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Geotechnical Engineering

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Building Science

Archaeological Services

Geotechnical Investigation

Block 166 - Proposed Apartment Buildings
Half Moon Bay West
Watercolours Way, Ottawa, Ontario

Prepared For

Mattamy Homes

July 15, 2019

Report: PG4877-1 Revision 1

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Table of Contents

Appendices

1.0 Introduction

Paterson Group (Paterson) was commissioned by Mattamy Homes to conduct a geotechnical investigation for Block 166 of the proposed apartment buildings to be located along Watercolours Way in Half Moon Bay West residential development in the City of Ottawa (refer to Figure 1 - Key Plan presented in Appendix 2).

The objective of the investigation was to:

☐ Determine the subsoil and groundwater conditions at this site by means of boreholes.

☐ provide geotechnical recommendations for the design of the proposed development including construction considerations which may affect its design.

The following report has been prepared specifically and solely for the aforementioned project which is described herein. It contains our findings and includes geotechnical recommendations pertaining to the design and construction of the subject development as they are 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. A report addressing environmental issues for the subject site was prepared under separate cover.

2.0 Proposed Development

It is our understanding that proposed project consists of 6 residential blocks where each block consists of 12 units stacked back to back with upper and lower units. It is also understood that the lower units will include a basement level. At-grade parking areas and landscaped areas are also anticipated as part of the proposed development.

3.0 Method of Investigation

3.1 Field Investigation

The field programs for the geotechnical investigations were carried out between October 2005 and March 2018. At that time, a combination of test holes were advanced to a maximum depth of 14.8 m with a total of 3 test hole within the immediate footprint of the subject site. The test hole locations were determined in the field by Paterson personnel taking into consideration site features and underground services. The locations of the boreholes are shown on Drawing PG4877-1 - Test Hole Location Plan included in Appendix 2.

The boreholes were put down using a track-mounted auger drill rig operated by a two person crew while the test pits were excavated using a hydraulic shovel. All fieldwork was conducted under the full-time supervision of personnel from Paterson's geotechnical division under the direction of a senior engineer. The testing procedure consisted of augering to the required depths and at the selected locations and sampling the overburden.

Sampling and In Situ Testing

Soil samples were collected from the boreholes using a 50 mm diameter split-spoon (SS) sampler, or using 73 mm diameter thin walled (TW) Shelby tubes in conjunction with a piston sampler. Soil samples from the test pits were recovered from the side walls of the open excavation and all soil samples were initially classified on site. The split-spoon and grab samples were placed in sealed plastic bags and the Shelby tubes were sealed at both ends on site. All samples were transported to our laboratory for further examination and classification. The depths at which the split-spoon, grab and Shelby tube samples were recovered from the boreholes are shown as SS, G and TW, respectively, on the Soil Profile and Test Data sheets presented in Appendix 1.

The grab samples were placed in sealed plastic bags and all samples were transported to our laboratory. The depths at which the grab samples were recovered from the test holes are shown as 'G', on the Soil Profile and Test Data sheets presented in Appendix 1.

The Standard Penetration Test (SPT) was conducted in conjunction with the recovery of the split-spoon samples. The SPT results are 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 sampler 300 mm into the soil after a 150 mm initial penetration using a 63.5 kg hammer falling from a height of 760 mm.

Undrained shear strength testing was carried out in cohesive soils using a field vane apparatus.

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 of this report.

Groundwater

Flexible standpipes were installed in the boreholes to permit monitoring of the groundwater levels subsequent to the completion of the sampling program.

Sample Storage

All samples will be stored in the laboratory for a period of one month after issuance of this report. They will then be discarded unless we are otherwise directed.

3.2 Field Survey

The test hole locations were determined by Paterson personnel taking into consideration the presence of underground and aboveground services. The location and ground surface elevation at the majority of the test hole locations was surveyed by JD Barnes. The ground surface elevations at the borehole locations are referenced to a geodetic datum. The borehole locations and ground surface elevation at each borehole location are presented on Drawing PG4877-1 - Test Hole Location Plan in Appendix 2.

3.3 Laboratory Testing

The soil samples recovered from the subject site were examined in our laboratory to review the results of the field logging.

4.0 Observations

4.1 Surface Conditions

Currently, the subject site is undeveloped with fill noted at ground surface across the site. The ground surface slopes gradually downward to the west across the site.

4.2 Subsurface Profile

Generally, the subsurface profile encountered at the boreholes locations consist of topsoil overlying stiff to firm brown silty clay and trace sand followed by a firm to soft grey silty clay deposit. Glacial till consisting of firm grey silty clay with sand, gravel cobbles and boulders was encountered below the above noted layers. Practical refusal to DCPT was encountered in BH3 at a depth of 19.4 m below original ground surface. It should be noted that the site was covered with a fill layer since the original investigation. The fill consists of brown silty sand with gravel, cobbles and boulders.

Silty Clay Deposit

In situ shear vane field testing carried out within the silty clay deposit yielded undrained shear strength values ranging from approximately 18.5 to 58 kPa. These values are indicative of a soft to stiff consistency. Consolidation testing, atterberg limit testing and grain size distribution testing were conducted for the silty clay within the subject site and surrounding and are summarized as follows:

Consolidation Testing

The results of the consolidation tests from our previous investigations are presented in Table 1 and in Appendix 1. The value for p'_c is the preconsolidation pressure and p'_o is the effective overburden pressure of the test sample. The difference between these values is the available preconsolidation. The increase in stress on the soil due to the cumulative effects of the fill surcharge, the footing pressures, the slab loadings and the lowering of the groundwater should not exceed the available preconsolidation if unacceptable settlements are to be avoided.

The values for C_{cr} and C_c are the recompression and compression indices, respectively. These soil parameters are a measure of the compressibility due to stress increases below and above the preconsolidation pressures. The higher values for the C_c, as compared to the C_{cr}, illustrate the increased settlement potential above, as compared to below, the preconsolidation pressure.

Table 1 - Summary of Consolidation Test Results

Borehole No.	Sample	Depth (m)	p'_c (kPa)	p'_o (kPa)	C_{cr}	C_c	Q (*)
BH 3	TW 3	2.65	50	31.7	0.019	0.252	A
BH 5-06	TW 2	4.37	96	38.5	0.026	1.185	A

* - Q - Quality assessment of sample - G: Good A: Acceptable P: Likely disturbed

The values of p'_c, p'_o, C_{cr} and C_c are determined using standard engineering testing procedures and are estimates only. Natural variations within the soil deposit will affect the results. The p'_o parameter is directly influenced by the groundwater level. Groundwater levels were measured during the site investigation. Groundwater levels vary seasonally which has an impact on the available preconsolidation. Lowering the groundwater level increases the p'_o and therefore reduces the available preconsolidation. Unacceptable settlements could be induced by a significant lowering of the groundwater level. The p'_o values for the consolidation tests carried out for the present investigation are based on the long term groundwater level observed at each borehole location. The groundwater level is based on the colour and undrained shear strength profile of the silty clay.

Atterberg Limit Tests

Atterberg limit testing of 3 samples was completed within a limited area surrounding the subject site. The Plasticity Index of the underlying silty clay was measured to range from 5 to 15. The results of the atterberg limit testing on select silty clay samples are presented in Table 2.

Table 2 - Summary of Atterberg Limit Test Results

Test hole No.	Sample	Moisture Content (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Classification
TP 8-18	G3	31.4	25	21	5	CL-ML
TP 9-18	G4	29.6	34	18	15	CL

* - CL - Inorganic clays of low plasticity
* - CL-ML - Inorganic Clayey Silt with low plasticity

Grain Size Distribution Tests

Two (2) sieve analyses were completed to classify selected soil samples according to the Unified Soil Classification System (USCS). The results are presented in Appendix 1.

Bedrock

Based on available geological mapping, the bedrock in this area consists of interbedded silty dolostone and crystalline limestone of the Gull River formation with an overburden drift thickness of 5 to 15 m depth.

4.3 Groundwater

The groundwater levels recovered from the piezometers installed at the borehole locations or based on field observations of the open test pits. It is important to note that groundwater readings at piezometers can be influenced by surface water perched within the borehole backfill material. Long-term groundwater conditions can also be estimated based on the observed colour and consistency of the recovered soil samples. Based on these observations, the long term groundwater table is anticipated to be at a 3 to 5 m depth. It should be further noted that the groundwater level could vary at the time of construction.

5.0 Discussion

5.1 Geotechnical Assessment

From a geotechnical perspective, the subject site is considered acceptable for the proposed residential blocks. It is expected that the proposed buildings can be founded by conventional style shallow foundations provided the bearing resistance values are sufficient to support design loads. Due to the sensitive silty clay layer encountered across the subject site, it is recommended to place footings as high as possible within the silty clay crust layer.

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

5.2 Site Grading and Preparation

Stripping Depth

Topsoil and deleterious fill, such as those containing organic materials, should be stripped from under any buildings, paved areas, pipe bedding and other settlement sensitive structures.

Fill Placement

Fill used for grading beneath the building 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 lifts no greater than 300 mm thick and compacted using suitable compaction equipment for the lift thickness. Fill placed beneath the building areas should be compacted to at least 98% of its standard Proctor maximum dry density (SPMDD).

Non-specified existing fill along with site-excavated soil can be used as general landscaping fill and beneath parking areas where settlement of the ground surface is of minor concern. In landscaped areas, these materials should be spread in thin lifts and at least compacted by the tracks of the spreading equipment to minimize voids. If these materials are to be used to build up the subgrade level for areas to be paved, they should be compacted in thin lifts to a minimum density of 95% of their respective SPMDD. Non-specified existing fill and site-excavated soils are not suitable for use as backfill against foundation walls unless a composite drainage blanket connected to a perimeter drainage system is provided.

5.3 Foundation Design

Conventional Shallow Footings - Bearing Resistance Values

Strip footings, up to 3 m wide, and pad footings, up to 6 m wide, placed over an undisturbed, stiff to firm silty clay bearing surface at or above geodetic elevation of 95.0 m can be designed using a bearing resistance value at SLS of **90 kPa** and a factored bearing resistance value at ULS of **150 kPa**.

An undisturbed soil bearing surface consists of one from which all topsoil and deleterious materials, such as loose, frozen or disturbed soil, have been removed prior to the placement of concrete for footings.

The bearing resistance values at SLS given for footings will be subjected to potential post construction total and differential settlements of 25 and 20 mm, respectively.

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 a stiff silty clay above the groundwater table when a plane extending down and out from the bottom edge of the footing at a minimum of 1.5H:1V passes only through in situ soil of the same or higher capacity as the bearing medium soil.

Permissible Grade Raise Recommendations

Consideration must be given to potential settlements which could occur due to the presence of the silty clay deposit if the proposed buildings are to be founded over the silty clay deposit. The foundation loads to be considered for the settlement case are the continuously applied loads which consist of the unfactored dead loads and the portion of the unfactored live load that is considered to be continuously applied. A minimum value of 50% of the live load is often recommended by Paterson.

A permissible grade raise elevation of **93.9 m** is recommended for finished grading within 5 m of the proposed buildings where the proposed buildings are founded over the silty clay deposit. A post-development groundwater lowering of 0.5 m was considered in our permissible grade raise restriction calculations.

5.4 Design for Earthquakes

The site class for seismic site response can be taken as **Class E** for the shallow foundations at the subject site. The soils underlying the subject site are not susceptible to liquefaction. Reference should be made to the latest revision of the 2012 Ontario Building Code for a full discussion of the earthquake design requirements.

5.5 Basement Slab

With the removal of all topsoil and deleterious fill, such as those containing organic materials, within the footprint of the proposed buildings, the native soil surface will be considered to be an acceptable subgrade on which to commence backfilling for floor slab construction.

Any soft areas should be removed and backfilled with appropriate backfill material prior to placing any fill. OPSS Granular B Type II are recommended for backfilling below the floor slab. It is recommended that the upper 200 mm of sub-floor fill consists of 19 mm clear crushed stone for a basement slab. All backfill material within the footprint of the proposed buildings should be placed in maximum 300 mm thick loose layers and compacted to at least 98% of the SPMDD.

5.6 Pavement Structure

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

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 - Either fill, in situ soil or OPSS Granular B Type I or II material placed over in situ soil or fill	

Table 4 - Recommended Pavement Structure - Access Lanes

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

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 excavated and replaced with OPSS Granular B Type II material. Weak subgrade conditions may be experienced over service trench fill materials. This may require the use of a geotextile, such as Terratrack 200 or equivalent, thicker subbase or other measures that can be recommended at the time of construction as part of the field observation program.

The pavement granular base and subbase should be placed in maximum 300 mm thick lifts and compacted to a minimum of 100% of the material's SPMDD using suitable vibratory equipment.

Pavement Structure Drainage

Satisfactory performance of the pavement structure is largely dependent on keeping 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 its load carrying capacity.

Due to the impervious nature of the subgrade materials consideration should be given to installing subdrains during the pavement construction. These drains should be installed at each catch basin, be at least 3 m long and should extend in four orthogonal directions or longitudinally when placed along a curb. The subdrain inverts should be approximately 300 mm below subgrade level. 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

It is recommended that a perimeter foundation drainage system be provided for the proposed structures. The system should consist of a 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.

Foundation Backfill

Backfill against the exterior sides of the foundation walls should consist of free-draining non frost susceptible granular materials. The greater part of the site excavated materials will be frost susceptible and, as such, are not recommended for re-use as backfill against the foundation walls, unless used in conjunction with a drainage geocomposite, such as Delta Drain 6000 or equivalent, connected to the perimeter foundation drainage system. Imported granular materials, such as clean sand or OPSS Granular B Type I granular material, should otherwise be used for this purpose.

6.2 Protection Against Frost Action

Perimeter footings of heated structures are required to be insulated against the deleterious effect of frost action. A minimum 1.5 m thick soil cover (or equivalent) should be provided in this regard.

A minimum of 2.1 m thick soil cover (or equivalent) should be provided for other exterior unheated footings.

6.3 Excavation Side Slopes

Unsupported Excavations

The side slopes of excavations in the soil and fill overburden materials should be either cut back at acceptable slopes or should be retained by shoring systems from the start of the excavation until the structure is backfilled. It is assumed that sufficient room will be available for the greater part of the excavation to be undertaken by open-cut methods (i.e. unsupported excavations).

The excavation side slopes above the groundwater level extending to a maximum depth of 3 m should be cut back at 1H:1V or flatter. The flatter slope is required for excavation below groundwater level. The subsoil at this site is considered to be mainly a 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 be kept away 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.

It is recommended that a trench box be used at all times to protect personnel working in trenches with steep or vertical sides. It is expected that services will be installed by “cut and cover” methods and excavations will not be left open for extended periods of time.

6.4 Pipe Bedding and Backfill

The pipe bedding for sewer and water pipes should consist of at least 150 mm of OPSS Granular A material. Where the bedding is located within the firm grey silty clay, the thickness of the bedding material should be increased to a minimum of 300 mm. The material should be placed in maximum 300 mm thick lifts and compacted to a minimum of 95% of its SPMDD. The bedding material should extent at least to the spring line of the pipe.

The cover material, which should consist of OPSS Granular A, should extend from the spring line of the pipe to at least 300 mm above the obvert of the pipe. The material should be placed in maximum 300 mm thick lifts and compacted to a minimum of 95% of its SPMDD.

It should generally be possible to re-use the moist (not wet) brown silty clay above the cover material if the excavation and filling operations are carried out in dry weather conditions. Wet silty clay materials will be difficult to re-use, as the high water contents make compacting impractical without an extensive drying period.

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 minimize differential frost heaving. The trench backfill should be placed in maximum 300 mm thick loose lifts and compacted to a minimum of 95% of the material’s SPMDD.

To reduce long-term lowering of the groundwater level at this site, clay seals should be provided in the service trenches. The seals should be at least 1.5 m long 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 material's SPMDD. The clay seals should be placed at the site boundaries and at strategic locations at no more than 60 m intervals in the service trenches.

6.5 Groundwater Control

Groundwater Control for Building Construction

It is anticipated that groundwater infiltration into the excavations should be low and controllable using open sumps. Pumping from open sumps should be sufficient to control the groundwater influx through the sides of the shallow excavation. 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.

A temporary Ministry of the Environment, Conservation and Parks (MECP) permit to take water (PTTW) may be required for this project if more than 400,000 L/day of ground and/or surface water is to be pumped during the construction phase. A minimum 4 to 5 months should be allowed for completion of the PTTW application package and issuance of the permit by the MECP.

For typical ground or surface water volumes being pumped during the construction phase, typically between 50,000 to 400,000 L/day, it is required to register on the Environmental Activity and Sector Registry (EASR). A minimum of two to four weeks should be allotted for completion of the EASR registration and the Water Taking and Discharge Plan to be prepared by a Qualified Person as stipulated under O.Reg. 63/16. If a project qualifies for a PTTW based upon anticipated conditions, and EASR will not be allowed as a temporary dewatering measure while awaiting the MECP review of the PTTW application.

Groundwater Control Using Sump Pits

It is understood that the proposed residential buildings within the subject site will include a basement level and sump pit and pump installed below the basement slab to provide an outlet for any storm water or spring melt water collected from the perimeter foundation drainage system. Based on our observations of the recovered soil samples from the borehole locations, the long-term groundwater level varies between 3 to 5 m below ground surface (approximate elevation of 89 to 91 m across the site).

It is recommended that the design underside of footing elevation be placed at least 0.3 m above the long-term groundwater level to ensure adequate separation between the design underside of footing elevation. It is anticipated that the subject site is suitable for a development, which includes the use of sump pumps, from a geotechnical perspective provided the above noted separation distance is adhered to. Based on Paterson's review of the proposed grading plan, the proposed underside of footing elevations range between 90.95 and 91.57 m. However, a 0.5 m groundwater lowering effect is expected to take place as a result of the subject development and the surrounding developments. Based on this information, the use of sump pumps with the proposed grades is acceptable from a geotechnical perspective.

6.6 Winter Construction

The subsoil conditions at this site mostly consist of frost susceptible materials. In presence of water and freezing conditions ice could form within the soil mass. Heaving and settlement upon thawing could occur. Precautions should be taken if winter construction is considered for this project.

In the event of construction during below zero temperatures, the founding stratum should be protected from freezing temperatures by the use of straw, propane heaters and tarpaulins or other suitable means. In this regard, the base of the excavations 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.

The trench excavations should be carried out in a manner that will avoid the introduction of frozen materials into the trenches. As well, pavement construction is difficult during winter. The subgrade consists of frost susceptible soils which will experience total and differential frost heaving as the work takes place. In addition, the introduction of frost, snow or ice into the pavement materials, which is difficult to avoid, could adversely affect the performance of the pavement structure. Additional information could be provided, if required.

6.7 Landscaping Considerations

Tree Planting Restrictions

In accordance with the City of Ottawa Tree Planting in Sensitive Marine Clay Soils (2017 Guidelines), Paterson completed a soils review of the site to determine applicable tree planting setbacks. Atterberg limits testing was completed for recovered silty clay samples at selected locations throughout the subject site. Sieve analysis testing was also completed on selected soil samples. The abovenoted soil samples were recovered from elevations below the anticipated design underside of footing elevation and 3.5 m depth below anticipated finished grade. The results of our testing are presented in Table 2 in Subsection 4.2 and in Appendix 1.

Since the modified plasticity limit (PI) does not exceed 40% based on our testing results, large trees (mature height over 14 m) can be planted at Half Moon Bay West provided a tree to foundation setback equal to the full mature height of the tree can be provided (e.g. in a park or other green space). Tree planting setback limits may be reduced to 4.5 m for small (mature tree height up to 7.5m) and medium size trees (mature tree height 7.5 m to 14 m) provided that the following conditions are met:

☐ The underside of footing (USF) is 2.1 m or greater below the lowest finished grade must be satisfied for footings within 10 m from the tree, as measured from the centre of the tree trunk and verified by means of the Grading Plan as indicated procedural changes below.

☐ A small tree must be provided with a minimum of 25 m^3 of available soil volume while a medium tree must be provided with a minimum of 30 m^3 of available soil volume, as determined by the Landscape Architect. The developer is to ensure that the soil is generally un-compacted when backfilling in street tree planting locations.

☐ The tree species must be small (mature tree height up to 7.5 m) to medium size (mature tree height 7.5 m to 14 m) as confirmed by the Landscape Architect.

☐ The foundation walls are to be reinforced at least nominally (minimum of two upper and two lower 15M bars in the foundation wall).

☐ Grading surrounding the tree must promote drainage to the tree root zone (in such a manner as not to be detrimental to the tree), as noted on the subdivision Grading Plan.

7.0 Recommendations

It is recommended that the following be carried out once the master plan and site development are determined:

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

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

☐ 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 placing backfilling materials.

☐ Field density tests to ensure that the specified level of compaction has been achieved.

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

A report confirming that these works have been conducted in general accordance with our recommendations could be issued upon request, following the completion of a satisfactory material testing and observation program by the geotechnical consultant.

8.0 Statement of Limitations

The recommendations made in this report are in accordance with our present understanding of the project. We request permission to review the grading plan once available. Also, our recommendations should be reviewed when the drawings and specifications are complete.

The client should be aware that any information pertaining to soils and all test hole logs are furnished as a matter of general information only and test hole descriptions or logs are not to be interpreted as descriptive of conditions at locations other than those of the test holes.

A soils investigation is a limited sampling of a site. Should any conditions at the site be encountered which differ from those at the test locations, we request that we be notified immediately in order to permit reassessment of our recommendations.

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 Mattamy Homes or their agent(s) is not authorized without review by this firm for the applicability of our recommendations to the altered use of the report.

Paterson Group Inc.

Colin Belcourt

LICENSED PROFESSIONAL ENGINEER
July 15, 2019
F. I. ABOU-SEIDO
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PROVINCE OF ONTARIO

Colin Belcourt, P.Eng. Faisal I. Abou-Seido, P.Eng.

APPENDIX 1

SOIL PROFILE AND TEST DATA SHEETS

SYMBOLS AND TERMS

CONSOLIDATION TESTING RESULTS

GRAIN SIZE DISTRIBUTION TESTING RESULTS

patersongroup Consulting Engineers

28 Concourse Gate, Unit 1, Ottawa, ON K2E 7T7

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Half Moon Bay - Phase 8 and Phase 9
Ottawa, Ontario

DATUM Geodetic, provided by JD Barnes Ltd.

REMARKS

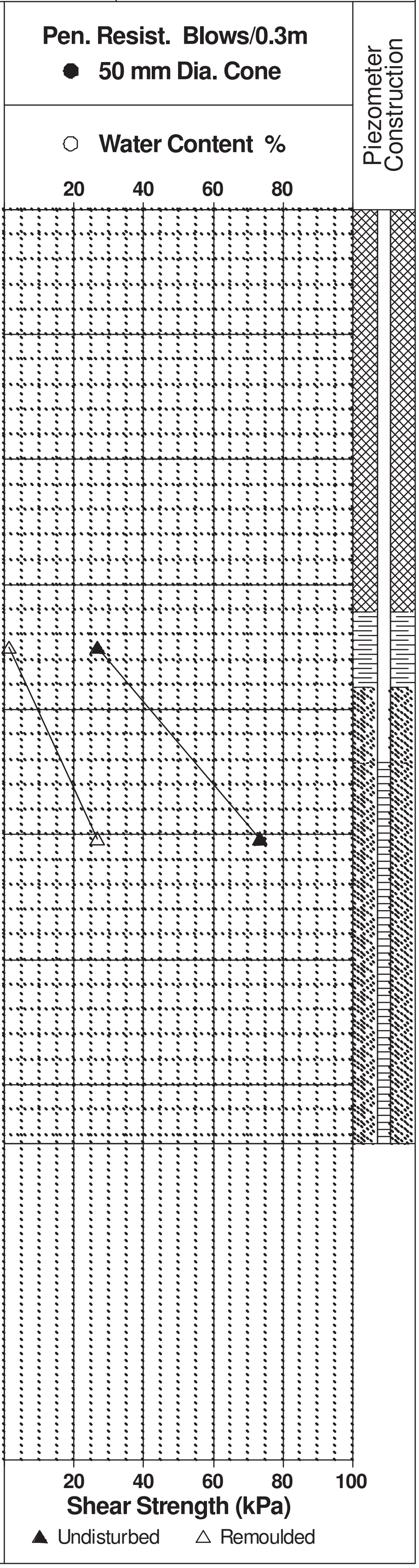
BORINGS BY CME 55 Power Auger

DATE 19 August 2010

FILE NO. PG2099

HOLE NO. BH 1-10

SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE					0	93.46
FILL: Brown silty sand with gravel, cobbles and boulders	AU	1				
	SS	2	73	50+	1	92.46
1.37						
Loose, brown **SANDY SILT** with clay	SS	3	83	6		
2.13					2	91.46
Firm to stiff, brown **SILTY CLAY**, trace sand	SS	4	100	2		
- grey by 2.9m depth					3	90.46
	TW	5			4	89.46
5.18					5	88.46
GLACIAL TILL: Loose to compact, grey silty sand with gravel, cobbles and boulders, trace clay	SS	6	33	7	6	87.46
	SS	7	21	16		
	SS	8	38	11	7	86.46
7.47						
End of Borehole						



patersongroup Consulting Engineers

154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Half-Moon Bay West - Cambrian Road
Ottawa, Ontario

DATUM Ground surface elevations provided by ASL.

REMARKS

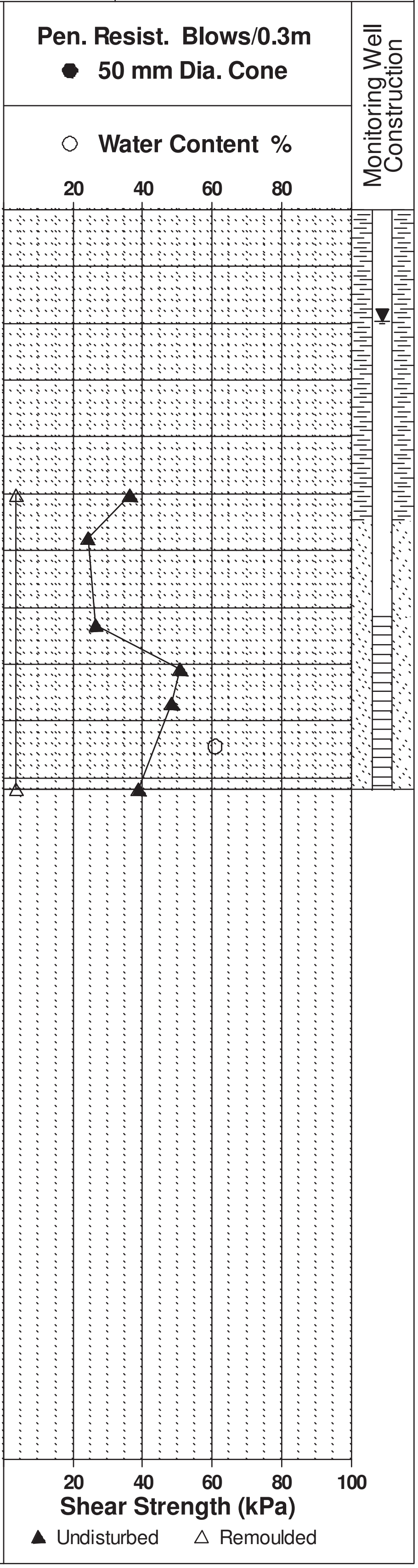
BORINGS BY CME 55 Power Auger

DATE October 27, 2010

FILE NO. PG2246

HOLE NO. BH 1-10

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	93.99
FILL: Brown silty clay with gravel and cobbles 1.24		SS	1	100	3	1	92.99
Firm, brown **SILTY CLAY** with sand		SS	2	33	2	2	91.99
2.97		SS	3	92	6	3	90.99
Firm, grey **SILTY CLAY**		SS	4	100	1	4	89.99
		TW	5	100		5	88.99
		TW	6	100		6	87.99
						7	86.99
						8	85.99
						9	84.99
10.21		TW	7	100		10	83.99
End of Borehole (GWL @ 1.96m-March 3/11)							



SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Half-Moon Bay West - Cambrian Road
Ottawa, Ontario

DATUM Ground surface elevations provided by ASL.

REMARKS

BORINGS BY CME 55 Power Auger

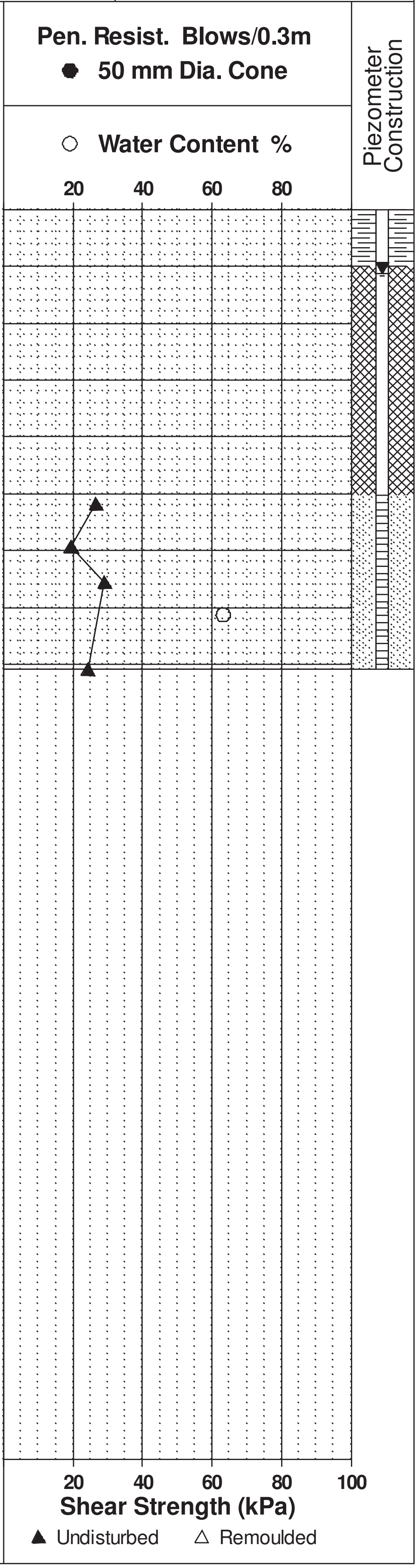
DATE October 29, 2010

FILE NO. PG2246

HOLE NO. BH 4-10

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD
GROUND SURFACE					
FILL: Brown, mixture of topsoil, clay and wood	▩	AU	1		
		AU	2		
1.39		SS	3	8	10
Firm, brown **SILTY CLAY** with sand and silt seams	▨	SS	4	12	10
		SS	5	83	3
3.35		SS	6	100	2
Firm, grey **SILTY CLAY**	▨	TW	7	100	
		TW	8	100	
8.08					
End of Borehole (GWL @ 1.13m-Jan. 10/11)					

DEPTH (m)	ELEV. (m)
0	93.79
1	92.79
2	91.79
3	90.79
4	89.79
5	88.79
6	87.79
7	86.79
8	85.79



SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development-Half Moon Bay
Ottawa, Ontario

DATUM Ground surface elevation at borehole locations provided by JD Barnes.

REMARKS

BORINGS BY CME 55 Power Auger

DATE 17 March 2008

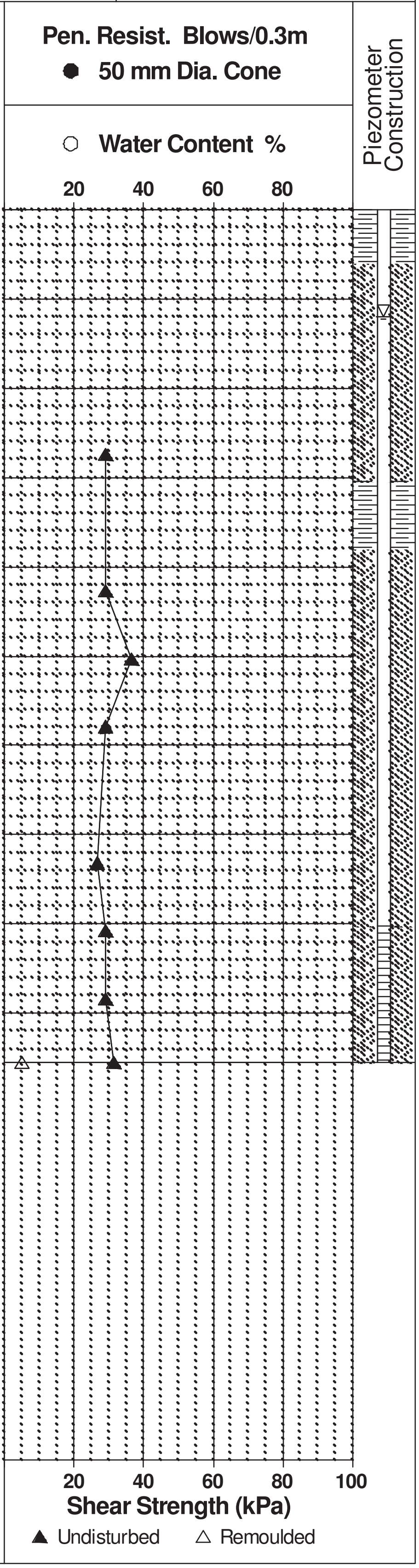
FILE NO. PG1618

HOLE NO. BH24-08

SOIL DESCRIPTION	Depth to base (m)
GROUND SURFACE	
PEAT	0.20
Grey **CLAYEY SILT** with sand and seashells	1.22
Dark grey **SILTY CLAY**	9.55
End of Borehole (Surficial water surrounding borehole - April 9/08)	

SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD
AU	1		
SS	2	50	4
SS	3	100	1
TW	4	83	
TW	5	100	

DEPTH (m)	ELEV. (m)
0	92.29
1	91.29
2	90.29
3	89.29
4	88.29
5	87.29
6	86.29
7	85.29
8	84.29
9	83.29



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28 Concourse Gate, Unit 1, Ottawa, ON K2E 7T7

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development-Half Moon Bay
Ottawa, Ontario

DATUM Ground surface elevations provided by J.D. Barnes Limited.

REMARKS

BORINGS BY CME 55 Power Auger

DATE 14 December 2006

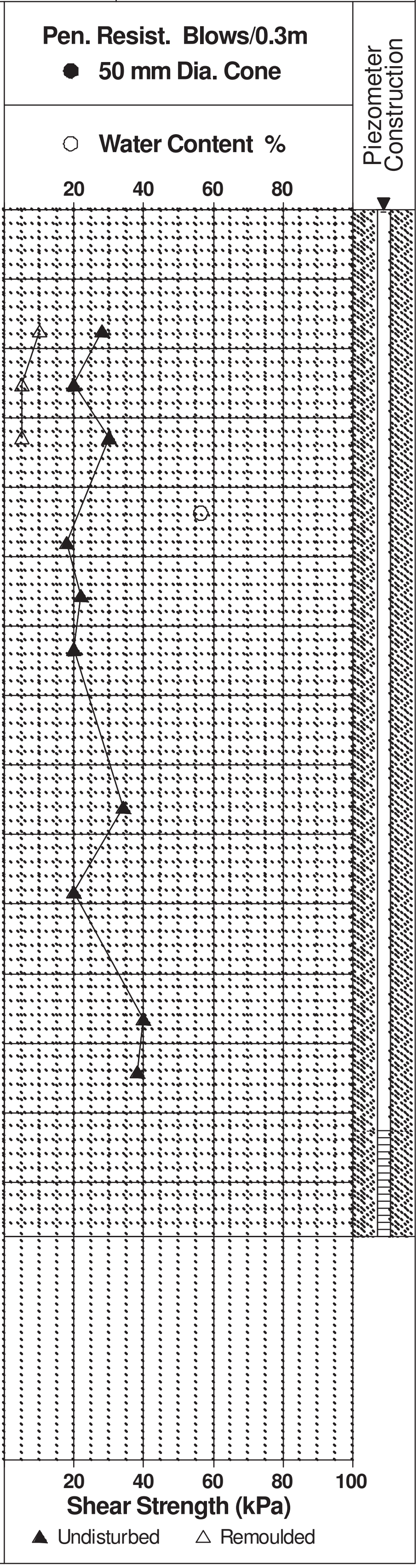
FILE NO. PG0177

HOLE NO. BH 5-06

SOIL DESCRIPTION	Depth (m)
GROUND SURFACE	
TOPSOIL	0.30
Stiff to firm, brown **SILTY CLAY**, trace sand - firm to soft and grey by 1.5m depth - firm by 7.0m depth (GWL @ 350mm above ground surface - Feb. 5/07)	14.17
GLACIAL TILL: Firm, grey silty clay with sand, gravel, cobbles and boulders	14.78
End of Borehole	

SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD
SS	1	75	3
TW	2	96	
TW	3	100	
TW	4	100	
TW	5		
SS	6	71	26

DEPTH (m)	ELEV. (m)
0	92.61
1	91.61
2	90.61
3	89.61
4	88.61
5	87.61
6	86.61
7	85.61
8	84.61
9	83.61
10	82.61
11	81.61
12	80.61
13	79.61
14	78.61



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28 Concourse Gate, Unit 1, Ottawa, ON K2E 7T7

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development-Half Moon Bay
Ottawa, Ontario

DATUM Ground surface elevations provided by J.D. Barnes Limited.

FILE NO. **PG0177**

REMARKS

HOLE NO. **BH14-05**

BORINGS BY CME 55 Power Auger

DATE 6 October 2005

SOIL DESCRIPTION	STRATA PLOT	SAMPLE				DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone ○ Water Content % 20 40 60 80	Piezometer Construction
		TYPE	NUMBER	% RECOVERY	N VALUE or RQD				
GROUND SURFACE						0	92.50		
TOPSOIL 0.28	■								
Stiff **SILTY CLAY/CLAYEY SILT** 1.50	▨					1	91.50		∇
End of Borehole (Open hole WL @ 0.95m depth)									

20 40 60 80 100

Shear Strength (kPa)

▲ Undisturbed △ Remoulded

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SOIL PROFILE AND TEST DATA

Preliminary Geotechnical Investigation
Nepean South Lands, South of Jock River
Ottawa, Ontario

DATUM

REMARKS

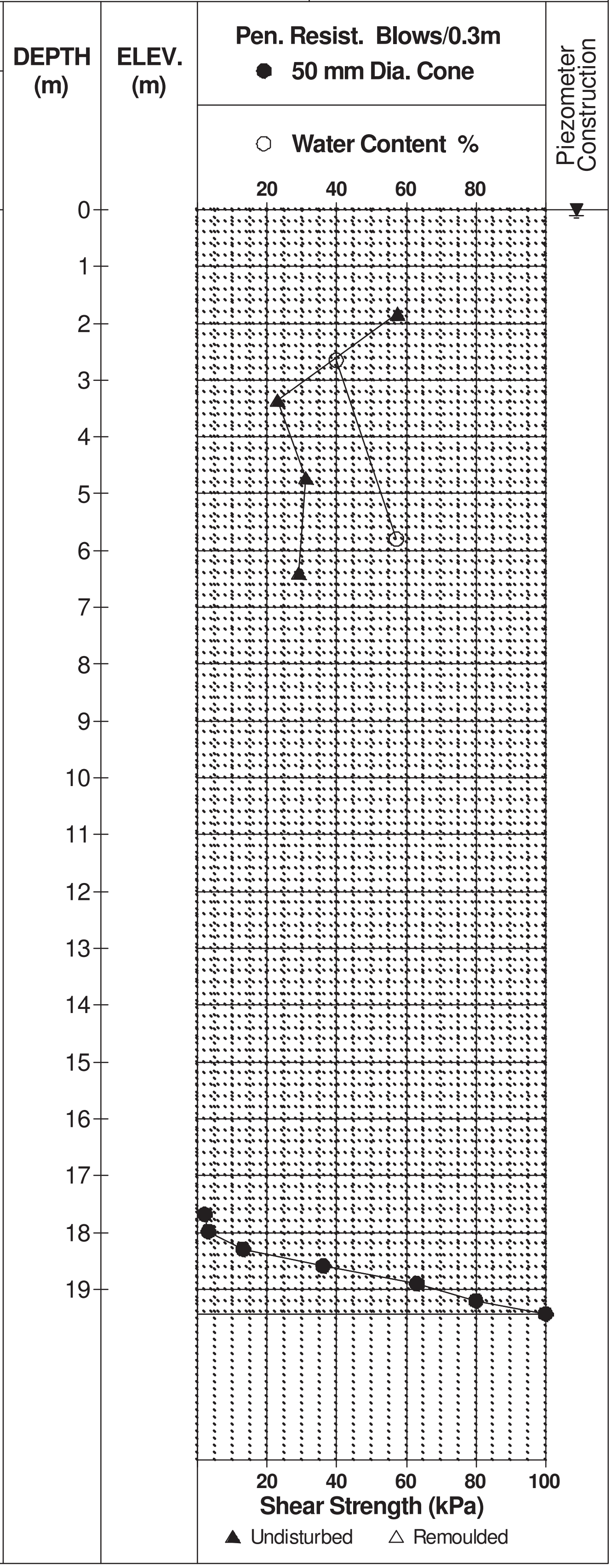
BORINGS BY CME 45 Power Auger

DATE 27 November 2003

FILE NO. G9132

HOLE NO. BH 3

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD
GROUND SURFACE					
TOPSOIL 0.15		AU	1		
Stiff, brown **SILTY CLAY**		SS	2		4
- organic matter in upper 150mm					
- soft to firm and grey by 2.3m depth		TW	3		
		SS	4	100	W
- soil running up the augers upon removing the auger plug starting at 6.1m depth		TW	5		
6.10					
Dynamic Cone Penetration Test commenced @ 6.10m depth. Cone pushed to 17.37m depth.					
Inferred **SILTY CLAY**					
17.40					
Inferred **GLACIAL TILL**					
19.43					
End of Borehole					
Cone refusal @ 19.43m depth					
(GWL @ 0.10m-Dec. 11/03)					



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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Half Moon Bay West - Greenbank at Cambrian Road
Ottawa, Ontario

DATUM Ground surface elevations provided by ASL.

REMARKS

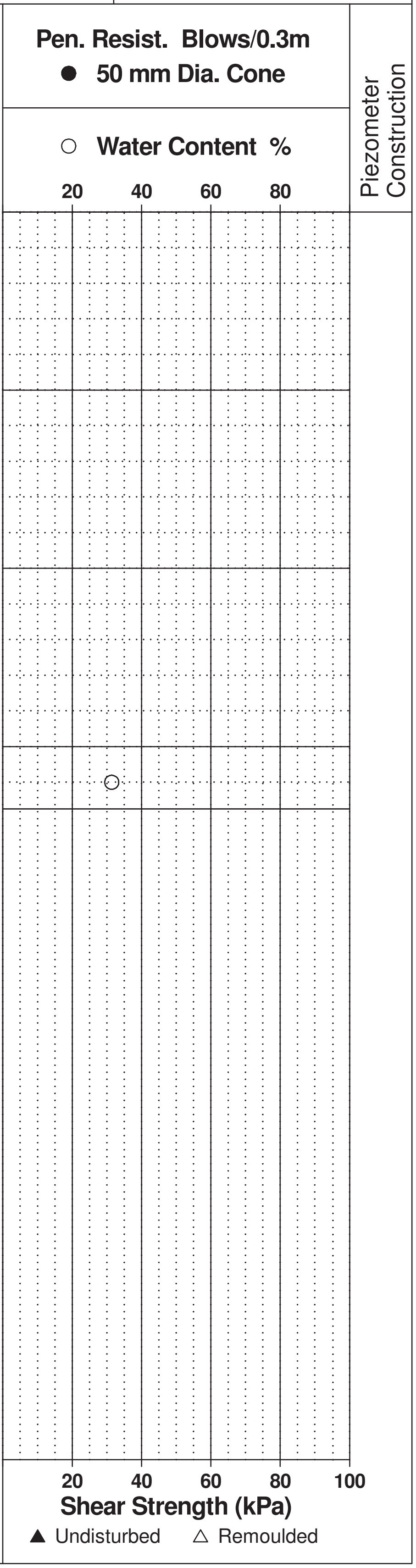
BORINGS BY Hydraulic Excavator

DATE March 6, 2018

FILE NO. PG2246

HOLE NO. TP 8-18

SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE					0	93.60
TOPSOIL 0.25						
FILL: Brown silty fine sand to silty clay, some gravel, cobbles and boulders 1.83	G	1			1	92.60
Compact, brown **SILTY FINE SAND to SANDY SILT,** some clay - clay content increasing with depth 2.90	G	2			2	91.60
Firm, grey **SILTY CLAY,** trace sand 3.35	G	3			3	90.60
End of Test Pit						



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Half Moon Bay West - Greenbank at Cambrian Road
Ottawa, Ontario

DATUM Ground surface elevations provided by ASL.

REMARKS

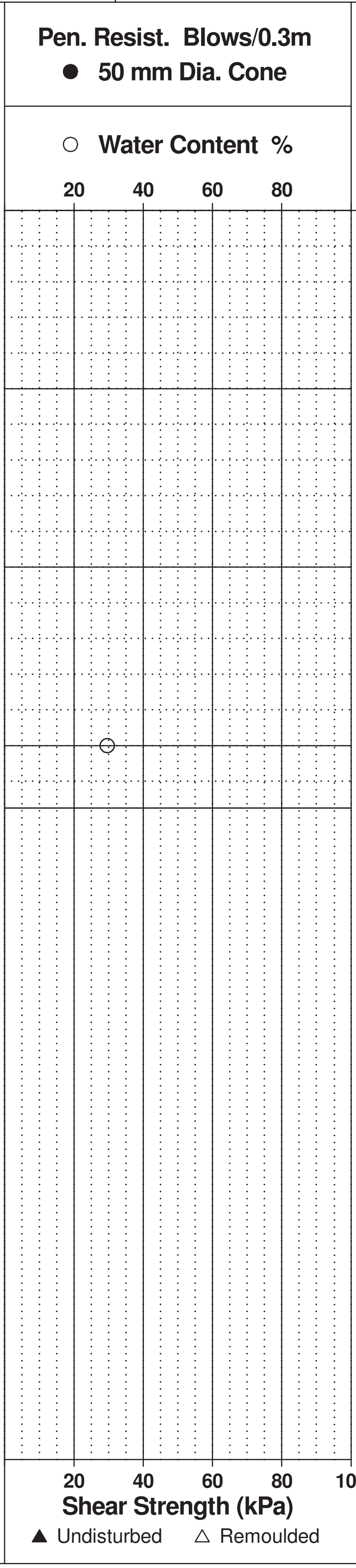
BORINGS BY Hydraulic Excavator

DATE March 6, 2018

FILE NO. PG2246

HOLE NO. TP 9-18

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	93.70
TOPSOIL 0.05							
Firm to stiff, brown **SILTY CLAY** with sand		G	1			1	92.70
2.13		G	2			2	91.70
Compact, brown **SILTY FINE SAND to SANDY SILT,** some clay - clay content increasing with depth 2.74		G	3				
Stiff, brown **SILTY CLAY** with sand 3.35		G	4			3	90.70
End of Test Pit							



Piezometer Construction

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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residential Development-Half Moon Bay
Ottawa, Ontario

DATUM Ground surface elevations provided by J.D. Barnes Limited.

REMARKS

BORINGS BY Backhoe

DATE 1 June 2007

FILE NO. PG0177

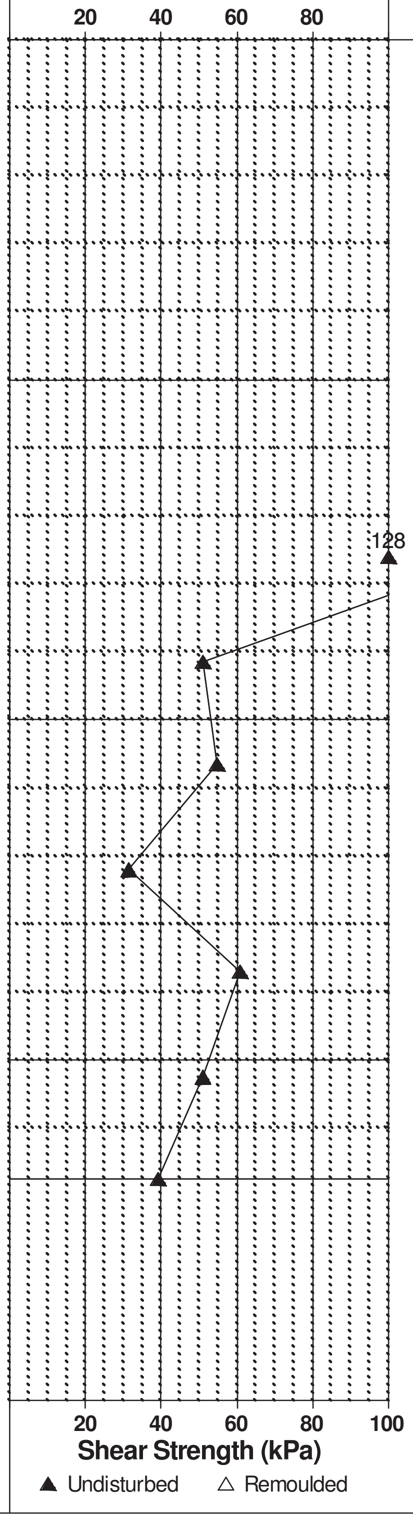
HOLE NO. TP24-07

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	92.75
TOPSOIL 0.28							
Very stiff to stiff, brown **SILTY CLAY**						1	91.75
						2	90.75
3.10						3	89.75
Firm, grey **SILTY CLAY** 3.35							
End of Test Pit (Open hole GWL @ 2.2m depth)							

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

○ Water Content %

Piezometer Construction



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28 Concourse Gate, Unit 1, Ottawa, ON K2E 7T7

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Half Moon Bay - Phase 8 and Phase 9
Ottawa, Ontario

DATUM Geodetic, provided by JD Barnes Ltd.

REMARKS

BORINGS BY Hydraulic Shovel

DATE 30 August 2010

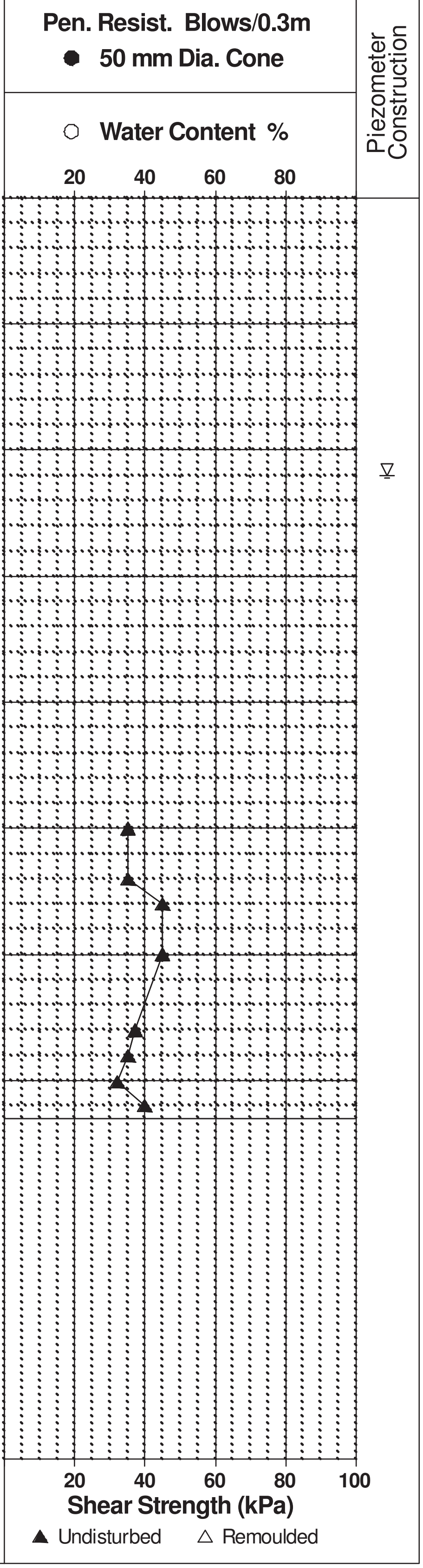
FILE NO. PG2099

HOLE NO. TP 3-10

SOIL DESCRIPTION	Depth (m)
GROUND SURFACE	
FILL: Grey silty sand with gravel and clay	0.85
Brown **SILTY FINE SAND,** trace clay	1.60
Stiff to firm, brown **SILTY CLAY** with sand seams - grey by 3.2m depth - no sand below 5.2 m depth	7.20
GLACIAL TILL: Grey silty sand with gravel, cobbles and boulders, trace clay	7.30
End of Test Pit (GWL @ 2.2m depth based on field observations)	

SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD
G	1		
G	2		
G	3		
G	4		
G	5		

DEPTH (m)	ELEV. (m)
0	93.32
1	92.32
2	91.32
3	90.32
4	89.32
5	88.32
6	87.32
7	86.32



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)

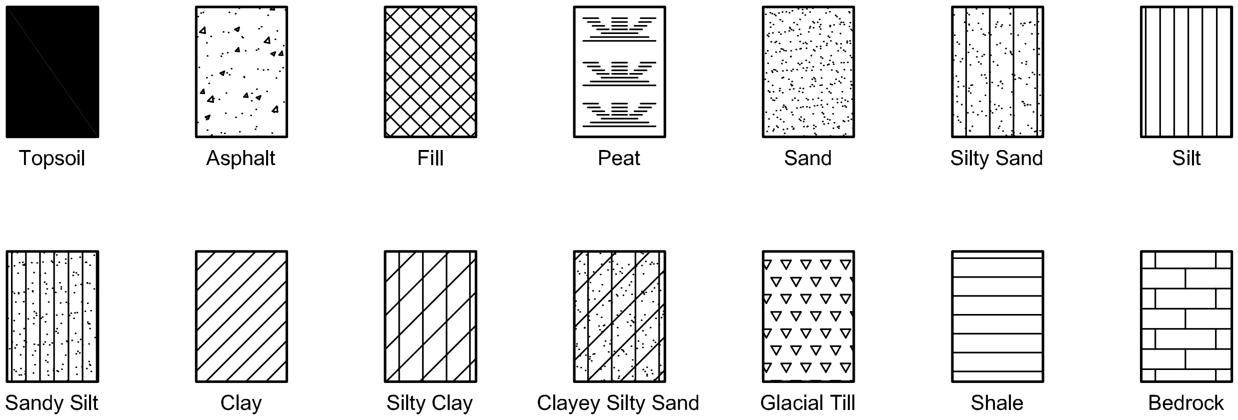
OC Ratio Overconsolidaton ratio = p'_c / p'_o
Void Ratio Initial sample void ratio = volume of voids / volume of solids
Wo - Initial water content (at start of consolidation test)

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.

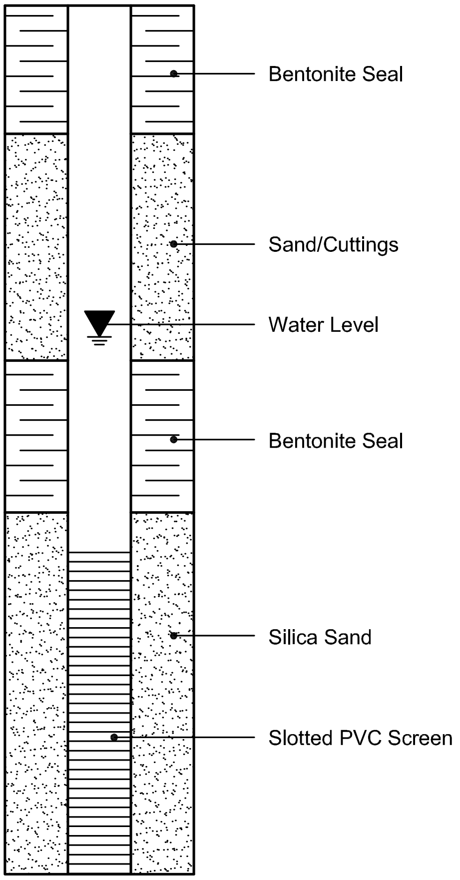
SYMBOLS AND TERMS (continued)

STRATA PLOT

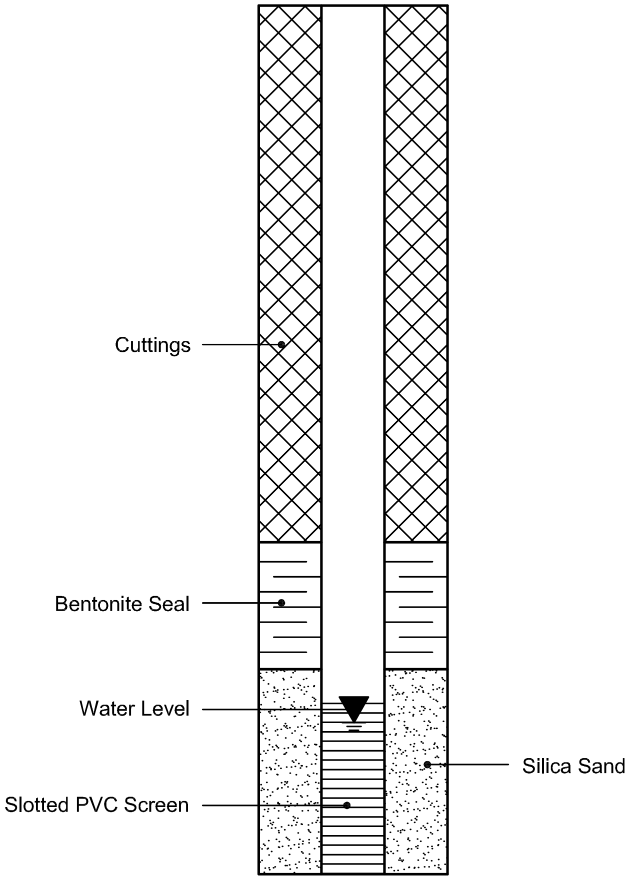


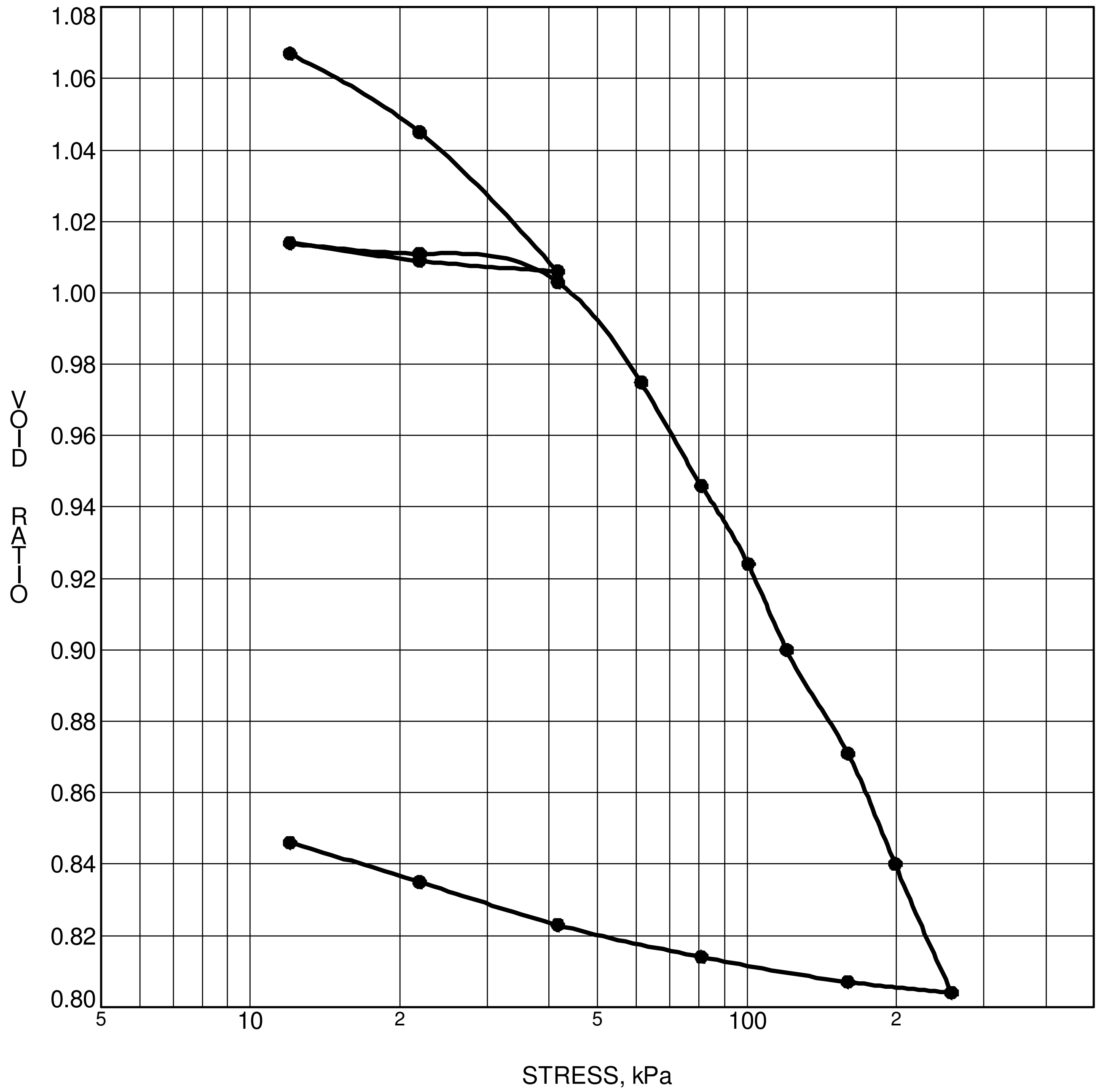
MONITORING WELL AND PIEZOMETER CONSTRUCTION

MONITORING WELL CONSTRUCTION



PIEZOMETER CONSTRUCTION





CONSOLIDATION TEST DATA SUMMARY					
Borehole No.	**BH 3**	p'$_o$	**31.7** kPa	Ccr	**0.019**
Sample No.	**TW 3**	p'$_c$	**50** kPa	Cc	**0.252**
Sample Depth	**2.65** m	OC Ratio	**1.6**	Wo	**39.8** %
Sample Elev.	m	Void Ratio	**1.09**	Unit Wt.	**18.1** kN/m^3

Note: Overburden stress calculated from original ground surface (92.60m)

CLIENT **Brickland Timberlay**

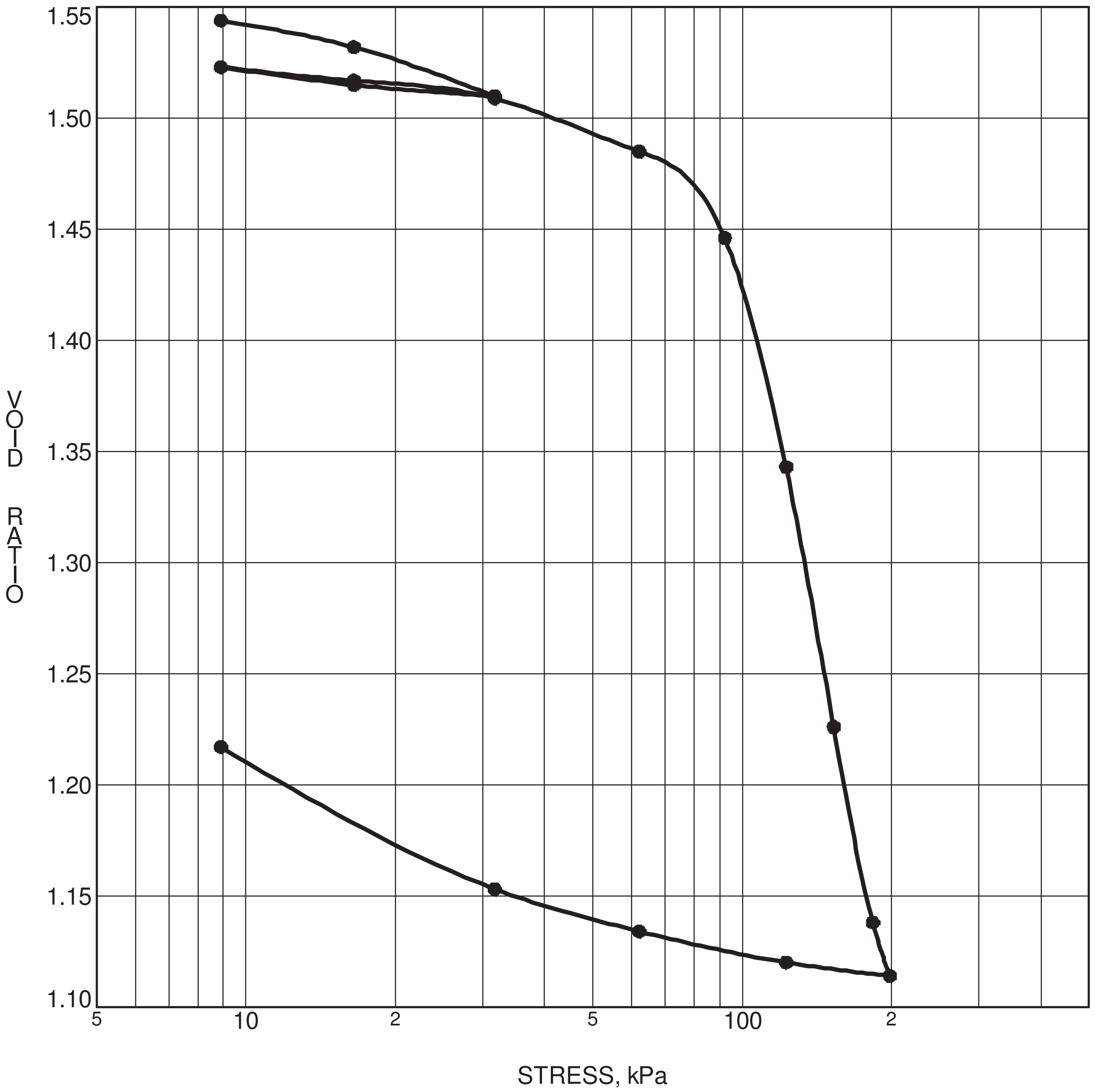
FILE NO. **G9132**

PROJECT **Preliminary Geotechnical Investigation - Nepean**
South Lands, South of Jock River

DATE **12/15/2003**

patersongroup **Consulting Engineers**
28 Concouse Gate, Unit 1, Ottawa, Ontario K2E 7T7

CONSOLIDATION TEST



CONSOLIDATION TEST DATA SUMMARY					
Borehole No.	**BH 5-06**	p'_o	**38.5** kPa	Ccr	**0.026**
Sample No.	**TW 2**	p'_c	**96** kPa	Cc	**1.185**
Sample Depth	**4.37** m	OC Ratio	**2.5**	Wo	**56.4** %
Sample Elev.	**88.24** m	Void Ratio	**1.55**	Unit Wt.	**16.5** kN/m ^{3}

Note: Overburden stress calculated from original ground surface (92.61m)

CLIENT **Mattamy Homes**

PROJECT **Geotechnical Investigation - Proposed Residential Development-Half Moon Bay**

FILE NO. **PG0177**

DATE **02/16/2007**

patersongroup **Consulting Engineers**

28 Concouse Gate, Unit 1, Ottawa, Ontario K2E 7T7

CONSOLIDATION TEST

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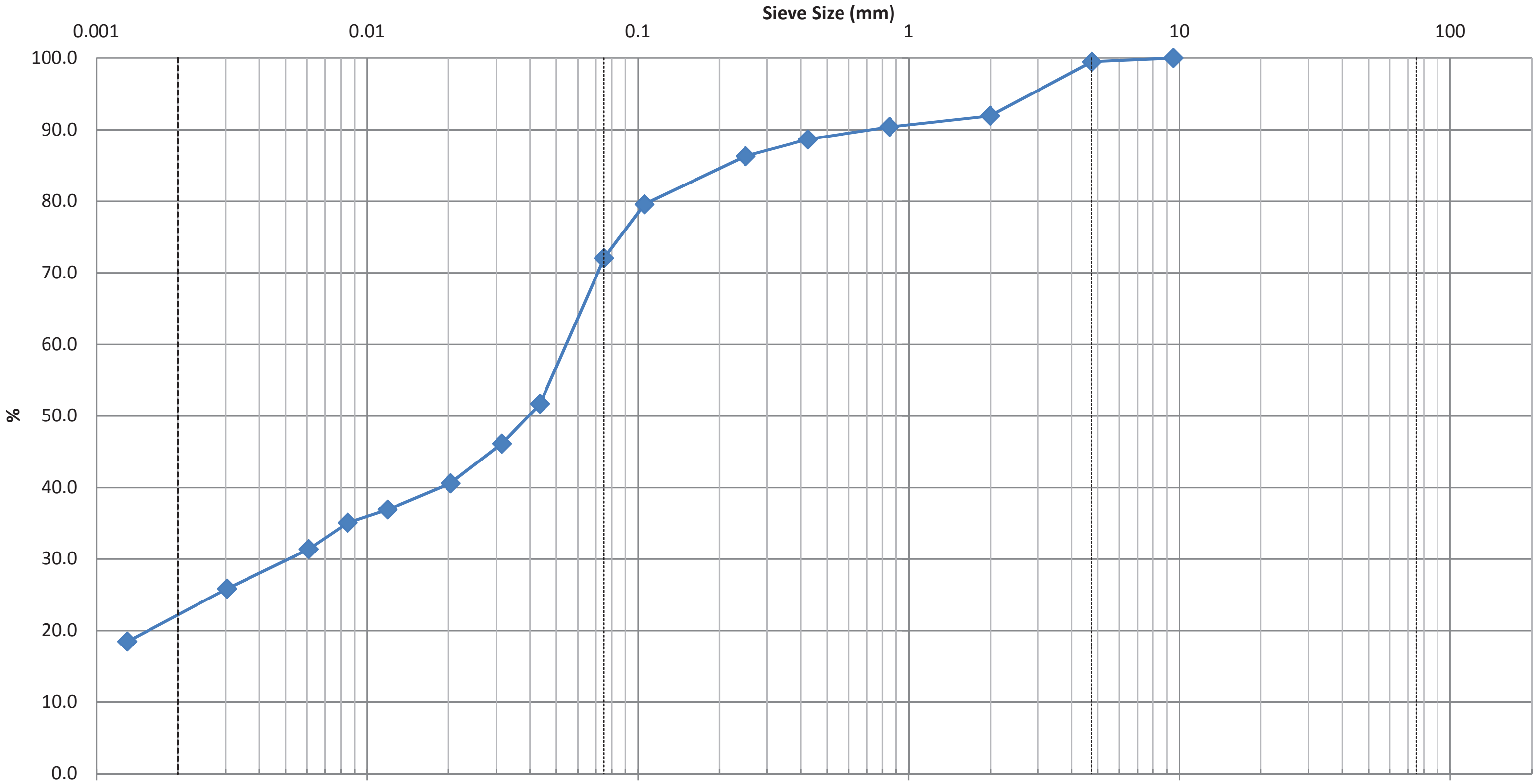
consulting engineers

CLIENT:	Mattamy Homes	DEPTH:	2.13 - 2.44	FILE NO:	PG2246
CONTRACT NO.:		BH OR TP No.:	TP8-18 - G2	LAB NO:	98984
PROJECT:	Half Moon Bay West	DESCRIPTION:	Silty Fine Sand to Sandy Silty, some Clay	DATE RECEIVED:	7-Mar-18
				DATE TESTED:	9-Mar-18
DATE SAMPLED:	6-Mar-18			DATE REPORTED:	12-Mar-18
SAMPLED BY:	N. Christie			TESTED BY:	D. Bertrand



	Clay	Silt	Sand			Gravel		Cobble
			Fine	Medium	Coarse	Fine	Coarse	

Identification	**Soil Classification**					**MC(%)**	**LL**	**PL**	**PI**	**Cc**	**Cu**
						18.7					

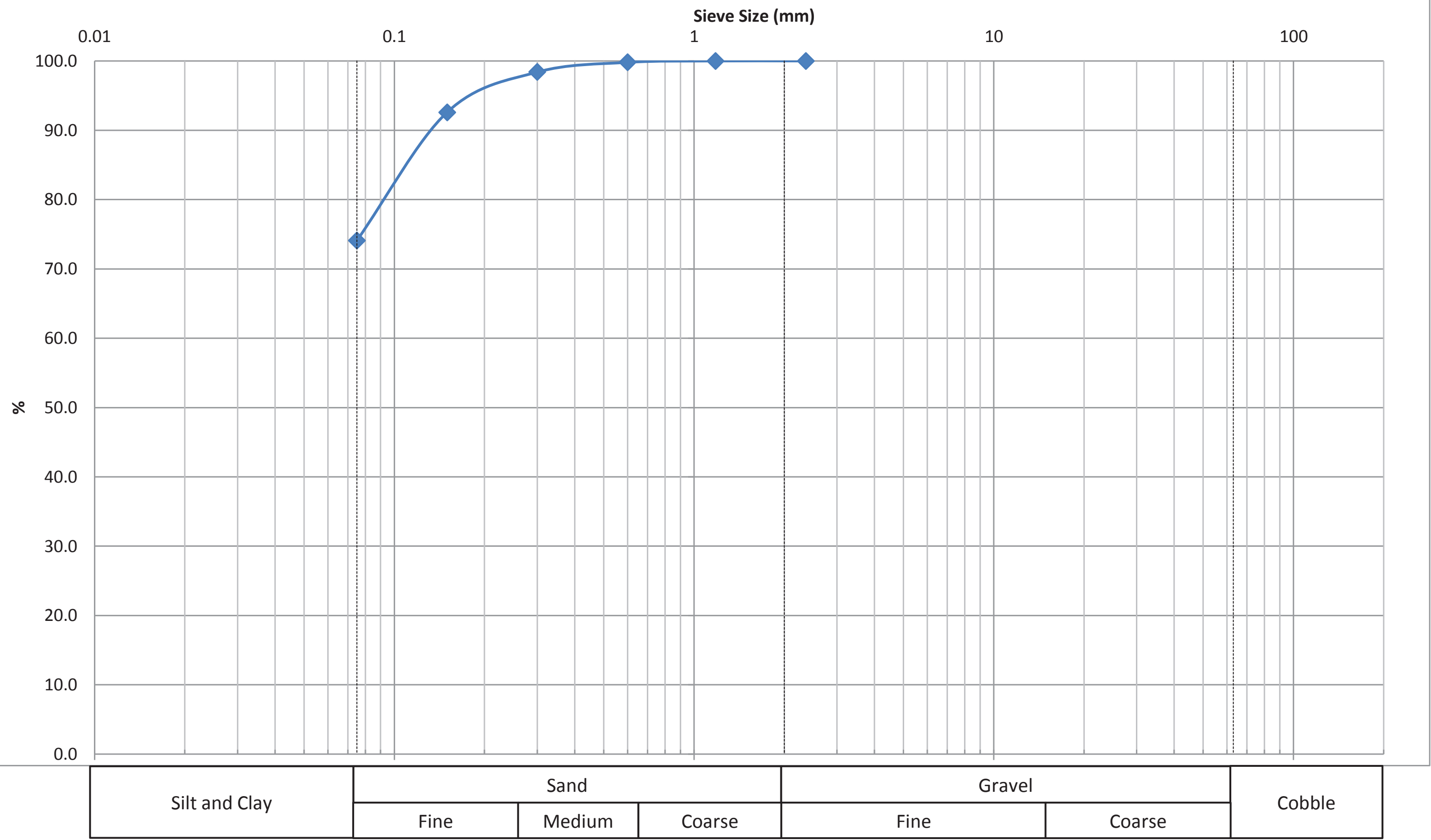
	D100	D60	D30	D10	Gravel (%)	Sand (%)	Silt (%)	Clay (%)
					0.5	27.5	49.5	22.5

Comments	

patersongroup
consulting engineers

SIEVE ANALYSIS
ASTM C136

CLIENT:	Mattamy Homes	DESCRIPTION:	Silty Fine Sand to Sandy Silty with Clay	FILE NO:	PG2246
CONTRACT NO.:	-	SPECIFICATION:	-	LAB NO:	98985
PROJECT:	Half Moon Bay West	INTENDED USE:	-	DATE RECEIVED:	7-Mar-18
		PIT OR QUARRY:	-	DATE TESTED:	8-Mar-18
DATE SAMPLED:	6-Mar-18	SOURCE LOCATION:	TP9-18 - G3	DATE REPORTED:	9-Mar-18
SAMPLED BY:	Nathan Christie	SAMPLE LOCATION:	2.44 to 2.74	TESTED BY:	D.B



Identification	Soil Classification	MC(%)	LL	PL	PI	Cc	Cu
						0.65	3.0

D100	D60	D30	D10	Gravel (%)	Sand (%)	Silt (%)	Clay (%)
2.5	0.045	0.021	0.015	0.0	25.9	74.1	

Comments

APPENDIX 2

FIGURE 1 - KEY PLAN

DRAWING PG4877-1 - TEST HOLE LOCATION PLAN

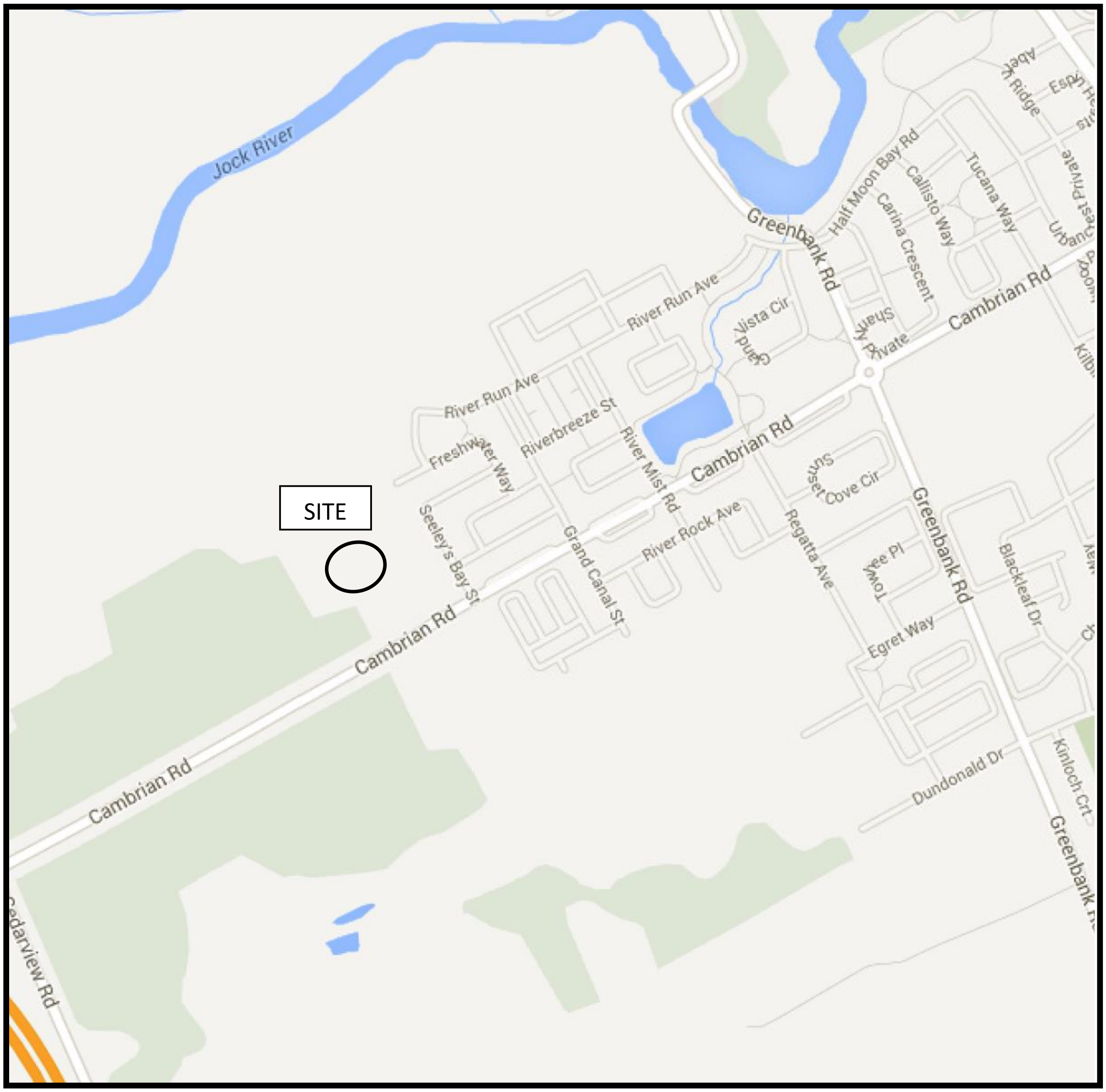
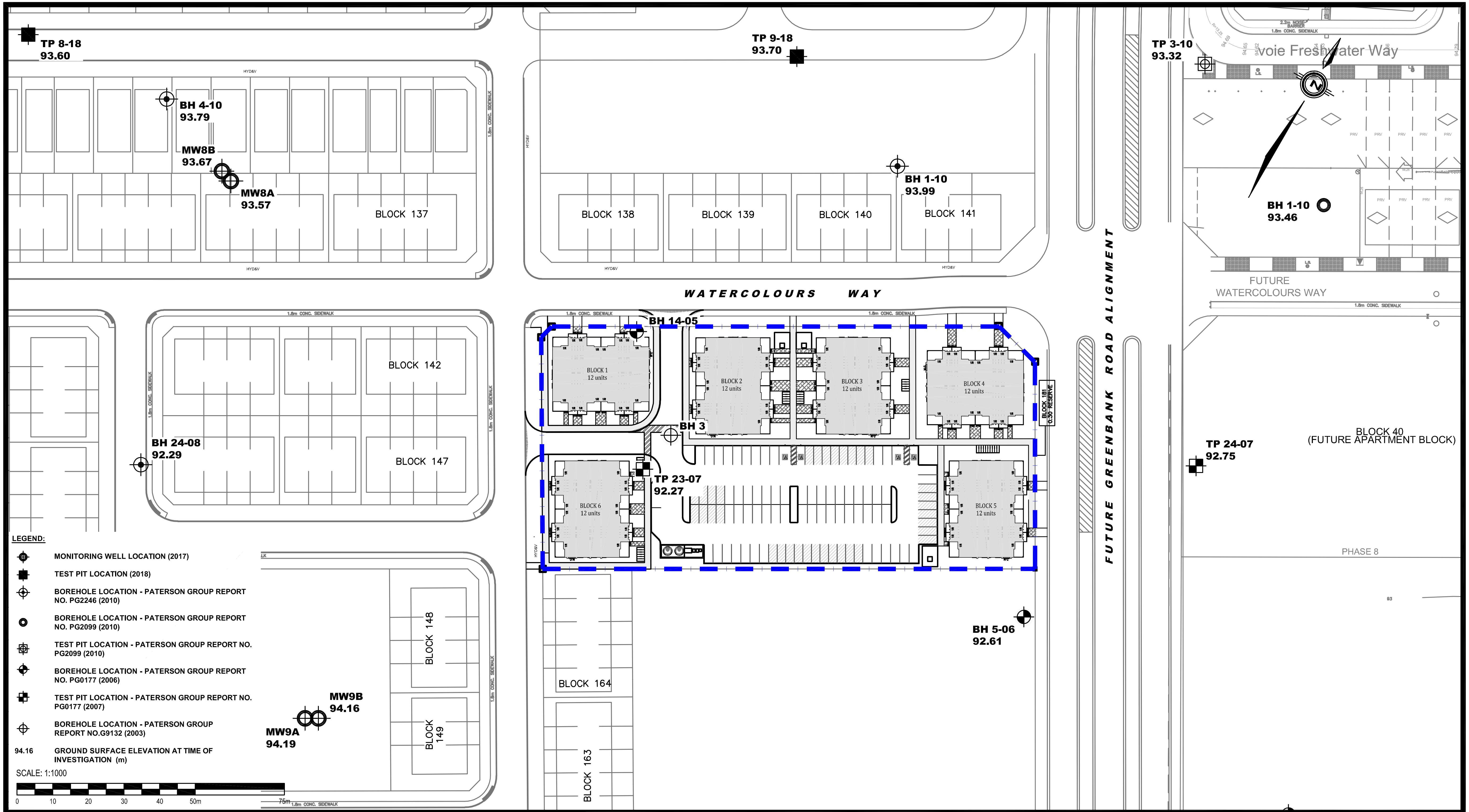


FIGURE 1

KEY PLAN

patersongroup



LEGEND:

⊕	MONITORING WELL LOCATION (2017)
■	TEST PIT LOCATION (2018)
⊕	BOREHOLE LOCATION - PATERSON GROUP REPORT NO. PG2246 (2010)
◉	BOREHOLE LOCATION - PATERSON GROUP REPORT NO. PG2099 (2010)
⊞	TEST PIT LOCATION - PATERSON GROUP REPORT NO. PG2099 (2010)
◐	BOREHOLE LOCATION - PATERSON GROUP REPORT NO. PG0177 (2006)
▚	TEST PIT LOCATION - PATERSON GROUP REPORT NO. PG0177 (2007)
⊕	BOREHOLE LOCATION - PATERSON GROUP REPORT NO.G9132 (2003)
94.16	GROUND SURFACE ELEVATION AT TIME OF INVESTIGATION (m)

SCALE: 1:1000

0 10 20 30 40 50m 75m

patersongroup
consulting engineers

154 Colonnade Road South
Ottawa, Ontario K2E 7J5
Tel: (613) 226-7381 Fax: (613) 226-6344

NO.	REVISIONS	DATE	INITIAL

MATTAMY HOMES

GEOTECHNICAL INVESTIGATION

PROPOSED APARTMENT BUILDINGS - HALF MOON BAY WEST - WATERCOLOURS WAY

OTTAWA, ONTARIO

Title:

TEST HOLE LOCATION PLAN

Scale: 1:1000
Date: 03/2019
Drawn by: RCG
Report No.: PG4877-1
Checked by: FA
Approved by: DJG

PG4877-1

Revision No.:

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