• City of Niagara Falls

Geotechnical Investigation

Type of Document
Final

Project Name
Montrose Business Park
Blackburn Parkway, Niagara Falls, Ontario

Project Number
HAM-00801583-A0

Prepared By:
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Canada

Date Submitted
22.3.2019

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1 Introduction

This report presents the results of the geotechnical investigation completed by EXP Services Inc. (EXP) for the proposed roadway extension and site servicing on Blackburn Parkway in Niagara Falls, Ontario, as part of the Montrose Business Park Development. Authorization to proceed with the geotechnical investigation was provided on October 16, 2018 by Nick Golia on behalf of the City of Niagara Falls (City).

The purpose of this investigation was to determine the subsoil and groundwater conditions by advancing eleven (11) boreholes at the site and based on an assessment of the factual data, provide an engineering report containing general geotechnical recommendations pertinent to the proposed construction.

The comments and recommendations given in this report are based on the assumption that the above-described design concept will proceed into construction. If changes are made either in the design phase or during construction, this office must be retained to review these modifications. The result of this review may be a modification of our recommendations or the requirement of additional field or laboratory work to check whether the changes are acceptable from a geotechnical viewpoint.

2 Investigation Program

2.1 General Fieldwork

As specified in our proposal, a total of eleven (11) boreholes, numbered BH-01 to BH-11, were advanced at the site. Boreholes BH-01 to BH-07 were advanced to provide geotechnical data for road construction and servicing along the proposed Blackburn Parkway extension. An additional (4) boreholes, as well as ten (10) shallow holes to obtain topsoil samples, were advanced as part of the environmental work on the site, which is reported under a separate cover.

The fieldwork for this investigation was carried out on November 8 and 9, 2018 by a combination of auger and split-spoon techniques using track mounted equipment owned and operated by a specialist drilling subcontractor. Prior to the commencement of the drilling operations, underground services were located to minimize the risk of contacting any such services during the drilling operations.

The boreholes were advanced to depths ranging from approximately 3.5 m to 6.6 m below existing grade. The approximate borehole and surface sample locations are shown on Drawing No. 1 in Appendix A. Details of the subsurface conditions encountered in the borings are shown on the borehole logs (Drawing No. 3 to 13) in Appendix A.

Soil samples were obtained using a 51 mm (2 inch) outside diameter split-spoon sampler driven in conjunction with Standard Penetration Test procedure (ASTM D1586) at the depths noted graphically on the borehole logs. The retained soil samples were logged in the field and then carefully packaged and transported to our Hamilton laboratory for detailed visual, textural and olfactory classification. The Standard Penetration Test (SPT) N values and pocket penetrometer measurements were recorded and used to provide an assessment of the compactness condition or consistency of the in-situ soils.

Groundwater levels within the boreholes were measured prior to backfilling. The boreholes were backfilled upon completion of drilling in accordance with O.Reg. 903. The boreholes were located in accessible areas in the field by EXP personnel, in general accordance with the requirements provided to our office. The ground surface elevations at the borehole locations were interpolated from the topographical information provided to our office by Upper Canada Planning & Engineering Ltd.

2.2 Environmental Testing

Environmental testing was conducted on selected soil samples recovered from the boreholes as part of this geotechnical investigation. The scope and results of this testing is reported under a separate cover.

3 Subsurface Conditions

Details of the soil and groundwater conditions encountered during the drilling program are summarized on the borehole logs in Appendix A.

The logs include textural descriptions of the subsoil and indicate the soil boundaries inferred from non-continuous sampling and observations during drilling. These boundaries reflect approximate transition zones for the purpose of geotechnical design and should not be interpreted as exact planes of geological change. The "Notes on Sample Description" preceding the borehole logs form an integral part of and should be read in conjunction with this report.

3.1 Stratigraphy

Boreholes BH-01 to BH-03 were advanced through the existing Blackburn Parkway pavement structure. All remaining boreholes were advanced in the vacant green space. Below the surficial pavement structure or topsoil, the boreholes encountered native silty clay, with native silt encountered below a depth of 6.1 m to 6.3 m in Boreholes BH-04 to BH-07. Details of the encountered materials are provided in the following sections.

3.1.1 Topsoil

Boreholes BH-4 to BH-11 were advanced in field areas, where approximately 150 mm to 200 mm of topsoil was encountered. An average depth of 200 mm of topsoil was also encountered at the ten (10) shallow surface sample locations. It is noted that the depth of topsoil may very across the site.

3.1.2 Pavement Structure

Boreholes BH-01 to BH-03 were advanced through the pavement structure of Blackburn Parkway. The pavement structure consisted of between 100 mm and 125 mm of asphalt overlying approximately 425 mm to 450 mm of granular fill. The granular fill generally consisted of crushed limestone bedrock. A summary of the encountered pavement structure is presented in the table below.

Table 3-1: Summary of Pavement Structure

Borehole No.	Asphalt Thickness (mm)	Granular Thickness (mm)
BH-01	125	425
BH-02	100	450
BH-03	100	450
Average	**110**	**440**

3.1.3 Silty Clay

Native silty clay was encountered at all borehole locations below the pavement structure or topsoil and extended to depths of 6.1 m to 6.3 m in Boreholes BH-04 to BH-07, and to the borehole termination depths in all other boreholes, i.e. 3.5 m to 6.6 m below grade. The silty clay contained trace sand, with occasional silt seams, was brown, and in a moist to wet state with moisture contents ranging from 8 to 38 percent of dry mass. SPT N values of the stratum ranged from 4 to 20 blows per 305 mm of penetration. Based on estimated undrained shear strengths from pocket penetrometer readings ranging from 25 kPa to greater than 225 kPa, the silty clay is classified as very stiff to hard above a depth of approximately 3.0 to 4.5 m and becoming firm to stiff below this level.

3.1.4 Silt

Silt was encountered below the silty clay in Boreholes BH-04 to BH-07 at a depth of approximately 6.1 m to 6.3 m, and extended to the borehole termination depth, i.e. 6.6 m below grade. The silt contained trace clay and sand, was brown to grey, and in a moist to wet state with moisture contents ranging from 20 to 32 percent of dry mass. Based on SPT N values of the stratum, ranging from 10 to 14 blows per 305 mm of penetration, the silt is classified as being in a compact condition.

3.1.5 Groundwater

Groundwater conditions were monitored in the open boreholes during and upon completion of the drilling operations. Free water was not encountered during the investigation. Due to the fine-grained nature of the soils, groundwater levels are not considered to have stabilized during the short-term of the investigation.

Seasonal variations in the water table should be anticipated, with higher levels occurring during wet weather conditions (spring thaw and late fall) and lower levels occurring during dry periods.

4 Engineering Discussion

It is understood that Blackburn Parkway will be extended westward approximately 440 m to Heartland Forest Road, and new services will be installed. We offer the following comments and recommendations for the planned construction.

4.1 Site Services

4.1.1 Trench Excavation

Final details of the proposed service installations were not available at the time of this report. The comments and recommendations are based on the assumption that excavations for the proposed servicing will extend to depths not exceeding 5 m below existing grades. In reference to the borehole data, the excavations for the proposed services will typically be carried out below the existing pavement structure / topsoil and into the native silty clay.

The contractor should be aware that the slope height, slope inclination, or excavation depths (including utility trench excavations) should in no case exceed those specified in local, provincial, or federal safety regulations. Installation of the proposed services by open-cut excavations is considered feasible. Should open-cut excavations not be feasible, e.g. due to adjacent structures etc., a properly designed shoring system or a trench box can be used. Side slopes of the temporary excavations must conform to the most recent Occupational Health and Safety Act (OHSA) and local regulations.

For guidance, the encountered very stiff to hard silty clay can be generally considered Type 2 soil above the groundwater level and the silt at depth can be classified as Type 3 soil. Locally, where loose/soft materials are encountered, or within zones of persistent seepage at depth, it may be necessary to flatten the slopes.

4.1.2 Groundwater Control

Free water was not encountered during the investigation. Some perched water may be encountered, particularly within the granular fill material of the roadway or from silt seams. However, given the fine-grained nature of the predominant soil on site, any encountered groundwater should be possible to remove using conventional construction dewatering techniques, i.e. pumping from sumps in conjunction with oversized excavations, as required.

Collected water should discharge a sufficient distance away from the excavated area to prevent the discharge from re-entering the excavation. Sediment control measures such as silt fences and filtered catch basin covers should be provided. Caution should also be taken to avoid any adverse impact to the environment.

Seasonal variations in the water table should be anticipated, with higher levels occurring during wet weather conditions (spring thaw and late fall) and lower levels occurring during dry weather conditions.

4.1.3 Temporary Support

Properly designed trench boxes may be used to reduce the lateral extent of the excavation in dewatered excavations. The lateral earth pressure acting on the trench box may be computed using the following equation, assuming a rectangular pressure distribution and dewatering will be carried out:

$$p = K(\gamma h + q)$$

where p = Lateral earth pressure (kPa)

K = Coefficient of earth pressure

γ = Unit weight of backfill (assume 21.0 kN/m^3)

h = Depth to point of interest (m)

q = Surcharge load acting adjacent to the wall at the ground surface (kPa)

In general, an earth pressure coefficient, K, of 0.45 may be used where movements must be minimized and 0.25 where minor movements can be tolerated.

4.1.4 Thrust Blocks

It is recommended that all thrust blocks for the proposed watermains be poured neat against the native soils without the use of forms in order to achieve the maximum restraint with minimum deflection.

Horizontal restraint for the thrust block is provided by the passive earth pressure developed in the soil behind the block and the friction along the base. The passive earth pressure may be estimated using the following equation and geotechnical parameters:

$$p = K(\gamma h)$$

where p = Passive earth pressure (kPa)

K = Coefficient of passive earth pressure

γ = Unit weight of soil (assume 19.0 kN/m^3)

h = Depth below ground surface at which the pressure is to be computed (m)

In general, an earth pressure coefficient, K, of 2.5 and an assumed coefficient of sliding friction of 0.4 may be used. These parameters should be verified by this office once the final design is completed.

4.1.5 Pipe Bedding

Based on the borehole data and the anticipated service invert levels, the encountered soils can provide adequate support for the proposed pipes. Bedding and cover materials shall conform to and shall be placed and compacted as specified by the City.

In order to obtain uniform pressure conditions around the pipes, it is advised that the supporting bedding of Granular A material be extended to at least one pipe diameter on each side of the pipe and for the entire width of the trench. The cover and bedding should be placed in thin (maximum 150 mm) lifts and compacted as specified by the City, based upon the size and type of pipe specified. Particular attention should be given to ensure material placed beneath the bottom quadrants of the pipe is adequately

compacted. The degree of compaction achieved in the field should be checked by in-situ nuclear density tests.

If construction proceeds during the winter months, the base of the trench and all fill materials should not be allowed to freeze.

4.1.6 Backfilling Operations

The backfilling operation should be subject to the approval of the City. Trench backfilling procedures and materials should be in accordance with the City requirements and specifications. Some water content adjustment of re-used materials may be required for efficient compaction, depending upon weather conditions at the time of construction. Any soil which contains organics or deleterious material or is excessively wet should not be used for backfill. Any shortfall of suitable on-site excavated material can be made-up with imported and approved fill or granular material, e.g. Granular A in accordance with OPSS 1010.

Above the pipes, a minimum 300 mm thick layer of Granular A is recommended for pipe protection.

Backfill and compaction operations must be closely monitored by a qualified geotechnical consultant on a full-time basis to ensure uniform compaction and compliance with specification requirements, especially near manholes, catch basins and all areas that are not readily accessible to compaction equipment. To mitigate the potential for differential settlement, the fill around catch basins and manholes should consist of granular material, e.g. Granular A or Granular B in accordance with OPSS 1010.

Backfill material should be placed in loose lifts not exceeding 200 mm in thickness. The backfill should be uniformly compacted to a minimum of 95 percent Standard Proctor Maximum Dry Density (SPMDD) to within 600 mm of final subgrade level and 98 percent of SPMDD within the upper 600 mm. Compaction equipment used should be soil specific (i.e. sheepsfoot roller for cohesive soils and smooth drum or vibratory plate for non-cohesive soils).

To minimize potential problems, backfilling operations should follow closely after excavation, so that only a minimal length of trench is exposed. This will minimize wetting of the subgrade material. Should construction extend to the winter season, particular attention should be given to ensure that frozen material is not used as backfill.

5 Roadway Construction

It is understood that Blackburn Parkway will be extended to connect to Heartland Forest Road. The pavement design recommendations presented in this section are based on an estimate of the subgrade soil properties determined from visual examination and textural classification of the soil samples and the City of Niagara Falls standards, . The proposed pavement structure is provided in Table 5-1 below. The pavement structure outlined assumes adequate provision for drainage.

Table 5-1: Proposed Pavement Structure Thickness

Pavement Layer	Compaction Requirements	Blackburn Parkway Extension
Asphaltic Concrete (OPSS 310)	Min 93.0% MRD[1] Min 92.0% MRD	40 mm HL3 HS 80 mm HL8 HS
Granular A[2] (OPSS 1010)	100% SPMDD[3]	450 mm

As part of the subgrade preparation, the proposed new pavement areas should be stripped of topsoil and any obviously unsuitable material, and the existing pavement materials should be removed from the paved section of Blackburn Parkway. The subgrade should be properly shaped, crowned, and then proof-rolled in the full-time presence of a geotechnical representative. Soft or spongy subgrade areas should be sub-excavated and properly replaced with suitable approved backfill compacted to at least 98 percent Standard Proctor Maximum Dry Density (SPMDD). Fill required to raise the grades to design elevations should be approved by the geotechnical representative and compacted to at least 98 percent SPMDD at or near the optimum moisture content.

The existing granular fill from the paved portion of Blackburn Parkway may be suitable for reuse as base material in the new pavement structure, though laboratory grain size analyses of the stockpiled granular would need to be performed at the time of construction to compare its gradation with OPSS requirements and determine its suitability for this use. Alternatively, the existing granular material may be reused as general backfill or in landscaped areas where a high degree of compaction is not required.

The foregoing design assumes construction is carried out during favourable weather periods and the subgrade is stable under the load of construction equipment. If construction is carried out during wet weather, and heaving or rolling of the subgrade is experienced, additional thickness of granular base course materials may be required.

The long-term performance of the pavement structure is highly dependent upon the subgrade support conditions. Stringent construction control procedures should be maintained to ensure uniform subgrade moisture and density conditions are achieved. In addition, the need for adequate drainage cannot be over emphasized. The finished pavement surface and underlying subgrade should be free of depressions and should be sloped to provide effective surface drainage toward catch basins or drainage areas. Surface water should not be allowed to pond adjacent to the outside edges of pavement areas.

Additional comments on the construction of the paved areas are as follows:

1. The most severe loading conditions on pavement areas and the subgrade may occur during construction. Consequently, special provisions such as half loads during paving, etc. may be required, especially if construction is carried out during unfavourable weather.

[1] Maximum Relative Density
[2] 100 percent quarried rock source
[3] Standard Proctor Maximum Dry Density

2. When the subgrade is totally or partially saturated the application of dynamic loadings cause increased pore pressures and therefore reduce the internal friction and lower resistance to shear. For prevention, an adequate surface and subsurface drainage system implementation is an imperative. Subsurface drainage should drain water, which has permeated the pavement structure and surrounding soil. Such water may enter through open joints and cracks, porous pavement surfaces, etc.
3. Use of a key-in joint transition where old asphalt pavement and new asphalt pavement layer abut is recommended. The existing pavement beyond the contract limits should be milled for a width of 300 mm, or 600 mm where trench depth exceeds 1.5 m, wide and with a partial depth of 40 mm, and overlaid when placing the top surface asphalt course in the project limits.

6 General Comments

The information presented in this report is based on a limited investigation designed to provide information to support an overall assessment of the current geotechnical conditions of the subject property. The conclusions presented in this report reflect site conditions existing at the time of the investigation.

EXP Services Inc. should be retained for a general review of the final design and specifications to verify that this report has been properly interpreted and implemented. If not accorded the privilege of making this review, EXP Services Inc. will assume no responsibility for interpretation of the recommendations in the report.

The comments given in this report are intended only for the guidance of design engineers. The number of boreholes required to determine the localized underground conditions between boreholes affecting construction costs, techniques, sequencing, equipment, scheduling, etc., would be much greater than has been carried out for design purposes. Contractors bidding on or undertaking the works should, in this light, decide on their own investigations, as well as their own interpretations of the factual borehole results, so that they may draw their own conclusions as to how the subsurface conditions may affect them.

More specific information, with respect to the conditions between samples, or the lateral and vertical extent of materials, may become apparent during excavation operations. Consequently, during the future development of the property, conditions not observed during this investigation may become apparent; should this occur, EXP Services Inc. should be contacted to assess the situation and additional testing and reporting may be required. EXP Services Inc. has qualified personnel to provide assistance in regard to future geotechnical and environmental issues related to this property.

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

EXP Services Inc.

Matt LiVecchi, P.Eng.
Geotechnical Project Manager

Jeffrey Golder, P.Eng.
Manager, Hamilton Geotechnical Services

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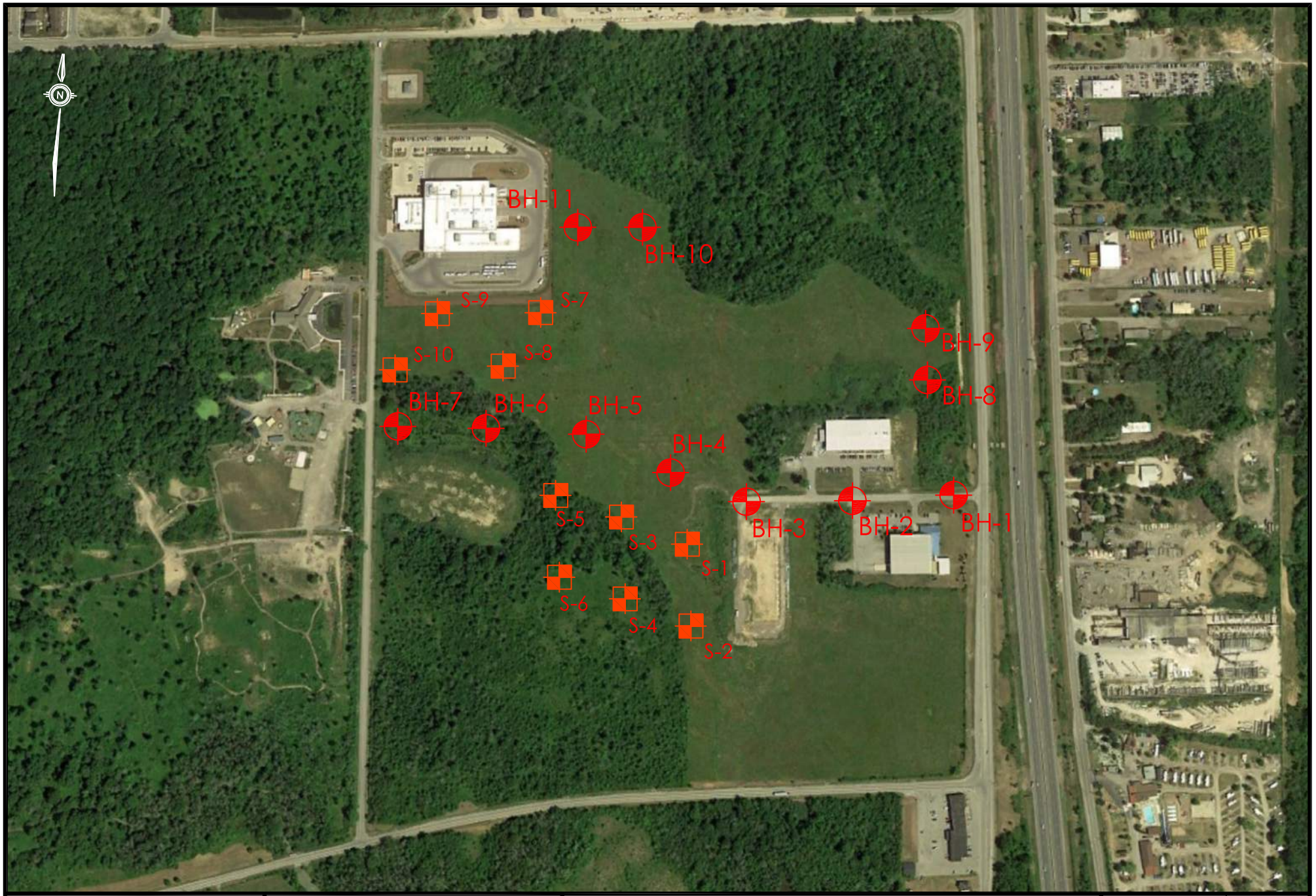
Appendix A – Drawings



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LEGEND:

APPROXIMATE BOREHOLE LOCATION

APPROXIMATE SURFACE SAMPLE LOCATION

TITLE AND LOCATION:

BOREHOLE LOCATION PLAN
GEOTECHNICAL INVESTIGATION
MONTROSE BUSINESS PARK
NIAGARA FALLS, ON

JOB NO.: HAM-00801583-A0	DRAWN BY: ML
SCALE: NTS	CHECKED BY: --
DATE: November 2018	DWG NO.: 1

Notes on Sample Descriptions

1. All sample descriptions included in this report follow the International Society for Soil Mechanics and Foundation Engineering (ISSMFE), as outlined in the Canadian Foundation Engineering Manual. Note, however, that behavioral properties (i.e. plasticity, permeability) take precedence over particle gradation when classifying soil. Please note that, with the exception of those samples where a grain size analysis has been made, all samples are classified visually. Visual classification is not sufficiently accurate to provide exact grain sizing or precise differentiation between size classification systems.

UNIFIED SOIL CLASSIFICATION

CLAY (PLASTIC) TO	FINE	MEDIUM	CRS.	FINE	COARSE
SILT (NONPLASTIC)	SAND			GRAVEL	

EQUIVALENT GRAIN DIAMETER IN MILLIMETRES

ISSMFE SOIL CLASSIFICATION

CLAY	SILT			SAND			GRAVEL			COBBLES	BOULDERS
	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE		

2. Fill: Where fill is designated on the borehole log it is defined as indicated by the sample recovered during the boring process. The reader is cautioned that fills are heterogeneous in nature and variable in density or degree of compaction. The borehole description may therefore not be applicable as a general description of site fill materials. All fills should be expected to contain obstruction such as wood, large concrete pieces or subsurface basements, floors, tanks, etc., none of these may have been encountered in the boreholes. Since boreholes cannot accurately define the contents of the fill, test pits are recommended to provide supplementary information. Despite the use of test pits, the heterogeneous nature of fill will leave some ambiguity as to the exact composition of the fill. Most fills contain pockets, seams, or layers of organically contaminated soil. This organic material can result in the generation of methane gas and/or significant ongoing and future settlements. Fill at this site may have been monitored for the presence of methane gas and, if so, the results are given on the borehole logs. The monitoring process does not indicate the volume of gas that can be potentially generated nor does it pinpoint the source of the gas. These readings are to advise of the presence of gas only, and a detailed study is recommended for sites where any explosive gas/methane is detected. Some fill material may be contaminated by toxic/hazardous waste that renders it unacceptable for deposition in any but designated land fill sites; unless specifically stated the fill on this site has not been tested for contaminants that may be considered toxic or hazardous. This testing and a potential hazard study can be undertaken if requested. In most residential/commercial areas undergoing reconstruction, buried oil tanks are common and are generally not detected in a conventional geotechnical site investigation.

3. Till: The term till on the borehole logs indicates that the material originates from a geological process associated with glaciation. Because of this geological process the till must be considered heterogeneous in composition and as such may contain pockets and/or seams of material such as sand, gravel, silt or clay. Till often contains cobbles (75 to 200 mm) or boulders (over 200 mm). Contractors may therefore encounter cobbles and boulders during excavation, even if they are not indicated by the borings. It should be appreciated that normal sampling equipment cannot differentiate the size or type of any obstruction. Because of the horizontal and vertical variability of till, the sample description may be applicable to a very limited zone; caution is therefore essential when dealing with sensitive excavations or dewatering programs in till materials.

Notes On Soil Descriptions

4. The following table gives a description of the soil based on particle sizes. With the exception of those samples where grain size analyses have been performed, all samples are classified visually. The accuracy of visual examination is not sufficient to differentiate between this classification system or exact grain size.

Soil Classification		Terminology	Proportion
Clay and Silt	<0.060 mm	"trace" (e.g. Trace sand)	1% to 10%
Sand	0.060 to 2.0 mm	"some" (e.g. Some sand)	10% to 20%
Gravel	2.0 to 75 mm	adjective (e.g. sandy, silty)	20% to 35%
Cobbles	75 to 200 mm	"and" (e.g. and sand)	35% to 50%
Boulders	>200 mm		

The compactness of Cohesionless soils and the consistency of the cohesive soils are defined by the following:

Cohesionless Soil		Cohesive Soil		
Compactness	**Standard Penetration Resistance "N" Blows / 0.3 m**	**Consistency**	**Undrained Shear Strength (kPa)**	**Standard Penetration Resistance "N" Blows / 0.3 m**
Very Loose	0 to 4	Very soft	<12	<2
Loose	4 to 10	Soft	12 to 25	2 to 4
Compact	10 to 30	Firm	25 to 50	4 to 8
Dense	30 to 50	Stiff	50 to 100	8 to 15
Very Dense	Over 50	Very Stiff	100 to 200	15 to 30
		Hard	>200	>30

5. **ROCK CORING**

Where rock drilling was carried out, the term RQD (Rock Quality Designation) is used. The RQD is an indirect measure of the number of fractures and soundless of the rock mass. It is obtained from the rock cores by summing the length of the core covered, counting only those pieces of sound core that are 100 mm or more length. The RQD value is expressed as a percentage and is the ratio of the summed core lengths to the total length of core run. The classification based on the RQD value is given below.

RQD Classification	RQD (%)
Very Poor Quality	<25
Poor Quality	25 to 50
Fair Quality	50 to 75
Good Quality	75 to 90
Excellent Quality	90 to 100

$$\text{Recovery Designation \% Recovery} = \frac{\text{Length of Core Per Run}}{\text{Total Length of Run}} \times 100$$

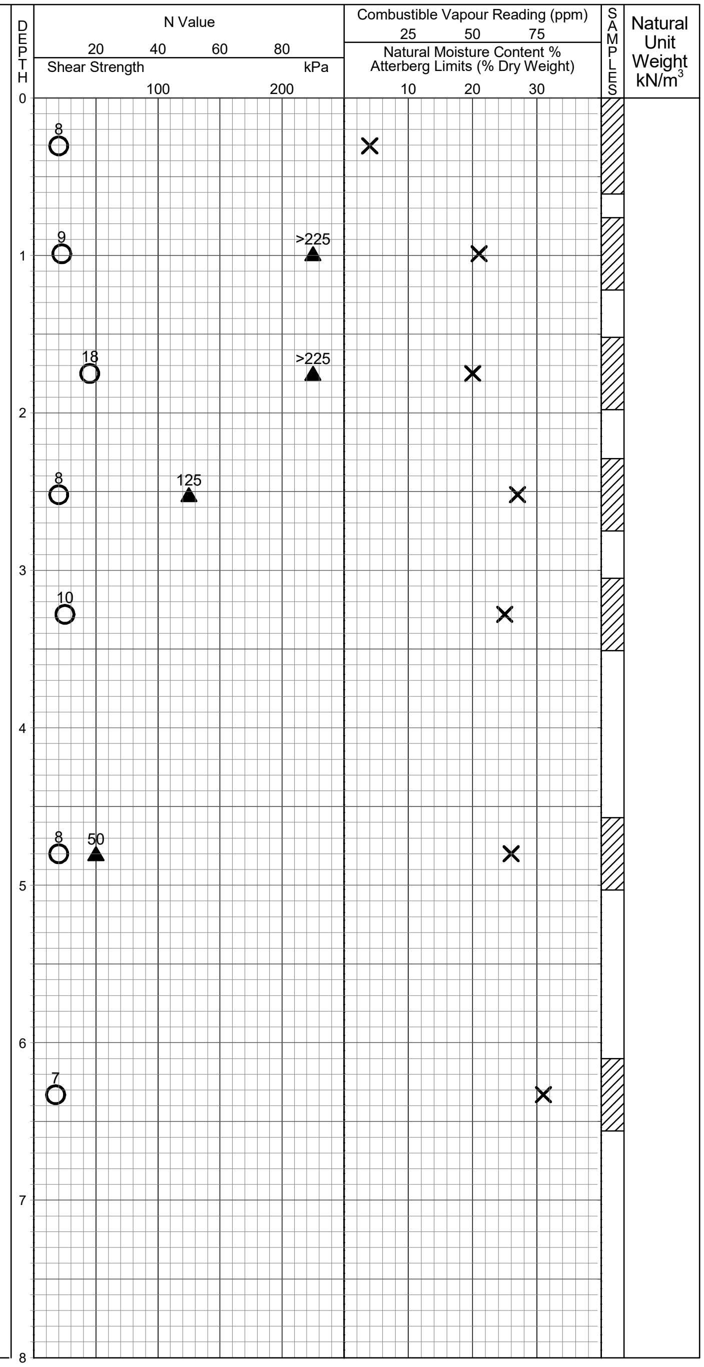
Log of Borehole BH-01

Project No.	HAM-00801583-A0	Drawing No.	3
Project:	Montrose Business Park	Sheet No.	1 of 1
Location:	Blackburn Parkway, Niagara Falls, ON		

Date Drilled:	November 9, 2018
Drill Type:	D-50 Track Mount. Solid Stem.
Datum:	Geodetic

Legend	Symbol
Auger Sample	⊠
SPT (N) Value	○ ▨
Dynamic Cone Test	—
Shelby Tube	■
Field Vane Test	✚ S
Combustible Vapour Reading	□
Natural Moisture	×
Plastic and Liquid Limit	├──○
Undrained Triaxial at % Strain at Failure	⊕
Penetrometer	▲

GWL	Symbol	Soil Description	ELEV. m
			177.20
		ASPHALT: (125 mm thick)	~177.1
		GRANULAR FILL: (~425 mm thick)	~176.7
		SILTY CLAY: trace sand, with occasional silt seams, brown, moist to wet, very stiff to hard	
		becoming stiff below 4.6 m	~170.7



NOTES:
1. This drawing is to be read with the subject report and project number as presented above.
2. Interpretation assistance by EXP is required before use by others.

LAGWGLJFHAM-EXP BH LOGS.GPJ NEW.GDT 12/3/18

exp.
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Facsimile: 905.573.9693

Time	Water Level (m)	Depth to Cave (m)
on completion	dry	no cave

Log of Borehole BH-02

Project No. HAM-00801583-A0 Drawing No. 4

Project: Montrose Business Park Sheet No. 1 of 1

Location: Blackburn Parkway, Niagara Falls, ON

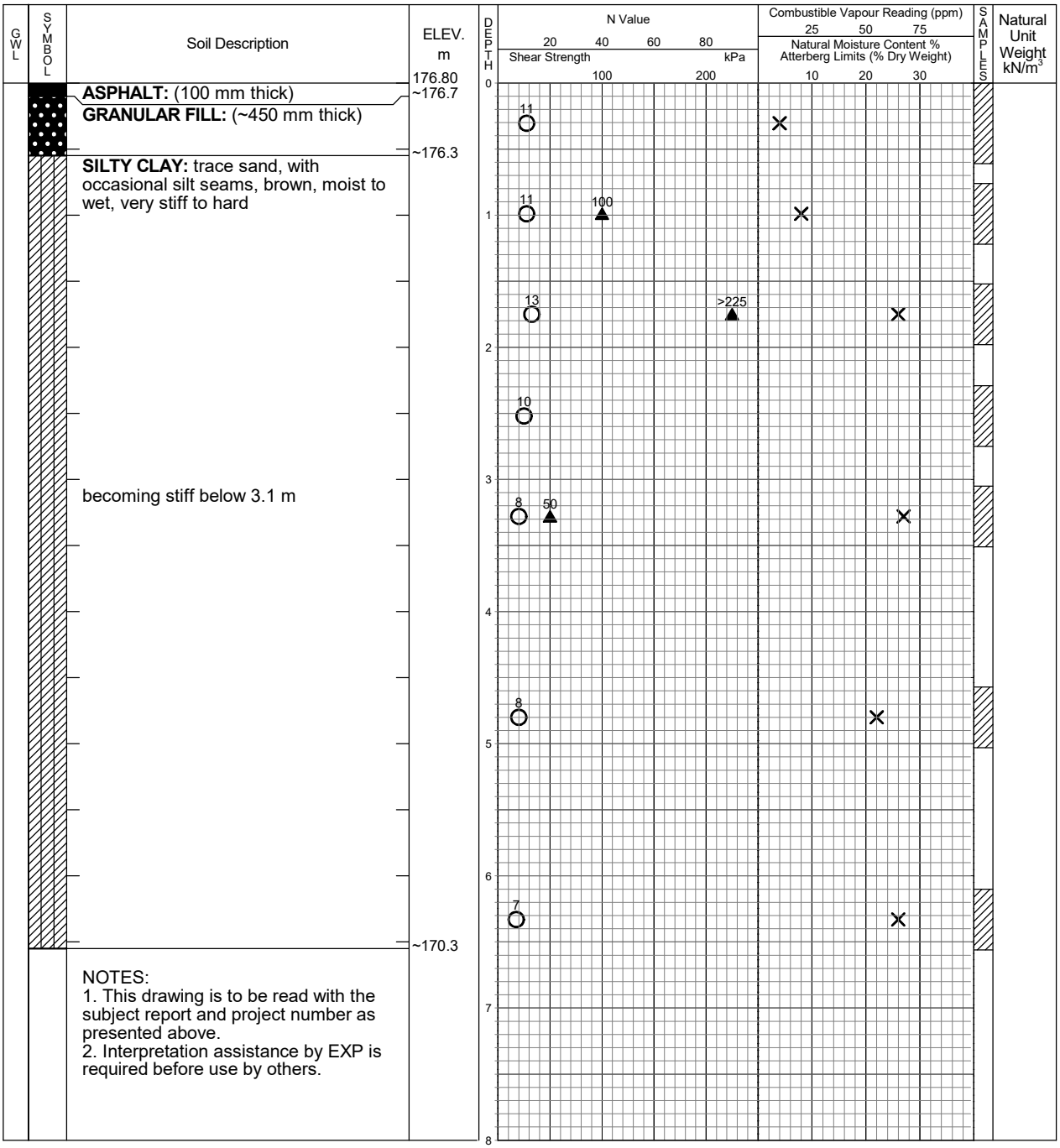
Date Drilled: November 9, 2018

Drill Type: D-50 Track Mount. Solid Stem.

Datum: Geodetic

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

Combustible Vapour Reading
Natural Moisture
Plastic and Liquid Limit
Undrained Triaxial at % Strain at Failure
Penetrometer



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Time	Water Level (m)	Depth to Cave (m)
on completion	dry	no cave

Log of Borehole BH-03

Project No. HAM-00801583-A0 | Drawing No. 5

Project: Montrose Business Park | Sheet No. 1 of 1

Location: Blackburn Parkway, Niagara Falls, ON

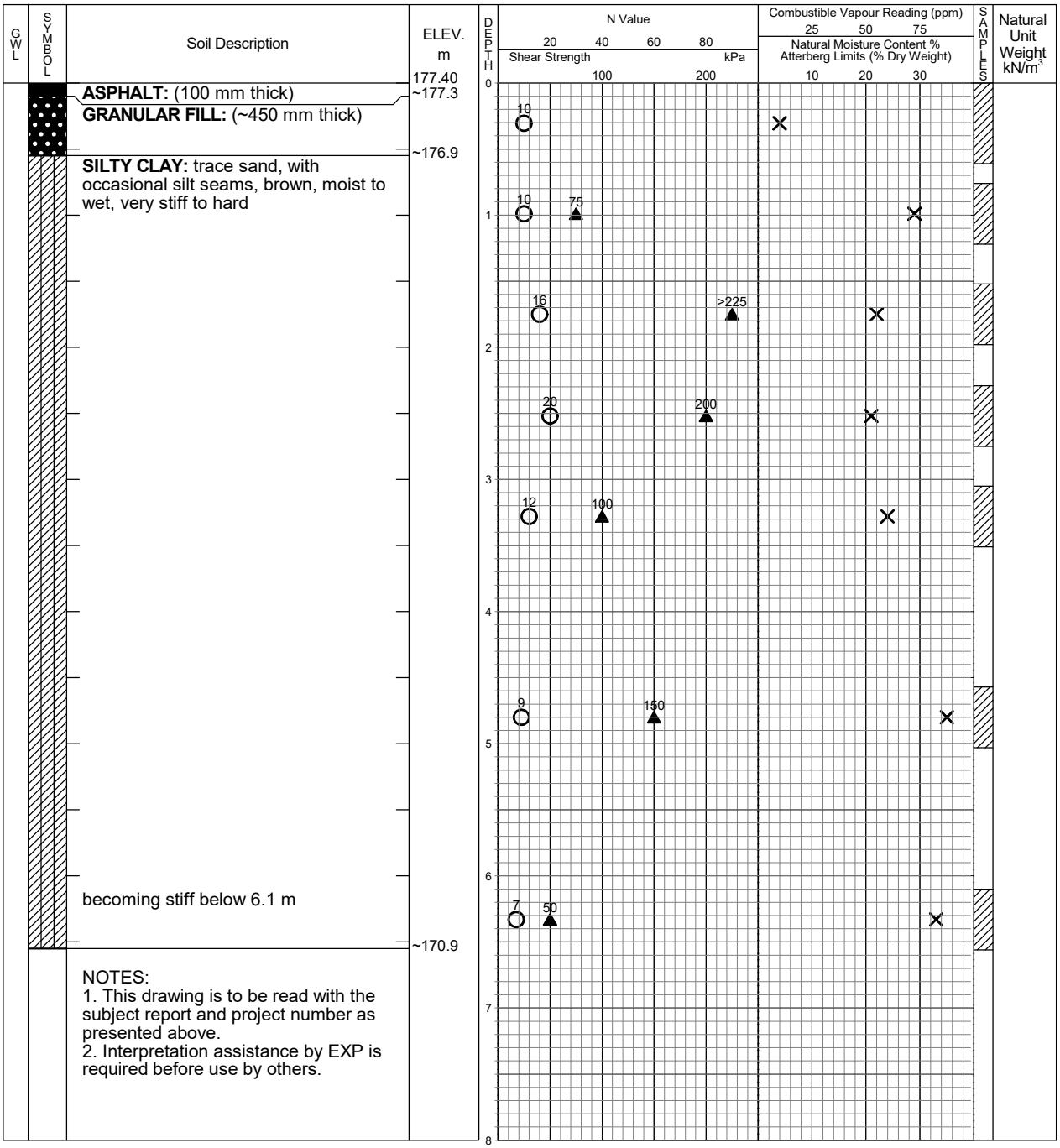
Date Drilled: November 9, 2018

Drill Type: D-50 Track Mount. Solid Stem.

Datum: Geodetic

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

Combustible Vapour Reading
Natural Moisture
Plastic and Liquid Limit
Undrained Triaxial at % Strain at Failure
Penetrometer



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Time	Water Level (m)	Depth to Cave (m)
on completion	dry	no cave

Log of Borehole BH-04

Project No. HAM-00801583-A0 Drawing No. 6

Project: Montrose Business Park Sheet No. 1 of 1

Location: Blackburn Parkway, Niagara Falls, ON

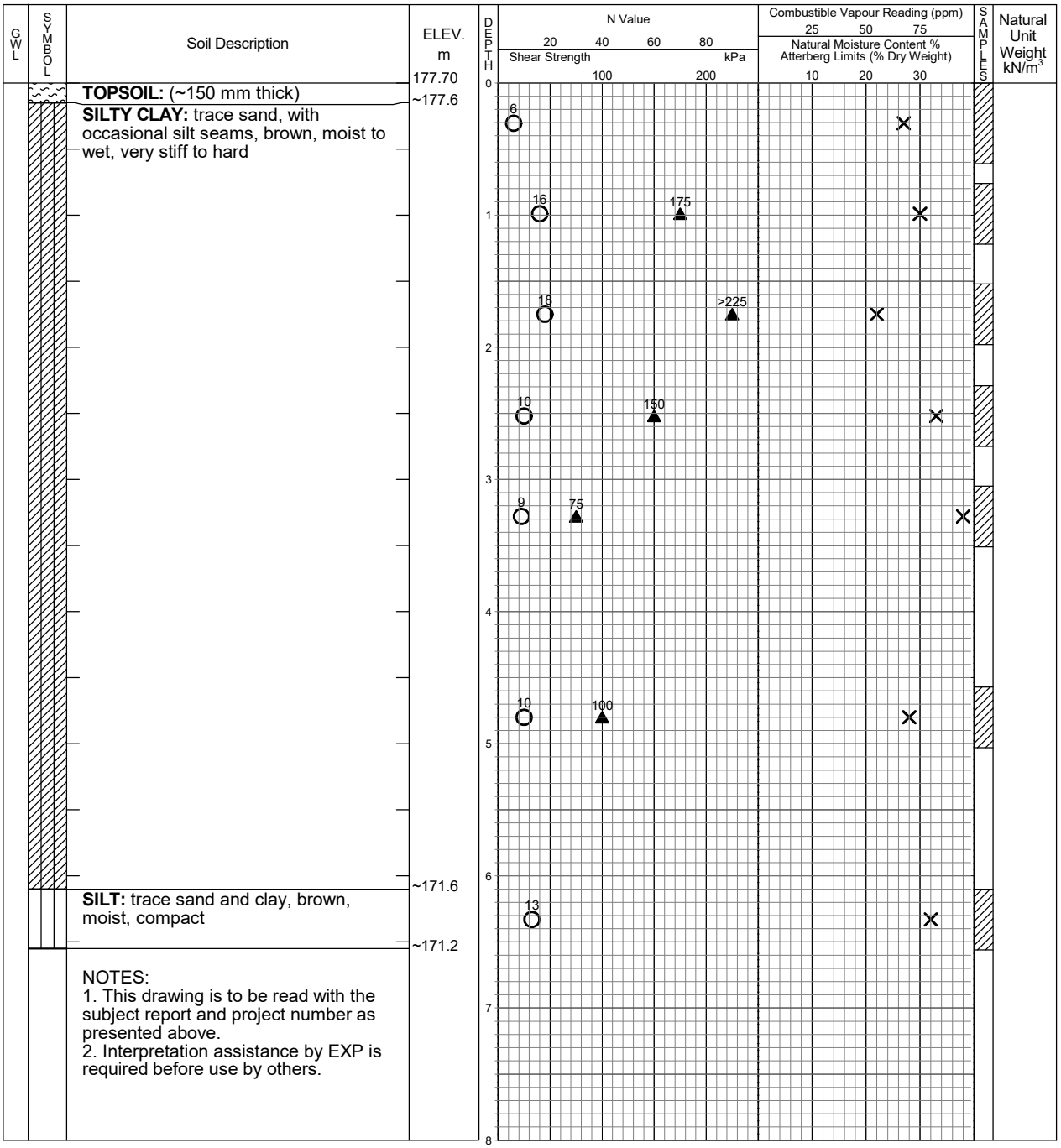
Date Drilled: November 9, 2018

Drill Type: D-50 Track Mount. Solid Stem.

Datum: Geodetic

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

Combustible Vapour Reading
Natural Moisture
Plastic and Liquid Limit
Undrained Triaxial at % Strain at Failure
Penetrometer



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Time	Water Level (m)	Depth to Cave (m)
on completion	dry	no cave

Log of Borehole BH-05

Project No. HAM-00801583-A0 Drawing No. 7

Project: Montrose Business Park Sheet No. 1 of 1

Location: Blackburn Parkway, Niagara Falls, ON

Date Drilled: November 8, 2018

Drill Type: D-50 Track Mount. Solid Stem.

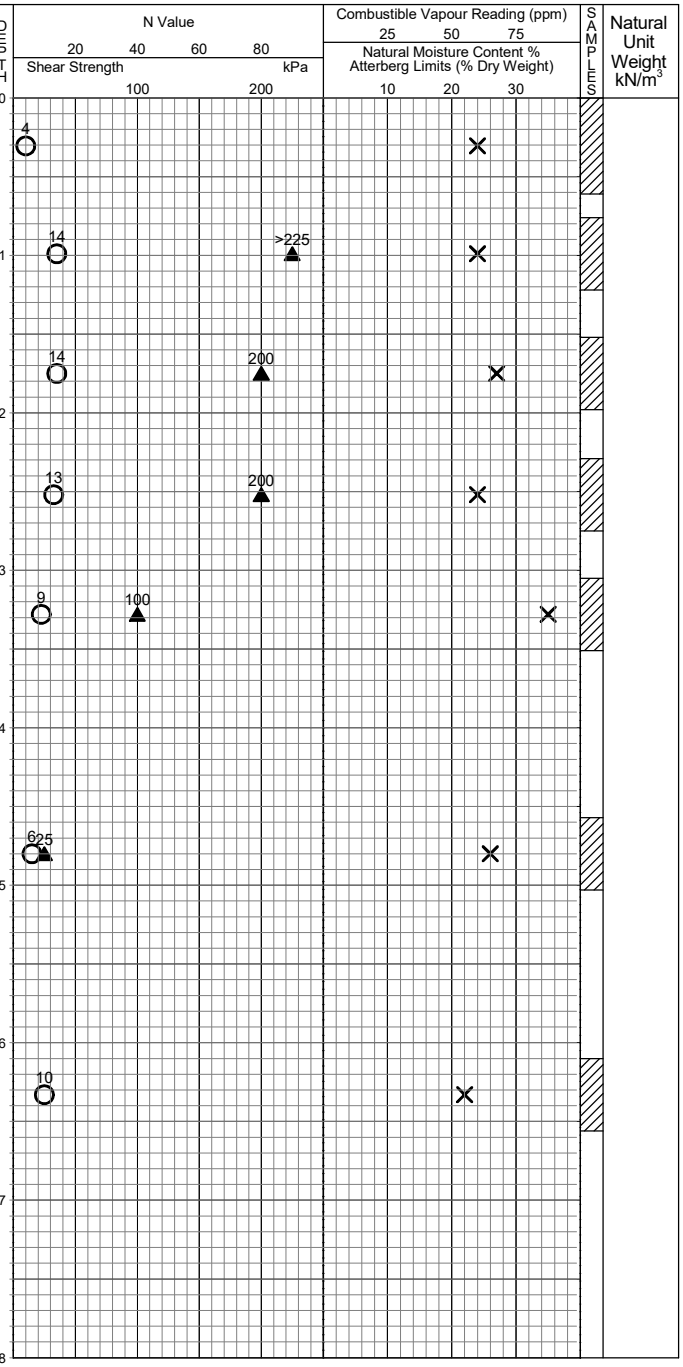
Datum: Geodetic

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

Combustible Vapour Reading
Natural Moisture
Plastic and Liquid Limit
Undrained Triaxial at % Strain at Failure
Penetrometer

GWL	SYMBOL	Soil Description	ELEV. m
		TOPSOIL: (~150 mm thick)	177.90
		SILTY CLAY: trace sand, with occasional silt seams, brown, moist to wet, very stiff to hard	~177.8
		becoming grey, firm below 4.6 m.	
		SILT: trace clay, grey, moist, compact	~171.8
			~171.4

NOTES:
1. This drawing is to be read with the subject report and project number as presented above.
2. Interpretation assistance by EXP is required before use by others.



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EXP Services Inc.
Hamilton, Ontario
Telephone: 905.573.4000
Facsimile: 905.573.9693

Time	Water Level (m)	Depth to Cave (m)
on completion	dry	no cave

Log of Borehole BH-06

Project No. HAM-00801583-A0 | Drawing No. 8

Project: Montrose Business Park | Sheet No. 1 of 1

Location: Blackburn Parkway, Niagara Falls, ON

Date Drilled: November 8, 2018

Drill Type: D-50 Track Mount. Solid Stem.

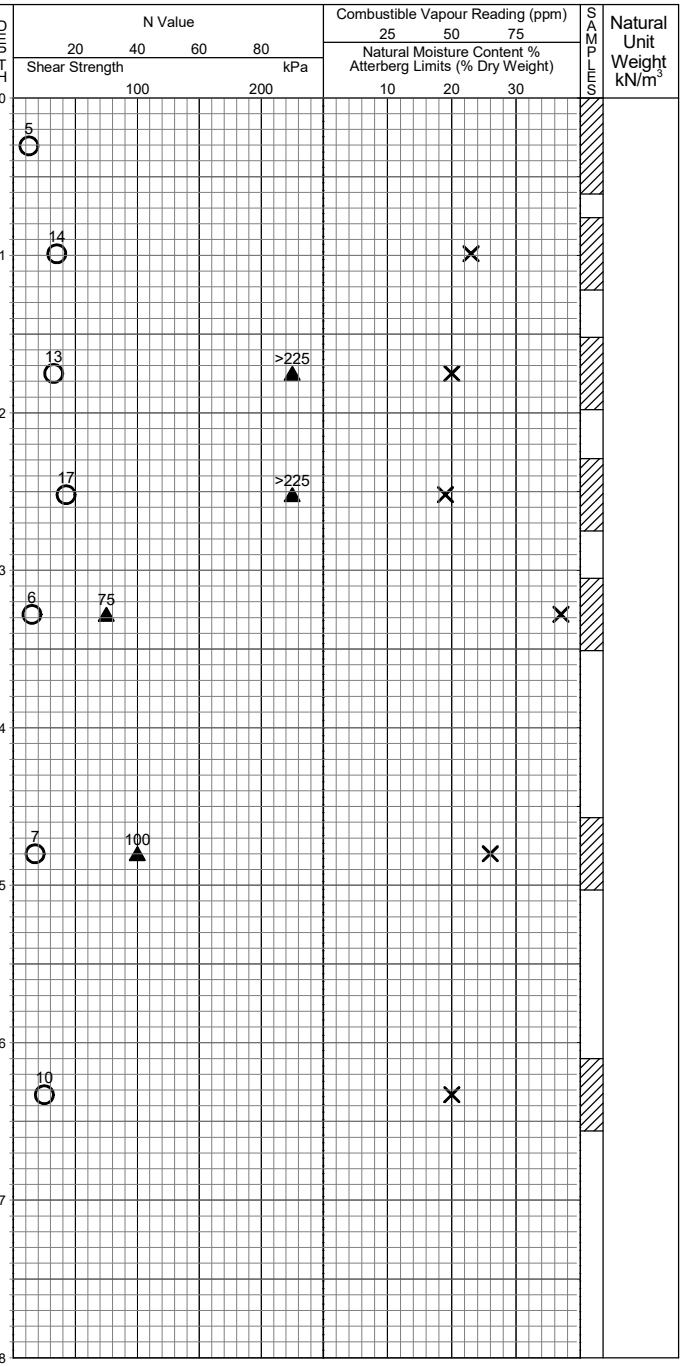
Datum: Geodetic

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

Combustible Vapour Reading
Natural Moisture
Plastic and Liquid Limit
Undrained Triaxial at % Strain at Failure
Penetrometer

GWL	SYMBOL	Soil Description	ELEV. m
		TOPSOIL: (~150 mm thick)	177.80
		SILTY CLAY: trace sand, with occasional silt seams, brown, moist to wet, hard	~177.7
		becoming stiff below 3.1 m	
		SILT: trace clay, brown, moist, compact	~171.7
			~171.3

NOTES:
1. This drawing is to be read with the subject report and project number as presented above.
2. Interpretation assistance by EXP is required before use by others.



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Facsimile: 905.573.9693

Time	Water Level (m)	Depth to Cave (m)
on completion	dry	no cave

Log of Borehole BH-07

Project No. HAM-00801583-A0 Drawing No. 9

Project: Montrose Business Park Sheet No. 1 of 1

Location: Blackburn Parkway, Niagara Falls, ON

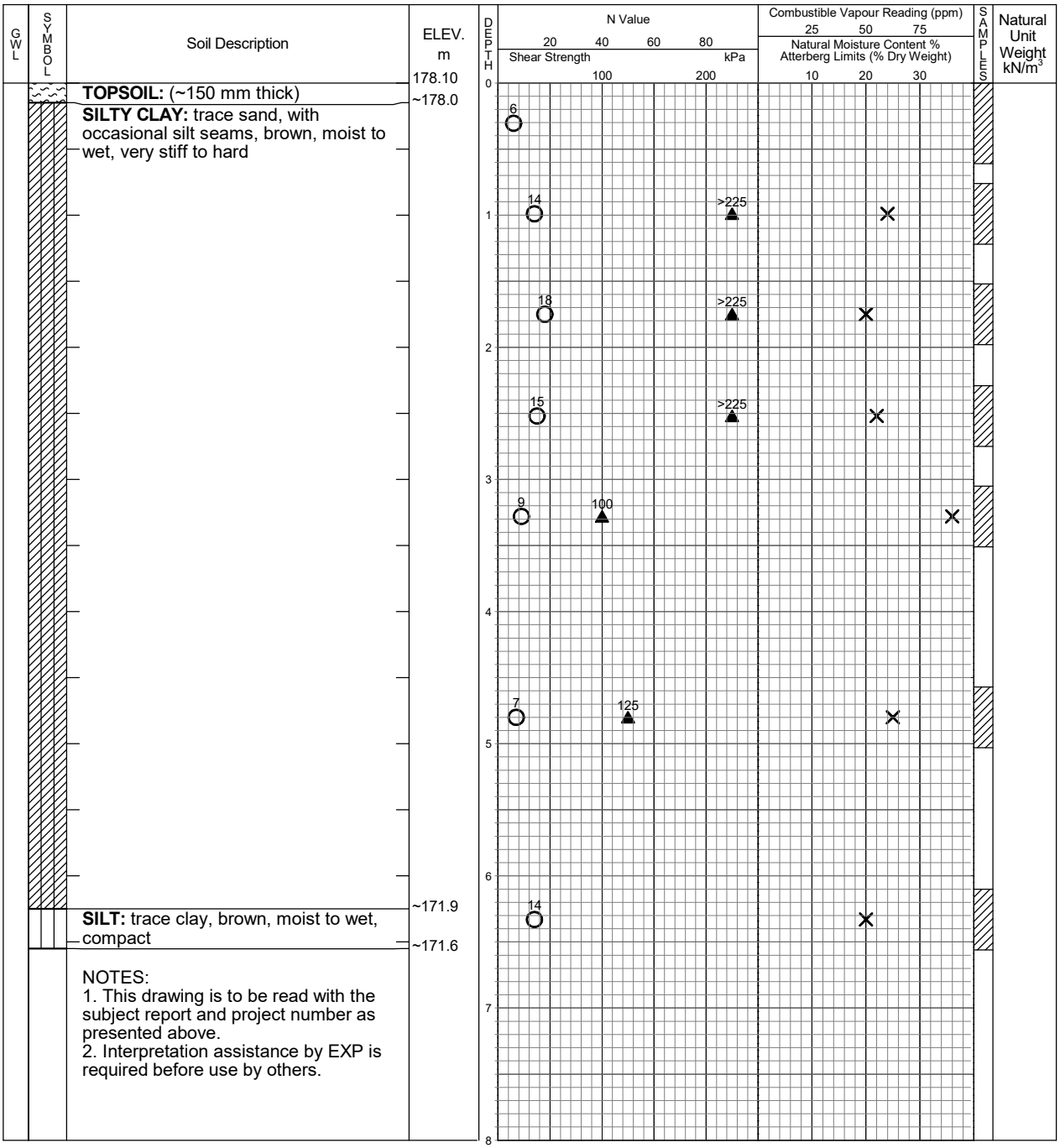
Date Drilled: November 8, 2018

Drill Type: D-50 Track Mount. Solid Stem.

Datum: Geodetic

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

Combustible Vapour Reading
Natural Moisture
Plastic and Liquid Limit
Undrained Triaxial at % Strain at Failure
Penetrometer



NOTES:
1. This drawing is to be read with the subject report and project number as presented above.
2. Interpretation assistance by EXP is required before use by others.

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Time	Water Level (m)	Depth to Cave (m)
on completion	dry	no cave

Log of Borehole BH-08

Project No. HAM-00801583-A0 Drawing No. 10

Project: Montrose Business Park Sheet No. 1 of 1

Location: Blackburn Parkway, Niagara Falls, ON

Date Drilled: November 8, 2018

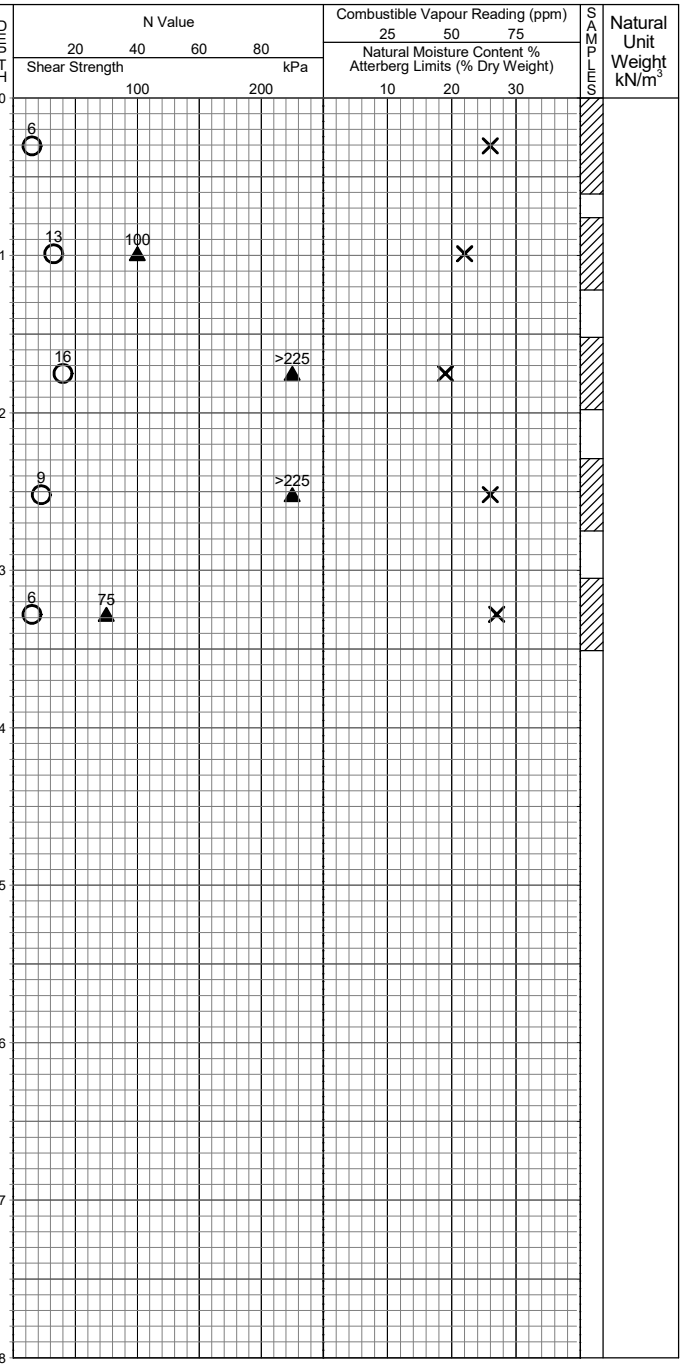
Drill Type: D-50 Track Mount. Solid Stem.

Datum: Geodetic

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

Combustible Vapour Reading
Natural Moisture
Plastic and Liquid Limit
Undrained Triaxial at % Strain at Failure
Penetrometer

GWL	SYMBOL	Soil Description	ELEV. m
		TOPSOIL: (~200 mm thick)	177.30
		SILTY CLAY: trace sand, with occasional silt seams, brown, moist to wet, very stiff to hard	~177.1
		becoming stiff below 3.1 m	~173.8
		NOTES: 1. This drawing is to be read with the subject report and project number as presented above. 2. Interpretation assistance by EXP is required before use by others.	



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Facsimile: 905.573.9693

Time	Water Level (m)	Depth to Cave (m)
on completion	dry	no cave

Log of Borehole BH-09

Project No. HAM-00801583-A0 Drawing No. 11

Project: Montrose Business Park Sheet No. 1 of 1

Location: Blackburn Parkway, Niagara Falls, ON

Date Drilled: November 8, 2018

Drill Type: D-50 Track Mount. Solid Stem.

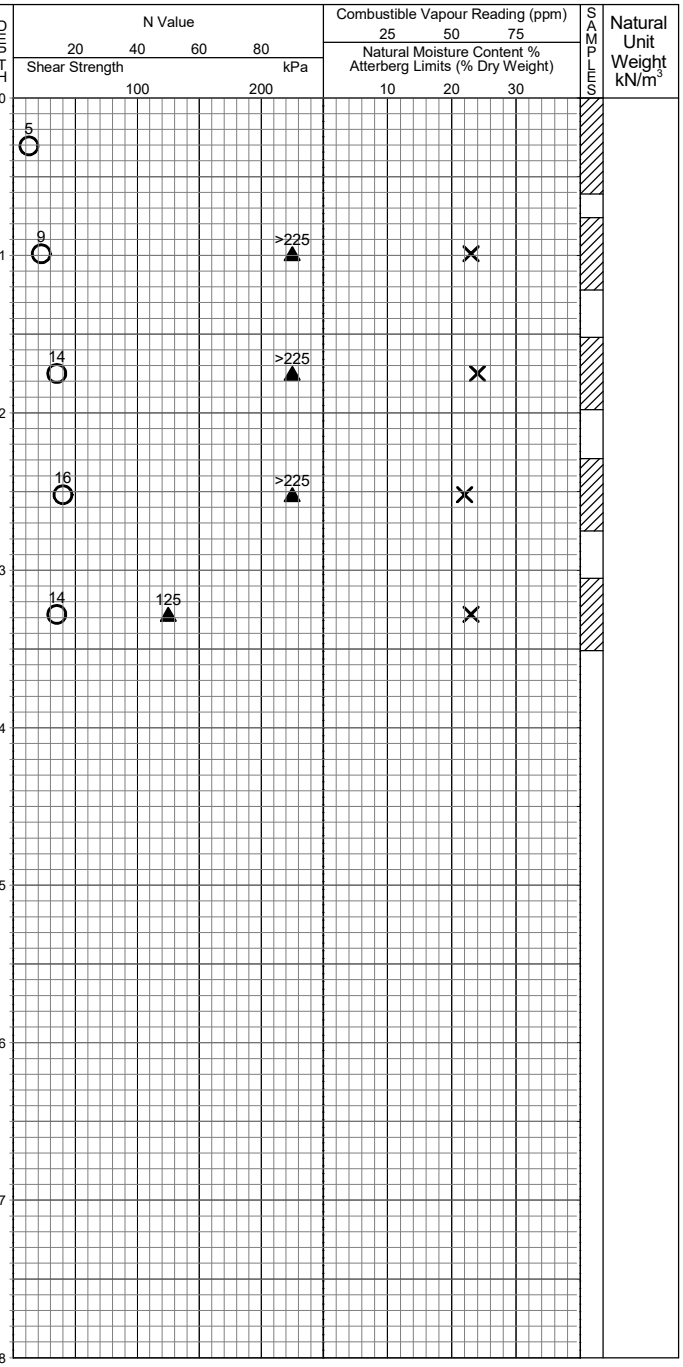
Datum: Geodetic

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

Combustible Vapour Reading
Natural Moisture
Plastic and Liquid Limit
Undrained Triaxial at % Strain at Failure
Penetrometer

GWL	SYMBOL	Soil Description	ELEV. m
		TOPSOIL: (~200 mm thick)	177.70
		SILTY CLAY: trace sand, with occasional silt seams, brown, moist to wet, very stiff to hard	~177.5
			~174.2

NOTES:
1. This drawing is to be read with the subject report and project number as presented above.
2. Interpretation assistance by EXP is required before use by others.



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Facsimile: 905.573.9693

Time	Water Level (m)	Depth to Cave (m)
on completion	dry	no cave

Log of Borehole BH-10

Project No. HAM-00801583-A0 | Drawing No. 12

Project: Montrose Business Park | Sheet No. 1 of 1

Location: Blackburn Parkway, Niagara Falls, ON

Date Drilled: November 8, 2018

Drill Type: D-50 Track Mount. Solid Stem.

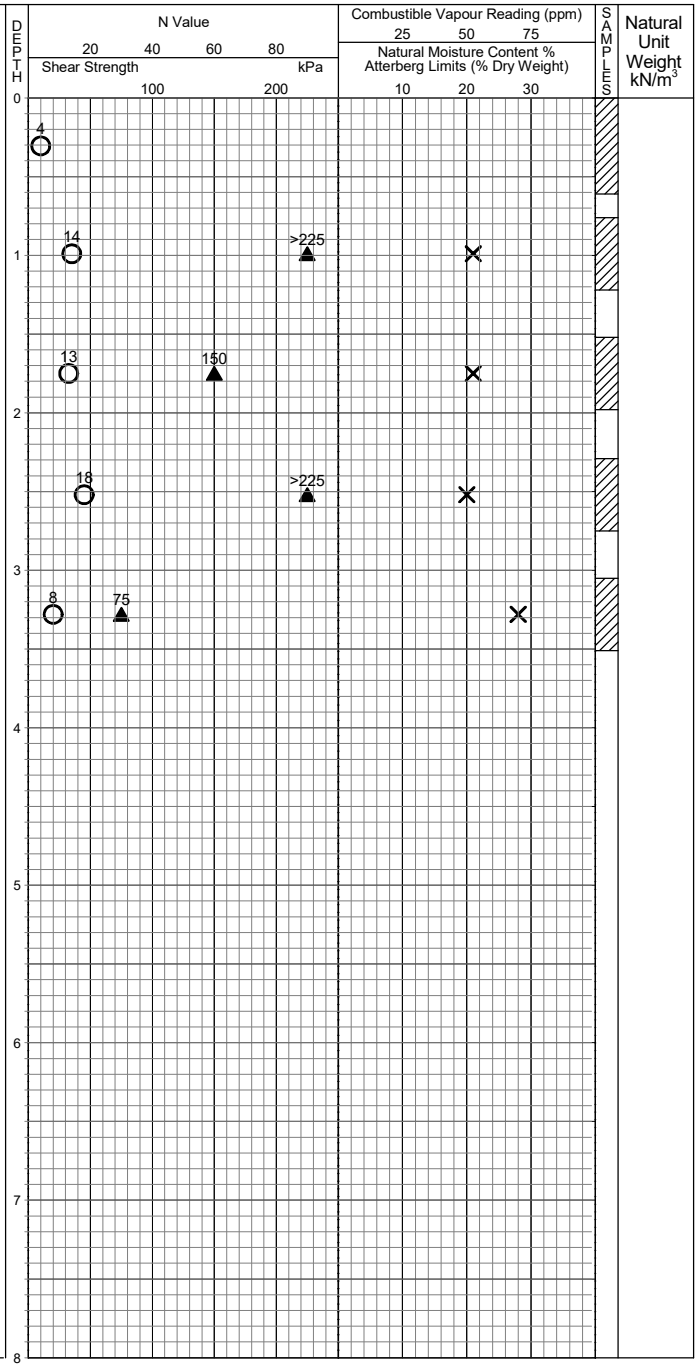
Datum: Geodetic

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

Combustible Vapour Reading
Natural Moisture
Plastic and Liquid Limit
Undrained Triaxial at % Strain at Failure
Penetrometer

GWL	SYMBOL	Soil Description	ELEV. m
		TOPSOIL: (~175 mm thick)	178.60
		SILTY CLAY: trace sand, with occasional silt seams, brown, moist, very stiff to hard	~178.4
		becoming stiff below 3.1 m	~175.1

NOTES:
1. This drawing is to be read with the subject report and project number as presented above.
2. Interpretation assistance by EXP is required before use by others.



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Telephone: 905.573.4000
Facsimile: 905.573.9693

Time	Water Level (m)	Depth to Cave (m)
on completion	dry	no cave

Log of Borehole BH-11

Project No. HAM-00801583-A0 Drawing No. 13

Project: Montrose Business Park Sheet No. 1 of 1

Location: Blackburn Parkway, Niagara Falls, ON

Date Drilled: November 8, 2018

Drill Type: D-50 Track Mount. Solid Stem.

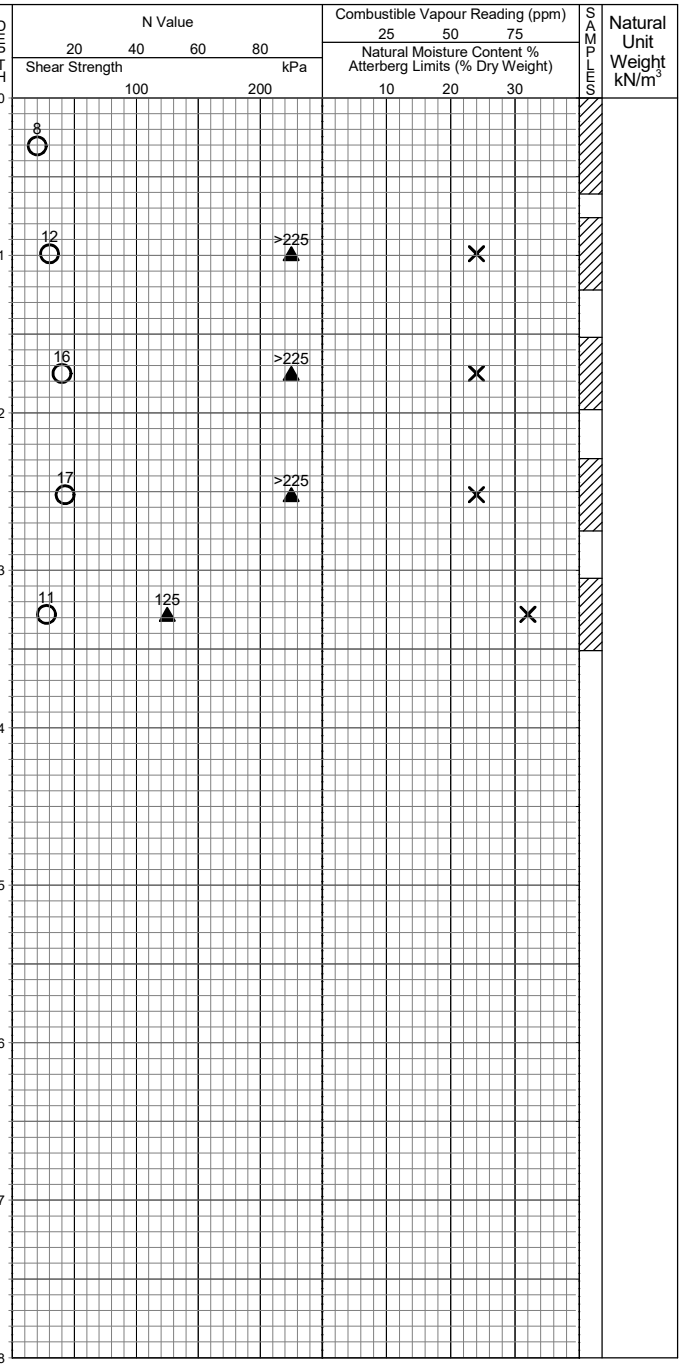
Datum: Geodetic

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

Combustible Vapour Reading
Natural Moisture
Plastic and Liquid Limit
Undrained Triaxial at % Strain at Failure
Penetrometer

GWL	SYMBOL	Soil Description	ELEV. m
		TOPSOIL: (~200 mm thick)	178.70
		SILTY CLAY: trace sand, with occasional silt seams, brown, moist to wet, very stiff to hard	~178.5
			~175.2

NOTES:
1. This drawing is to be read with the subject report and project number as presented above.
2. Interpretation assistance by EXP is required before use by others.



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Facsimile: 905.573.9693

Time	Water Level (m)	Depth to Cave (m)
on completion	dry	no cave