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Geotechnical Investigation Report
Proposed Storm Sewer and Sanitary Sewer Installation
Hospital Drive
St. Catharines, Ontario

Prepared for:

Niagara Health System
5546 Portage Road
Niagara Falls, Ontario, Canada
L2E 6X2

Landtek File: 17118
June 9, 2017

EXECUTIVE SUMMARY

SCOPE OF SERVICES

Proposed Development	Niagara Health System is intending to construct a storm sewer and sanitary sewer as well as construct a new roadway along Hospital Drive in St. Catharines, Ontario.
Report Deliverables	The purposes of the Geotechnical Investigation were to confirm the subsurface conditions at the site and to provide design and construction recommendations with regards to pavement reinstatement/reconstruction, and municipal and utility service installations.

SITE DETAILS AND SETTING

UTM 17T Coordinates	639730, 4779376	**Geodetic Elevation(Range)**	99 m to 101 m

Site Description	The project site is situated to the west of First Street Louth and to the east of Third Street Louth and is bound to the north by Fourth Avenue. The area surrounding the site is relatively undeveloped and covered predominantly by grasses with a small number of trees. Approximately 130 m east of the site is a developed area comprising primarily of commercial premises with at-grade paved parking areas and access routes.
Geology	Pavement material was encountered at the surface. Underlying the pavement material are clayey silt till and silty clay till deposits. The deposits extend to the maximum drill depth at a depth of 5.0 m below the existing ground surface. No bedrock was encountered during this investigation.

ENGINEERING CONSIDERATIONS

Sewer Pipe Installations	The native soils generally present favorable support conditions for storm and sanitary sewer design and construction.
Settlements	The general limiting of the total settlement of 25 mm and the differential settlement to 19 mm by the recommended geotechnical reaction at the SLS is considered appropriate for the native soils at the site.
Earthquake Considerations	The subject property is considered to be a 'D' Site Class.
Foundations Considerations	Any proposed access chambers or valve boxes associated with the proposed service installations, can be founded in the undisturbed, native silty clay for a geotechnical reaction of 50 kPa at the Serviceability Limit State (SLS), and for a factored geotechnical resistance of 75 kPa at the Ultimate Limit State (ULS).

CONSTRUCTION CONSIDERATIONS

Excavations	The subsurface soils to be encountered during excavation at the site are expected, in general, to behave as Type "2" materials according to the OHSA classification in Part III. Type 2 materials are characteristic of the generally very stiff clayey and silty till soils.
Dewatering	It should be possible to control water seepage into excavations by pumping from sumps using perimeter drainage swales at the base of the excavations. Water seepage into open excavations is not expected be a construction issue such that the project would require registration under the Environmental Activity and Sector Registry (herein "*EASR*") framework (i.e. exceeding 50,000 l/day but less than 400,000 l/day)
Material Reuse	The native soils encountered on site are considered from a geotechnical perspective as suitable for re-use as engineered backfill.
Pavements	The subgrade soil should be inspected and proof-rolled using a loaded tandem axle truck to traverse the exposed subgrade, prior to the placement of pavement granular fill.

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1.0 INTRODUCTION

Landtek Limited (herein "*Landtek*") is pleased to submit this geotechnical investigation report for the proposed storm sewer and sanitary sewer construction as well as new roadway construction on Hospital Drive in St. Catharines, Ontario. The work was initiated following receipt of the authorization to proceed from Mr. William Heikoop of Upper Canada Consultants (herein *"UCC")* on April 19, 2017. The work was carried out in accordance with Landtek proposal number P17113 dated April 17, 2017.

Preliminary design information indicates that the project will consist of the construction of a new storm sewer and sanitary sewer on Hospital Drive as well as new roadway construction. Design details of the proposed storm sewer and sanitary sewer were not available at the time of authoring this report.

The primary objectives of this investigation were:

- To determine the subsurface soil and groundwater conditions to be encountered during utility and municipal service installations;
- Provide design and construction recommendations with regards to pavement reconstruction, where required;
- Provide recommendations regarding excavations, trench backfill, and compaction requirements; and,
- Assess the characteristics of the soils to be excavated and their suitability for reuse on the site and/or off-site disposal.

This report has been prepared for the client, their nominated engineers, designers, and project managers. Further dissemination of this report is not permitted without Landtek Limited's prior written approval. The full details of the limitations of this report are presented in Appendix A.

2.0 METHODOLOGY

Fieldwork undertaken at the site by Landtek included clearance of underground services, borehole layout, borehole drilling and soil sampling, field supervision and traffic management. Two boreholes (boreholes BH1 to BH2) were drilled at the site on May 8, 2017. All boreholes were logged using those standard symbols and terms defined in Appendix B. The borehole location plan, Drawing 1, and the borehole logs are provided in Appendix C.

All boreholes were drilled using a CME-55 truck-mounted drilling rig equipped with continuous flight, solid stem augers, and were advanced to a maximum depth of 5.0 m below existing ground level.

Standard Penetration Tests (SPT's) and split spoon samples were taken during drilling at selected depths. Full time supervision of drilling and soil sampling operations was carried out by a representative of Landtek Limited. The boreholes were backfilled with bentonite and soils cuttings to pavement subgrade, with the excavated granular materials placed on top, and the surface was reinstated with cold mix asphalt.

The soil samples were then transported to Landtek`s in-house, Canadian Council of Independent Laboratories (CCIL) certified laboratory and visually examined to determine their textural classification. Moisture contents were carried out on all samples.

The geodetic elevations at the boreholes were approximated by Landtek based on field measurements relative to the site Topographic Survey drawings (Drawing Numbers 1731-PP1 and 1731-PP2) prepared by UCC and dated April 14, 2017.

3.0 SITE AND SUBSURFACE CONDITIONS

3.1 Site Location

The site is located in the City of St. Catharines, Ontario, and is centered at approximate grid reference 639730, 4779376 (UTM 17T coordinates). The general Geodetic elevation of the ground surface in the area of the site ranges between 99 m and 101 m.

The site location is shown in Figure 1 below.



Figure 1
Site Location Plan

The project site is situated to the west of First Street Louth and to the east of Third Street Louth and is bound to the north by Fourth Avenue. The area surrounding the site is relatively undeveloped and covered predominantly by grasses with a small number of trees. Approximately 130 m east of the site is a developed area comprising primarily of commercial premises with at-grade paved parking areas and access routes.

Based on published geological information [1,2] for the area, the predominant subsurface soil is silty and clayey till, identified as a sequence of the Halton Till. The bedrock in the area is identified as red shale of the Queenston Formation.

The borehole information is generally consistent with the geological data, and the predominant soils comprise of clayey and silty till deposits. No bedrock was encountered during this

investigation. The detailed borehole logs are presented in Appendix C, and the ground conditions encountered by the boreholes are discussed further in the following sections.

Surface Material

The boreholes were drilled through the existing asphalt surface on Hospital Drive. The asphalt thickness is approximately 100 mm.

Fill (Granular)

Pavement granular material was encountered in all boreholes underlying the asphalt, and consisted of approximately 400 mm (borehole BH1) to 500 mm (borehole BH2) of sand and gravel.

Clayey Silt Till

Clayey silt till deposits were encountered in all the boreholes underlying the pavement granular material and extend to a depth of between 4.5 m and to the maximum drill depth of 5.0 m below existing pavement surface. The clayey silt till deposits are generally greyish brown and contain traces of gravel, and rust staining.

SPT 'N' values ranging from 15 to 27 were reported, indicating the clayey silt till deposits to be of a very stiff condition. Moisture contents in the clayey silt till range between 18 % and 22 %.

Silty Clay Till

Silty clay till was encountered in borehole BH2 underlying the clayey silt till at a depth of approximately 4.5 m and extends to the terminus of the borehole at depth of of 5.0 m below existing pavement surface. The silty clay till is greyish brown in colour and contain traces of gravel, and rust staining.

A single SPT 'N' value of 14 was reported, indicating the silty clay till to be stiff. The moisture content in the silty clay till is 23 %.

Bedrock

Bedrock was not encountered during this investigation.

Groundwater

Water seepage was encountered in borehole BH2 at a depth of 0.6 m below the existing pavement surface. It should be noted that this groundwater level is not considered to reflect the long term stabilized water table, and is considered likely to be more representative of draining surface water becoming trapped within the granular fill soils by the underlying, low permeability soils.

Groundwater conditions are expected to vary according to the time of the year and seasonal precipitation levels. During wet weather water is expected to be perched in fill deposits.

4.0 EXCAVATION AND BACKFILL CONSIDERATIONS

All temporary, open-cut excavations and unbraced side slopes in the soils should conform to standards set out in the Occupational Health and Safety Act. The majority of the subsurface strata to be encountered during excavation at the site are expected to be Type "2" materials according to the Occupational Health and Safety Act classification in Part III. Type 2 materials are characteristic of the generally very stiff clayey and silty till soils.

It should be possible to excavate service trenches through the overburden soils using a hydraulic backhoe. It is anticipated that the excavation walls in the native soils are expected to be stable for short construction periods at slopes of about 45° to the horizontal (i.e. 1V:1H). As well, there may be service trenches and backfill directly behind cut slopes in the native soils that appear to be stable. In these cases slopes can suddenly slough or collapse due to the effects of the adjacent backfill. Consequently, for trench conditions that cannot satisfy the Occupational Health and Safety Act requirements for unbraced 1H:1V side slopes, a trench box system should be used, or temporary shoring should be installed to maintain safe working conditions.

Groundwater seepage was generally not observed during the drilling. It is expected that groundwater seepage during service trench excavation work should be able to be controlled by pumping from sumps at the base of the excavation. Water seepage into open excavations is not expected to be a construction issue such that the project would require either registration under the Environmental Activity and Sector Registry (herein "*EASR*") framework (i.e. exceeding 50,000 l/day but less than 400,000 l/day) or a Permit To Take Water (herein "*PTTW*") for amounts greater than 400,000 l/day.

In accordance with the Corporation of the City of St. Catharines (herein *"City of St. Catharines"*) Standard Drawing 110-2015 "*Road Reinstatement Requirements*", the trench is to be backfilled with OPSS 1010 Granular A material. The trench backfill should be uniformly compacted to a density that minimizes the risk of long-term settlements. As per Standard Drawing 110-2015, the target compaction specification for trench backfill be 100 % Standard Proctor Maximum Dry Density (herein "*SPMDD*").

The excavated materials should generally be considered to be re-usable from a geotechnical perspective, where required, though are subject to any required moisture conditioning. The fill placement and compaction protocol should be discussed and agreed upon at a preconstruction meeting to minimize the risk of backfill settlements.

Where used, and during inclement weather, the excavated soils may become too wet to achieve satisfactory compaction. If construction is proposed for late in the year, a reduced level of trench compaction with a higher risk of future settlements is to be anticipated, and it is recommended that provisional contract quantities be established for the supply and placement of imported granular fill under such circumstances. The imported granular should meet the requirements of Ontario Provincial Standard Specification (herein "*OPSS*") 1010 for Granular B Type I material as a minimum requirement.

5.0 SEWER PIPE INSTALLATION

5.1 Sewer Pipe Installation Considerations

It is expected that the storm sewer will be installed at a minimum depth of 1.4 m below existing pavement surface, and the sanitary sewer at a minimum depth of 2.5 m below existing pavement surface, as per City of St. Catharines requirements. The subgrade support conditions under the sewer pipes are anticipated to be native clayey silt till and silty clay till deposits. It is considered that the native soils generally present favorable support conditions for sewer installation.

Should soft soils be encountered during construction, such soft areas should be sub-excavated and replaced with suitably compacted, engineered fill and approved by a Geotechnical Engineer to redevelop the required subgrade. A Geotechnical Engineer should be engaged during construction to examine the exposed sub-soil quality and condition, and confirm the subsurface conditions are consistent with design assumptions. This is in compliance with field review requirements in the National Building Code (herein "*NBC*"), Volume 1, Clause 4.2.2.3.

5.2 Foundation Considerations for Associated Infrastructure

Based on the findings of the investigation, it is considered by Landtek that any proposed access or connection chambers associated with the proposed sewer installations, can be founded in the undisturbed, native soils for a geotechnical reaction of 50 kPa at the SLS, and for a factored geotechnical resistance of 75 kPa at the ULS.

Subsurface conditions can vary over relatively short distances and the subsurface conditions revealed at the test locations may not be representative of subsurface conditions across the site. Therefore, a Geotechnical Engineer should be engaged during construction to examine the exposed sub-soil quality and condition, and confirm the subsurface conditions are consistent with design assumptions. This is in compliance with field review requirements in the National Building Code, Volume 1, Clause 4.2.2.3.

Settlement Considerations

It is anticipated that the loads to be applied to the ground by any such structures will be generally very low in intensity. As such, associated settlements are not expected to be large. Therefore, the general limiting of the total settlement to 25 mm and the differential settlement to 19 mm by the recommended geotechnical reaction at the SLS is considered appropriate.

Seismic Design Considerations

In accordance with Table 4.1.8.4.A. of the current Ontario Building Code (herein "*OBC*") the subject property is considered to be a "D" Site Class. The acceleration and velocity-based site coefficients, F_a and F_v, should be determined from Tables 4.1.8.4.B. and 4.1.8.4.C. respectively of the OBC for the above recommended Site Class. The seismic design data given in Table 1.2 of Supplementary Standard SB-1 in Volume 2 of the OBC, for selected Municipal locations, should be used to complete the seismic analysis.

5.3 Bedding Cover and Backfill

There is no indication that special pipe bedding materials or procedures are required for the installation of rigid sewer pipes. All bedding cover and backfill materials should be selected in

accordance with OPSS 1010 Aggregates – Base, Subbase, Select Subgrade, and Backfill Material, or the City of St. Catharines' Engineering Standards Manual, whichever is more stringent.

The pipes should be placed with a minimum bedding thickness in conformance of Ontario Provincial Standard Drawing (herein "*OPSD*") 802.010 series (typical 150 mm for rigid pipes, OPSD 802.010, 802.013 and 802.014). The use of normal Class B type bedding is applicable for the pipe.

Bedding material shall be placed in layers not exceeding 300 mm in thickness, loose measurement, and compacted to 100 % of the SPMDD before a subsequent layer is placed. Bedding on each side of the pipe shall be completed simultaneously. At no time shall the fill levels on each side of the sewer pipe differ by more than one, 300 mm uncompacted layer.

6.0 SUBSURFACE CONCRETE

6.1 General Considerations

The requirements for subsurface concrete subject to a sulphate environment are presented in Canadian Standards Association (CSA) specification CAN/CSA-A3000-13. Experience in the area indicates that the native soils generally have a mild sulphate environment and are not aggressive to concrete (CSA criteria of less than 0.2 % water soluble sulphate in the soils). It is recommended that subsurface concrete at the site have the following characteristics for an S-3 exposure class:

- minimum 28-day compressive strength = 25 MPa;
- minimum 56-day strength = 30 MPa;
- maximum water to cement ratio = 0.50;
- cementing materials:
  MS hydraulic cement or MSb; as per tables 3 and 4 respectively in CSA A23.1-04; and,
- air content:
  4 – 7 % for 14 mm to 20 mm nominal size coarse aggregate
  3 – 6 % for 28 mm to 40 mm nominal size coarse aggregate

6.2 Methods for Specifying Concrete

Alternative methods of specifying concrete for a project are outlined in CSA A23.1-14 and allow for "*Performance*" or "*Prescription*" based methods. Each method attaches different levels of responsibility to the owner, the contractor, and the concrete supplier. The pros and cons of each method should be examined prior to completion of the specifications for the project.

7.0 PAVEMENT CONSTRUCTION CONSIDERATIONS

Hospital Drive is regarded as an urban local road. Specific traffic data and growth projections were not available consequently observed site conditions were used to develop pavement structure design criteria. The recommendations for pavement structure construction reflect the fact that the existing roadway will accommodate primarily local traffic and the majority of vehicles will be cars with occasional truck traffic.

7.1 Pavement Structure Recommendations

The pavement structure thicknesses presented in Table 1 includes the City of St. Catharines standard section for the class of road as well as recommended pavement layer thicknesses based on a 20-year design life. The recommended pavement design section takes into account the accepted design practice that the total pavement structure thickness should meet or exceed one-half the anticipated depth of frost penetration for the geographical area. Pavement reinstatement should either match the existing structure per OPSS requirements, or the below recommendations.

Table 1
Recommended Pavement Structure Layer Thicknesses

Pavement Layer	City of St. Catharines Standard Roadway Section	Recommended Pavement Structure Layer Thicknesses
Surface Course Asphalt OPSS HL 3	50 mm	50 mm
Binder Course Asphalt OPSS HL 8	50 mm	50 mm
OPSS Granular A Base	325 mm	400 mm
Total Thickness	425 mm	500 mm

7.2 Subgrade Preparation and Drainage

The overall performance of the pavement structure will greatly depend upon the support provided by the subgrades. A number of factors should be considered at the construction stages to ensure that an acceptable subgrade condition is developed and maintained:

- Any soft areas of notable deflection to the subgrade should be sub-excavated and replaced with a suitable backfill material approved by a qualified geotechnical engineer and compacted to 98 % of its SPMDD;
- The subgrade should be properly shaped, crowned and then proof-rolled under the full time observation of a geotechnical representative of this office to delineate any soft areas which may require repair before placing the granular materials; and,
- Surface water should not be allowed to pond on the surface of or adjacent to the outside edges of any developed subgrade.

It is important to ensure that any necessary repairs are undertaken to the subgrades prior to pavement construction to avoid creating "*bathtub*" conditions in the subgrade that will ultimately translate through the overlying pavement structure.

Any proposed subdrains and associated connections are to be installed in accordance with the City of St. Catharines' Standard Drawings.

7.3 Pavement Construction Considerations

The following considerations should be maintained during paving:

- The requirements defined by OPSS 310 and OPSS.PROV.313 for the design and construction of lap joints between and transitions from existing and new asphaltic concrete pavements when connecting the new pavement construction to the existing pavements of adjacent roads;
- A tack coat should be applied to all contact surfaces prior to placing any hot mix asphalt layers or between asphaltic layers as per OPSS 308; and,
- The placing, spreading and rolling of the asphalt should be in accordance with current provincial standards or the City of St. Catharines' Engineering Standards.

Granular Base Course and Subbase

The granular base course materials should meet OPSS Granular "A" specifications. Quarried 20 mm limestone crushed to Granular "A" gradation specifications is recommended. If the option with granular subbase material is used, the granular subbase should meet OPSS Granular B Type II requirements for 100 % crushed quarried bedrock (50 mm crusher-run limestone).

Hot Mix Asphalt

The binder course and surface course asphalt should meet current specifications for HL 8 HS and HL 3 HS respectively, as prescribed by City of St. Catharines or, alternatively, OPSS 1150.

The standard asphalt binder grade for the climate conditions in the City of St. Catharines is PG 58-28. Given the observed low volume of commercial truck traffic it is considered that there is no requirement for a bump up to a higher PG grade of asphalt cement.

Compaction

Granular base course and subbase course fill material should be compacted to 100 % SPMDD. Hot mix asphalt should be compacted to the criteria set out by the City of St. Catharines.

Subgrade Preparation

The subgrade conditions and bearing strength may be variable along the road section and some subgrade repairs should be anticipated. It is recommended that prior to the placement of pavement granular fill, the exposed subgrade soil should be inspected and proof-rolled using a loaded tandem axle truck to traverse the exposed subgrade and provide for full coverage. The proof-rolling should be monitored by a geotechnical representative of this office to delineate any soft areas which may require repair. Repairs should be undertaken to avoid creating "bathtub" conditions in the subgrade within the pavement structure.

8.0 CLOSURE

The Limitations of Report, as stated in Appendix A, are an integral part of this report.

Soil samples will be retained and stored by Landtek for a period of three months after the report is issued. The samples will be disposed of at the end of the three month period unless a written request from the client to extend the storage period is received.

We trust this report will be of assistance with the design and construction of the proposed development. Should you have any questions, please do not hesitate to contact our office.

Yours sincerely,

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REFERENCES

[1] Freenstra, B.H, 1984 Quaternary Geology of Niagara-Welland Area, Map 2496, Quaternary Geology Series, Scale 1: 50 000, Geology 1969-1972.

[2] Liberty, B.A., Feenstra, B.H. and Telford, P.G. 1976. Paleozoic geology, Niagara, southern Ontario; Ontario Division of Mines, Map 2344, 1: 50 000,

APPENDIX A
LIMITATIONS OF REPORT

The conclusions and recommendations given in this report are based on information determined at the borehole locations. Subsurface and ground water conditions between and beyond the Boreholes may be different from those encountered at the borehole locations, and conditions may become apparent during construction that could not be detected or anticipated at the time of the geotechnical investigation. It is recommended practice that Landtek be retained during construction to confirm that the subsurface conditions throughout the site are consistent with the conditions encountered in the Boreholes.

The comments made in this report on potential construction problems and possible remedial methods are intended only for the guidance of the designer. The number of Boreholes may not be sufficient to determine all the factors that may influence construction methods and costs. For example, the thickness and quality of surficial topsoil or fill layers may vary markedly and unpredictably. Additionally, bedrock contact depths throughout the site may vary significantly from what was encountered at the exact borehole locations. Contractors bidding on the project, or undertaking construction on the site should make their own interpretation of the factual borehole information, and establish their own conclusions as to how the subsurface conditions may affect their work.

The survey elevations in the report were obtained by Landtek Limited or others, and are strictly for use by Landtek in the preparation of the geotechnical report. The elevations should not be used by any other parties for any other purpose.

Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. Landtek Limited accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions taken based on this report.

This report does not reflect environmental issues or concerns related to the property unless otherwise stated in the report. The design recommendations given in the report are applicable only to the project described in the text and then only if constructed substantially in accordance with the details stated in this report. Since all details of the design may not be known, it is recommended that Landtek Limited be retained during the final design stage to verify that the design is consistent with the report recommendations, and that the assumptions made in the report are still valid.

APPENDIX B
SYMBOLS AND TERMS USED IN THE REPORT



RELATIVE PROPORTIONS

Term	Range
Trace	0 - 5%
A Little	5 – 15%
Some	15 – 30%
With	30 – 50%

CLASSIFICATION BY PARTICLE SIZE

Boulder ---------- > 200 mm
Cobble ---------- 80 mm – 200 mm
Gravel -
Coarse ---------- 19 mm – 80 mm
Fine ---------- 4.75 mm – 19 mm
Sand -
Coarse ---------- 4.75 mm – 2 mm
Medium -------- 2 mm – 0.425 mm
Fine ---------- 0.425 mm – 0.75 mm
Silt ---------- 0.075 mm – 0.002 mm
Clay ---------- < 0.002 mm

DENSITY OF NON-COHESIVE SOILS

Descriptive Term	Relative Density	Standard Penetration Test
Very Loose	0 – 15%	0 – 4 Blows Per 300 mm Penetration
Loose	15 – 35%	4 – 10 Blows Per 300 mm Penetration
Compact	35 – 65%	10 – 30 Blows Per 300 mm Penetration
Dense	65 – 85%	30 – 50 Blows Per 300 mm Penetration
Very Dense	85 – 100%	Over 50 Blows Per 300 mm Penetration

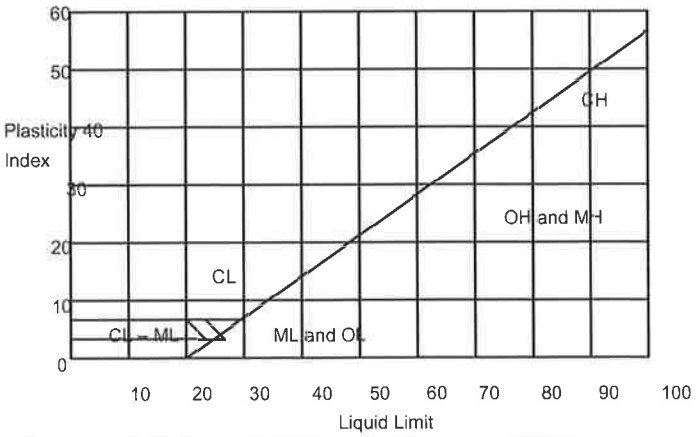
CONSISTENCY OF COHESIVE SOILS

Descriptive Term	Undrained Shear Strength kPa (psf)	N Value Standard Penetration Test	Remarks
Very Soft	< 12 (< 250)	< 2	Can penetrate with fist
Soft	12 – 25 (250 – 500)	2 – 4	Can indent with fist
Firm	25 – 50 (500 –1000)	4 – 8	Can penetrate with thumb
Stiff	50 – 100 (1000 – 2000)	8 – 15	Can indent with thumb
Very Stiff	100 – 200 (2000 – 4000)	15 – 30	Can indent with thumb-nail
Hard	> 200 (> 4000)	> 30	Can indent with thumb-nail

Notes: 1. Relative density determined by standard laboratory tests.
2. N value – blows/300 mm penetration of a 623 N (140 Lb.) hammer falling 760 mm (30 in.) on a 50 mm O.D. split spoon soil sampler. The split spoon sampler is driven 450 mm (18 in.) or 610 mm (24 in.). The "N" value is the Standard Penetration Test (SPT) value and is normally taken as the number of blows to advance the sampler the last 300 mm.

APPENDIX B CONTINUED
CLASSIFICATION OF SOILS FOR ENGINEERING PURPOSES
ASTM Designation: D 2487 - 69 AND D 2488 – 69
(Unified Soil Classification System)

Major Divisions			Group Symbols	Typical Names	Classification Criteria	
Coarse-grained soils More than 50% retained on No. 200 sieve *	Gravels 50% or more of coarse fraction retained on No. 4 sieve	Clean gravels	GW	Well-graded gravels and gravel-sand mixtures, little or no fines	Classification on basis of percentage of fines Less than 5% pass No. 200 sieve . . . . . GW, GP, SW, SP More than 12% pass No. 200 sieve . . . . . GM, GC, SM, SC 5 to 12% pass No.200 sieve . . . . . Borderline classifications requiring use of dual symbols	C_u=D60/D10 greater than 4; $C_z = (D30)^2/(D10xD60)$ between 1 and 3
			GP	Poorly graded gravels and gravel-sand mixtures, little or no fines		Not meeting both criteria for GW
		Gravels with fines	GM	Silty gravels, gravel-sand-silt mixtures	Atterberg limits below "A" line or P.I. less than 4	Atterberg limits plotting in hatched area are borderline classifications requiring use of dual symbols
			GC	Clayey gravels, gravel-sand-clay mixtures	Atterberg limits above "A" line with P.I. greater than 7	
	Sands More than 50% of coarse fraction passes No. 4 sieve	Clean Sands	SW	Well-graded sands and gravelly sands, little or no fines		C_u=D60/D10 greater than 6; $C_z = (D30)^2/(D10xD60)$ between 1 and 3
			SP	Poorly graded sands and gravelly sands, little or no fines		Not meeting both criteria for SW
		Sands with fines	SM	Silty sands, sand-silt mixtures	Atterberg limits below "A" line or P.I. less than 4	Atterberg limits plotting in hatched area are borderline classifications requiring use of dual symbols
			SC	Clayey sands, sand-clay mixtures	Atterberg limits above "A" line with P.I. greater than 7	
Fine-grained soils 50% or more passes No. 200 sieve *	Silts and clays Liquid limit 50% or less		ML	Inorganic silts, very fine sands, rock flour, silty or clayey fine sands	Plasticity Chart For classification of fine-grained soils and fine fraction of coarse-grained soils. Atterberg limits plotting in hatched area are borderline classifications requiring use of dual symbols. Equation of A-line: PI=0.73 (LL-20)	
			CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silts		
			OL	Organic silts and organic silts of low plasticity		
	Silts and clays Liquid limit greater than 50%		MH	Inorganic silts, micaceous or diatomaceous fine sands or silts, elastic silts		
			CH	Inorganic clays of high plasticity, fat clays		
			OH	Organic clays of medium to high plasticity		
	Highly organic soils		Pt	Peat, much and other highly organic soils	* Based on the material passing the 3 in. (76mm) sieve.	



APPENDIX C

DRAWING 1 - SITE PLAN SHOWING BOREHOLE LOCATIONS

LOGS OF BOREHOLES





Key Plan - NTS

LEGEND

Approximate locations of boreholes drilled by Landtek Limited on May 8, 2017.

NOTES

1. Base plan provided by google maps.
2. Borehole locations are considered approximate.

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DRAWING:	Borehole Location Plan		
PROJECT:	Geotechnical Investigation Report Hospital Drive, St. Catharines, Ontario		
SCALE:	NTS	**PROJECT NO.**	17118
DATE:	June, 2017	**DRAWING NO.**	1

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LOG OF BOREHOLE NO. 1

Project No.:	17118	Drill Date:	May 8, 2017
Project:	Geotechnical Investigation Report	Drill Method:	[x] solid stem [ ] hollow stem [ ] vibratory
Location:	Hospital Drive, St. Catharines, Ontario	Datum:	Geodetic (Approximate)

Material Description	Symbol	Elev. Depth	Samples No.	Samples Type	SPT "N" Value	Soil Moisture (%)	GWL	Monitor Details	Test Data
Ground Surface		99.8							
±100 mm of Asphalt		0.0							
sand and gravel fill (±400 mm)		99.3							
CLAYEY SILT TILL trace gravel, trace iron staining, greyish brown, very stiff, moist 0.5 m to 1.2 m: stratified, some grey mottling, trace white specks		0.5	1	SS	19	18			
1.5 m to 5.0 m: homogeneous, trace silt lens			2	SS	27	18			
			3	SS	22	19			
			4	SS	20	22			
3.8 m to 5.0 m: stiff to very stiff			5	SS	15	20			
			6	SS	15	22			
		94.8							
END OF BOREHOLE AT TARGET DEPTH		5.0							

Scale (m): 0.0, -0.5, -1.0, -1.5, -2.0, -2.5, -3.0, -3.5, -4.0, -4.5, -5.0, -5.5, -6.0

SPT "N" Value: 0 25 50 75 100

Soil Moisture (%): 0 25 50

Notes:
1. On completion, borehole open to 3.0 m.
2. No groundwater encountered.

PP = pocket penetrometer TCV = total combustible vapour BRD = bulk relative density
PL = plastic limit LL = liquid limit PI = plasticity index FV = field vane LV = lab vane VS = vane sensitivity

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LOG OF BOREHOLE NO. 2

Project No.:	17118	Drill Date:	May 8, 2017
Project:	Geotechnical Investigation Report	Drill Method:	[x] solid stem [ ] hollow stem [ ] vibratory
Location:	Hospital Drive, St. Catharines, Ontario	Datum:	Geodetic (Approximate)

Material Description	Symbol	Elev. Depth	Samples No.	Samples Type	Scale (m)	SPT "N" Value	Soil Moisture (%)	GWL	Monitor Details	Test Data
Ground Surface		99.9								
±100 mm of Asphalt		0.0								
sand and gravel fill (500 mm)										
water seepage at 0.6 m		99.3								
CLAYEY SILT TILL trace gravel, trace iron staining, greyish brown, very stiff, moist		0.6	1	SS		21	19			
0.6 m to 1.2 m: trace grey mottling, trace white crystals			2	SS		22	20			
1.3 m to 4.5 m: homogeneous			3	SS		24	20			
3.0 m to 4.5 m: stiff to very stiff			4	SS		15	22			
			5	SS						
		95.4								
SILTY CLAY TILL trace gravel, trace iron staining, stiff, low to medium plastic, greyish brown, moist		4.5	6	SS		14	23			
		94.9								
END OF BOREHOLE AT TARGET DEPTH		5.0								

SPT "N" Value: 0 25 50 75 100 | Soil Moisture (%): 0 25 50 | Scale (m): 0.0, -0.5, -1.0, -1.5, -2.0, -2.5, -3.0, -3.5, -4.0, -4.5, -5.0, -5.5, -6.0

Notes: 1. On completion, borehole open to 3.0 m.
2. No groundwater encountered.

PP = pocket penetrometer TCV = total combustible vapour BRD = bulk relative density
PL = plastic limit LL = liquid limit PI = plasticity index FV = field vane LV = lab vane VS = vane sensitivity

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