road, Niagara-on-the-Lake**



October 19, 2016

Grain Size Analysis No. 4

Project No.: SM 166999-G

Firelake 166999-6

TABLE 1.1 - SLOPE STABILITY RATING CHART

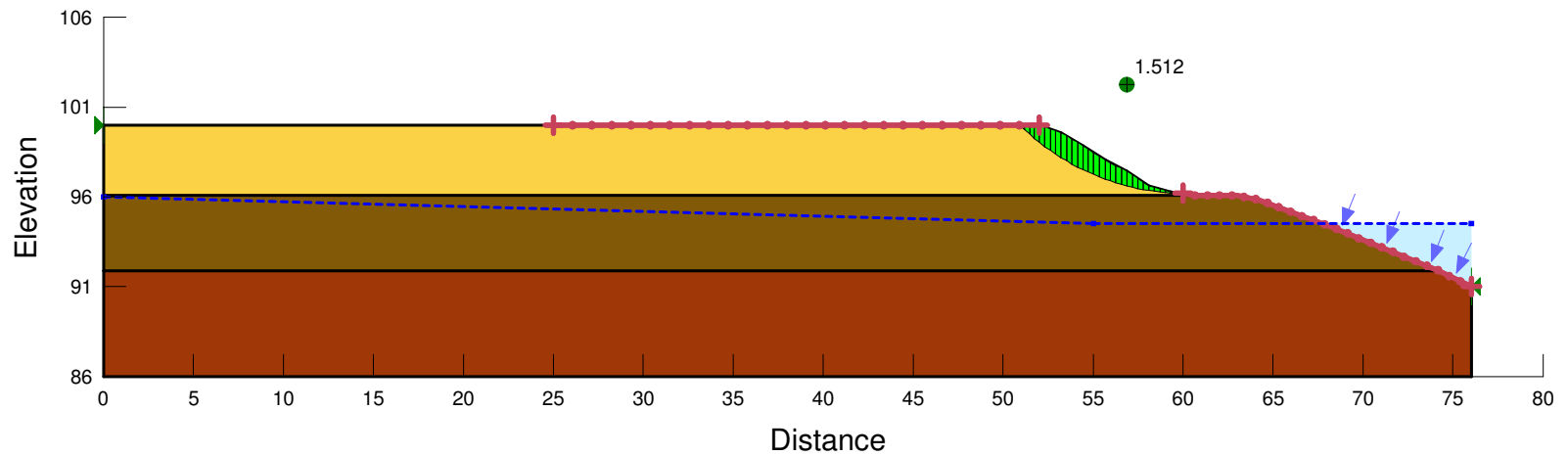
Site Location:		File No	
Property Owner:		Inspection Date	
Inspected By:		Weather:	
<b>1. SLOPE INCLINATION</b>	<b>degrees</b>	<b>horiz. : vert.</b>	<b>Rating Value</b>
a)	18 or less	3 : 1 or flatter	0
b)	18 - 26	2 : 1 to more than 3 : 1	7
c)	more than 26	steeper than 2 : 1	16
<b>2. SOIL STRATIGRAPHY</b>			
a)	Shale, Limestone, Granite (Bedrock)		0
b)	Sand, Gravel		6
c)	Glacial Till		9
d)	Clay, Silt		16
e)	Fill		16
f)	Loess Clay		24
<b>3. SEEPAGE FROM SLOPE FACE</b>			
a)	None or Near bottom only		0
b)	Near mid-slope only		6
c)	Near crest only or, From several levels		12
<b>4. SLOPE HEIGHT</b>			
a)	2 m or less		0
b)	2.1 to 5 m		2
c)	5.1 to 10 m		8
d)	more than 10 m		8
<b>5. VEGETATION COVER ON SLOPE FACE</b>			
a)	Well vegetated: heavy shrubs or forested with mature trees		0
b)	Light vegetation; Mostly grass, weeds, occasional trees, shrubs		8
c)	No vegetation, bare		8
<b>6. TABLE LAND DRAINAGE</b>			
a)	Table land flat, no apparent drainage over slope		0
b)	Minor drainage over slope, no active erosion		2
c)	Drainage over slope, active erosion, gullies		4
<b>7. PROXIMITY OF WATERCOURSE TO SLOPE TOE</b>			
a)	15 metres or more from slope toe		0
b)	Less than 15 metres from slope toe		6
<b>8. PREVIOUS LANDSLIDE ACTIVITY</b>			
a)	No		0
b)	Yes		6
<b>SLOPE INSTABILITY RATING</b>	<b>RATING VALUES</b>	<b>INVESTIGATION REQUIREMENTS</b>	<b>TOTAL</b>
	<b>TOTAL</b>		<b>34</b>
1.	Low potential	< 24	Site inspection only, confirmation, report letter
2.	Slight potential	25-35	Site inspection and surveying, preliminary study, detailed report.
3.	Moderate potential	> 35	Boreholes, piezometers, lab tests, surveying, detailed report
<b>NOTES:</b>	a) Choose only one from each category; compare total rating value with above requirements. b) If there is a water body (stream, creek, river, pond, bay, lake) at the slope toe; the potential for toe erosion and undercutting should be evaluated in detail and, protection provided if required		

Slope Stability Assessment  
Firelane 13B Road  
St. Catharines, Ontario  
Profile A-A

Name: Sandy Silt  
Unit Weight: 19.5 kN/m<sup>3</sup>  
Cohesion: 0 kPa  
Phi: 36 °

Name: Silty Clay/Clayey Silt  
Unit Weight: 19 kN/m<sup>3</sup>  
Cohesion: 5 kPa  
Phi: 34 °

Name: Queenston Shale  
Unit Weight: 20 kN/m<sup>3</sup>  
Cohesion: 10 kPa  
Phi: 40 °

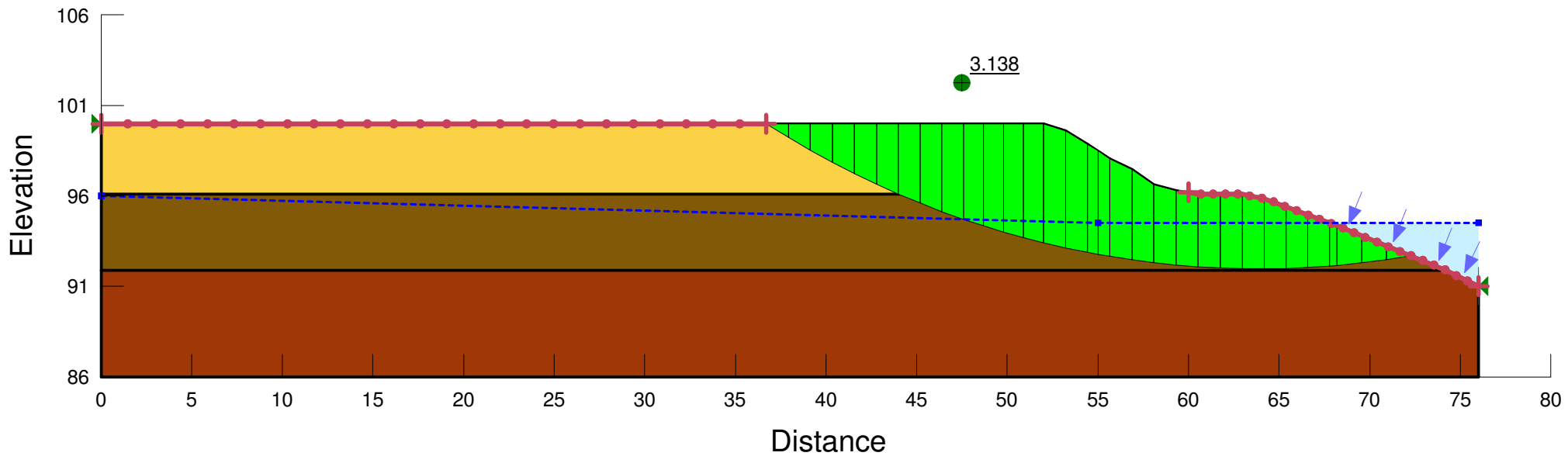


Slope Stability Assessment  
Firelane 13B Road  
St. Catharines, Ontario  
Profile A-A

Name: Sandy Silt  
Unit Weight: 19.5 kN/m<sup>3</sup>  
Cohesion: 0 kPa  
Phi: 36 °

Name: Silty Clay/Clayey Silt  
Unit Weight: 19 kN/m<sup>3</sup>  
Cohesion: 5 kPa  
Phi: 34 °

Name: Queenston Shale  
Unit Weight: 20 kN/m<sup>3</sup>  
Cohesion: 10 kPa  
Phi: 40 °

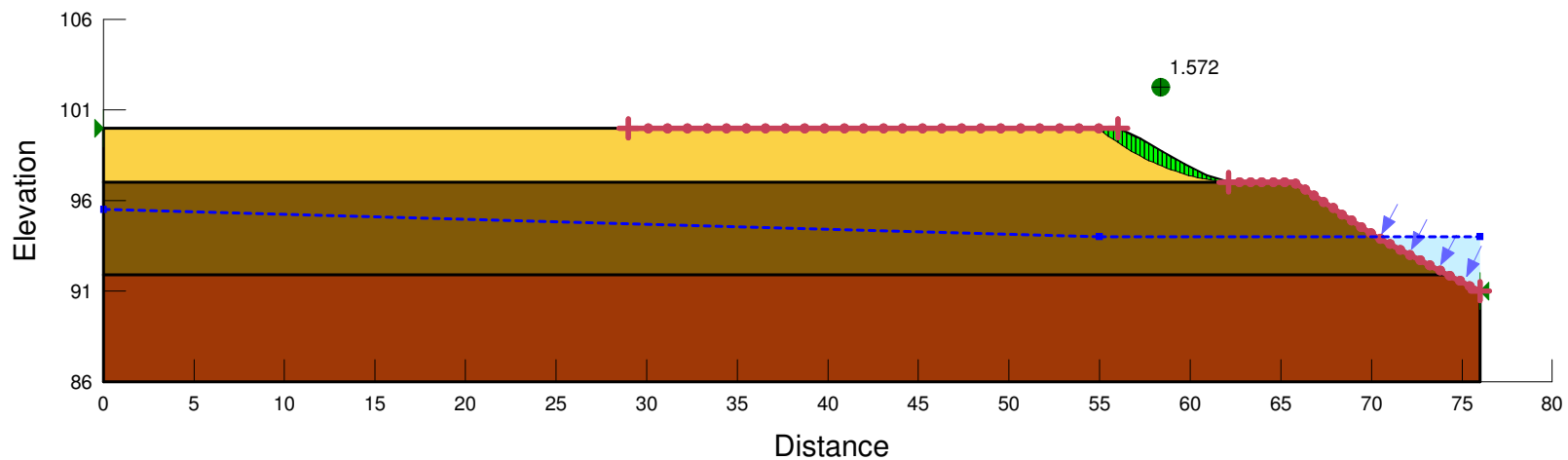


Slope Stability Assessment  
Firelane 13B Road  
St. Catharines, Ontario  
Profile B-B

Name: Sandy Silt  
Unit Weight: 19.5 kN/m<sup>3</sup>  
Cohesion: 0 kPa  
Phi: 36 °

Name: Silty Clay/Clayey Silt  
Unit Weight: 19 kN/m<sup>3</sup>  
Cohesion: 5 kPa  
Phi: 34 °

Name: Queenston Shale  
Unit Weight: 20 kN/m<sup>3</sup>  
Cohesion: 10 kPa  
Phi: 40 °



# Slope Stability Assessment

## Firelane 13B Road

### St. Catharines, Ontario

### Profile B-B

Name: Sandy Silt  
 Unit Weight: 19.5 kN/m<sup>3</sup>  
 Cohesion: 0 kPa  
 Phi: 36 °

Name: Silty Clay/Clayey Silt  
 Unit Weight: 19 kN/m<sup>3</sup>  
 Cohesion: 5 kPa  
 Phi: 34 °

Name: Queenston Shale  
 Unit Weight: 20 kN/m<sup>3</sup>  
 Cohesion: 10 kPa  
 Phi: 40 °

