Geotechnical Engineering

Environmental Engineering

Hydrogeology

Geological Engineering

Materials Testing

Building Science

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Geotechnical Investigation

Proposed Mixed Use Development
5731 Hazeldean Road
Ottawa, Ontario

Prepared For

Nautical Lands Group

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Report PG3710-1

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APPENDICES

1.0 Introduction

Paterson Group (Paterson) was commissioned by Nautical Lands Group to conduct a geotechnical investigation for the proposed mixed use development to be located at 5731 Hazeldean Road in the City of Ottawa, Ontario (refer to Figure 1 - Key Plan in Appendix 2).

The objectives of the current investigation were to:

- ☐ determine the subsurface conditions by means of boreholes.
- ☐ provide geotechnical recommendations for the design of the proposed development including construction considerations which may affect the design.

The following report has been prepared specifically and solely for the aforementioned project. This report contains geotechnical findings and includes recommendations pertaining to the design and construction of the proposed development as understood at the time of writing this report.

Investigating the presence or potential presence of contamination on the subject property was not part of the scope of work of this present investigation. Therefore, the present report does not address environmental issues.

2.0 Proposed Development

The proposed development will consist of four multi-storey buildings with mixed use. The proposed buildings will include two 4 storey retirement buildings along the south-west property line and the north-east property line. Also, a two storey office building in the south corner and a two storey retail building in the east corner. One level of underground parking is expected to be constructed at the proposed development. At-grade parking areas, access lanes, and landscaped areas are also anticipated as part of the development.

3.0 Method of Investigation

3.1 Field Investigation

Field Program

The field program for the investigation was carried out from January 13, 2016 to January 18, 2016. At that time, 25 boreholes were drilled to a maximum depth of 6.7 m. The borehole locations were distributed in a manner to provide general coverage of the subject site. The locations of the boreholes are shown on Drawing PG3710-1 - Test Hole Location Plan included in Appendix 2.

The boreholes were drilled using a track-mounted auger drill rig operated by a two-person crew. All fieldwork was conducted under the full-time supervision of Paterson personnel with the direction of a senior engineer. The drilling procedure consisted of augering to the required depths at the selected locations, sampling and testing the overburden.

Sampling and In Situ Testing

Soil samples were recovered from a 50 mm diameter split-spoon or the auger flights. The split-spoon and auger samples were classified on site and placed in sealed plastic bags. All samples were transported to our laboratory. The depths at which the split-spoon and auger samples were recovered from the boreholes are presented as SS and AU, respectively, on the Soil Profile and Test Data sheets.

Standard Penetration Tests (SPT) were conducted and recorded as “N” values on the Soil Profile and Test Data sheets. The “N” value is the number of blows required to drive the split-spoon sample 300 mm into the soil after the initial penetration of 150 mm using a 63.5 kg hammer falling from a height of 760 mm.

Undrained shear strength tests were conducted in cohesive soils with a field vane apparatus.

The overburden thickness was evaluated by a dynamic cone penetration test (DCPT) at some borehole locations. The DCPT consists of driving a steel drill rod, equipped with a 50 mm diameter cone at the tip, using a 63.5 kg hammer falling from a height of 760 mm. The number of blows required to drive the cone into the soil is recorded for each 300 mm increment.

The subsurface conditions observed in the boreholes were recorded in detail in the field. The soil profiles are presented on the Soil Profile and Test Data sheets in Appendix 1.

Groundwater

Flexible polyethylene standpipes were installed in 14 boreholes to permit groundwater results subsequent to the sampling program completion.

Sample Storage

All samples will be stored in the laboratory for a period of one month after issuance of this report at which time the samples will be discarded unless otherwise directed.

3.2 Field Survey

The borehole locations were selected by Paterson and surveyed by Annis, O'Sullivan, Vollebekk LTD. The locations and ground surface elevation at the boreholes are presented on Drawing PG3710-1 - Test Hole Location Plan in Appendix 2.

3.3 Analytical Testing

One soil sample was submitted for analytical testing to assess the potential for exposed ferrous metals and the sulphate potential against subsurface concrete structures. The results are discussed further in Subsection 6.7.

4.0 Observations

4.1 Surface Conditions

Generally, the subject site is grass and tree covered, relatively flat and approximately at grade with adjacent roadways and properties. Poole Creek Ravine runs across the north-west corner of the site.

4.2 Subsurface Profile

Generally, the subsurface profile at the boreholes consists of a topsoil layer followed by a stiff to very stiff brown silty clay layer, which is underlain by loose to compact sandy silt and a compact to dense glacial till. A layer of firm silty clay was encountered below the stiff brown silty clay layer in BH 5, BH 6, BH 7, BH 10, BH 11, BH 12 and BH 14 at an approximate elevation of 99.50 m and below.

Practical refusal to DCPT was encountered at 8.71 and 10.01 m in BH 1 and BH 6, respectively. Also, practical refusal to auger was encountered in BH 7, BH 14 BH 16 to BH 21 and BH 23 to BH 25 at depths ranging depth 2.8 m to 5.9 m.

Specific details of the soil profile at each test hole location are presented on the Soil Profile and Test Data sheets provided in Appendix 1.

Based on available geological mapping, the subject site consists of interbedded dolostone and limestone of the Gull River formation and an approximate drift thickness of 2 to 15 m.

4.3 Groundwater

The measured groundwater levels at the borehole locations are presented in Table 1. Groundwater readings could be influenced by surface water infiltrating the backfilled boreholes. Also, groundwater levels are subject to seasonal fluctuations and could vary at the time of construction.

Table 1 - Groundwater Elevation Summary

Test Hole Number	Ground Elevation, m	Groundwater Levels, m		Recording Date
		Depth	Elevation	
BH 1	102.93	1.16	101.77	January 28, 2016
BH 3	103.07	DRY	n/a	January 28, 2016
BH 4	103.15	DRY	n/a	January 28, 2016
BH 6	103.25	3.06	100.19	January 28, 2016
BH 7	102.91	3.52	99.39	January 28, 2016
BH 9	103.12	1.43	101.69	January 28, 2016
BH 11	103.23	2.39	100.84	January 28, 2016
BH 13	103.14	4.53	98.58	January 28, 2016
BH 14	103.04	3.63	99.41	January 28, 2016
BH 16	103.19	3.67	99.52	January 28, 2016
BH 18	103.40	1.23	102.17	January 28, 2016
BH 21	103.14	1.83	101.31	January 28, 2016
BH 23	103.28	1.54	101.74	January 28, 2016
BH 25	103.52	2.95	100.57	January 28, 2016

Note: Groundwater levels are subject to seasonal fluctuations and therefore levels could differ at the time of construction. The borehole locations were selected by Paterson and surveyed by Annis, O'Sullivan, Vollebekk LTD.

5.0 Discussion

5.1 Geotechnical Assessment

From a geotechnical perspective, the subject site is adequate for the proposed mixed use development. The proposed buildings will be founded on shallow foundations placed on the native stiff silty clay, glacial till or bedrock bearing surface.

Due to the presence of the silty clay layer, the subject site will be subjected to grade raise restrictions. If higher than permissible grade raises are required, preloading with or without a surcharge, lightweight fill and/or other measures could reduce the risks of unacceptable long-term post construction total and differential settlements.

Depending on the extent of the underground parking garage and potential grade raise, the top portion of the bedrock may be encountered during excavation and construction. All contractors should be prepared to remove some bedrock within the southwest portion of the subject site. If a contractor requires more information on the bedrock quality, additional boreholes could be drilled into the bedrock to determine characteristics.

The above and other considerations are discussed in the following sections.

5.2 Site Grading and Preparation

Stripping Depth

Topsoil, deleterious fill and soils containing significant amounts of organics, should be stripped from under any buildings and other settlement sensitive structures. All bearing surfaces and subgrade soils should be protected during construction to ensure an undisturbed surface is maintained during site preparation activities.

Fill Placement

Fill placed for grading beneath the structure(s) or other settlement sensitive areas should consist, unless otherwise specified, of clean imported granular fill, such as Ontario Provincial Standard Specifications (OPSS) Granular A or Granular B Type II. This material should be tested and approved prior to delivery to the site. The fill should be placed in maximum 300 mm thick lifts and compacted to 98% of standard Proctor maximum dry density (SPMDD).

Non-specified existing fill along with site-excavated soil can be placed as general landscaping fill where surface settlement is a minor concern. The backfill materials should be spread in thin lifts and at a minimum compacted by the tracks of the spreading equipment to minimize voids. If the non-specified backfill is to be placed to increase the subgrade level for areas to be paved, the fill should be compacted in maximum 300 mm lifts and compacted to 95% of SPMDD. Non-specified existing fill and site-excavated soils are not suitable for placement as backfill against foundation walls unless a composite drainage blanket connected to a perimeter drainage system is provided.

5.3 Foundation Design

Shallow Foundation

Using continuously applied loads, footings for the proposed buildings can be designed with the following bearing resistance values presented in Table 2.

Table 2 - Bearing Resistance Values

Bearing Surface	Bearing Resistance Value at SLS (kPa)	Factored Bearing Resistance Value at ULS (kPa)
Stiff to Very Stiff Silty Clay	150	250
Firm Silty Clay	75	125
Compact to Dense Glacial Till	150	250

Note: Strip footings, up to 2 m wide, and pad footings, up to 3 m wide, placed over an undisturbed, silty clay bearing surface can be designed using the abovenoted bearing resistance values. The firm silty clay bearing resistance values should be considered for footings placed below an elevation of approximately 99.50 m within the northeastern portion of the subject site.

The bearing resistance values are provided on the assumption that the footings are placed on undisturbed soil bearing surfaces. An undisturbed soil bearing surface consists of one from which all topsoil and deleterious materials, such as loose, frozen or disturbed soil, whether in situ or not, have been removed, in the dry, prior to the placement of concrete for footings.

Bearing resistance values for footing design should be confirmed at the time of construction.

The above-noted bearing resistance value at SLS will be subjected to potential post-construction total and differential settlements of 25 and 20 mm, respectively. A geotechnical resistance factor of 0.5 was applied to the above noted bearing resistance value at ULS.

For the parking garage structure, footings may be founded partially on bedrock on the west portion and on firm silty clay on the east portion. Concrete filled trenches that extend through the silty clay to the dense glacial till deposit. Provided the trenches can be completed with stable excavations and in dry condition, the bearing resistance value will be 150 kPa (SLS) and 250 kPa (ULS) for the concrete fill trench footings founded on the dense glacial till.

Lateral Support

The bearing medium under footing-supported structures is required to be provided with adequate lateral support with respect to excavations and different foundation levels. Adequate lateral support is provided to an engineered fill, stiff silty clay or glacial till above the groundwater table when a plane extending horizontally and vertically from the underside of the footing at a minimum of 1.5H:1V passing through in situ soil of the same or higher bearing capacity as the bearing medium soil.

Footings placed on a clean surface sounded bedrock surface can be designed using a factored bearing resistance value at ultimate limit states (ULS) of **1,000 kPa** incorporating a geotechnical resistance factor of 0.5 was applied to the bearing resistance value at ULS and a bearing resistance value at serviceability limit states (SLS) of **500 kPa**.

A clean, surface-sounded bedrock bearing surface should be free of loose materials, and have no near surface seams, voids, fissures or open joints which can be detected from surface sounding with a rock hammer.

Footings bearing on an acceptable bedrock bearing surface and designed for the bearing resistance values provided herein will be subjected to negligible potential post-construction total and differential settlements.

Permissible Grade Raise Restriction

Based on the current borehole hole information, a permissible grade raise restriction of **1 m** is recommended for the subject site. A post-development groundwater lowering of 0.5 m was assumed.

If higher grade raises and/or higher loading conditions are required, post construction settlements can be reduced by several methods. The following options can be considered:

- ☐ preloading and surcharging
- ☐ lightweight fill (LWF)

5.4 Design for Earthquakes

Based on current information, the foundations for the proposed buildings can be designed using a seismic site response **Class D** as defined in the Ontario Building Code 2012 (OBC 2012; Table 4.1.8.4.A). A higher site class, such as Class C, may be applicable for foundation design. However, a site specific seismic shear wave velocity test is recommended to confirm the higher site class. Based on the long-term groundwater level, undrained shear strength values noted throughout the silty clay deposit and depth of the silty clay/clayey silt deposit, the underlying soils are not considered to be susceptible to liquefaction.

5.5 Basement Slab

With the removal of all topsoil and deleterious fill, containing organic matter, within the proposed building footprint, the undisturbed native soil surface is considered acceptable subgrade to commence backfilling for floor slab construction. Any soft areas should be removed and backfilled with appropriate backfill material. OPSS Granular B Type II, with a maximum particle size of 50 mm, are recommended for backfilling below the floor slab. The upper 200 mm of sub-slab fill is recommended to consist of 19 mm clear crushed stone.

The subgrade is expected to be susceptible to disturbance by construction traffic (labourers and equipment). A mud slab or granular pad, approved by the geotechnical consultant at the time of construction, should be considered to ensure that disturbance does not occur during construction activities.

5.6 Basement Wall Design

There are several combinations of backfill materials and retained soils that could be applicable for the proposed structure's basement walls. However, the conditions can be well-represented by assuming the retained soil consists of a material with an angle of internal friction of 30 degrees and a dry unit weight of 20 kN/m^3.

The foundation wall is anticipated to be provided with a perimeter drainage system; therefore, the retained soils should be considered drained. For the undrained conditions, the applicable effective unit weight of the retained soil can be designed with13 kN/m^3. A hydrostatic pressure should be added to the total static earth pressure when calculating the effective unit weight. The total earth pressure (P_{AE}) includes both the static earth pressure component (P_o) and the seismic component (ΔP_{AE}).

Two distinct conditions, static and seismic, should be reviewed for design calculations. The parameters for design calculations for the two conditions are presented below.

Static Conditions

The static horizontal earth pressure (p_o) could be calculated with a triangular earth pressure distribution equal to $K_o \cdot \gamma \cdot H$ where:

K_o = at-rest earth pressure coefficient of the applicable retained soil, 0.5
γ = unit weight of fill of the applicable retained soil (kN/m^3)
H = height of the wall (m)

An additional pressure with a magnitude equal to $K_o \cdot q$ and acting on the entire height of the wall should be added to the above formula for any surcharge loading, q (kPa), that may be placed at ground surface adjacent to the wall. The surcharge pressure should only be applicable for static analyses and not be calculated in conjunction with the seismic loading case. Actual earth pressures could be higher than the “at-rest” case if care is not exercised during the compaction of the backfill materials to maintain a minimum separation of 0.3 m from the walls with the compaction equipment.

Seismic Conditions

The total seismic force (P_{AE}) includes both the earth force component (P_o) and the seismic component (ΔP_{AE}).

The seismic earth force (ΔP_{AE}) could be calculated using $0.375 \cdot a_c \cdot \gamma \cdot H^2/g$ where:

a_c = $(1.45-a_{max}/g)a_{max}$
γ = unit weight of fill of the applicable retained soil (kN/m^3)
H = height of the wall (m)
g = gravity, 9.81 m/s^2

The peak ground acceleration, (a_{max}), for the Ottawa area is 0.32g according to OBC 2012. The vertical seismic coefficient is assumed to be zero. The earth force component (P_o) under seismic conditions could be calculated using $P_o = 0.5\ K_o\ \gamma\ H^2$, where $K_o = 0.5$ for the soil conditions presented above.

The total earth force (P_{AE}) is considered to act at a height, h (m), from the base of the wall, where:

$$h = \{P_o \cdot (H/3) + \Delta P_{AE} \cdot (0.6 \cdot H)\}/P_{AE}$$

The earth forces calculated are unfactored. For the ULS case, the earth loads should be factored as live loads, as per OBC 2012.

5.7 Pavement Structure

For design purposes, the pavement structure presented in the following tables could be used for the design of car only parking areas and access lanes, if required.

Table 3 - Recommended Pavement Structure - Car Only Parking Areas

Thickness (mm)	Material Description
50	**Wear Course** - HL-3 or Superpave 12.5 Asphaltic Concrete
150	**BASE** - OPSS Granular A Crushed Stone
300	**SUBBASE** - OPSS Granular B Type II
	SUBGRADE - In situ soil, or OPSS Granular B Type I or II material placed over in situ soil

**Table 4 - Recommended Pavement Structure
Access Lanes and Heavy Truck Parking Areas**

Thickness (mm)	Material Description
40	**Wear Course** - HL-3 or Superpave 12.5 Asphaltic Concrete
50	**Binder Course** - HL-8 or Superpave 19.0 Asphaltic Concrete
150	**BASE** - OPSS Granular A Crushed Stone
450	**SUBBASE** - OPSS Granular B Type II
	SUBGRADE - In situ soil, or OPSS Granular B Type I or II material placed over in situ soil

Minimum Performance Graded (PG) 58-34 asphalt cement should be used for this project.

If soft spots develop in the subgrade during compaction or due to construction traffic, the affected areas should be sub-excavated and replaced with OPSS Granular B Type II material.

The pavement granular base and subbase should be placed in maximum 300 mm thick lifts and compacted to a minimum of 98% of the SPMDD.

Pavement Design over Parking Garage

All pavement designs overtop of the parking garage area should be approved by the structural engineer to ensure loads are acceptable with the parking garage structure design.

The current details for above the parking garage are unknown. However, upon request, Paterson can provide details and information if hardscaping is expected to be placed over the proposed parking garage structure.

Pavement Structure Drainage

Satisfactory performance of the pavement structure is largely dependent on the contact zone between the subgrade material and the base stone in a dry condition. Failure to provide adequate drainage under conditions of heavy wheel loading can result in the fine subgrade soil being pumped into the voids in the stone subbase, thereby reducing load carrying capacity.

Due to the impervious nature of the subgrade materials consideration should be provided to installing subdrains during the pavement construction. The subdrains should extend in four orthogonal directions and longitudinally when placed along a curb. The clear crushed stone surrounding the drainage lines or the pipe, should be wrapped with suitable filter cloth. The subdrain inverts should be approximately 300 mm below subgrade level and placed in accordance with City of Ottawa standard drawing R1. The subgrade surface should be shaped to promote water flow to the drainage lines.

6.0 Design and Construction Precautions

6.1 Foundation Drainage and Backfill

Water Infiltration Control Measures at Founding Level

Most of the lower parking level is anticipated to be founded on a silty clay or glacial till layer. At the time of construction, an inspection is recommended to be completed by the geotechnical engineer to determine if any significant groundwater infiltration is noted through the subsurface profile, at the time of construction. If any significant water infiltration from excavation side walls or excavation base is observed, a waterproofing membrane will be recommended to reduce the volume of water infiltration to allow for a relatively dry excavation base.

Underfloor Drainage

Underfloor drainage is recommended to control water infiltration due to potential groundwater infiltration at the proposed founding elevation. For design purposes, Paterson recommends, a 150 mm in diameter perforated pipes be placed at 6 m centres. The spacing of the underfloor drainage system should be confirmed at the time of completing the excavation when water infiltration can be better assessed.

Foundation Drainage

A perimeter foundation drainage system is recommended to be provided for proposed structures. The system should consist of a 100 to 150 mm diameter, geotextile-wrapped, perforated, corrugated, plastic pipe, surrounded on all sides by 150 mm of 10 mm clear crushed stone, placed at the footing level around the exterior perimeter of the structure. The pipe should have a positive outlet, such as a gravity connection to the storm sewer.

Backfill against the exterior sides of the foundation walls should consist of freedraining, non frost susceptible granular materials. The site materials will be frost susceptible and, as such, are not recommended for placement as backfill unless a composite drainage system (such as system Platon or Miradrain G100N) connected to a drainage system is provided.

6.2 Protection of Footings Against Frost Action

Perimeter footings of heated structures are recommended to be protected against the deleterious effects of frost action. A minimum of 1.5 m of soil cover alone, or a combination of soil cover and foundation insulation should be provided.

Exterior unheated footings, such as isolated exterior piers, are more prone to deleterious movement associated with frost action than the exterior walls of the structure proper and require additional protection, such as soil cover of 2.1 m or a combination of soil cover and foundation insulation.

The parking garage should not require protection against frost action due to the founding depth. Unheated structures, such as the access ramp wall footings, may be required to be insulated against the deleterious effect of frost action. A minimum of 2.1 m of soil cover alone, or a minimum of 0.6 m of soil cover, in conjunction with foundation insulation, should be provided.

6.3 Excavation Side Slopes

Temporary Side Slopes

The temporary excavation side slopes should either be excavated to acceptable slopes or retained by shoring systems from the beginning of the excavation until the structure is backfilled.

The excavation side slopes above the groundwater level extending to a maximum depth of 3 m should be excavated at 1H:1V or shallower. The shallower slope is required for excavation below groundwater level. The subsurface soil is considered to be mainly Type 2 and 3 soil according to the Occupational Health and Safety Act and Regulations for Construction Projects.

Excavated soil should not be stockpiled directly at the top of excavations and heavy equipment should maintain safe working distance from the excavation sides.

Slopes in excess of 3 m in height should be periodically inspected by the geotechnical consultant in order to detect if the slopes are exhibiting signs of distress.

A trench box is recommended to be installed at all times to protect personnel working in trenches with steep or vertical sides. Services are expected to be installed by “cut and cover” methods and excavations should not be remain exposed for extended periods of time.

Temporary Shoring

Temporary shoring may be required to complete the excavation of the overburden soil where insufficient room is available for open cut methods. The shoring requirements should be reviewed by the contractor completing the excavation work and designed by a structural engineer, specializing in shoring design. The shoring will depend on the depth of the excavation, the proximity of the adjacent structures and the elevation of the adjacent building foundations, roadways and underground services. Additional recommendations and parameters can be provided upon request.

6.4 Pipe Bedding and Backfill

Bedding and backfill materials should be in accordance with the most recent Material Specifications and Standard Detail Drawings from the Department of Public Works and Services, Infrastructure Services Branch of the City of Ottawa.

A minimum of a 150 mm of OPSS Granular A should be placed for pipe bedding for sewer and water pipes for a soil subgrade. The bedding thickness should be increased to 300 mm for areas where the subgrade consists of bedrock. The bedding should extend to the spring line of the pipe. Cover material, from the spring line to at least 300 mm above the obvert of the pipe should consist of OPSS Granular A. The bedding and cover materials should be placed in maximum 300 mm thick lifts compacted to a minimum of 95% of the SPMDD.

The site excavated material may be placed above cover material if the excavation operations are completed in dry weather conditions and the site excavated material is approved by the geotechnical consultant. All cobbles greater than 200 mm in the longest dimension should be removed prior to the site materials being reused.

Where hard surface areas are considered above the trench backfill, the trench backfill material within the frost zone (about 1.8 m below finished grade) should match the soils exposed at the trench walls to reduce differential frost heaving. The trench backfill should be placed in maximum 225 mm thick loose lifts and compacted to a minimum of 95% of the SPMDD. Within the frost zone (1.8 m below finished grade), non frost susceptible materials should be used when backfilling trenches below the original bedrock level.

If the trench excavations are within the silty clay layer only, clay seals should be provided in the service trenches to reduce long-term lowering of the groundwater level. The seals should be a minimum of 1.5 m long (in the trench direction) and should extend from trench wall to trench wall. Generally, the seals should extend from the frost line and fully penetrate the bedding, subbedding and cover material. The barriers should consist of relatively dry and compactable brown silty clay placed in maximum 225 mm thick loose layers and compacted to a minimum of 95% of the SPMDD. The clay seals should be placed at the site boundaries, roadway intersections and at a maximum distance of every 50 m in the service trenches.

6.5 Groundwater Control

Groundwater Control for Building Construction

The contractor should be prepared to direct water away from all bearing surfaces and subgrades, regardless of the source, to prevent disturbance to the founding medium.

Infiltration levels are anticipated to be low to moderate through the excavation face, depending on the local groundwater table and the glacial till gradation throughout the excavation surface. The groundwater infiltration should be controllable with open sumps and pumps.

A temporary MOE permit to take water (PTTW) may be required for this project if more than 50,000 L/day are to be pumped during the construction phase. A minimum of four to five months should be allocated for completion of the application and issuance of the permit by the MOE.

6.6 Winter Construction

Precautions must be provided if winter construction is considered for this project.

Where excavations are completed in proximity of existing structures which may be adversely affected due to the freezing conditions. In particular, where a shoring system is constructed, the soil behind the shoring system will be subjected to freezing conditions and could result in heaving of the structure(s) placed within or above frozen soil. Provisions in the contract documents should be provided to protect the excavation walls from freezing, if applicable.

In the event of construction during below zero temperatures, the founding stratum should be protected from freezing temperatures by the installation of straw, propane heaters and tarpaulins or other suitable means. The excavation base should be insulated from sub-zero temperatures immediately upon exposure and until such time as heat is adequately supplied to the building and the footings are protected with sufficient soil cover to prevent freezing at founding level.

Trench excavations and pavement construction are difficult activities to complete during freezing conditions without introducing frost in the subgrade or in the excavation walls and bottoms. Precautions should be considered if such activities are to be completed during freezing conditions. Additional information could be provided, if required.

6.7 Corrosion Potential and Sulphate

The analytical testing results are presented in Table 5 along with industry standards for the applicable threshold values. The results are indicative that Type 10 Portland cement (Type GU, or normal cement) would be appropriate for this site.

Table 5 - Corrosion Potential

Parameter	Laboratory Results	Threshold	Commentary
	BH 16 - SS 4		
Chloride	<5 µg/g	Chloride content greater than 400 mg/g	Negligible concern
pH	7.63	pH value less than 5.0	Neutral Soil
Resistivity	65.5 ohm.m	Resistivity greater than 1,500 ohm.cm	Low to Moderate Corrosion Potential
Sulphate	15 µg/g	Sulphate value greater than 1 mg/g	Negligible Concern

7.0 Recommendations

A materials testing and observation services program is a requirement for the provided foundation design data to be applicable. The following aspects of the program should be performed by the geotechnical consultant:

❏ Review detailed grading plan(s) from a geotechnical perspective.

❏ Review groundwater conditions at the time of construction to determine if waterproofing is required.

❏ Observation of all bearing surfaces prior to the placement of concrete.

❏ Sampling and testing of the concrete and fill materials used.

❏ Periodic observation of the condition of unsupported excavation side slopes in excess of 3 m in height, if applicable.

❏ Observation of all subgrades prior to backfilling.

❏ Field density tests to determine the level of compaction achieved.

❏ Sampling and testing of the bituminous concrete including mix design reviews.

A report confirming that the construction work has been conducted in general accordance with the above recommendations could be issued, upon request, following the completion of a satisfactory materials testing and observation program by the geotechnical consultant.

8.0 Statement of Limitations

The recommendations provided in the report are in accordance with Paterson's present understanding of the project. Paterson request permission to review the recommendations when the drawings and specifications are completed.

A geotechnical investigation is a limited sampling of a site. Should any conditions encountered during construction differ from the borehole locations, Paterson requests immediate notification to permit reassessment of the recommendations.

The recommendations provided should only be used by the design professionals associated with this project. The recommendations are not intended for contractors bidding on or constructing the project. The latter should evaluate the factual information provided in the report. The contractor should also determine the suitability and completeness for the intended construction schedule and methods. Additional testing may be required for the contractors purpose.

The present report applies only to the project described in this document. Use of this report for purposes other than those described herein or by person(s) other than Nautical Lands Group, or their agent(s) is not authorized without review by Paterson Group for the applicability of our recommendations to the altered use of the report.

Paterson Group Inc.

CBenn

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APPENDIX 1

SOIL PROFILE AND TEST DATA SHEETS

SYMBOLS AND TERMS

ANALYTICAL TEST RESULTS

patersongroup Consulting Engineers

154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Retirement & Commercial Development
5731 Hazeldean Road, Ottawa, Ontario

DATUM Ground surface elevations provided by Annis, O'Sullivan, Vollebekk Ltd.

REMARKS

BORINGS BY CME 55 Power Auger

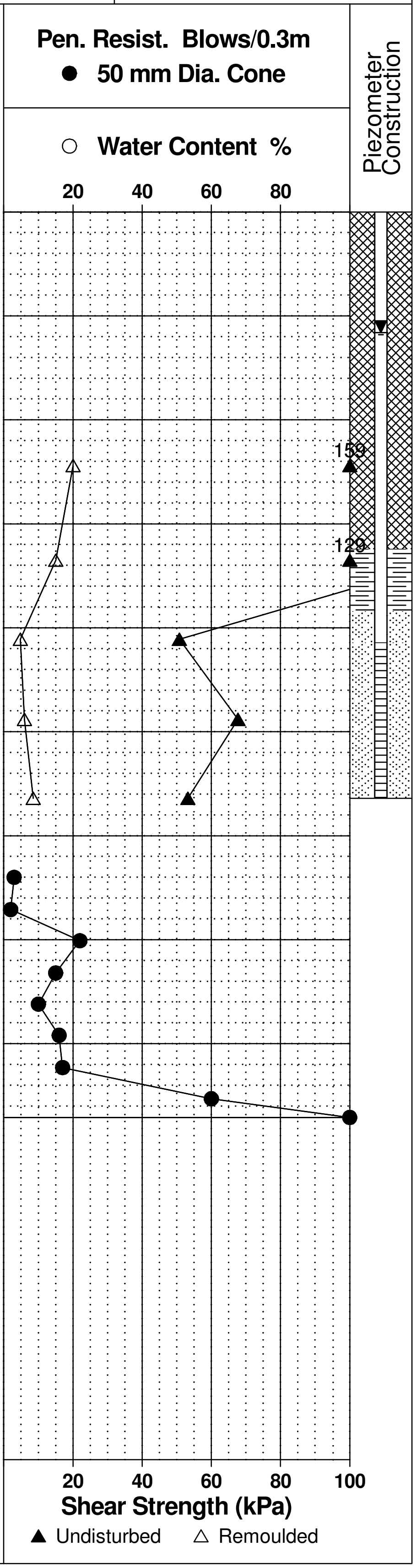
DATE January 18, 2016

FILE NO. PG3710

HOLE NO. BH 1

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD
GROUND SURFACE					
TOPSOIL	0.20				
Very loose, brown **SANDY SILT,** some clay	1.07	SS	1	83	2
Very stiff to stiff, brown **SILTY CLAY,** some sand - grey by 3.7m depth		SS	2	100	2
	6.10				
Dynamic Cone Penetration Test commenced at 6.10m depth	8.71				
End of Borehole Practical refusal to DCPT at 8.71m depth (GWL @ 1.16m-Jan. 28, 2016)					

DEPTH (m)	ELEV. (m)
0	102.93
1	101.93
2	100.93
3	99.93
4	98.93
5	97.93
6	96.93
7	95.93
8	94.93



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Retirement & Commercial Development
5731 Hazeldean Road, Ottawa, Ontario

DATUM Ground surface elevations provided by Annis, O'Sullivan, Vollebekk Ltd.

REMARKS

BORINGS BY CME 55 Power Auger

DATE January 18, 2016

FILE NO. PG3710

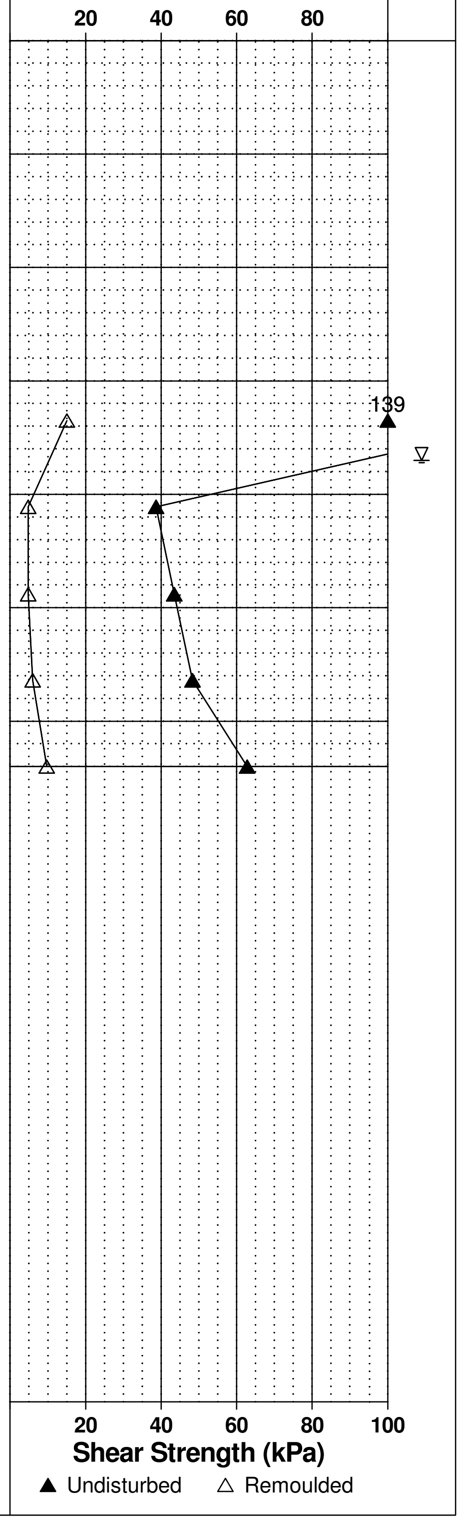
HOLE NO. BH 2

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE							
TOPSOIL 0.25						0	103.02
Very stiff to stiff, brown **SILTY CLAY,** some sand		SS	1	17	5	1	102.02
		SS	2	100	3	2	101.02
		SS	3	100	4	3	100.02
- firm to stiff and grey by 3.7m depth						4	99.02
						5	98.02
6.40						6	97.02
End of Borehole (GWL at 3.7m depth based on field observations)							

Pen. Resist. Blows/0.3m
● 50 mm Dia. Cone

○ Water Content %

Piezometer Construction



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Retirement & Commercial Development
5731 Hazeldean Road, Ottawa, Ontario

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REMARKS

BORINGS BY CME 55 Power Auger

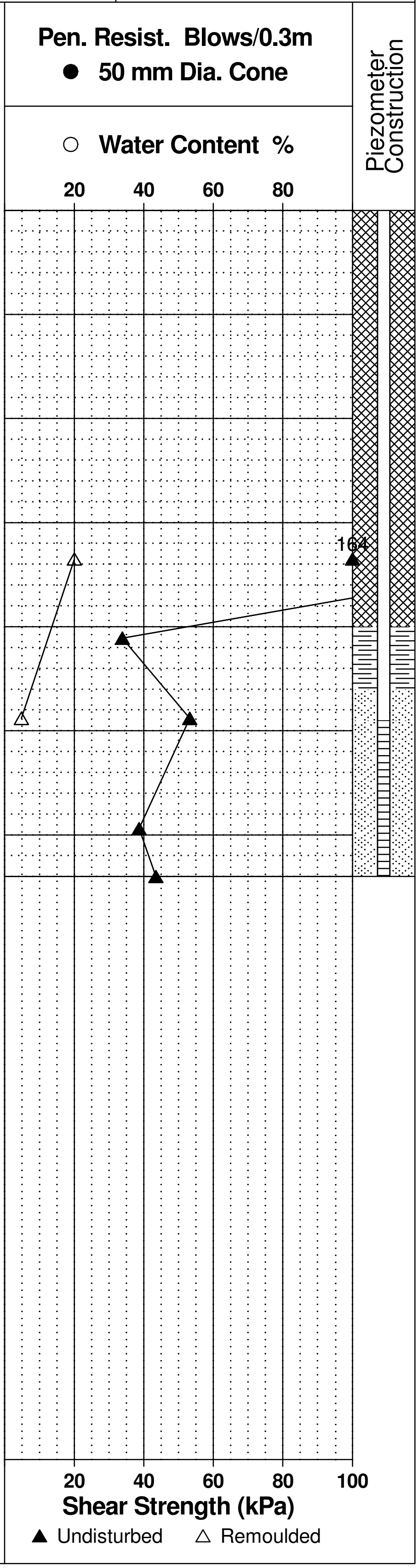
DATE January 18, 2016

FILE NO. PG3710

HOLE NO. BH 3

SOIL DESCRIPTION		SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD
GROUND SURFACE					
TOPSOIL	0.28				
Loose, brown **SANDY SILT,** trace clay	1.27	SS	1	71	5
Very stiff to stiff, brown **SILTY CLAY,** some sand - firm and grey by 3.7m depth	6.40	SS SS	2 3	100 100	4 4
End of Borehole (BH dry - Jan. 28, 2016)					

DEPTH (m)	ELEV. (m)
0	103.07
1	102.07
2	101.07
3	100.07
4	99.07
5	98.07
6	97.07



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Proposed Retirement & Commercial Development
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REMARKS

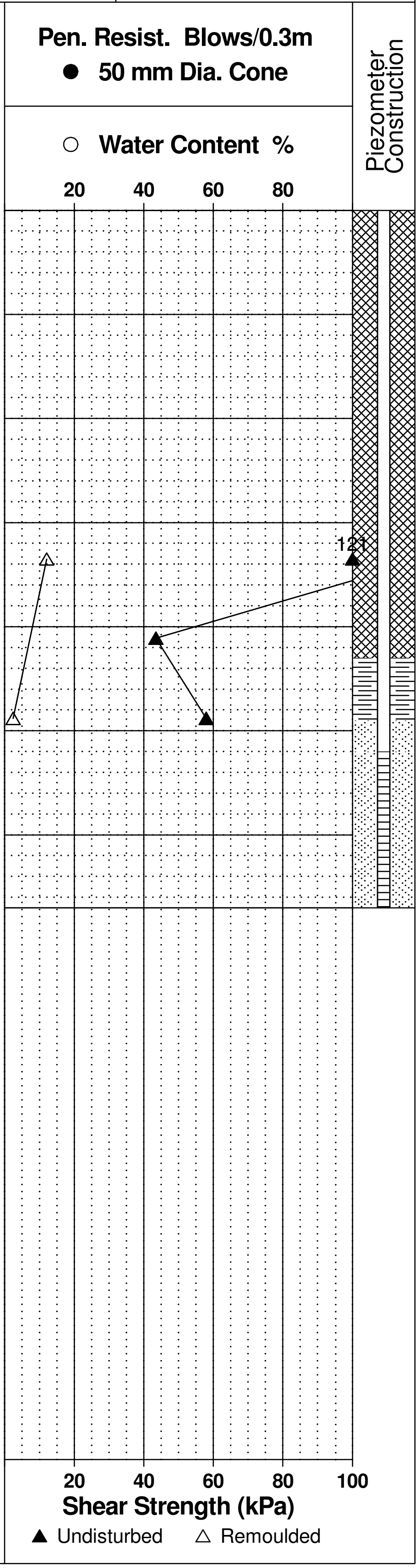
BORINGS BY CME 55 Power Auger

DATE January 18, 2016

FILE NO. PG3710

HOLE NO. BH 4

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	103.15
TOPSOIL 0.25		AU	1				
		SS	2	100	4	1	102.15
		SS	3	100	5	2	101.15
Very stiff to stiff, brown **SILTY CLAY,** some sand		SS	4	100	3	3	100.15
- grey by 4.0m depth						4	99.15
						5	98.15
		SS	5	100	1	6	97.15
6.70		SS	6	100	1		
End of Borehole (BH dry - Jan. 28, 2016)							



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Geotechnical Investigation
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DATUM Ground surface elevations provided by Annis, O'Sullivan, Vollebekk Ltd.

FILE NO. **PG3710**

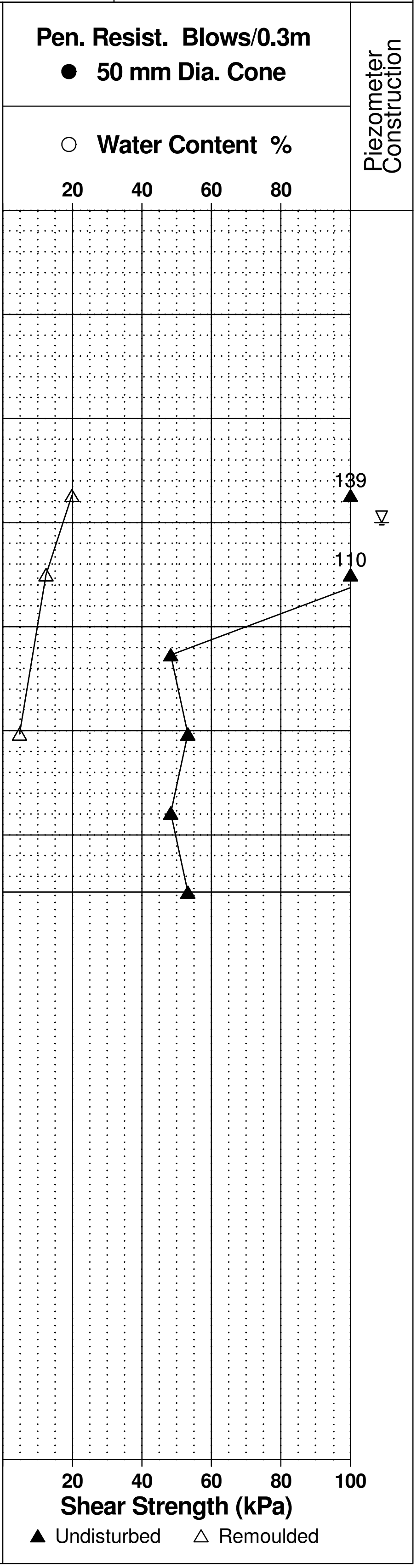
REMARKS

HOLE NO. **BH 5**

BORINGS BY CME 55 Power Auger

DATE January 15, 2016

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE							
TOPSOIL 0.25						0	103.22
		SS	1	25	3	1	102.22
		SS	2	100	3	2	101.22
Very stiff to stiff, brown **SILTY CLAY,** some sand						3	100.22
						4	99.22
- firm to stiff and grey by 4.3m depth						5	98.22
						6	97.22
6.55							
End of Borehole (GWL at 3.0m depth based on field observations)							



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Geotechnical Investigation
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DATUM Ground surface elevations provided by Annis, O'Sullivan, Vollebekk Ltd.

FILE NO. PG3710

REMARKS

HOLE NO. BH 6

BORINGS BY CME 55 Power Auger

DATE January 15, 2016

SOIL DESCRIPTION

GROUND SURFACE

TOPSOIL 0.25

Very stiff to stiff, brown **SILTY CLAY,** some sand

- firm and grey by 4.3m depth

6.55

Dynamic Cone Penetration Test commenced at 6.55m depth

10.01

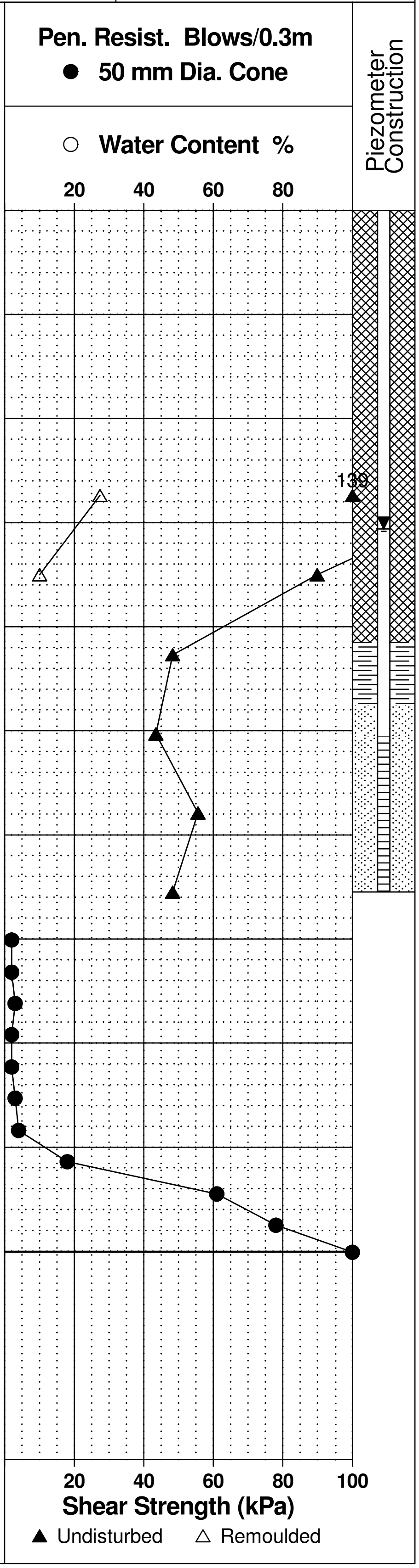
End of Borehole

Practical refusal to DCPT at 10.01m depth

(GWL @ 3.06m-Jan. 28, 2016)

SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD
SS	1	100	7
SS	2	100	4

DEPTH (m)	ELEV. (m)
0	103.25
1	102.25
2	101.25
3	100.25
4	99.25
5	98.25
6	97.25
7	96.25
8	95.25
9	94.25
10	93.25



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SOIL PROFILE AND TEST DATA

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Proposed Retirement & Commercial Development
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FILE NO. PG3710

REMARKS

HOLE NO. BH 7

BORINGS BY CME 55 Power Auger

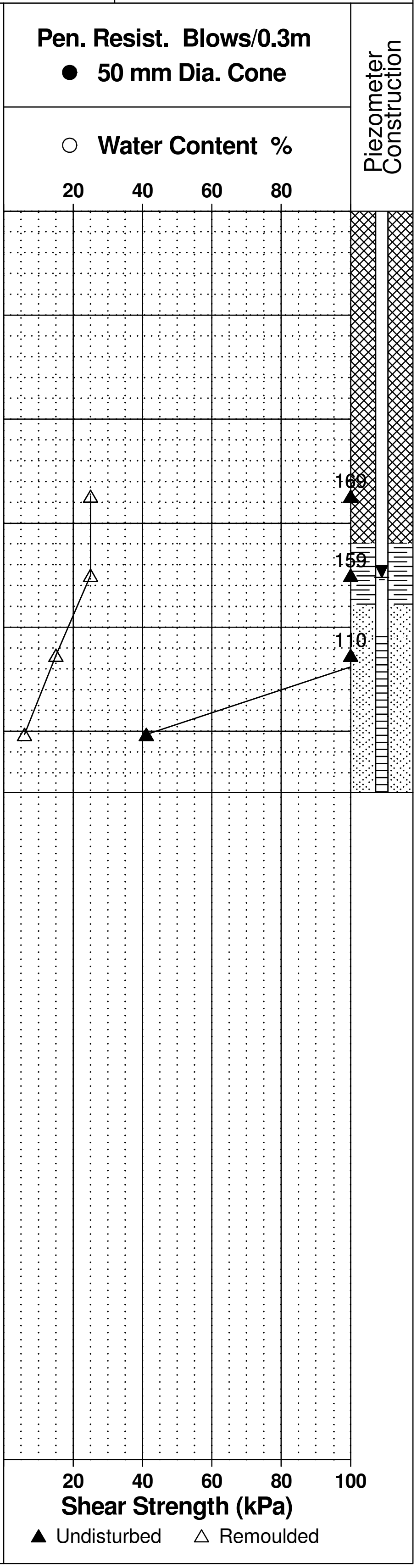
DATE January 14, 2016

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	102.91
TOPSOIL 0.46							
		SS	1	100	4	1	101.91
		SS	2	100	4	2	100.91
Very stiff to stiff, brown **SILTY CLAY,** some sand						3	99.91
						4	98.91
- firm and grey by 4.9m depth		G	3			5	97.91
5.59		SS	4	90	50+		

End of Borehole

Practical refusal to augering at 5.59m depth

(GWL @ 3.52m-Jan. 28, 2016)



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
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FILE NO. **PG3710**

REMARKS

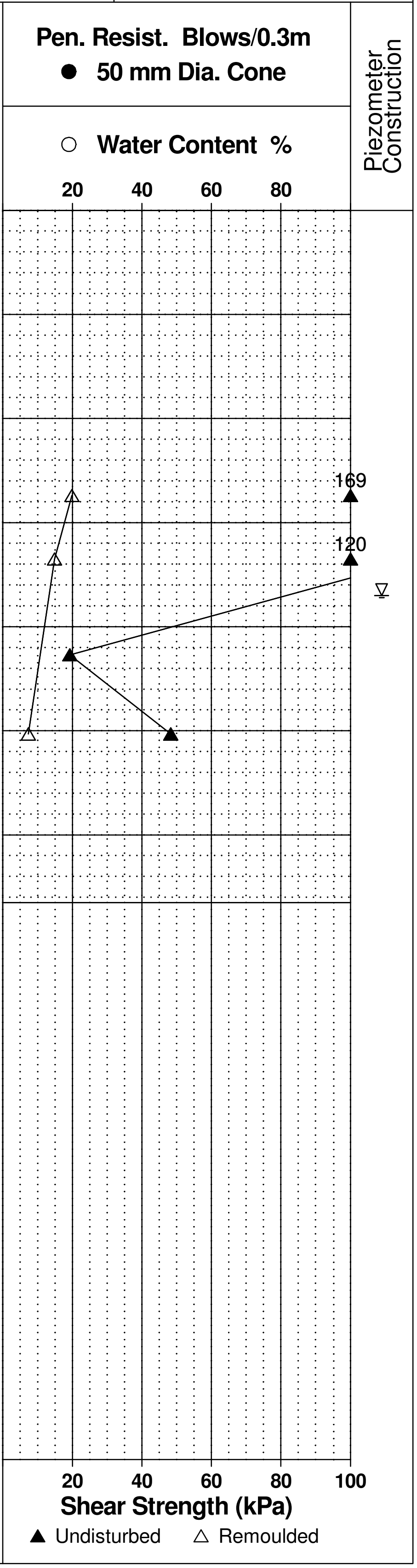
HOLE NO. **BH 8**

BORINGS BY CME 55 Power Auger

DATE January 14, 2016

SOIL DESCRIPTION	Depth to base (m)	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD
GROUND SURFACE					
TOPSOIL	0.30				
Very stiff to stiff, brown **SILTY CLAY,** some sand - soft to firm and grey by 4.0m depth	5.33	SS	1	100	3
		SS	2	100	4
		G	3		
		G	4		
		G	5		
Loose, grey **SILT**	5.64	SS	6	83	4
GLACIAL TILL: Dense, grey silty sand, some gravel and clay	6.65	SS	7	91	36
End of Borehole (GWL @ 3.7m depth based on field observations)					

DEPTH (m)	ELEV. (m)
0	103.01
1	102.01
2	101.01
3	100.01
4	99.01
5	98.01
6	97.01



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SOIL PROFILE AND TEST DATA

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REMARKS

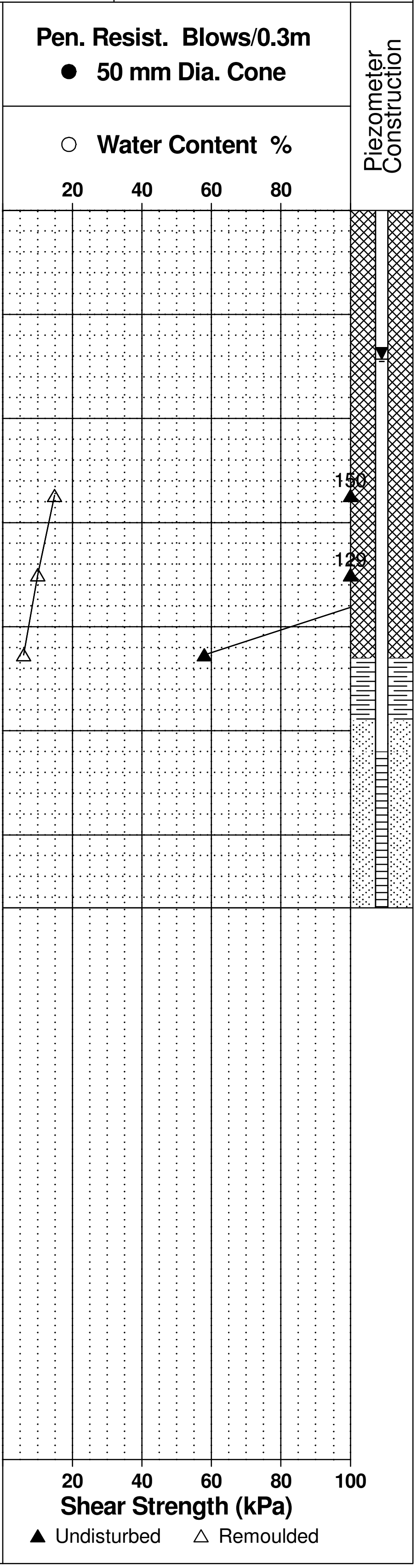
BORINGS BY CME 55 Power Auger

DATE January 15, 2016

FILE NO. PG3710

HOLE NO. BH 9

SOIL DESCRIPTION		TYPE	NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	103.12
TOPSOIL	0.25						
Very stiff to stiff, brown **SILTY CLAY,** some sand		SS	1	100	3	1	102.12
		SS	2	100	4	2	101.12
						3	100.12
	4.40					4	99.12
Compact, grey **SILT**	5.18	SS	3	58	10	5	98.12
GLACIAL TILL: Loose to compact, grey clayey sand with silt and gravel		SS	4	100	3	6	97.12
	6.70	SS	5	67	13		
End of Borehole (GWL @ 1.43m-Jan. 28, 2016)							



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
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FILE NO. PG3710

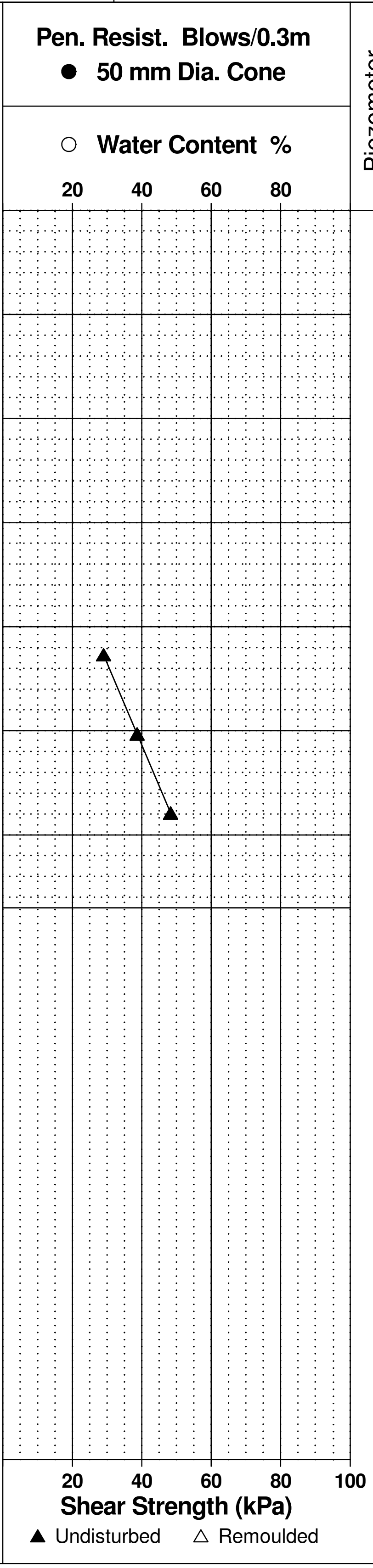
REMARKS

HOLE NO. BH10

BORINGS BY CME 55 Power Auger

DATE January 15, 2016

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)	Piezometer Construction
GROUND SURFACE						0	103.09	
TOPSOIL 0.30								
Loose, brown **SANDY SILT,** some clay 1.50		SS	1	75	6	1	102.09	
Interlayered brown **SANDY SILT** and brown **CLAYEY SILT**		SS	2	92	4	2	101.09	
		SS	3	100	3	3	100.09	∇
3.70		SS	4	100	3			
Firm to stiff, grey **SILTY CLAY,** some sand						4	99.09	
5.79						5	98.09	
GLACIAL TILL: Compact, grey silty sand with some clay and gravel 6.70		SS	5	100	18	6	97.09	
End of Borehole (GWL @ 3.0m depth based on field observations)								



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Retirement & Commercial Development
5731 Hazeldean Road, Ottawa, Ontario

DATUM Ground surface elevations provided by Annis, O'Sullivan, Vollebekk Ltd.

FILE NO. PG3710

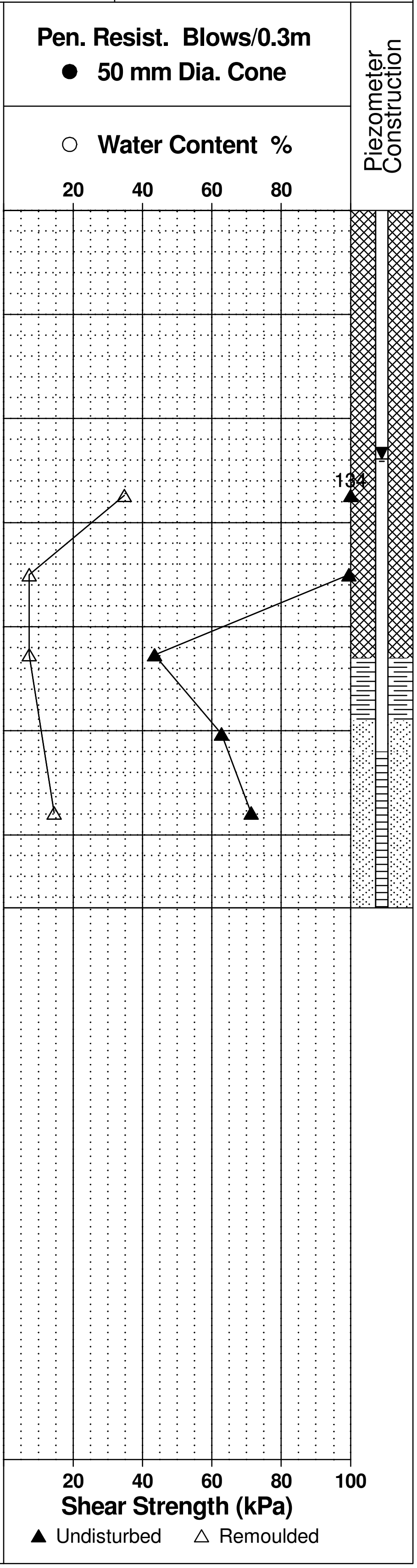
REMARKS

HOLE NO. BH11

BORINGS BY CME 55 Power Auger

DATE January 15, 2016

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	103.23
TOPSOIL 0.38							
		SS	1	100	3	1	102.23
		SS	2	100	4	2	101.23
Very stiff to stiff, brown **SILTY CLAY,** some sand						3	100.23
- firm to stiff and grey by 4.2m depth						4	99.23
						5	98.23
5.80						6	97.23
GLACIAL TILL: Compact, grey silty sand with clay and gravel 6.70		SS	3	83	18		
End of Borehole							
(GWL @ 2.39m-Jan. 28, 2016)							



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Retirement & Commercial Development
5731 Hazeldean Road, Ottawa, Ontario

DATUM Ground surface elevations provided by Annis, O'Sullivan, Vollebekk Ltd.

REMARKS

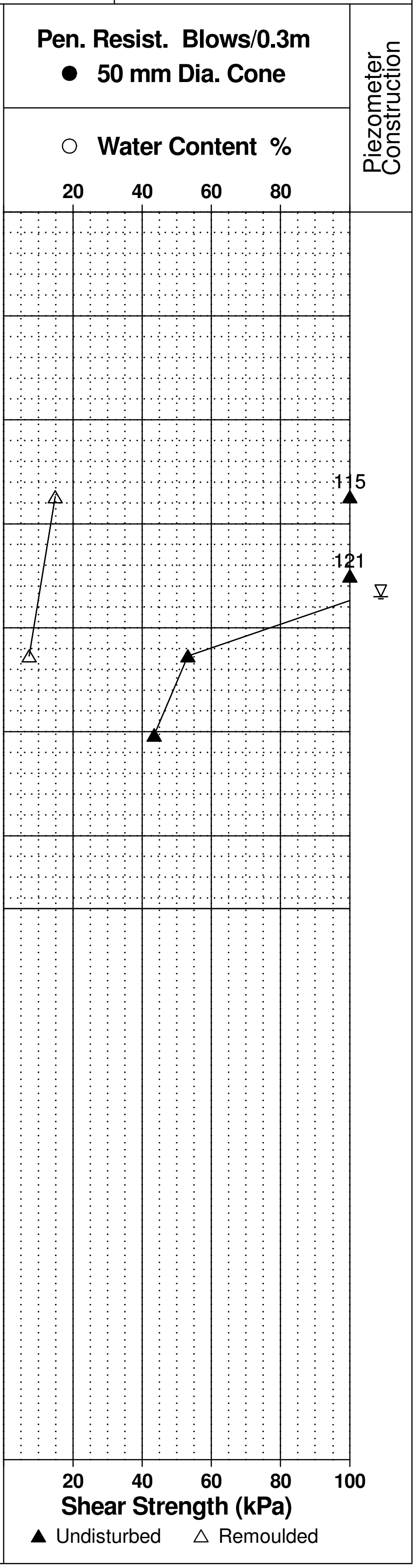
BORINGS BY CME 55 Power Auger

DATE January 15, 2016

FILE NO. PG3710

HOLE NO. BH12

SOIL DESCRIPTION		SAMPLE				DEPTH (m)	ELEV. (m)
		TYPE	NUMBER	% RECOVERY	N VALUE or RQD		
GROUND SURFACE						0	103.21
TOPSOIL	0.30						
Brown **SILTY CLAY,** some sand	0.76						
Very loose, brown **SANDY SILT,** some clay		SS	1	83	4	1	102.21
	2.30	SS	2	100	3	2	101.21
Very stiff to stiff, brown **SILTY CLAY,** some sand - firm and grey by 4.5m depth						3	100.21
						4	99.21
						5	98.21
	6.00	SS	3	75	13		
GLACIAL TILL: Loose, grey clayey silty sand with gravel	6.70	SS	4	100	4	6	97.21
End of Borehole (GWL @ 3.7m depth based on field observations)							



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SOIL PROFILE AND TEST DATA

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5731 Hazeldean Road, Ottawa, Ontario

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REMARKS

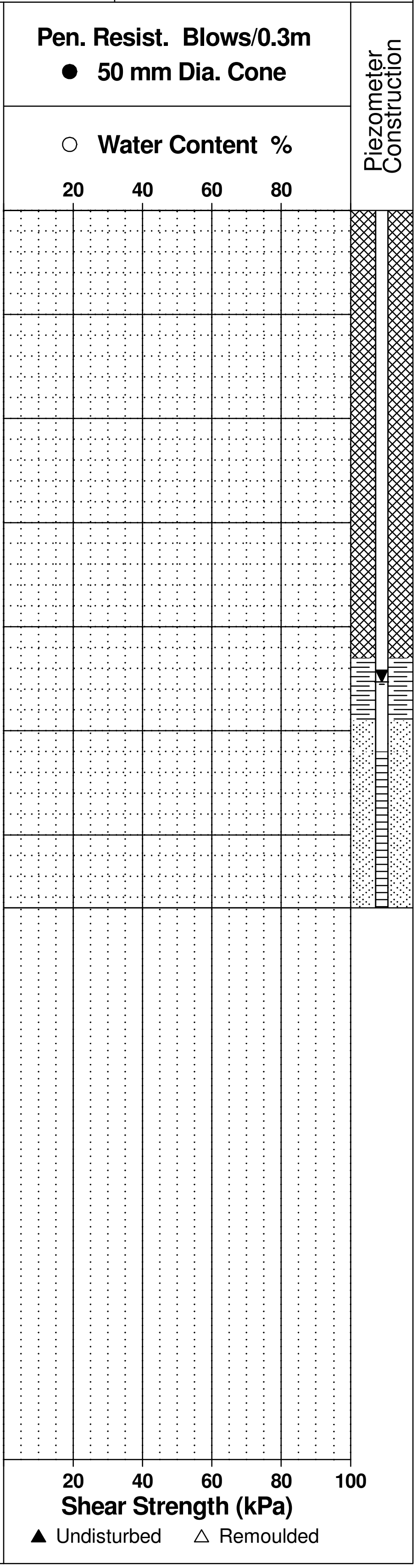
BORINGS BY CME 55 Power Auger

DATE January 14, 2016

FILE NO. PG3710

HOLE NO. BH13

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	103.14
TOPSOIL 0.30							
Brown **SILTY CLAY**		SS	1	100	3	1	102.14
2.20		SS	2	100	4	2	101.14
Compact, brown **SANDY SILT,** some clay		SS	3	100	15	3	100.14
3.66		SS	4	100	17		
Compact, grey **SILT** 4.27		SS	5	67	10	4	99.14
GLACIAL TILL: Loose to compact, grey silty sand with clay and gravel		SS	6	58	8	5	98.14
						6	97.14
6.70		SS	7	50	19		
End of Borehole (GWL @ 4.53m-Jan. 28, 2016)							



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FILE NO. PG3710

REMARKS

HOLE NO. BH14

BORINGS BY CME 55 Power Auger

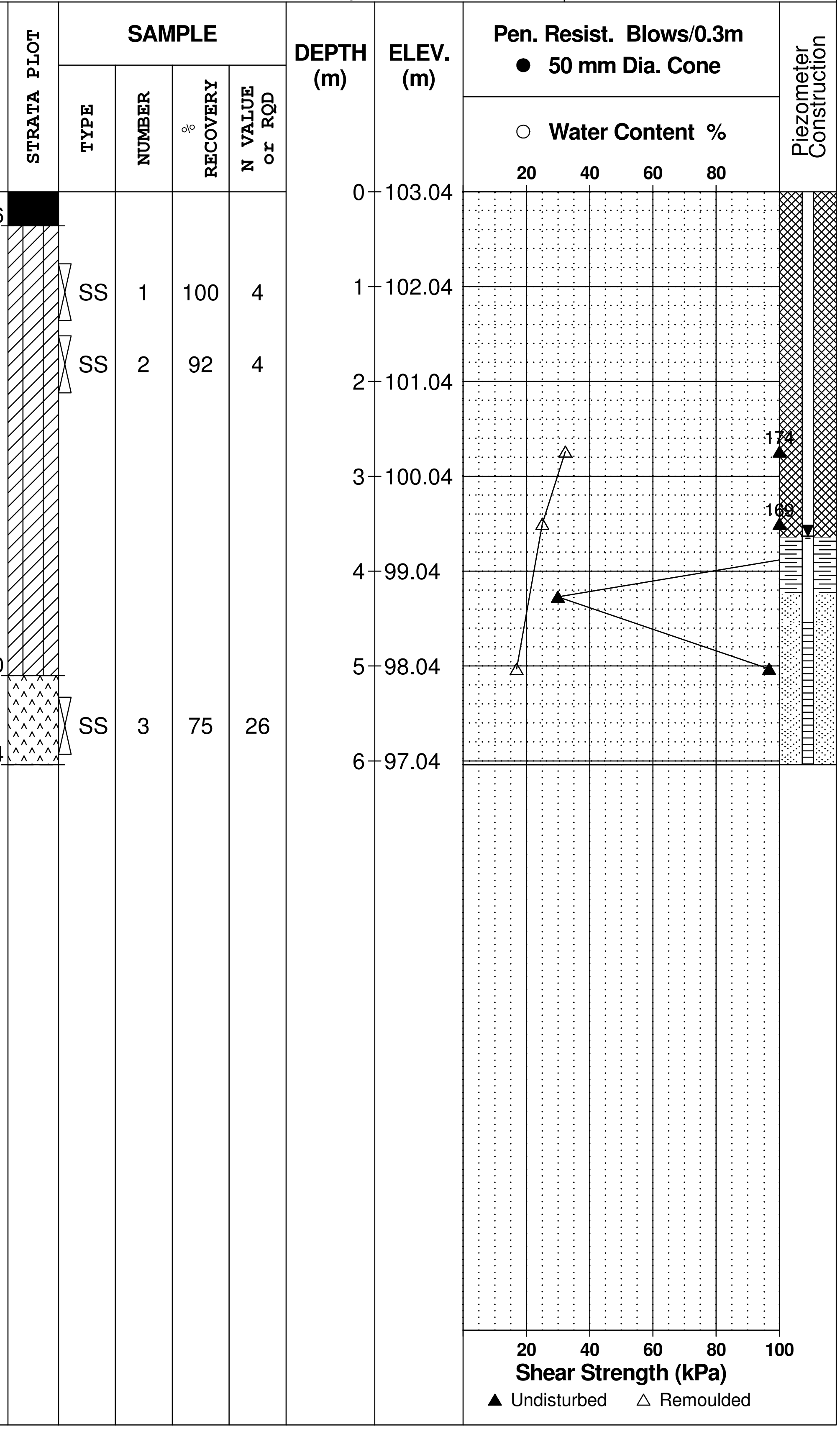
DATE January 14, 2016

SOIL DESCRIPTION	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE					0	103.04
TOPSOIL 0.36						
Very stiff to stiff, brown **SILTY CLAY,** some sand	SS	1	100	4	1	102.04
	SS	2	92	4	2	101.04
					3	100.04
- firm to stiff and grey by 4.3m depth					4	99.04
5.10					5	98.04
GLACIAL TILL: Compact, grey silty sand, some clay and gravel	SS	3	75	26		
6.04					6	97.04

End of Borehole

Practical refusal to augering at 6.04m depth

(GWL @ 3.63m-Jan. 28, 2016)



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FILE NO. PG3710

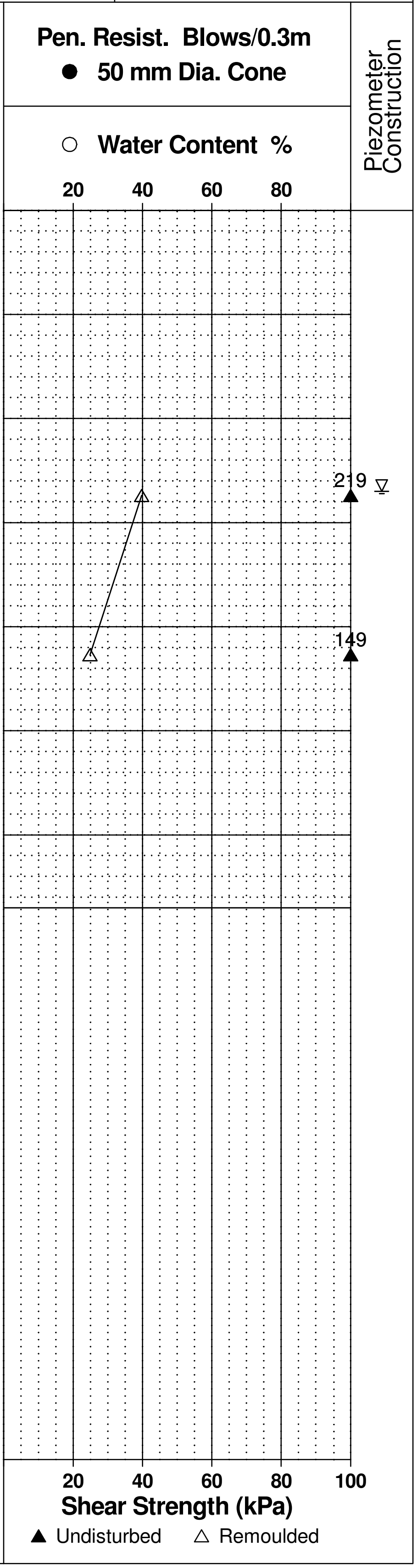
REMARKS

HOLE NO. BH15

BORINGS BY CME 55 Power Auger

DATE January 14, 2016

SOIL DESCRIPTION		SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	103.02
TOPSOIL	0.30						
Brown **SILTY CLAY,** some sand	0.76						
Loose, brown **SILTY SAND,** some clay	1.50	SS	1	100	4	1	102.02
Hard to very stiff, brown **SILTY CLAY,** some sand	4.50	SS SS	2 3	100 100	4 5	2 3 4	101.02 100.02 99.02
GLACIAL TILL: Dense, grey silty sand with clay and gravel	6.70	SS SS SS	4 5 6	88 33 100	50+ 31 39	5 6	98.02 97.02
End of Borehole (GWL @ 2.7m depth based on field observations)							



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FILE NO. PG3710

REMARKS

HOLE NO. BH16

BORINGS BY CME 55 Power Auger

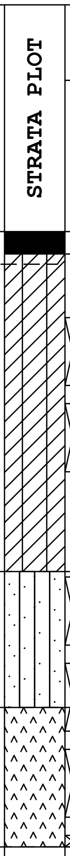
DATE January 14, 2016

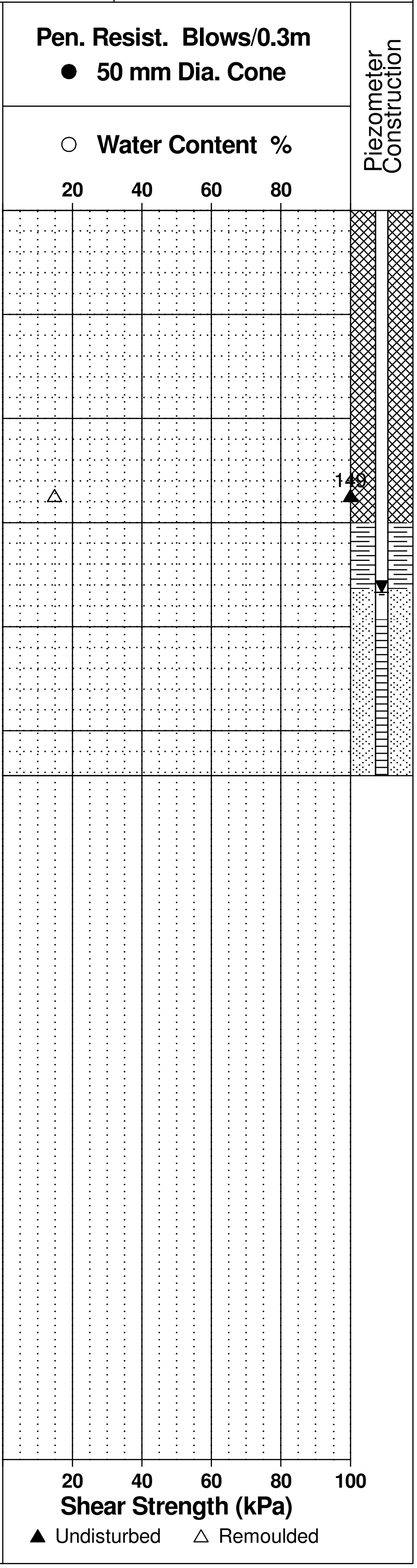
SOIL DESCRIPTION		SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	103.19
TOPSOIL	0.20						
Very stiff to stiff, brown **SILTY CLAY,** some sand		SS	1	100	3	1	102.19
		SS	2	100	3	2	101.19
	3.00					3	100.19
Loose, brown **SANDY SILT,** some clay		SS	3	92	9		
	4.20	SS	4	92	5	4	99.19
GLACIAL TILL: Compact to dense, grey silty sand, some clay and gravel		SS	5	75	16	5	98.19
	5.43	SS	6	0	50+		

End of Borehole

Practical refusal to augering at 5.43m depth

(GWL @ 3.67m-Jan. 28, 2016)





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FILE NO. PG3710

REMARKS

HOLE NO. BH17

BORINGS BY CME 55 Power Auger

DATE January 14, 2016

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone ○ Water Content %	Piezometer Construction
GROUND SURFACE						0	103.15		
TOPSOIL 0.20									
Very stiff to stiff, brown **SILTY CLAY**		SS	1	100	5	1	102.15		
		SS	2	100	4	2	101.15		∇
2.20									
Compact, brown **SANDY SILT,** some clay		SS	3	100	16	3	100.15		
3.05									
GLACIAL TILL: Compact to dense, grey silty sand with clay and gravel		SS	4	100	10				
		SS	5	67	26	4	99.15		
4.72		SS	6	100	50+				

End of Borehole

Practical refusal to augering at 4.72m depth

(GWL @ 2.0m depth based on field observations)

20 40 60 80 100

Shear Strength (kPa)

▲ Undisturbed △ Remoulded

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REMARKS

BORINGS BY CME 55 Power Auger

DATE January 13, 2016

FILE NO. PG3710

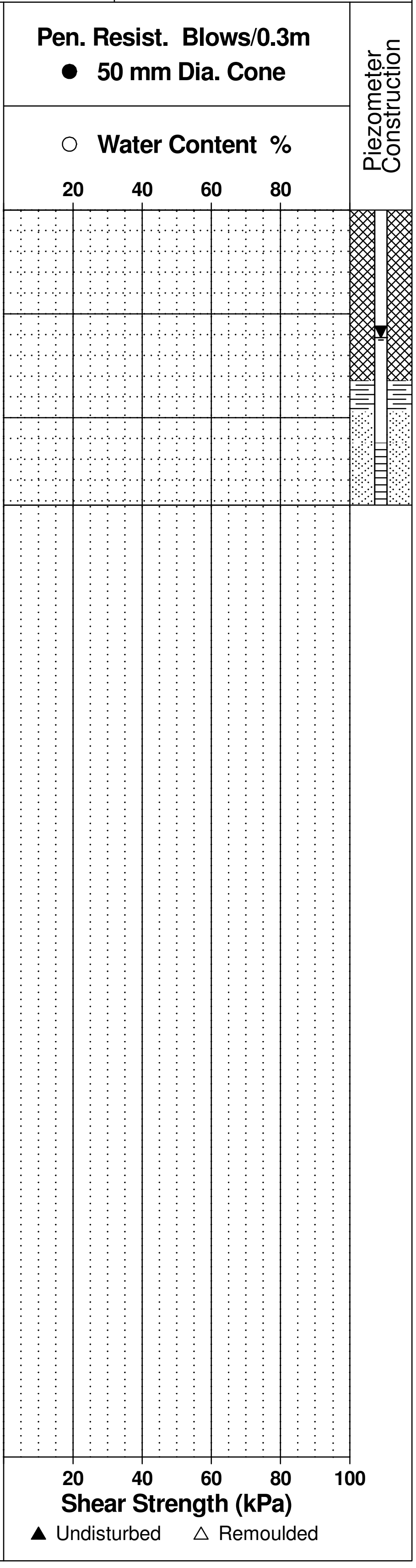
HOLE NO. BH18

SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE					0	103.40
TOPSOIL 0.20						
Very stiff, brown **SILTY CLAY,** some sand	SS	1	100	9	1	102.40
1.50						
Compact, brown **SANDY SILT,** some clay	SS	2	100	11	2	101.40
	SS	3	100	11		
2.84						

End of Borehole

Practical refusal to augering at 2.84m depth

(GWL @ 1.23m-Jan. 28, 2016)



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Retirement & Commercial Development
5731 Hazeldean Road, Ottawa, Ontario

DATUM Ground surface elevations provided by Annis, O'Sullivan, Vollebekk Ltd.

FILE NO. PG3710

REMARKS

HOLE NO. BH19

BORINGS BY CME 55 Power Auger

DATE January 13, 2016

SOIL DESCRIPTION	Depth to base (m)	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD
GROUND SURFACE					
TOPSOIL	0.25				
Very stiff to stiff, brown **SILTY CLAY,** some sand	3.00	SS	1	75	4
		SS	2	100	3
		SS	3	100	14
GLACIAL TILL: Brown silty sand with clay and gravel	3.28	SS	4	67	50+

End of Borehole

Practical refusal to augering at 3.28m depth

(GWL @ 2.4m depth based on field observations)

DEPTH (m)	ELEV. (m)
0	103.30
1	102.30
2	101.30
3	100.30

Pen. Resist. Blows/0.3m
● 50 mm Dia. Cone

○ Water Content %

20 40 60 80

20 40 60 80 100
Shear Strength (kPa)
▲ Undisturbed △ Remoulded

Piezometer Construction

∇

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SOIL PROFILE AND TEST DATA

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FILE NO. PG3710

REMARKS

HOLE NO. BH20

BORINGS BY CME 55 Power Auger

DATE January 13, 2016

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone ○ Water Content %	Piezometer Construction
GROUND SURFACE						0	103.04		
TOPSOIL 0.20									
Very stiff to stiff, brown **SILTY CLAY,** some sand		SS	1	75	3	1	102.04		
		SS	2	100	4	2	101.04		
		SS	3	100	4	3	100.04		
3.50		SS	4	100	4				∇
GLACIAL TILL: Loose to dense, brown silty sand with clay and gravel		SS	5	100	8	4	99.04		
4.95		SS	6	53	50+				

End of Borehole

Practical refusal to augering at 4.95m depth

(GWL @ 3.7m depth based on field observations)

20 40 60 80 100
Shear Strength (kPa)
▲ Undisturbed △ Remoulded

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REMARKS

BORINGS BY CME 55 Power Auger

DATE January 13, 2016

FILE NO. PG3710

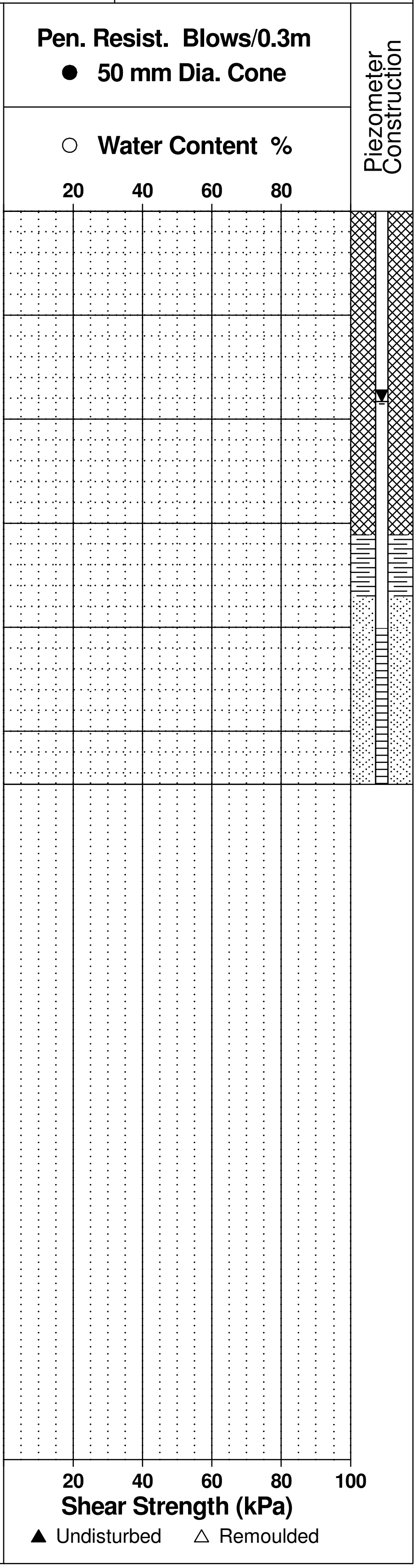
HOLE NO. BH21

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	103.14
TOPSOIL 0.25							
Very stiff, brown **SILTY CLAY,** some sand		SS	1	100	4	1	102.14
		SS	2	100	4	2	101.14
		SS	3	100	3	3	100.14
		SS	4	0	16	4	99.14
4.50		SS	5	17	12		
GLACIAL TILL: Dense, grey silty and with clay and gravel		SS	6	58	36	5	98.14
5.51		SS	7	100	50+		

End of Borehole

Practical refusal to augering at 5.51m depth

(GWL @ 1.83m-Jan. 28, 2016)



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Retirement & Commercial Development
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DATUM Ground surface elevations provided by Annis, O'Sullivan, Vollebekk Ltd.

FILE NO. PG3710

REMARKS

HOLE NO. BH22

BORINGS BY CME 55 Power Auger **DATE** January 13, 2016

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone ○ Water Content %	Piezometer Construction
GROUND SURFACE						0	103.24		
TOPSOIL 0.25									
Very stiff, brown **SILTY CLAY,** some sand		SS	1	100	4	1	102.24		
		SS	2	100	3	2	101.24		
2.20									
Loose, brown **SILT,** some to trace clay		SS	3	100	6	3	100.24		∇
		SS	4	100	5				
3.50									
GLACIAL TILL: Compact to very dense, grey silty sand, some clay and gravel		SS	5	33	20	4	99.24		
		SS	6	92	48	5	98.24		
		SS	7	100	60	6	97.24		
6.30		SS	8	100	50+				
End of Borehole (GWL @ 3.0m depth based on field observations)									

20 40 60 80 100

Shear Strength (kPa)

▲ Undisturbed △ Remoulded

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SOIL PROFILE AND TEST DATA

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DATUM Ground surface elevations provided by Annis, O'Sullivan, Vollebekk Ltd.

FILE NO. PG3710

REMARKS

HOLE NO. BH23

BORINGS BY CME 55 Power Auger

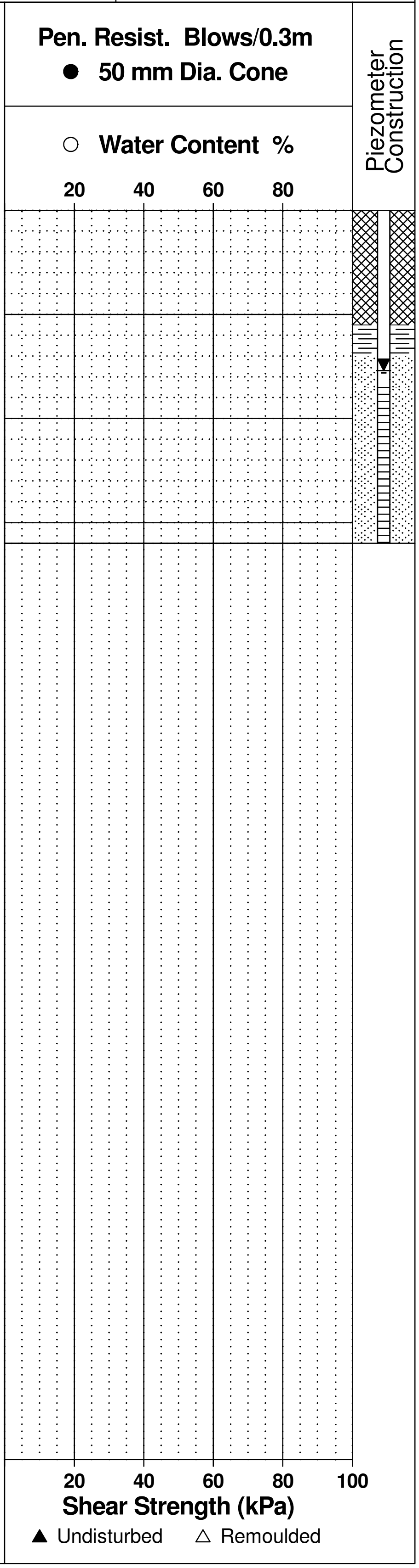
DATE January 13, 2016

SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE					0	103.28
TOPSOIL 0.25						
Very stiff, brown **SILTY CLAY,** some sand	SS	1	100	4	1	102.28
	SS	2	100	3	2	101.28
3.00	SS	3	100	34	3	100.28
Dense, grey **SILTY SAND,** some clay 3.20	SS	4	80	50+		

End of Borehole

Practical refusal to augering at 3.20m depth

(GWL @ 1.54m-Jan. 28, 2016)



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SOIL PROFILE AND TEST DATA

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DATUM Ground surface elevations provided by Annis, O'Sullivan, Vollebekk Ltd.

FILE NO. PG3710

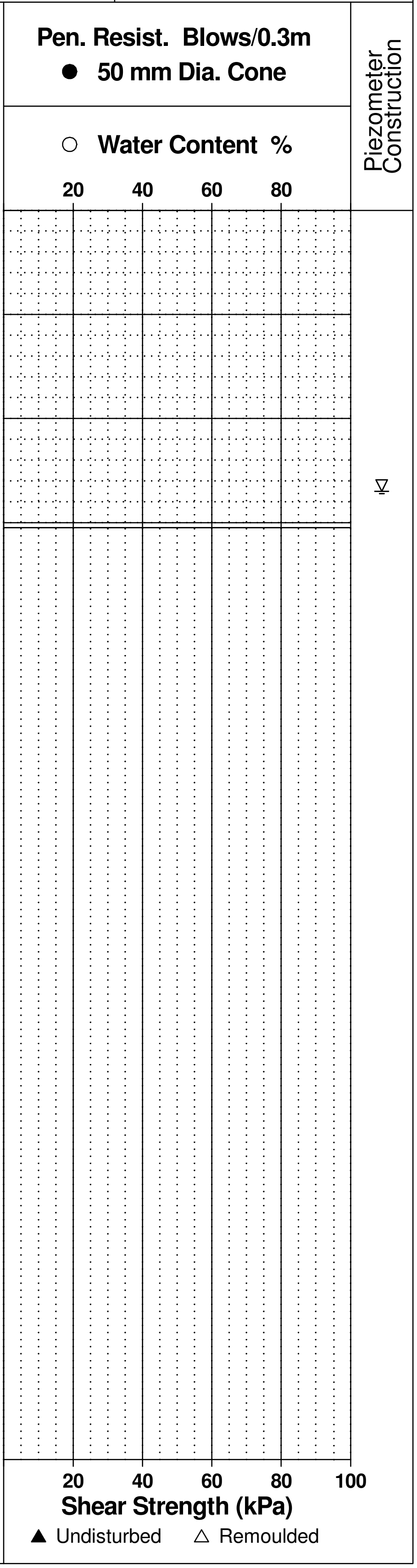
REMARKS

HOLE NO. BH24

BORINGS BY CME 55 Power Auger

DATE January 13, 2016

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	103.30
TOPSOIL 0.20							
Very stiff, brown **SILTY CLAY**		SS	1	100	6	1	102.30
		SS	2	100	5		
2.20						2	101.30
GLACIAL TILL: Dense, grey silty sand with clay and gravel		SS	3	100	50+		
3.05						3	100.30
End of Borehole Practical refusal to augering at 3.05m depth (GWL @ 2.7m depth based on field observations) Note: Additional borehole was drilled 2.5m off of BH 24 to confirm practical refusal.							



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Retirement & Commercial Development
5731 Hazeldean Road, Ottawa, Ontario

DATUM Ground surface elevations provided by Annis, O'Sullivan, Vollebekk Ltd.

FILE NO. PG3710

REMARKS

HOLE NO. BH25

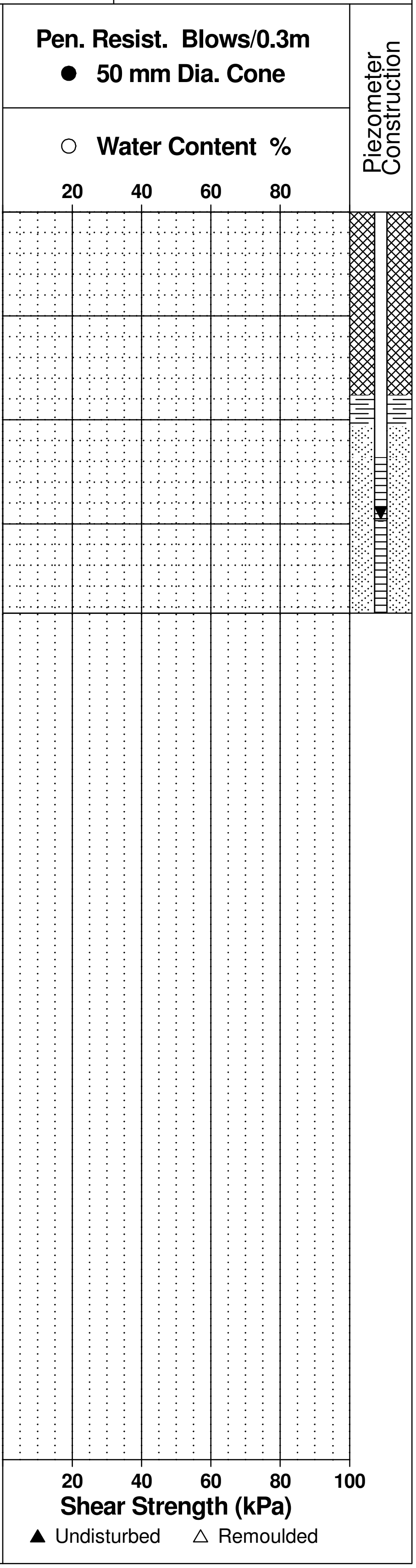
BORINGS BY CME 55 Power Auger

DATE January 13, 2016

SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE					0	103.52
TOPSOIL 0.25						
Very stiff, brown **SILTY CLAY,** some sand	AU	1				
	SS	2	50	6	1	102.52
1.50						
GLACIAL TILL: Dense, brown silty sand with clay and gravel	SS	3	75	44	2	101.52
	SS	4	83	31	3	100.52
	SS	5	83	32		
3.86	SS	5	33	50+		
End of Borehole						

Practical refusal to augering at 3.86m depth

(GWL @ 2.95m-Jan. 28, 2016)



SYMBOLS AND TERMS

SOIL DESCRIPTION

Behavioural properties, such as structure and strength, take precedence over particle gradation in describing soils. Terminology describing soil structure are as follows:

Desiccated	-	having visible signs of weathering by oxidation of clay minerals, shrinkage cracks, etc.
Fissured	-	having cracks, and hence a blocky structure.
Varved	-	composed of regular alternating layers of silt and clay.
Stratified	-	composed of alternating layers of different soil types, e.g. silt and sand or silt and clay.
Well-Graded	-	Having wide range in grain sizes and substantial amounts of all intermediate particle sizes (see Grain Size Distribution).
Uniformly-Graded	-	Predominantly of one grain size (see Grain Size Distribution).

The standard terminology to describe the strength of cohesionless soils is the relative density, usually inferred from the results of the Standard Penetration Test (SPT) ‘N’ value. The SPT N value is the number of blows of a 63.5 kg hammer, falling 760 mm, required to drive a 51 mm O.D. split spoon sampler 300 mm into the soil after an initial penetration of 150 mm.

Relative Density	‘N’ Value	Relative Density %
Very Loose	<4	<15
Loose	4-10	15-35
Compact	10-30	35-65
Dense	30-50	65-85
Very Dense	>50	>85

The standard terminology to describe the strength of cohesive soils is the consistency, which is based on the undisturbed undrained shear strength as measured by the in situ or laboratory vane tests, penetrometer tests, unconfined compression tests, or occasionally by Standard Penetration Tests.

Consistency	Undrained Shear Strength (kPa)	‘N’ Value
Very Soft	<12	<2
Soft	12-25	2-4
Firm	25-50	4-8
Stiff	50-100	8-15
Very Stiff	100-200	15-30
Hard	>200	>30

SYMBOLS AND TERMS (continued)

SOIL DESCRIPTION (continued)

Cohesive soils can also be classified according to their “sensitivity”. The sensitivity is the ratio between the undisturbed undrained shear strength and the remoulded undrained shear strength of the soil.

Terminology used for describing soil strata based upon texture, or the proportion of individual particle sizes present is provided on the Textural Soil Classification Chart at the end of this information package.

ROCK DESCRIPTION

The structural description of the bedrock mass is based on the Rock Quality Designation (RQD).

The RQD classification is based on a modified core recovery percentage in which all pieces of sound core over 100 mm long are counted as recovery. The smaller pieces are considered to be a result of closely-spaced discontinuities (resulting from shearing, jointing, faulting, or weathering) in the rock mass and are not counted. RQD is ideally determined from NXL size core. However, it can be used on smaller core sizes, such as BX, if the bulk of the fractures caused by drilling stresses (called “mechanical breaks”) are easily distinguishable from the normal in situ fractures.

RQD %	**ROCK QUALITY**
90-100	Excellent, intact, very sound
75-90	Good, massive, moderately jointed or sound
50-75	Fair, blocky and seamy, fractured
25-50	Poor, shattered and very seamy or blocky, severely fractured
0-25	Very poor, crushed, very severely fractured

SAMPLE TYPES

SS - Split spoon sample (obtained in conjunction with the performing of the Standard Penetration Test (SPT))

TW - Thin wall tube or Shelby tube

PS - Piston sample

AU - Auger sample or bulk sample

WS - Wash sample

RC - Rock core sample (Core bit size AXT, BXL, etc.). Rock core samples are obtained with the use of standard diamond drilling bits.

SYMBOLS AND TERMS (continued)

GRAIN SIZE DISTRIBUTION

MC% - Natural moisture content or water content of sample, %
LL - Liquid Limit, % (water content above which soil behaves as a liquid)
PL - Plastic limit, % (water content above which soil behaves plastically)
PI - Plasticity index, % (difference between LL and PL)

Dxx - Grain size which xx% of the soil, by weight, is of finer grain sizes
These grain size descriptions are not used below 0.075 mm grain size
D10 - Grain size at which 10% of the soil is finer (effective grain size)
D60 - Grain size at which 60% of the soil is finer

Cc - Concavity coefficient = $(D30)^2$ / (D10 x D60)
Cu - Uniformity coefficient = D60 / D10

Cc and Cu are used to assess the grading of sands and gravels:
Well-graded gravels have: $1 < Cc < 3$ and $Cu > 4$
Well-graded sands have: $1 < Cc < 3$ and $Cu > 6$
Sands and gravels not meeting the above requirements are poorly-graded or uniformly-graded.
Cc and Cu are not applicable for the description of soils with more than 10% silt and clay (more than 10% finer than 0.075 mm or the #200 sieve)

CONSOLIDATION TEST

p'_o - Present effective overburden pressure at sample depth
p'_c - Preconsolidation pressure of (maximum past pressure on) sample
Ccr - Recompression index (in effect at pressures below p'_c)
Cc - Compression index (in effect at pressures above p'_c)

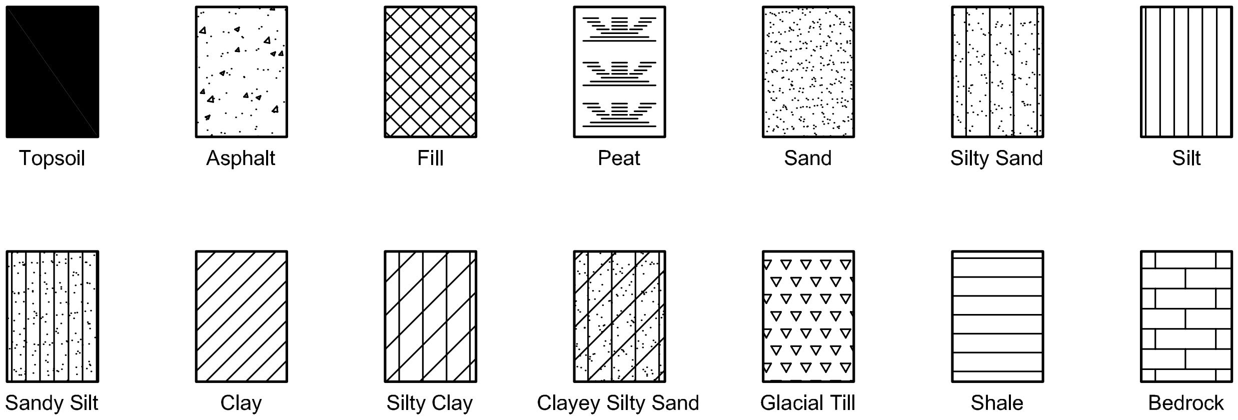
OC Ratio Overconsolidaton ratio = p'_c / p'_o
Void Ratio Initial sample void ratio = volume of voids / volume of solids
Wo - Initial water content (at start of consolidation test)

PERMEABILITY TEST

k - Coefficient of permeability or hydraulic conductivity is a measure of the ability of water to flow through the sample. The value of k is measured at a specified unit weight for (remoulded) cohesionless soil samples, because its value will vary with the unit weight or density of the sample during the test.

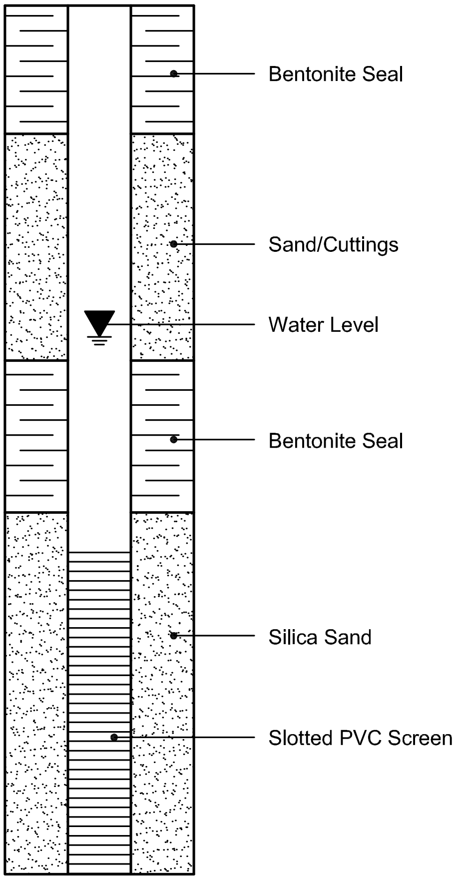
SYMBOLS AND TERMS (continued)

STRATA PLOT

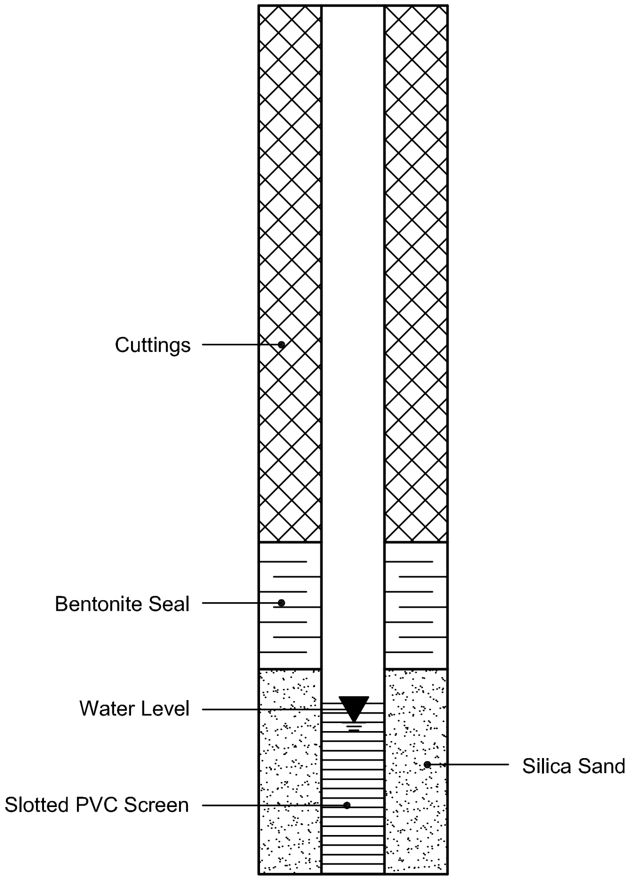


MONITORING WELL AND PIEZOMETER CONSTRUCTION

MONITORING WELL CONSTRUCTION



PIEZOMETER CONSTRUCTION



Order #: 1604086

Certificate of Analysis

Report Date: 22-Jan-2016

Client: **Paterson Group Consulting Engineers**

Order Date:18-Jan-2016

Client PO: 18948

Project Description: PG3710

	Client ID:	BH16 SS4	-	-	-
	Sample Date:	18-Jan-16	-	-	-
	Sample ID:	1604086-01	-	-	-
	MDL/Units	Soil	-	-	-
Physical Characteristics					
% Solids	0.1 % by Wt.	77.8	-	-	-
General Inorganics					
pH	0.05 pH Units	7.63	-	-	-
Resistivity	0.10 Ohm.m	65.5	-	-	-
Anions					
Chloride	5 ug/g dry	<5	-	-	-
Sulphate	5 ug/g dry	15	-	-	-

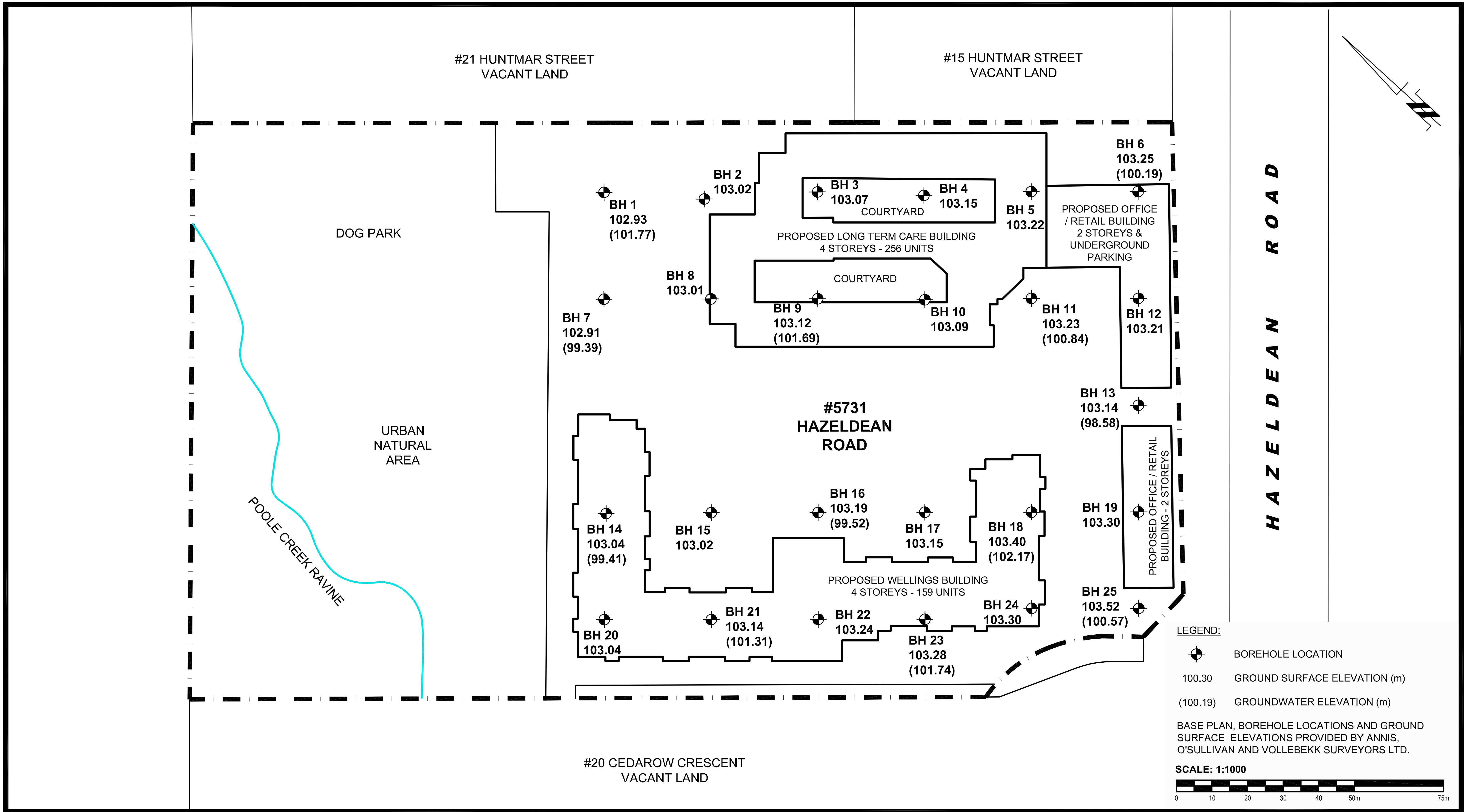
APPENDIX 2

FIGURE 1 - KEY PLAN

DRAWING PG3710-1 - TEST HOLE LOCATION PLAN

FIGURE 1

KEY PLAN



LEGEND:

⌖	BOREHOLE LOCATION
100.30	GROUND SURFACE ELEVATION (m)
(100.19)	GROUNDWATER ELEVATION (m)

BASE PLAN, BOREHOLE LOCATIONS AND GROUND SURFACE ELEVATIONS PROVIDED BY ANNIS, O'SULLIVAN AND VOLLEBEKK SURVEYORS LTD.

SCALE: 1:1000

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NO.	REVISIONS	DATE	INITIAL

NAUTICAL LANDS GROUP
GEOTECHNICAL INVESTIGATION
PROPOSED RETIREMENT & COMMERCIAL DEVELOPMENT - 5731 HAZELDEAN ROAD
OTTAWA, ONTARIO

Title:

TEST HOLE LOCATION PLAN

Scale: 1:1000
Date: 1/2016
Drawn by: CPB
Report No.: PG3710-1
Checked by: CPB
Dwg. No.: **PG3710-1**
Approved by: DG
Revision No.: 0

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