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Geotechnical
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Building Science

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Geotechnical Investigation

Proposed Residential Development
Blackstone Community - Phases 4 to 8
Terry Fox Drive - Ottawa

Prepared For

Mattamy Homes

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Report: PG4053-1

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Appendices

1.0 Introduction

Paterson Group (Paterson) was commissioned by Mattamy Homes to conduct a geotechnical investigation for the current phases (Phases 4 to 8) of the proposed Blackstone Community residential development, which is located west of Terry Fox Drive, in the City of Ottawa (refer to Figure 1 - Key Plan presented in Appendix 2).

The objectives of the investigation were to:

❏ determine the subsurface soil and groundwater conditions by means of boreholes, and existing soils information.

❏ 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 which is described herein. The report contains our findings and includes geotechnical recommendations pertaining to the design and construction of the proposed development as understood at the time of this report.

Investigating the presence or potential presence of contamination on the proposed development was not part of the scope of work. Therefore, the present report does not address environmental issues.

2.0 Proposed Development

It is understood that the proposed development consists of low rise residential dwellings and townhouse style housing. Local roadways, residential driveways, municipal services and park areas are further anticipated for the proposed development.

3.0 Method of Investigation

3.1 Field Investigation

Field Program

The field program for the current investigation was carried out on March 10 and 13, 2017. During that time, eight (8) boreholes were drilled to a maximum depth of 7.1 m below the existing ground surface. The borehole locations were distributed in a manner to provide general coverage of the subject site taking into consideration existing borehole coverage, site features and underground utilities. The locations of the boreholes are shown on Drawing PG4053-1 - Test Hole Location Plan included in Appendix 2.

Several previous field programs were also carried out within the subject site by Paterson and others between December 2006 to March 2011. A total of 11 boreholes and 4 test pits were completed as part of our previous investigations. The relevant test hole logs from the previous investigations are presented in Appendix 1.

The boreholes were completed using a track-mounted auger drill rig operated by a two person crew. The test pits were completed using a rubber tire backhoe. All fieldwork was conducted under the full-time supervision of personnel from our geotechnical division under the direction of a senior engineer. The testing procedure consisted of augering to the required depths and at the selected locations sampling the overburden.

Sampling and In Situ Testing

Soil samples were collected from the boreholes using a 50 mm diameter split-spoon (SS) sampler, using 73 mm diameter thin walled (TW) Shelby tubes in conjunction with a piston sampler, or from the auger flights. All soil samples were visually inspected and initially classified on site. The split-spoon 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 examination and classification. The depths at which the split-spoon, Shelby tube and auger samples were recovered from the test holes are shown as SS, TW and AU, respectively, 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 conducted in cohesive soils using a field vane apparatus.

Overburden thickness was evaluated during the course of the site investigation by dynamic cone penetration testing (DCPT). DCPT was completed at one borehole location of the current investigation and several of the borehole locations during previous investigations. 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 at the boreholes and test pits 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 standpipes were installed in all boreholes to monitor the groundwater levels subsequent to the completion of the sampling program. Groundwater infiltration levels were noted at the time of excavation at the test pit locations.

Sample Storage

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

3.2 Field Survey

The test holes were located in the field by Annis O'Sullivan Vollebekk. It is understood that the elevations are referenced to a geodetic datum. The ground surface elevation and location of the test holes are presented on Drawing PG4053-1 - Test Hole Location Plan in Appendix 2.

3.3 Laboratory Testing

The soil samples recovered from the investigation were examined in our laboratory to review field notes and soil samples.

A series of Shelby tube samples were submitted for unidimensional consolidation during previous investigations and Atterberg limit testing was completed from both current and previous investigations.

The results of the consolidation and Atterberg testing are presented on the Consolidation Test sheets and Atterberg Limits' Results presented in Appendix 1 and are further discussed in Sections 4 and 5.

3.4 Analytical Testing

One (1) soil sample was submitted for analytical testing to assess the corrosion potential for exposed ferrous metals and the potential of sulphate attacks against subsurface concrete structures. The sample was submitted to determine the concentration of sulphate and chloride, the resistivity and the pH of the sample. The results are presented in Appendix 1 and are discussed further in Subsection 6.7.

4.0 Observations

4.1 Surface Conditions

Currently, the subject site consists of agricultural fields . The ground surface across the subject site is relatively flat and gradually slopes towards existing ditches. The site is bordered to the north by a large drainage ditch (Monahan Drain) followed by completed phases of the Blackstone residential development. The site is bordered to the west by former agricultural fields and a stormwater management pond, to the south by Fernbank Road and to the east by Terry Fox Drive and a commercial development. Several fill piles were noted across the subject site at the time of the investigation as well as a drainage ditch running through the site between the stormwater management pond at the northeast corner of the site and Fernbank Road.

4.2 Subsurface Profile

Generally, the soil conditions encountered at the test hole locations consists of a cultivated topsoil/organic layer followed by a silty sand, and/or clayey silt layer overlying a sensitive silty clay deposit. Silty clay overlying a glacial till deposit was noted within the southwest portion of the subject site. Reference should be made to the Soil Profile and Test Data sheets in Appendix 1 for specific details of the soil profiles encountered at each test hole location.

Based on available geological mapping, the bedrock in this area mostly consists of interbedded limestone and dolomite of the Gull River formation with an overburden drift thickness of 10 to 50 m depth.

4.3 Groundwater

The groundwater levels in the boreholes from the current and previous geotechnical investigations are presented in Table 1. 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 level can also be estimated based on the observed colour and consistency of the recovered soil samples. Based on these observations, the long-term groundwater level can be expected between 2 to 3 m depth. Groundwater levels are subject to seasonal fluctuations and therefore could vary during time of construction.

Table 1 - Continued
Summary of Groundwater Level Readings - (Geotechnical Investigation PG2233)

Test Hole Number	Ground Elevation, m	Groundwater Levels, m		Recording Date
		Depth	Elevation	
BH 1	98.86	5.11	93.75	November 18, 2010
BH 2	98.88	Damaged	-	November 18, 2010
BH 7	97.49	4.96	92.53	November 18, 2010
BH 8	97.71	4.41	93.30	November 18, 2010
BH 8A	97.71	0.42	97.29	November 18, 2010

Note: Assumed geodetic elevations at the test hole locations were provided by Annis O'Sullivan Vollebekk Ltd.

Table 1 - Continued
Summary of Groundwater Level Readings - (Current Geotechnical Investigation PG4053)

Test Hole Number	Ground Elevation, m	Groundwater Levels, m		Recording Date
		Depth	Elevation	
BH 1-17	100.31	above ground surface	-	42814
BH 2-17	100.23	2.33	97.9	42814
BH 3-17	99.9	1.14	98.76	42814
BH 4-17	99.07	1.82	96.52	42814
BH 5-17	99.19	2.55	96.7	42814
BH 6-17	99.57	0.84	94.92	42814
BH 7-17	98.6	2.49	97.76	42814
BH 8-17	100.05	4.65	98.23	42814

Note: Geodetic elevations at the test hole locations were provided 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 residential development. Due to the presence of the sensitive silty clay layer, the proposed development will be subjected to grade raise restrictions.

Permissible grade raise recommendations are discussed in Subsection 5.3 and recommended permissible grade raise areas are presented in Drawing PG4053-2 - Permissible Grade Raise Plan in Appendix 2. If higher than permissible grade raises are required, preloading with or without a surcharge, lightweight fill and/or other measures should be investigated to reduce the risks of unacceptable long-term post construction total and differential settlements.

Seismic site classification recommendations are discussed in Subsection 5.5 and are presented in Drawing PG4053-3 - Seismic Site Classification Plan in Appendix 2.

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. Granular material should be tested and approved prior to delivery to the site. The fill should be placed in lifts of 300 mm thick or less and compacted using suitable compaction equipment for the lift thickness. Fill placed beneath the building areas should be compacted to at least 98% of the Standard Proctor Maximum Dry Density (SPMDD).

Non-specified existing fill along with site-excavated soil could be placed as general landscaping fill where settlement of the ground surface is of minor concern. These materials should be spread in lifts with a maximum thickness of 300 mm and compacted by the tracks of the spreading equipment to minimize voids. Non-specified existing fill and site-excavated soils are not suitable for placement as backfill against foundation walls, unless used in conjunction with a geocomposite drainage membrane, such as Miradrain G100N or Delta Drain 6000.

Ditch Area

The existing drainage ditches will be backfilled as part of the proposed development. The drainage ditches, regardless of whether a roadway or building is constructed above, is recommended to be backfilled by the following methodology;

- ❏ Remove the topsoil material.
- ❏ Provide benching in existing slope at a minimum of 2H:1V profile.
- ❏ Backfill in maximum 300 mm thick loose lifts and compact to 95% of the SPMDD to 1.0 m below finished grade. All material placed within 1.0 m of finished grade should be compacted to 98% of the SPMDD.
- ❏ The backfill materials should consist of site approved material or engineered fill.
- ❏ The backfilling procedure should be reviewed on-site by Paterson personnel.

Park Blocks

For grading within the proposed park blocks, site-excavated soil can be used as general landscaping fill 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. A site specific review should be completed to provide recommendations for any settlement sensitive structures, such as splash pads or shade structures.

5.3 Foundation Design

Based on the results of the geotechnical investigation, lightly loaded structures, such as the residential buildings anticipated, could be founded on shallow footings bearing on compact sandy silt or firm to stiff clayey silt/silty clay, provided that the required grade raise is within tolerable limits.

Bearing Resistance Values

Footngs for the proposed buildings can be designed using the 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)
Compact sandy silt	60	125
Firm Clayey Silt/Silty Clay	60	125
Stiff Silty Clay/Clayey Silt	100	150
Glacial Till	150	225

The bearing resistance values are provided on the condition that the footings will be 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.

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 the in-situ bearing medium soils 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.

Settlement/Grade Raise

Consideration must be given to potential settlements which could occur due to the presence of the silty clay deposit and the combined loads from the proposed footings, any groundwater lowering effects, and grade raise fill. 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. For dwellings, a minimum value of 50% of the live load is recommended by Paterson.

Generally, the potential long term settlement is evaluated based on the compressibility characteristics of the silty clay. These characteristics are estimated in the laboratory by conducting unidimensional consolidation tests on undisturbed soil samples collected using Shelby tubes in conjunction with a piston sampler. Eight (8) site specific consolidation tests were conducted within the subject portion of the proposed development. The results of the consolidation tests from the previous investigations are presented in Table 3 and 4 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 3 - Summary of Consolidation Test Results (Paterson Investigation PG2233)

Borehole No.	Sample	Depth (m)	p'_c (kPa)	p'_o (kPa)	C_{cr}	C_c	Q (*)
BH 1	TW 2	3.45	78	40	0.012	0.471	A
BH 2	TW 2	5.76	113	54	0.009	0.934	P
BH 9	TW 5	4.19	77	45	0.015	0.290	G
BH 9	TW 6	8.06	116	69	0.015	1.104	A
BH 10	TW 5	3.3	70	36	0.015	0.586	A
BH 12	TW 5	3.38	85	34	0.014	0.281	A

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

Table 4 - Summary of Consolidation Test Results (Investigation by Others)

Borehole No.	Sample	Depth (m)	p'_c (kPa)	p'_o (kPa)	C_{cr}	C_c
06 - 2	4	5	130	37	0.020	0.560
06 - 7	4	4.8	130	42	0.020	1.600

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 during the investigation are based on the long term groundwater level being at 0.5 m below the existing groundwater table. The groundwater level is based on the colour and undrained shear strength profile of the silty clay.

The total and differential settlements will be dependent on characteristics of the proposed buildings. For design purposes, the total and differential settlements are estimated to be 25 and 20 mm, respectively. A post-development groundwater lowering of 0.5 m was assumed.

The potential post construction total and differential settlements are dependent on the position of the long term groundwater level when building are situated over deposits of compressible silty clay. Efforts can be made to reduce the impacts of the proposed development on the long term groundwater level by placing clay dykes in the service trenches, reducing the sizes of paved areas, leaving green spaces to allow for groundwater recharge or limiting planting of trees to areas away from the buildings. However, it is not economically possible to control the groundwater level.

To reduce potential long term liabilities, consideration should be given to accounting for a larger groundwater lowering and to provide means to reduce long term groundwater lowering (e.g. clay dykes, restriction on planting around the dwellings, etc). Buildings on silty clay deposits increases the likelihood of movements and therefore of cracking. The use of steel reinforcement in foundations placed at key structural locations will tend to reduce foundation cracking compared to unreinforced foundations.

The recommended permissible grade raise areas are defined in Drawing PG4053-2 - Permissible Grade Raise Plan in Appendix 2.

Park Block

Based on current information, a permissible grade raise of 1.5 m is recommended for settlement sensitive structures, such as splash pads or picnic shelters, located within the community park area. A permissible grade raise restriction is not required for general landscaping purposes within the park area.

5.4 Design for Earthquakes

Shear wave velocity testing was completed for the subject site during a previous investigation to accurately determine the applicable seismic site classification for the proposed buildings from Table 4.1.8.4.A of the Ontario Building Code 2012. The shear wave velocity testing was completed by Paterson personnel. The shear wave velocity profile at two (2) locations are presented in Appendix 2.

Field Program

One (1) shear wave velocity test was completed within the north portion of the current development phases as presented in Drawing PG4053-3 - Seismic Site Classification Plan presented in Appendix 2 and a second shear wave velocity test was completed to the southwest of the current development phases. Paterson field personnel placed 24 horizontal geophones in a straight line at each test location. The 4.5 Hz. horizontal geophones were mounted to the surface by means of a 75 mm ground spike attached to the geophone land case. The geophones were spaced at 3 m intervals and were connected by a geophone spread cable to a Geode 24 Channel seismograph.

The seismograph was also connected to a computer laptop and a hammer trigger switch attached to a 12 pound dead blow hammer. The hammer trigger switch sends a start signal to the seismograph. The hammer is used to strike an I-Beam seated into the ground surface, which creates a polarized shear wave. The hammer shots are repeated between four (4) to eight (8) times at each shot location to improve signal to noise ratio. The shot locations are completed in forward and reverse directions (i.e.- striking both sides of the I-Beam seated parallel to the geophone array). The shot locations are located at the centre of the geophone array and 3, 4.5 and 30 m away from the first and last geophone.

The methods of testing completed by Paterson are guided by the standard testing procedures used by the expert seismologists at Carleton University and Geological Survey of Canada (GSC).

Data Processing and Interpretation

Interpretation for the shear wave velocity results were completed by Paterson personnel. Shear wave velocity measurement was made using reflection/refraction methods. The interpretation is performed by recovering arrival times from direct and refracted waves. The interpretation is repeated at each shot location to provide an average shear wave velocity, Vs_{30}, of the upper 30 m profile, immediately below the building's foundation. The layer intercept times, velocities from different layers and critical distances are interpreted from the shear wave records to compute the bedrock depth at each location. The bedrock velocity was interpreted using the main refractor wave velocity, which is considered a conservative estimate of the bedrock velocity due to the increasing quality of the bedrock with depth. As bedrock quality increases, the bedrock shear wave velocity also increases.

The overburden velocity was noted to be 130 and 150 m/s, and the bedrock velocity was noted to be 2,850 and 2,049 m/s at the test locations. It should be further noted that the bedrock depth increases towards the northeast across the subject site and based on seismic and DCPT results, the bedrock was noted to be 10 to 40 m below ground surface.

The Vs_{30} was calculated using the standard equation for average shear wave velocity calculation from the Ontario Building Code (OBC) 2012.

$$V_{s30} = \frac{Depth_{OfInterest}(m)}{\sum\left(\frac{(Depth_{Layer1}(m)}{Vs_{Layer1}(m/s)} + \frac{Depth_{Layer2}(m)}{Vs_{Layer2}(m/s)}\right)}$$

$$V_{s30} = \frac{30m}{\sum\left(\frac{30m}{150m/s}\right)}$$

$$V_{s30} = 150m/s$$

Based on the results of the seismic testing within the north portion of the site, the average shear wave velocity, Vs_{30}, is **150 m/s**. Therefore, a **Site Class E** is applicable for foundation design within that area where similar soil conditions are encountered, as per Table 4.1.8.4.A of the OBC 2012. Based on the results of the seismic testing to the northwest of the current phases and our observations of the soil and bedrock profiles across the remainder of the subject site, the average shear wave velocity of the upper 30 m profile, Vs_{30}, was calculated to be **391 m/s**. Therefore, a seismic **Site Class C** is applicable for areas with similar subsoil conditions. Based on our seismic testing results and our field investigations, the recommended seismic site classification areas are presented in Drawing PG4053-3 - Seismic Site Classification in Appendix 2.

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, with a maximum particle size of 50 mm, 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. 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 its 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/local residential streets. These guidelines should be reviewed once the details of the development are known.

Table 5 - Recommended Pavement Structure - Car 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 6 - Recommended Pavement Structure - Local Residential Roadways

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	

Table 7 - Recommended Pavement Structure - Roadways with Bus Traffic

Thickness mm	Material Description
40	**Wear Course -** Superpave 12.5 Asphaltic Concrete
50	**Upper Binder Course** - Superpave 19.0 Asphaltic Concrete
50	**Lower Binder Course** - Superpave 19.0 Asphaltic Concrete
150	**BASE** - OPSS Granular A Crushed Stone
600	**SUBBASE** - OPSS Granular B Type II
SUBGRADE - Either in situ soil or OPSS Granular B Type 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 excavated and replaced with OPSS Granular B Type I or II material. Weak subgrade conditions may be experienced over service trench fill materials. This may require the use of a geotextile, 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 98% of the material's SPMDD using suitable vibratory equipment.

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 low permeability of the subgrade materials consideration should be given to installing subdrains during the pavement construction as per City of Ottawa standards. The subdrain inverts should be approximately 300 mm below subgrade level. The subgrade surface should be crowned to promote water flow to the drainage lines.

6.0 Design and Construction Precautions

6.1 Foundation Drainage and Backfill

A perimeter foundation drainage system is recommended 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 structures. 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 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 placement as backfill against the foundation walls unless used in conjunction with a composite drainage system, such as Delta Drain 6000 or Miradrain G100N. Imported granular materials, such as clean sand or OPSS Granular B Type I granular material, should be placed for this purpose.

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 those for 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.

6.3 Excavation Side Slopes

The excavation for the current phase of the proposed development will be mostly through sandy silt and/or clayey silt/silty clay. Above the groundwater level, for excavations to depths of approximately 3 m, the excavation side slopes should be stable in the short term at 1H:1V. Flatter slopes could be required for deeper excavations or for excavation below the groundwater level. Where such side slopes are not permissible or practical, temporary shoring should be used. The subsoil at this site is considered to be mainly a Type 2 or 3 soil according to the Occupational Health and Safety Act and Regulations for Construction Projects.

The slope cross-sections recommended above are for temporary slopes. 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.

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 remain exposed for extended periods of time.

Excavation Base Stability

The base of supported excavations can fail by three (3) general modes:

- ☐ Shear failure within the ground caused by inadequate resistance to loads imposed by grade difference inside and outside of the excavation,
- ☐ Piping from water seepage through granular soils, and
- ☐ Heave of layered soils due to water pressures confined by intervening low permeability soils.

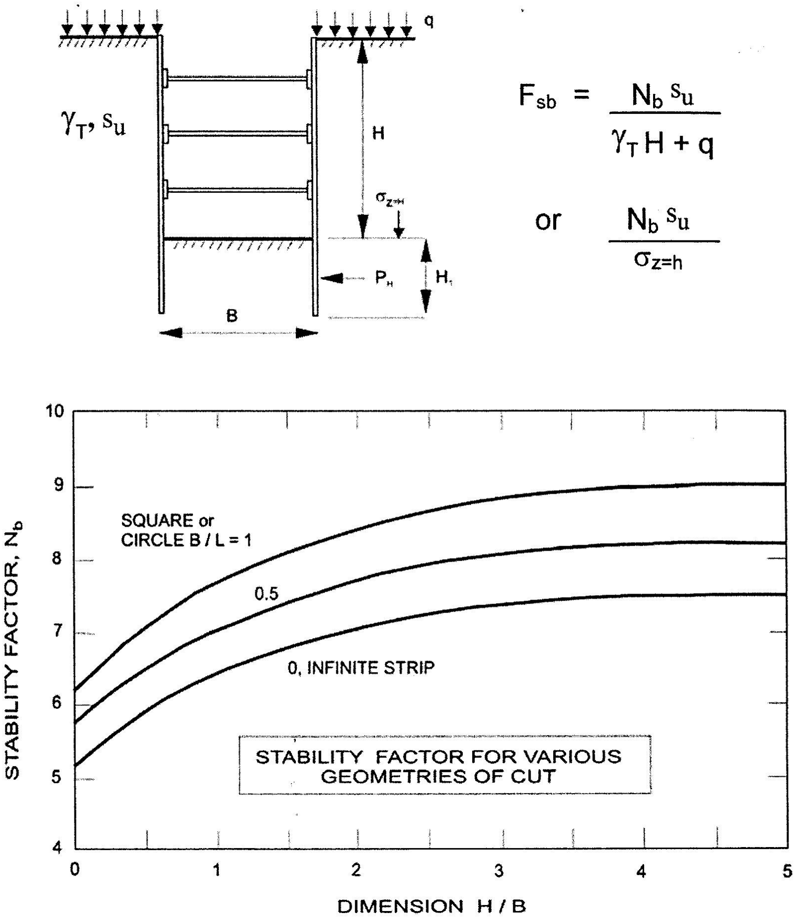
Shear failure of excavation bases is typically rare in granular soils if adequate lateral support is provided. Inadequate dewatering can cause instability in excavations made through granular or layered soils. The potential for base heave in cohesive soils should be determined for stability of flexible retaining systems.

The factor of safety with respect to base heave, FS_b, is:

$$FS_b = N_b s_u / \sigma_z$$

where:

N_b - stability factor dependent upon the geometry of the excavation and given in Figure 1 on the following page.
s_u - undrained shear strength of the soil below the base level
σ_z - total overburden and surcharge pressures at the bottom of the excavation



$$F_{sb} = \frac{N_b\, s_u}{\gamma_T H + q} \quad \text{or} \quad \frac{N_b\, s_u}{\sigma_{z=h}}$$

Figure 1 - Stability Factor for Various Geometries of Cut

In the case of soft to firm clays, a factor of safety of 2 is recommended for base stability.

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 could 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 extend 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.

Generally, it should 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 (in the trench direction) and should extend from trench wall to trench wall. 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 and at strategic locations at no more than 60 m intervals in the service trenches. Periodic inspection of the clay seal placement work should be completed by Paterson personnel during servicing installation work.

6.5 Groundwater Control

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.

Due to the relatively impervious nature of the silty clay/clayey silt materials, it is anticipated that groundwater infiltration into the excavations should be low and controllable using open sumps. A perched groundwater condition may be encountered within the sandy silt deposit which may produce significant temporary groundwater infiltration levels. Pumping from open sumps should be sufficient to control the groundwater influx through the sides of shallow excavations.

A temporary Ministry of the Environment and Climate Change (MOECC) 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 MOECC.

For typical ground or surface water volumes, being pumped during the construction phase, 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, an EASR will not be allowed as a temporary dewatering measure while awaiting the MOECC review of the PTTW application.

6.6 Winter Construction

The subsurface 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, 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 constructed 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 Corrosion Potential and Sulphate

The results of analytical testing show that the sulphate content is less than 0.1%. These results are indicative that Type 10 Portland cement (normal cement) would be appropriate for this site. The results of the chloride content, pH and resistivity indicate the presence of a non-aggressive to slightly aggressive environment for exposed ferrous metals at this site.

6.8 Landscaping Considerations

Tree Planting Restrictions

The proposed development is located in an area of medium sensitive silty clay deposits for tree planting. Tree planting for this subject development should be limited to low water demand trees. The minimum permissible distance from the foundation will depend on the nature of the tree, the depth of the clay crust and the final grade raise in relation to the permissible grade raise. A minimum permissible distance of 4.5 m from the foundation wall is recommended for a tree planting.

It is well documented in the literature, and is our experience, that fast-growing trees located near buildings founded on cohesive soils that shrink on drying can result in long-term differential settlements of the structures. Tree varieties that have the most pronounced effect on foundations are seen to consist of poplars, willows and some maples (i.e. Manitoba Maples) and, as such, they should not be considered in the landscaping design.

Swimming Pools

The in-situ soils are considered to be acceptable for swimming pools. Above ground swimming pools must be placed at least 4 m away from the residence foundation and neighbouring foundations. Otherwise, pool construction is considered routine, and can be constructed in accordance with the manufacturer`s requirements.

Installation of Decks or Additions

If consideration is given to construction of a deck or addition, a geotechnical consultant should be retained by the homeowner to review the site conditions. Additional grading around proposed deck or addition should not exceed permissible grade raises. Otherwise, standard construction practices are considered acceptable.

7.0 Recommendations

It is recommended that the following be completed 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 Paterson's 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 Paterson's present understanding of the project. Paterson requests permission to review the grading plan once available. Paterson's 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. 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, Paterson requests to be notified immediately in order to permit reassessment of the 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.

LICENSED PROFESSIONAL ENGINEER
May 8, 2017
D. J. GILBERT
100116130
PROVINCE OF ONTARIO

Colin Belcourt, M.Eng.

David J. Gilbert, P.Eng.

Report Distribution:

- ☐ Mattamy Homes (6 copies)
- ☐ Paterson Group (1 copy)

APPENDIX 1

SOIL PROFILE AND TEST DATA SHEETS

SYMBOLS AND TERMS

CONSOLIDATION TEST RESULTS

ATTERBERG LIMITS' TESTING RESULTS

ANALYTICAL TESTING RESULTS

patersongroup Consulting Engineers

154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Residential Development - Blackstone Phases 4 to 8
Ottawa, Ontario

DATUM Ground surface elevations at borehole locations provided by Annis, O'Sullivan, Vollebekk Limited.

REMARKS

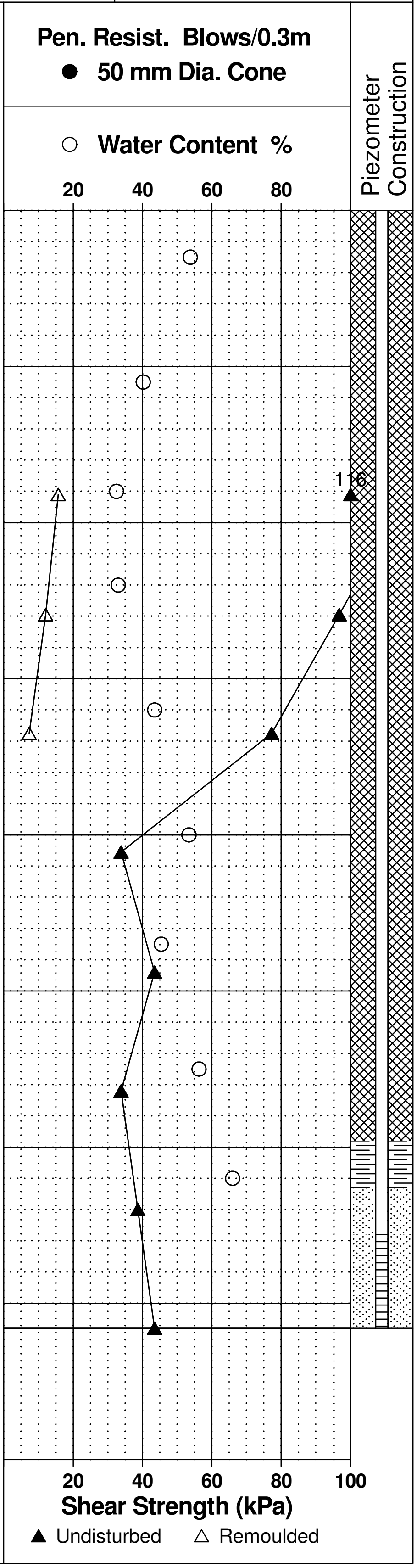
BORINGS BY CME 55 Power Auger

DATE March 10, 2017

FILE NO. PG4053

HOLE NO. BH 1-17

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	100.31
FILL: Topsoil with sand, gravel and organics 0.18		AU	1				
FILL: Brown silty clay with sand, gravel and cobbles 0.56							
		SS	2	12	2	1	99.31
		SS	3	58	P	2	98.31
Very stiff to stiff, brown **SILTY CLAY,** some sand - firm and grey by 3.8m depth						3	97.31
						4	96.31
						5	95.31
						6	94.31
						7	93.31
7.16							
End of Borehole (GWL at 0.3m above ground surface - March 21, 2017)							



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Residential Development - Blackstone Phases 4 to 8
Ottawa, Ontario

DATUM Ground surface elevations at borehole locations provided by Annis, O'Sullivan, Vollebekk Limited.

REMARKS

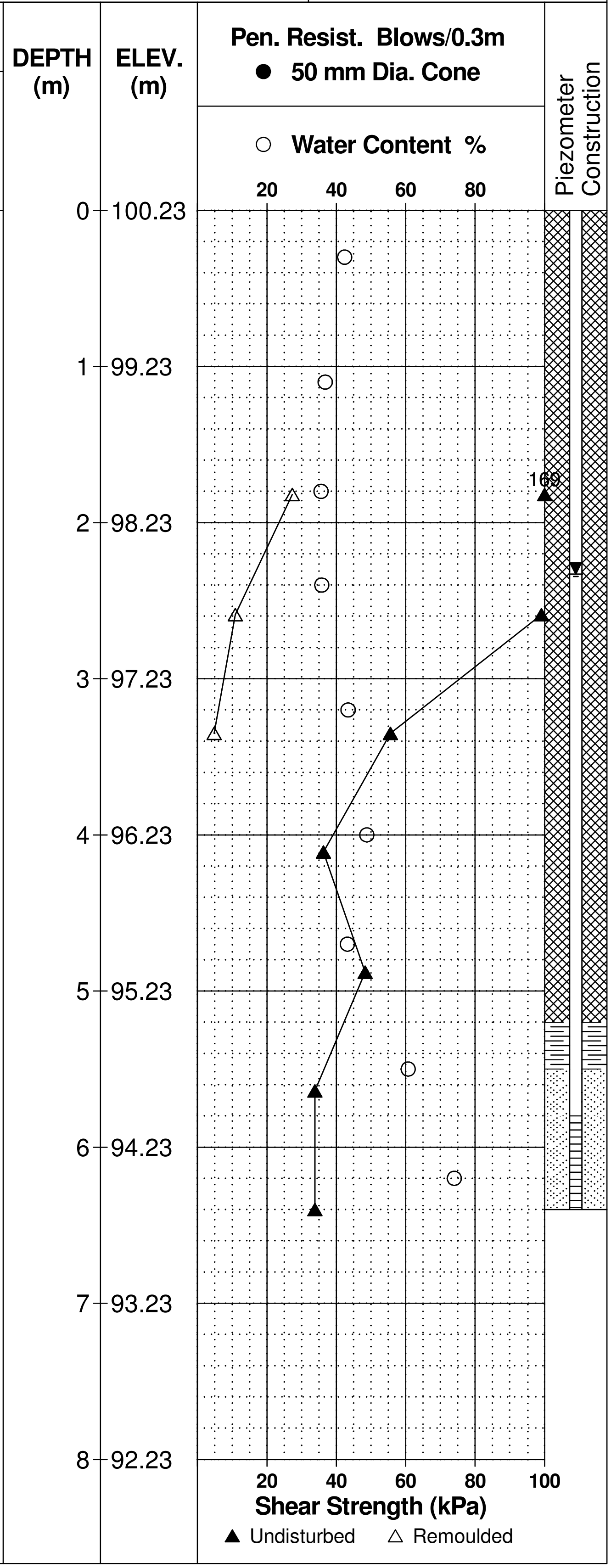
BORINGS BY CME 55 Power Auger

DATE March 10, 2017

FILE NO. PG4053

HOLE NO. BH 2-17

SOIL DESCRIPTION	TYPE	NUMBER	% RECOVERY	N VALUE or RQD
GROUND SURFACE				
TOPSOIL 0.15	AU	1		
Very stiff to stiff, brown **SILTY CLAY,** trace sand	SS	2	54	4
- firm and grey by 3.6m depth	SS	3	100	P
6.40				
Dynamic Cone Penetration Test (DCPT) commenced at 6.40m depth. Cone pushed to 10.8m depth.				



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Residential Development - Blackstone Phases 4 to 8
Ottawa, Ontario

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REMARKS

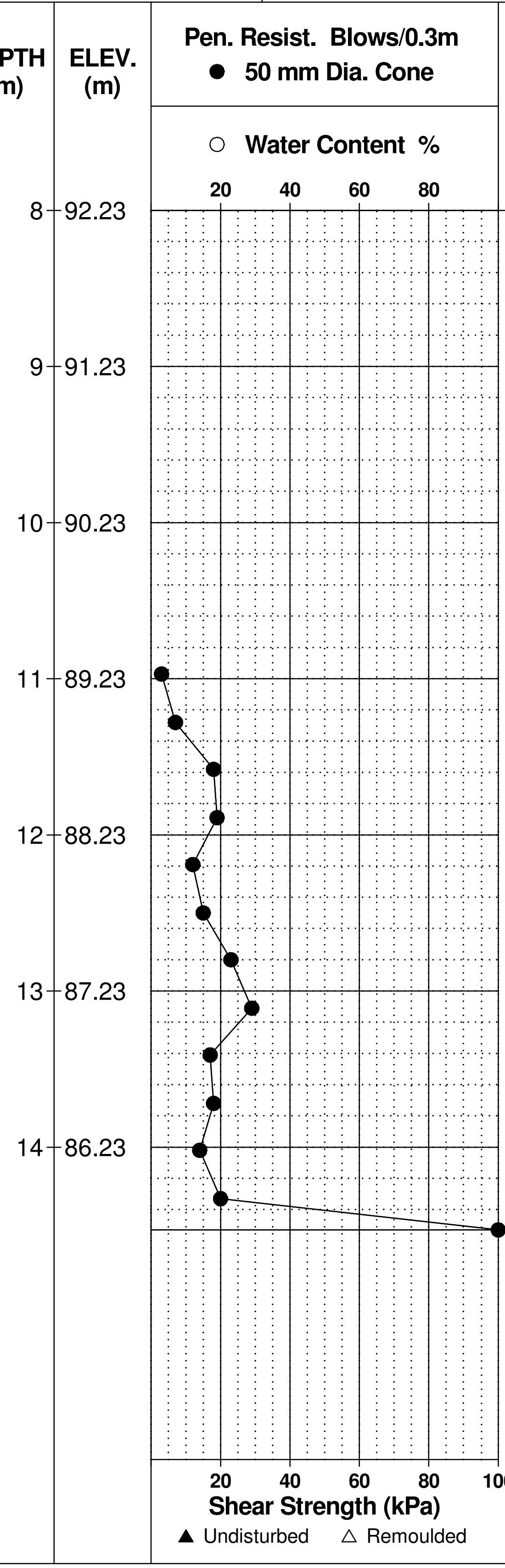
BORINGS BY CME 55 Power Auger

DATE March 10, 2017

FILE NO. PG4053

HOLE NO. BH 2-17

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	Piezometer Construction
GROUND SURFACE						
14.53						
End of Borehole Practical DCPT refusal at 14.53m depth (GWL @ 2.33m-March 21, 2017)						



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Residential Development - Blackstone Phases 4 to 8
Ottawa, Ontario

DATUM Ground surface elevations at borehole locations provided by Annis, O'Sullivan, Vollebekk Limited.

REMARKS

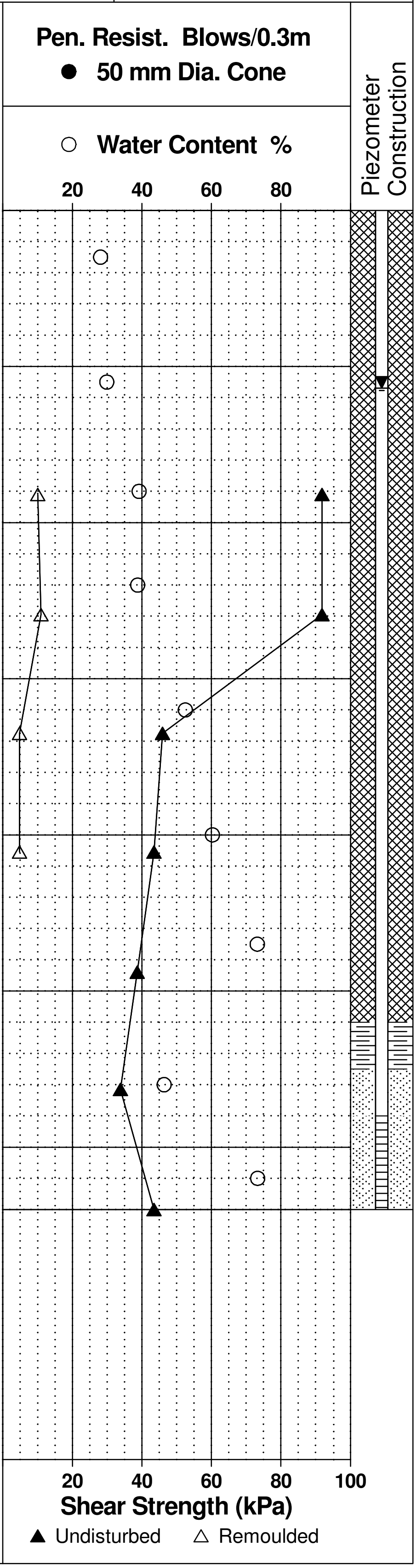
BORINGS BY CME 55 Power Auger

DATE March 10, 2017

FILE NO. **PG4053**

HOLE NO. **BH 3-17**

SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE					0	99.90
TOPSOIL 0.18	AU	1				
	SS	2	67	2	1	98.90
	SS	3	71	P	2	97.90
Stiff, brown **SILTY CLAY,** some sand						
- firm and grey by 3.0m depth					3	96.90
					4	95.90
- firm and grey by 4.2m depth						
					5	94.90
	SS	4	100	P		
					6	93.90
6.40						
End of Borehole (GWL @ 1.14m-March 21, 2017)						



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Residential Development - Blackstone Phases 4 to 8
Ottawa, Ontario

DATUM Ground surface elevations at borehole locations provided by Annis, O'Sullivan, Vollebekk Limited.

REMARKS

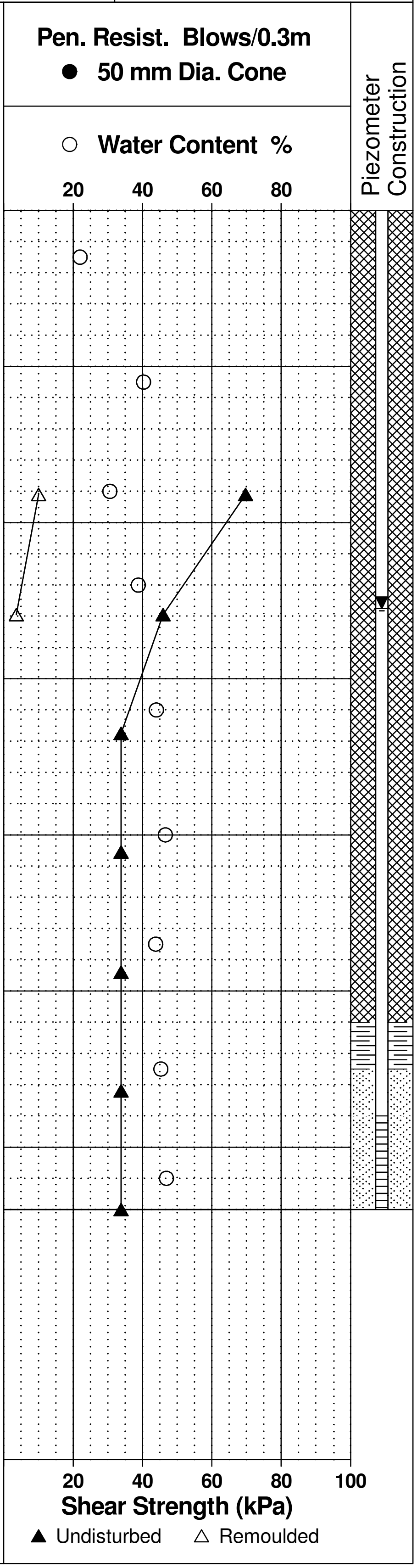
BORINGS BY CME 55 Power Auger

DATE March 10, 2017

FILE NO. **PG4053**

HOLE NO. **BH 4-17**

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	99.07
TOPSOIL 0.28		AU	1				
		SS	2	71	4	1	98.07
		SS	3	83	P	2	97.07
Stiff, brown **SILTY CLAY,** some sand - grey and firm by 2.5m depth						3	96.07
						4	95.07
						5	94.07
6.40						6	93.07
End of Borehole (GWL @ 2.55m-March 21, 2017)							



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Residential Development - Blackstone Phases 4 to 8
Ottawa, Ontario

DATUM Ground surface elevations at borehole locations provided by Annis, O'Sullivan, Vollebekk Limited.

REMARKS

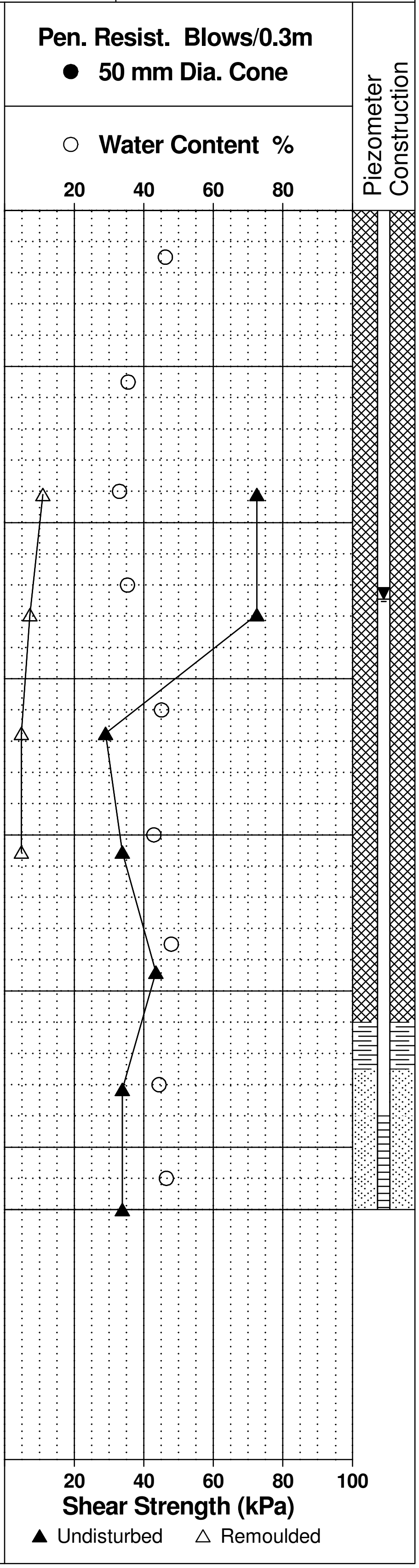
BORINGS BY CME 55 Power Auger

DATE March 10, 2017

FILE NO. PG4053

HOLE NO. BH 5-17

SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE					0	99.19
TOPSOIL 0.28	AU	1				
Stiff, brown **SILTY CLAY,** some sand - firm and grey by 3.0m depth	SS	2	50	3	1	98.19
	SS	3	67	P	2	97.19
					3	96.19
					4	95.19
					5	94.19
6.40	SS	4	100		6	93.19
End of Borehole (GWL @ 2.49m-March 21, 2017)						



SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Residential Development - Blackstone Phases 4 to 8
Ottawa, Ontario

DATUM Ground surface elevations at borehole locations provided by Annis, O'Sullivan, Vollebekk Limited.

REMARKS

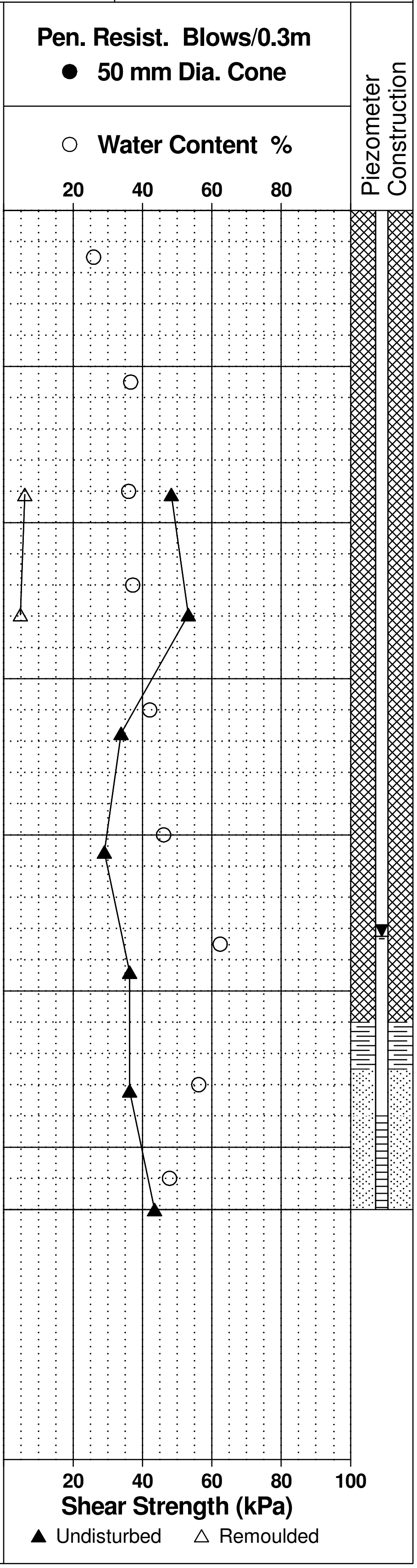
BORINGS BY CME 55 Power Auger

DATE March 13, 2017

FILE NO. PG4053

HOLE NO. BH 6-17

SOIL DESCRIPTION	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE					0	99.57
TOPSOIL 0.25	AU	1				
Stiff, brown **SILTY CLAY,** some sand - firm and grey by 3.0m depth	SS	2	25	1	1	98.57
	SS	3	50	P	2	97.57
					3	96.57
					4	95.57
					5	94.57
					6	93.57
6.40 End of Borehole (GWL @ 4.65m-March 21, 2017)						



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Residential Development - Blackstone Phases 4 to 8
Ottawa, Ontario

DATUM Ground surface elevations at borehole locations provided by Annis, O'Sullivan, Vollebekk Limited.

REMARKS

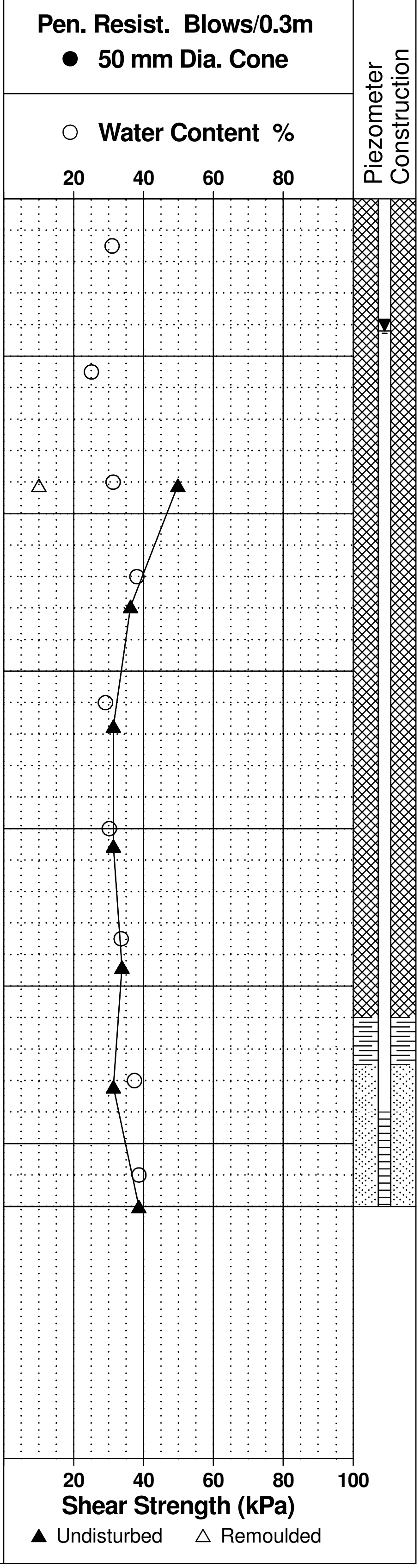
BORINGS BY CME 55 Power Auger

DATE March 13, 2017

FILE NO. **PG4053**

HOLE NO. **BH 7-17**

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	98.60
TOPSOIL 0.28		AU	1				
Stiff to firm, brown **SILTY CLAY,** some sand - grey by 3.0m depth		SS	2	71	4	1	97.60
		SS	3	50	P	2	96.60
						3	95.60
						4	94.60
						5	93.60
6.40						6	92.60
End of Borehole (GWL @ 0.84m-March 21, 2017)							



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Residential Development - Blackstone Phases 4 to 8
Ottawa, Ontario

DATUM Ground surface elevations at borehole locations provided by Annis, O'Sullivan, Vollebekk Limited.

REMARKS

BORINGS BY CME 55 Power Auger

DATE March 13, 2017

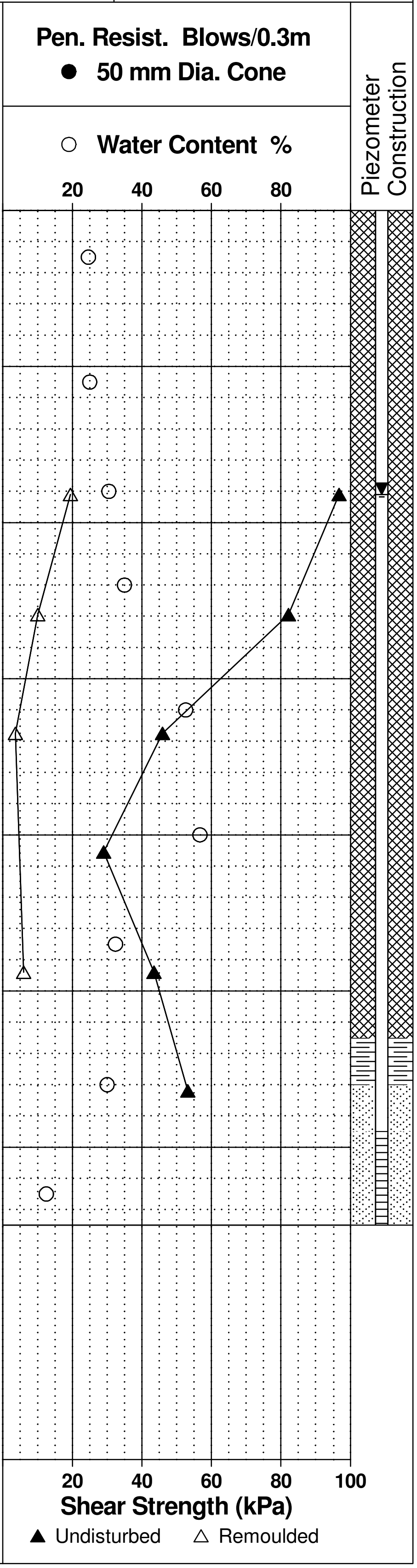
FILE NO. PG4053

HOLE NO. BH 8-17

SOIL DESCRIPTION	TYPE	NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE					0	100.05
TOPSOIL 0.25	AU	1				
	SS	2	14	5	1	99.05
	SS	3	46	P		
Stiff, brown **SILTY CLAY,** some sand					2	98.05
- firm and grey by 3.2m depth					3	97.05
					4	96.05
					5	95.05
6.10					6	94.05
GLACIAL TILL: Brown silty clay with sand, gravel, cobbles and boulders 6.50	SS	4	25	50+		

End of Borehole

(GWL @ 1.82m-March 21, 2017)



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

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
West Park Residential Development
Ottawa, Ontario

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

REMARKS

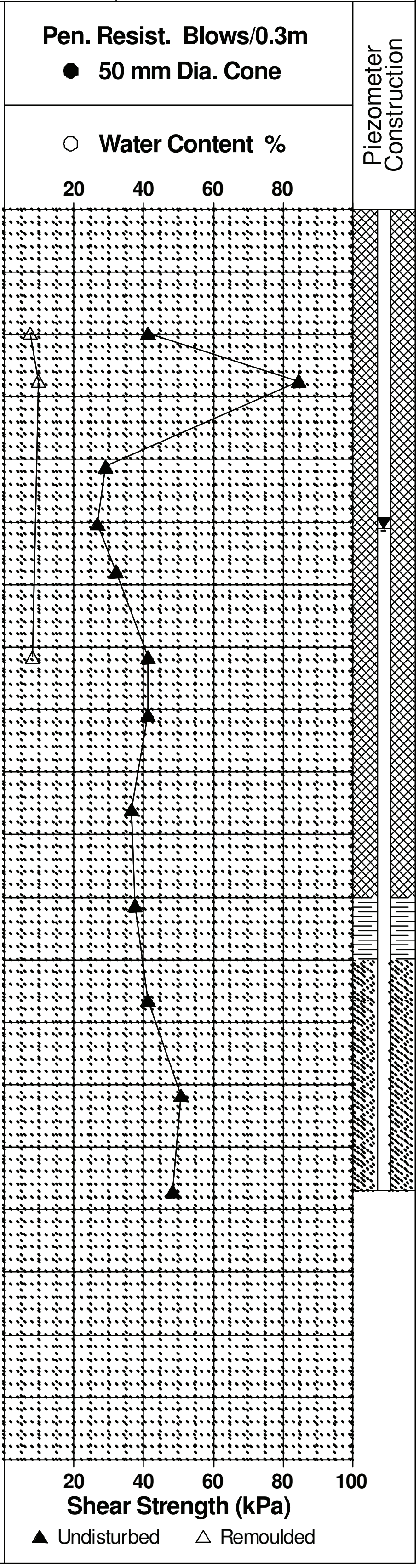
BORINGS BY CME 75 Power Auger

DATE 5 November 2010

FILE NO. PG2233

HOLE NO. BH 1

SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE					0	98.86
TOPSOIL 0.36						
Very loose, brown **SILTY SAND** 1.45	SS	1	92	2	1	97.86
Stiff to firm, brown interlayered **SILTY CLAY** and **CLAYEY SILT**					2	96.86
- grey by 2.2m depth	TW	2	100		3	95.86
					4	94.86
					5	93.86
	TW	3	100		6	92.86
					7	91.86
					8	90.86
					9	89.86
					10	88.86
					11	87.86
					12	86.86
					13	85.86
					14	84.86
(GWL @ 5.11m-Nov. 11/10) 15.70					15	83.86
Dynamic Cone Penetration Test commenced @ 15.70m depth. Cone push to 28.35m and hit refusal at 28.50m depth					16	82.86
					17	81.86
					18	80.86
					19	79.86
					20	78.86



SOIL PROFILE AND TEST DATA

Geotechnical Investigation
West Park Residential Development
Ottawa, Ontario

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

FILE NO. **PG2233**

REMARKS

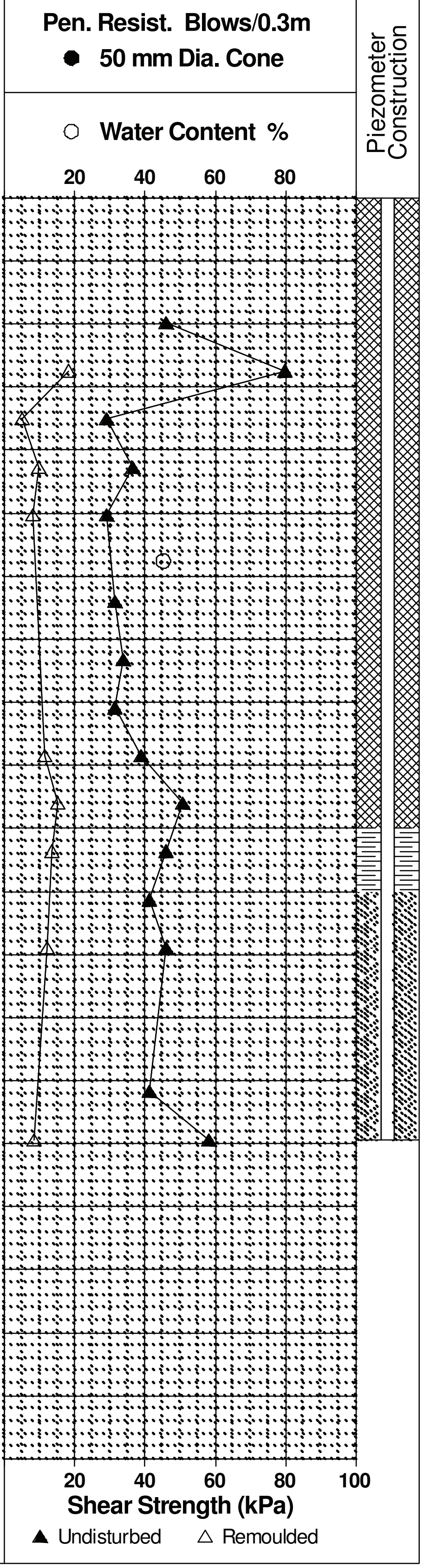
HOLE NO. **BH 2**

BORINGS BY CME 75 Power Auger

DATE 8 November 2010

SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD
GROUND SURFACE				
TOPSOIL 0.46				
Very loose, grey-brown **SILTY SAND** 1.45	SS	1		3
Stiff to firm, grey-brown **SILTY CLAY,** some silt seams - grey by 4.4m depth	TW	2	100	
	TW	3	100	
14.94				
Dynamic Cone Penetration Test commenced @ 14.94m depth. Cone push to 31.1m and hit refusal at 31.60m depth 31.09m - 36 31.39m - 45 31.60m - 100+				

DEPTH (m)	ELEV. (m)
0	98.88
1	97.88
2	96.88
3	95.88
4	94.88
5	93.88
6	92.88
7	91.88
8	90.88
9	89.88
10	88.88
11	87.88
12	86.88
13	85.88
14	84.88
15	83.88
16	82.88
17	81.88
18	80.88
19	79.88
20	78.88



SOIL PROFILE AND TEST DATA

Geotechnical Investigation
West Park Residential Development
Ottawa, Ontario

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

REMARKS

BORINGS BY CME 75 Power Auger

DATE 9 November 2010

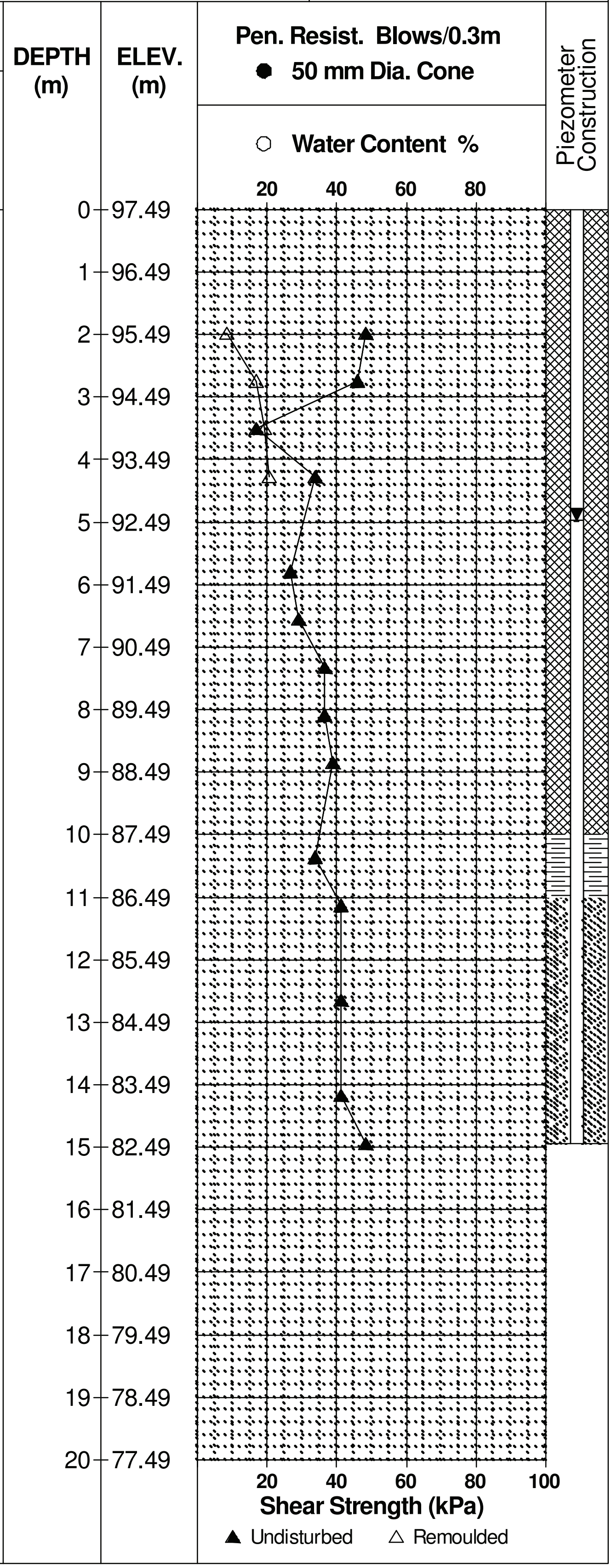
FILE NO. PG2233

HOLE NO. BH 7

SOIL DESCRIPTION	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD
GROUND SURFACE				
TOPSOIL 0.36				
Very loose, brown **SILTY SAND** 4.26	SS	1		3
Firm, grey **SILTY CLAY,** some silt seams	TW	2	100	
	TW	3	100	
14.94				
Dynamic Cone Penetration Test commenced @ 14.94m depth. Cone push to 39.32m and hit refusal at 39.88m depth				

39.62m - 29
39.93m - 57
39.88m - 100+

(GWL @ 4.96m-Nov. 18/10)



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
West Park Residential Development
Ottawa, Ontario

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

FILE NO. **PG2233**

REMARKS

HOLE NO. **BH 8**

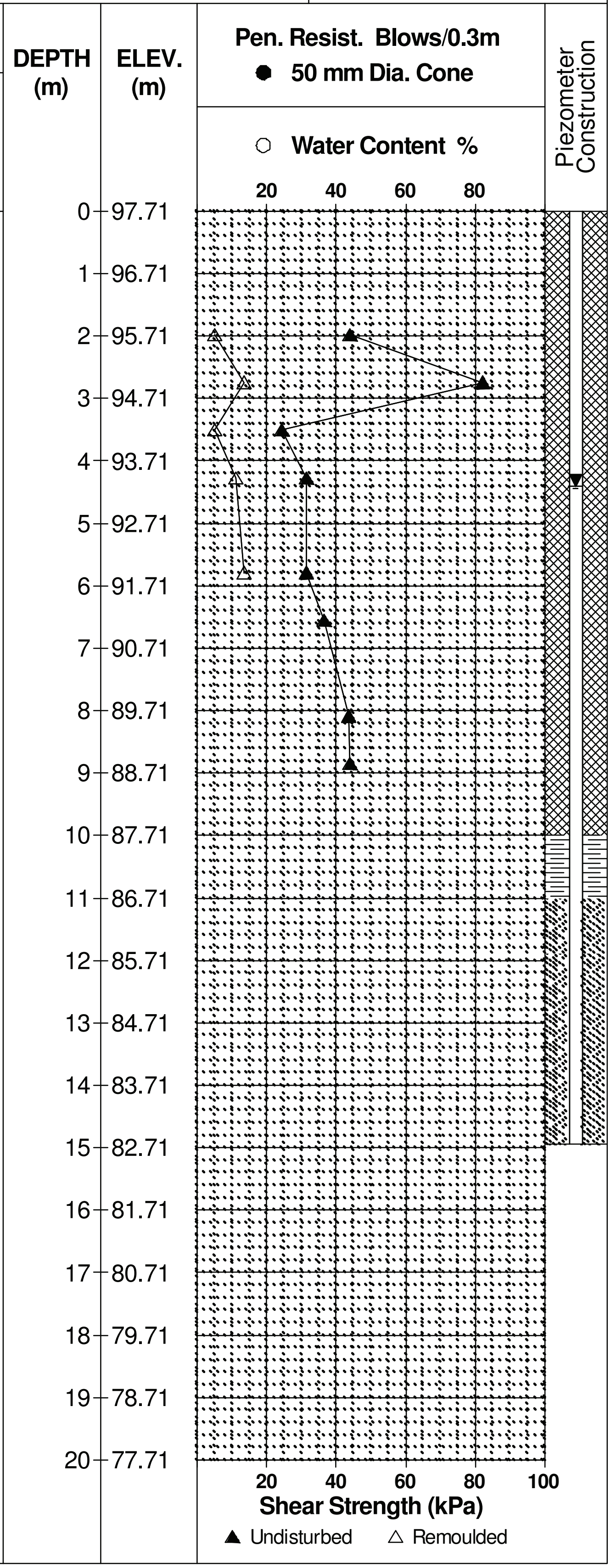
BORINGS BY CME 75 Power Auger

DATE 9 November 2010

SOIL DESCRIPTION		SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD
GROUND SURFACE					
TOPSOIL	0.51				
Very loose, grey-brown **SILTY SAND**	1.52	SS	1	92	3
Firm to stiff, grey **SILTY CLAY,** some silt seams throughout	14.94	TW TW	2 3	100 100	

Dynamic Cone Penetration Test commenced @ 14.94m depth. Cone push to 44.20m.

(GWL @ 4.41m-Nov. 18/10)



patersongroup **Consulting Engineers**

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

SOIL PROFILE AND TEST DATA

Supplemental Geotechnical Investigation
West Park Residential Development
Ottawa, Ontario

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

REMARKS

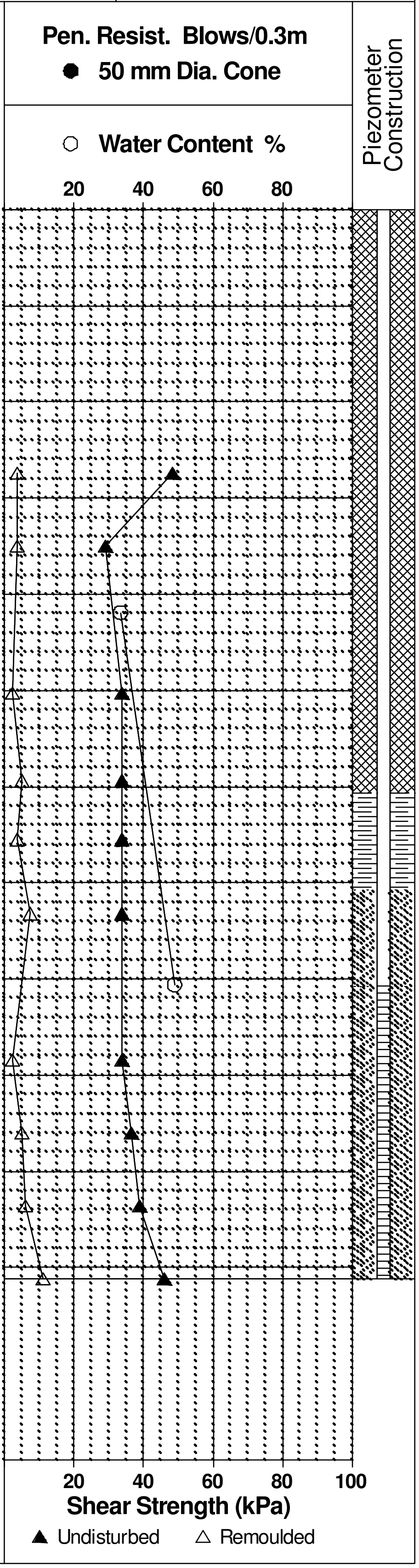
BORINGS BY CME 55 Power Auger

DATE 7 March 2011

FILE NO. **PG2233**

HOLE NO. **BH 9**

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	98.36
TOPSOIL 0.30		AU	1				
		AU	2				
Very loose, brown **SILTY SAND**, increasing clay content with depth		SS	3	12	6	1	97.36
		SS	4	0	4		
2.21						2	96.36
						3	95.36
		TW	5	100		4	94.36
						5	93.36
Firm to stiff, grey **SILTY CLAY**, occasional silt seams to 5 m depth						6	92.36
						7	91.36
		TW	6	100		8	90.36
						9	89.36
						10	88.36
11.12						11	87.36
End of Borehole							



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SOIL PROFILE AND TEST DATA

Supplemental Geotechnical Investigation
West Park Residential Development
Ottawa, Ontario

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

REMARKS

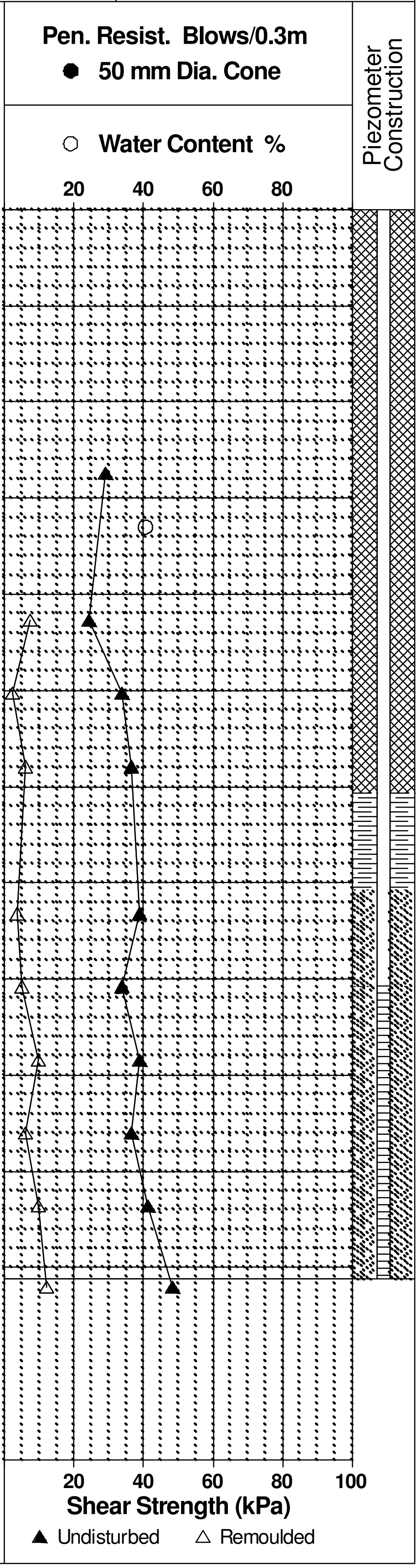
BORINGS BY CME 55 Power Auger

DATE 7 March 2011

FILE NO. PG2233

HOLE NO. BH10

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	98.11
TOPSOIL 0.30		AU	1				
		AU	2				
Very loose, brown **SILTY SAND**, increasing clay content with depth		SS	3	12	6	1	97.11
		SS	4	8	2		
2.20						2	96.11
						3	95.11
		TW	5	100			
						4	94.11
						5	93.11
Firm to stiff, grey **SILTY CLAY**, occasional silt seams to 6 m depth						6	92.11
		TW	6	100			
						7	91.11
						8	90.11
						9	89.11
						10	88.11
						11	87.11
11.12							
End of Borehole							



patersongroup Consulting Engineers

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

SOIL PROFILE AND TEST DATA

Supplemental Geotechnical Investigation
West Park Residential Development
Ottawa, Ontario

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

REMARKS

BORINGS BY CME 55 Power Auger

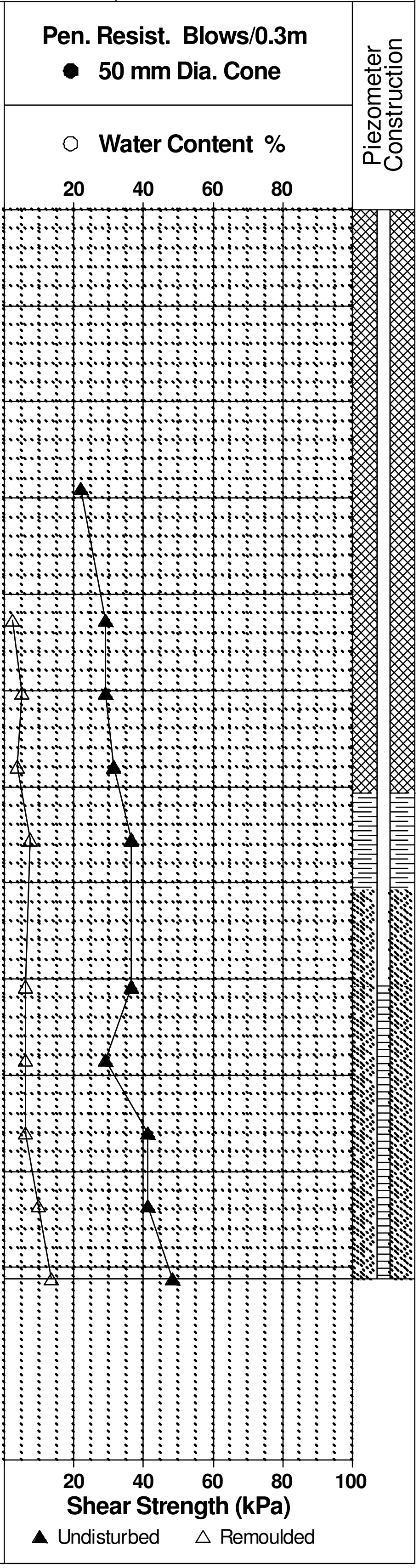
DATE 4 March 2011

FILE NO. PG2233

HOLE NO. BH11

SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD
GROUND SURFACE				
TOPSOIL 0.30	AU	1		
	AU	2		
Very loose, brown **SILTY SAND**, increasing clay conent with depth	SS	3	75	6
2.20	SS	4	100	1
Firm to stiff, grey **SILTY CLAY**, occasional silt seams to 6 m depth	TW	5	100	
11.12	TW	6		
End of Borehole				

DEPTH (m)	ELEV. (m)
0	98.13
1	97.13
2	96.13
3	95.13
4	94.13
5	93.13
6	92.13
7	91.13
8	90.13
9	89.13
10	88.13
11	87.13



patersongroup Consulting Engineers

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

SOIL PROFILE AND TEST DATA

Supplemental Geotechnical Investigation
West Park Residential Development
Ottawa, Ontario

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

FILE NO. **PG2233**

REMARKS

HOLE NO. **BH12**

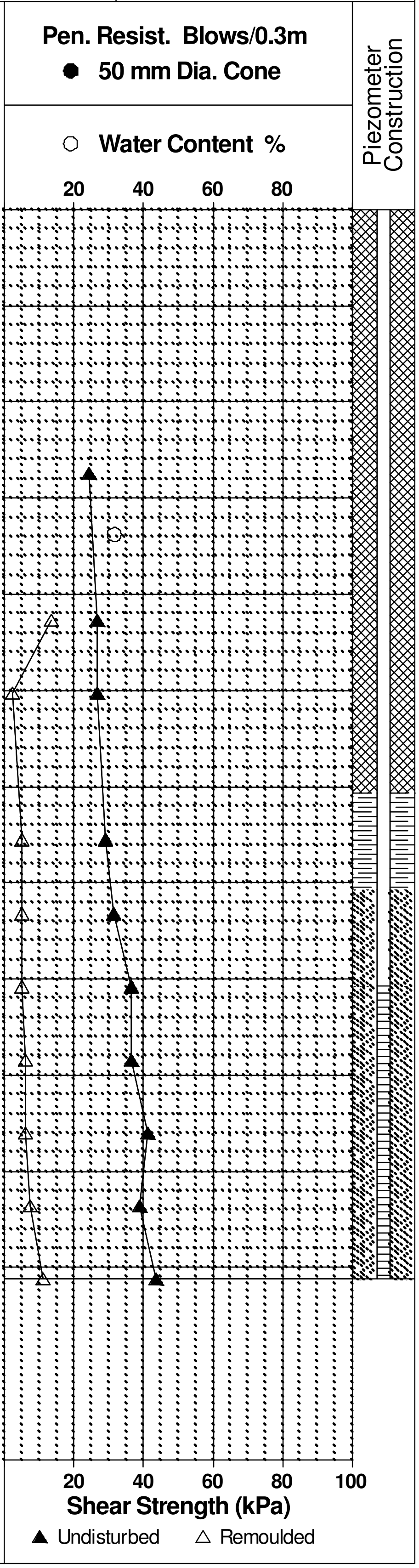
BORINGS BY CME 55 Power Auger

DATE 4 March 2011

SOIL DESCRIPTION	Depth (m)
GROUND SURFACE	
TOPSOIL	0.30
Very loose, brown **SILTY SAND**, increasing clay content with depth	2.21
Firm to stiff, grey **SILTY CLAY**, occasional silt seams to 6 m depth	11.12
End of Borehole	

SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD
AU	1		
AU	2		
SS	3	75	5
SS	4	92	1
TW	5	100	
TW	6	100	

DEPTH (m)	ELEV. (m)
0	98.43
1	97.43
2	96.43
3	95.43
4	94.43
5	93.43
6	92.43
7	91.43
8	90.43
9	89.43
10	88.43
11	87.43



PROJECT: 08-1121-0001

LOCATION:

SAMPLER HAMMER, 64kg; DROP, 760mm

RECORD OF BOREHOLE: BH 08-1

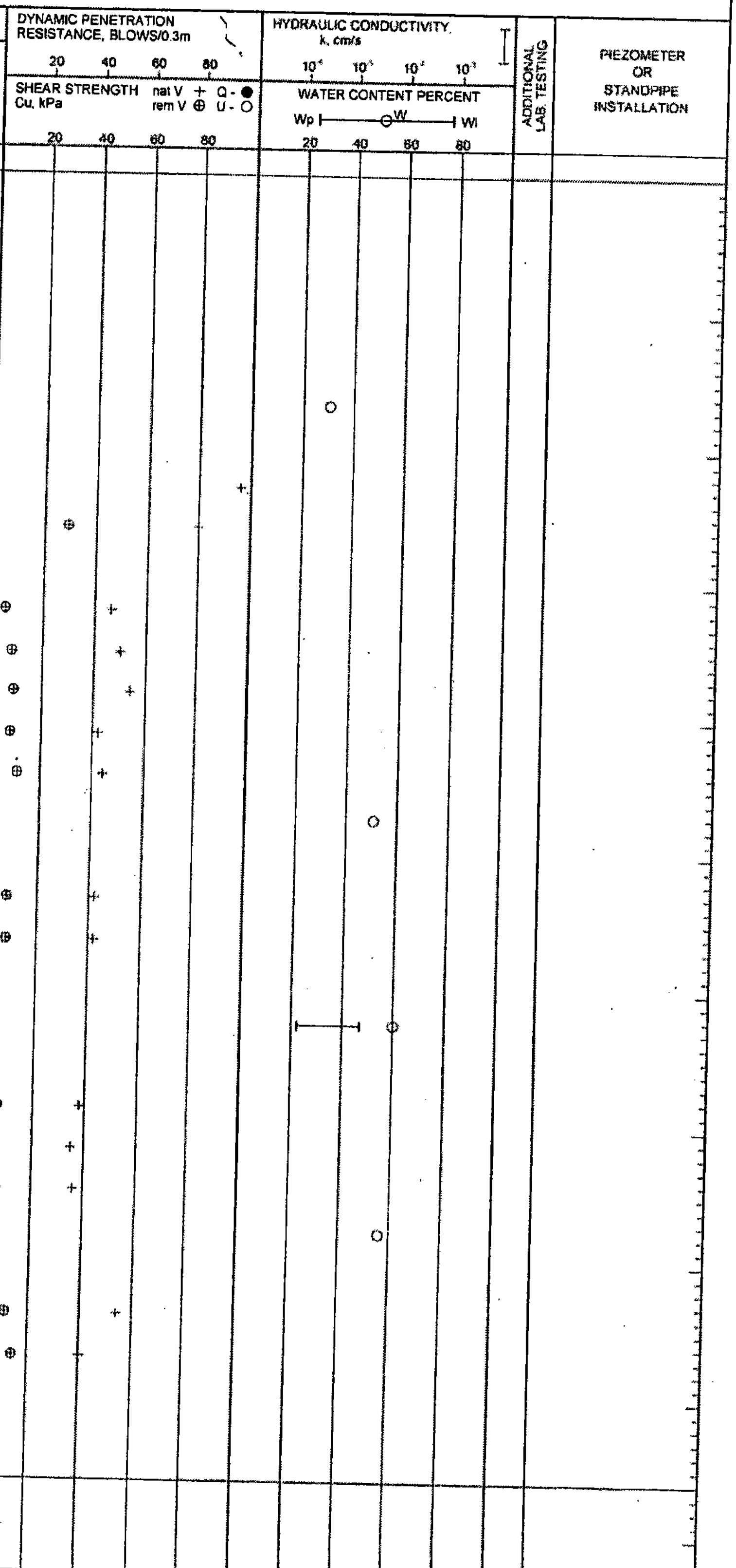
BORING DATE: 28 January 2008

SHEET 1 OF 1

DATUM: Geodetic

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m
0	Power Auger 200 mm Diam. (Hollow Stem)	Ground Surface	100.31			
		TOPSOIL	0.00			
		Stiff grey brown SILTY CLAY, with sandy silt and silty fine sand layers and seams (Weathered Crust)	100.09 0.22			
1				1	50 DO	3
2				2	50 DO	2
		Stiff to firm grey SILTY CLAY	97.87 2.44			
3						
4						
5				3	50 DO	WH
6				4	50 DO	WH
7						
8				5	50 DO	WH
9		Loose grey SANDY SILT, some gravel, trace clay (GLACIAL TILL)	91.35 8.96	6	50 DO	7
		End of Borehole	90.71 9.60			
10						



DEPTH SCALE
1 : 50

LOGGED: P.A.H.

CHECKED: S.A.T.

BOREHOLE 0811220001.GPJ HYDROGEO.GDT 4/3/08

PROJECT: 08-1121-0001

RECORD OF BOREHOLE: BH 08-2

SHEET 1 OF 1

LOCATION:

BORING DATE: 29 January 2008

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	SOIL PROFILE: STRATA PLOT	SOIL PROFILE: ELEV. DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80 SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - O 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3} WATER CONTENT PERCENT Wp ⊢—O W—⊣ Wl 20 40 60 80	ADDITIONAL LAB TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		Ground Surface		100.68							
0	Power Auger 200mm Diam. (Hollow Stem)	Dark brown TOPSOIL		0.00							
				100.41							
1		Very stiff grey brown SILTY CLAY, with sandy silt layers (Weathered Crust)		0.27	1	50 DO	6				
				99.22							
2		Loose grey brown SANDY SILT, some gravel, trace clay (GLACIAL TILL)		1.46	2	50 DO	7				
				98.39							
3		Dense grey SANDY SILT, some gravel, trace clay, with cobbles (GLACIAL TILL)		2.29	3	50 DO	57				
				97.63							
		End of Borehole		3.05							
4											
5											
6											
7											
8											
9											
10											

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: P.A.H.
CHECKED: S.A.T.

PROJECT: 08-1121-0001

LOCATION:

SAMPLER HAMMER, 64kg; DROP, 760mm

RECORD OF BOREHOLE: BH 08-3

BORING DATE: 29 January 2008

SHEET 1 OF 1

DATUM: Geodetic

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV. / DEPTH (m)	SAMPLES: NUMBER	SAMPLES: TYPE	SAMPLES: BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m (20 40 60 80) / SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ (20 40 60 80)	HYDRAULIC CONDUCTIVITY, k, cm/s (10^{-6} 10^{-5} 10^{-4} 10^{-3}) / WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl (20 40 60 80)	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0		Ground Surface		100.31							
	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL		0.00							
		Very stiff to stiff grey brown SILTY CLAY (Weathered Crust)		100.06 0.25							
1					1	50 DO	6				
2					2	50 DO	4				
					3	50 DO	3				
3		Stiff grey SILTY CLAY, with clayey silt layers		97.26 3.05							
					4	50 DO	2				
		Compact grey SANDY SILT, some gravel, trace clay (GLACIAL TILL)		96.59 3.72							
4					5	50 DO	18				
		End of Borehole		95.89 4.42							
5											
6											
7											
8											
9											
10											

BOREHOLE 0811220001.GPJ HYDROGEO.GDT 4/3/08

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: P.A.H.

CHECKED: S.A.T.

PROJECT: 08-1121-0001

LOCATION:

SAMPLER HAMMER, 64kg; DROP, 760mm

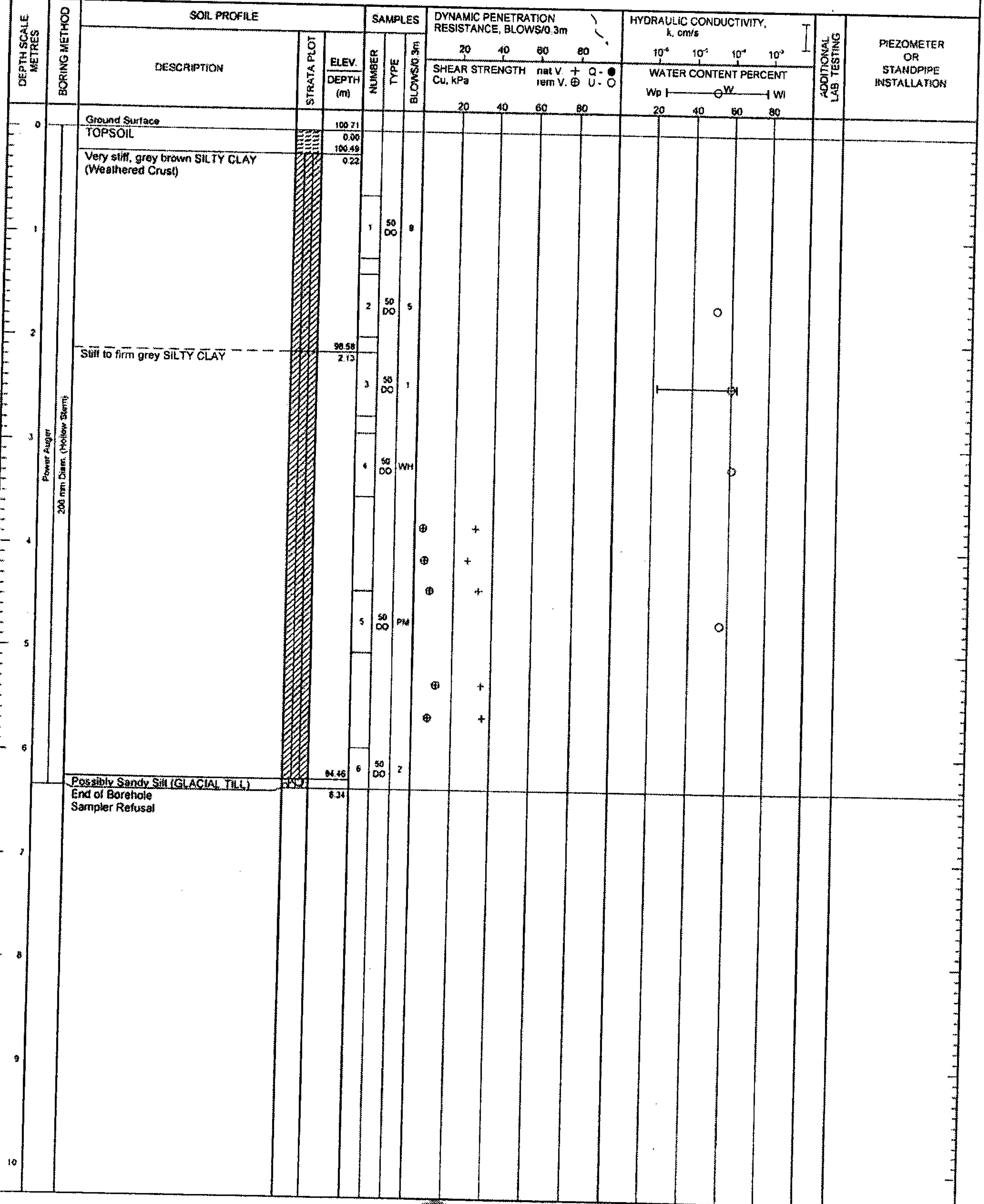
RECORD OF BOREHOLE: BH 08-5

BORING DATE: 31 January 2008

SHEET 1 OF 1

DATUM: Geodetic

PENETRATION TEST HAMMER, 64kg; DROP, 760mm



DESCRIPTION	ELEV. DEPTH (m)
Ground Surface	100.71
TOPSOIL	0.00
Very stiff, grey brown SILTY CLAY (Weathered Crust)	100.49 0.22
Stiff to firm grey SILTY CLAY	98.58 2.13
Possibly Sandy Silt (GLACIAL TILL)	94.46
End of Borehole Sampler Refusal	6.34

NUMBER	TYPE	BLOWS/0.3m
1	50 DO	8
2	50 DO	5
3	50 DO	1
4	50 DO	WH
5	50 DO	PM
6	50 DO	2

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: P.A.H.

CHECKED: S.A.T.

PROJECT: 08-1121-0001

LOCATION:

SAMPLER HAMMER, 64kg; DROP, 760mm

RECORD OF BOREHOLE: BH 08-6

BORING DATE: 31 January 2008

SHEET 1 OF 1

DATUM: Geodetic

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80; SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3}; WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl 20 40 60 80	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0		Ground Surface		101.28							
	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL		0.00							
		Grey brown layered CLAYEY SILT and fine SILTY SAND		101.06 0.22	1	AS					
		Compact grey brown SANDY SILT, trace to some gravel and clay (GLACIAL TILL)		100.67 0.61							
1					2	50 DO	25				
					3	50 DO	14				
2		End of Borehole		99.30 1.98							
3											
4											
5											
6											
7											
8											
9											
10											

BOREHOLE 0811220001.GPJ HYDROGEO.GDT 4/3/08

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: P.A.H.

CHECKED: S.A.T.

PROJECT: 08-1121-0001

RECORD OF BOREHOLE: BH 08-7

SHEET 1 OF 1

LOCATION:

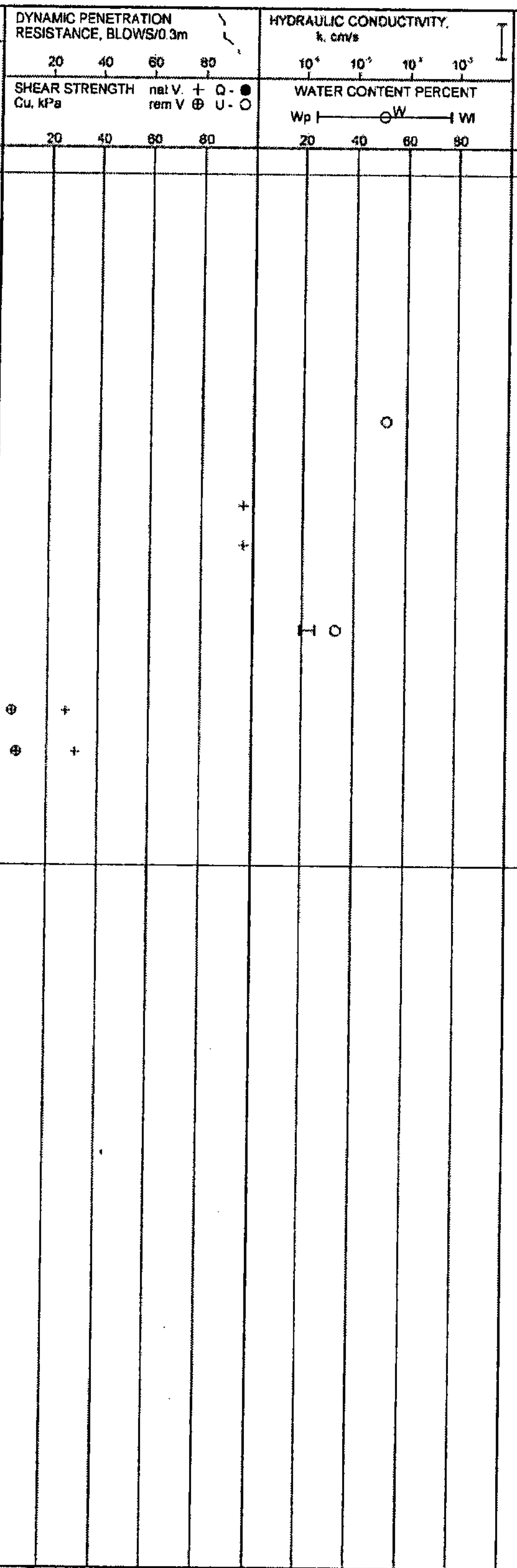
BORING DATE: 31 January 2008

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.3m
0		Ground Surface		100.44			
	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL		0.00			
		Very stiff grey brown SILTY CLAY (Weathered Crust)		100.19 0.25			
2					1	50 DO	5
		Stiff layered SILTY CLAY and grey CLAYEY SILT, occasional band of send and gravel		97.67 2.77			
3					2	50 DO	3
		Firm grey SILTY CLAY		96.78 3.66			
		Dense grey SANDY SILT, some gravel, trace clay (GLACIAL TILL)		95.96 4.48			
5					3	50 DO	>50
		End of Borehole Sampler Refusal		95.33 5.11			



PIEZOMETER OR STANDPIPE INSTALLATION

∇

W.L. in
open hole at
Elev. 98.31 m
upon completion
of drilling
Jan. 31, 2008

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: P.A.H.
CHECKED: S.A.T.

PROJECT: 08-1121-0001

RECORD OF BOREHOLE: BH 08-8

SHEET 1 OF 1

LOCATION:

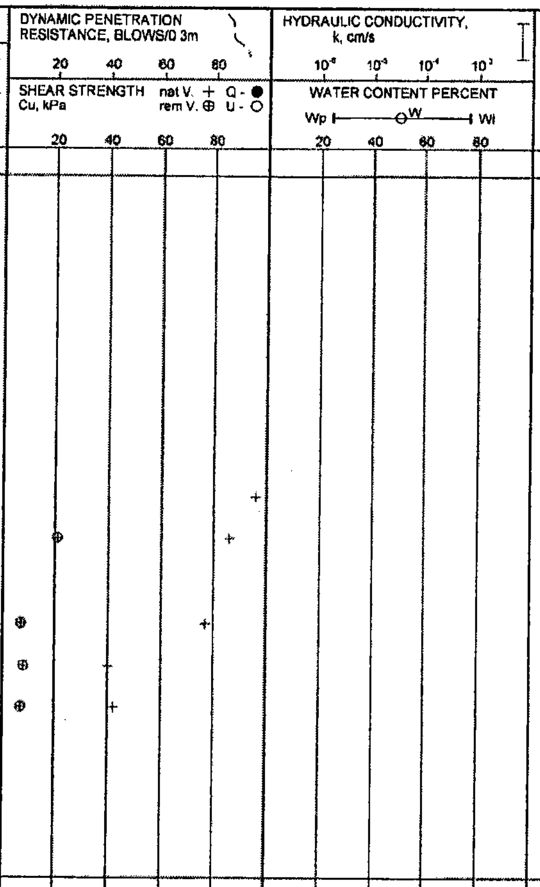
BORING DATE: 31 January 2008

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.3m
0		Ground Surface		100.63			
	Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL		0.00			
		Stiff grey brown SILTY CLAY, with sandy silt and clayey silt layers and seams (Weathered Crust)		100.41 0.22			
1					1	50 DO	3
					2	50 DO	2
2							
		Stiff to firm grey brown to grey SILTY CLAY		98.19 2.44			
3							
4		Very dense grey SANDY SILT and SILTY SAND, some gravel, trace clay with cobbles (GLACIAL TILL)		96.73 3.90			
					3	50 DO	69
5		End of Borehole		95.60 5.03			
6							
7							
8							
9							
10							



ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

∇

W.L. in
open hole at
Elev. 99.78 m
upon completion
of drilling
Jan 31, 2008

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: P.A.H.
CHECKED: S.A.T.

PROJECT: 08-1121-0001

RECORD OF BOREHOLE: BH 08-9

SHEET 1 OF 1

LOCATION:

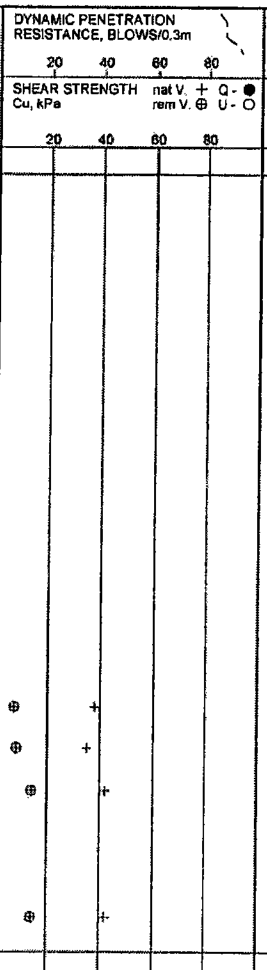
BORING DATE: 1 February 2008

DATUM: Geodetic

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

BORING METHOD	SOIL PROFILE: DESCRIPTION	STRATA PLOT	ELEV / DEPTH (m)	SAMPLES: NUMBER	TYPE	BLOWS/0.3m
	Ground Surface		100.62			
Power Auger 200 mm Diam. (Hollow Stem)	TOPSOIL					
	Very stiff to stiff grey brown SILTY CLAY (Weathered Crust)	▨	100.42 0.20	1 2	50 DO 50 DO	7 2
	Firm grey SILTY CLAY	▨	98.49 2.13	3 4 5	50 DO 50 DO 50 DO	WH WH WH
	End of Borehole Auger Refusal		95.04 5.58			



HYDRAULIC CONDUCTIVITY, k, cm/s

10^{-6} 10^{-5} 10^{-4} 10^{-3}

WATER CONTENT PERCENT

Wp ⊢—○W—⊣ Wl

20 40 60 80

ADDITIONAL LAB. TESTING

PIEZOMETER OR STANDPIPE INSTALLATION

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: P.A.H.

CHECKED: S.A.T.

PROJECT: 08-1121-0001

LOCATION:

SAMPLER HAMMER, 64kg; DROP, 760mm

RECORD OF BOREHOLE: BH 08-10

BORING DATE: 1 February 2008

SHEET 1 OF 1

DATUM: Geodetic

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80 SHEAR STRENGTH Cu, kPa nat V. + Q- ● rem V. ⊕ U- ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3} WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl 20 40 60 80	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	Power Auger 200 mm Diam. (Hollow Stem)	Ground Surface		101.10							
		TOPSOIL		0.00							
		Very stiff grey brown SILTY CLAY with clayey silt layers (Weathered Crust)		100.80 0.30							
1											
2					1	50 DO	7				
		Dense grey SANDY SILT and SILTY SAND, some gravel, trace clay (GLACIAL TILL)		98.85 2.25							
					2	50 DO	35				
3		End of Borehole		98.20 2.90							
4											
5											
6											
7											
8											
9											
10											

BOREHOLE 0811220001.GPJ HYDROGEO.GDT 4/3/08

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: P.A.H.
CHECKED: S.A.T.

RECORD OF TEST PIT 38

DEPTH SCALE METRES	DESCRIPTION	STRATA PLOT	ELEV DEPTH (m)	SAMPLE NUMBER	SHEAR STRENGTH (Cu, kPa)	WATER CONTENT PERCENT	ADDITIONAL LAB TESTING	WATER LEVEL IN OPEN TEST PIT OR STANDPIPE INSTALLATION
0	Ground Surface							
	TOPSOIL							
	Very stiff to stiff grey brown SILTY CLAY (weathered crust)		[illegible]					
1								
	Grey brown silty sand with gravel (GLACIAL TILL)		1.40					
2								
3								
4								
	End of test pit		4.20				No groundwater inflow observed on completion of excavating on December 5, 2006	
5								
6								
7								

RECORD OF TEST PIT 48

0	Ground Surface	[illegible]	
	TOPSOIL	[illegible]	
	Very stiff to stiff grey brown SILTY CLAY (weathered crust)		
1			
2		97.69 2.10	
	Grey SILTY CLAY		
3			
4			
5	End of test pit	95.49 4.90	Groundwater inflow observed at 2.80 metres below ground surface on December 5, 2006

Houle Chevrier Engineering Ltd.

PROJECT: 06-1120-392

RECORD OF BOREHOLE: BH 06-1

SHEET 1 OF 1

LOCATION: See Site Plan

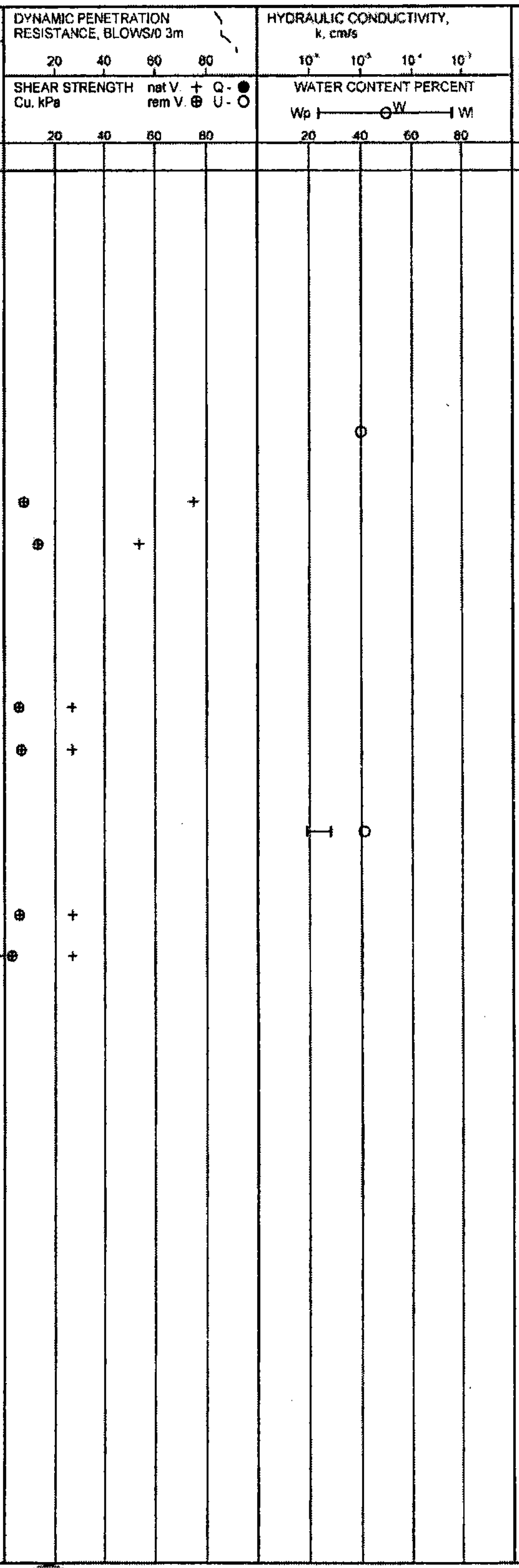
BORING DATE: Dec. 12, 2006

DATUM: Local

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE			SAMPLES			ADDITIONAL LAB TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	NUMBER	TYPE	BLOWS/0.3m		
		GROUND SURFACE		100.02					
0	Power Auger 200mm Diam. (Hollow Stem)	Dark brown TOPSOIL		0.00					
		Stiff grey brown SILTY CLAY, some sand seams, trace organic matter (Weathered Crust)		99.79 0.23					
1					1	50 DO	2		
2					2	50 DO	1		
3		Firm grey SILTY CLAY with black streaking		96.97 3.05	3	50 DO	1		
4									
5					4	50 DO	PH		
		End of Borehole		94.23 5.79					
6									
7									
8									
9									
10									



MIS-BHS 001 06-1120-392.GPJ GLDR_CAN.GDT 11/1/07 NBHS

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: J.A.S.

CHECKED: J.A.S.

PROJECT: 06-1120-392

RECORD OF BOREHOLE: BH 06-2

SHEET 1 OF 1

LOCATION: See Site Plan

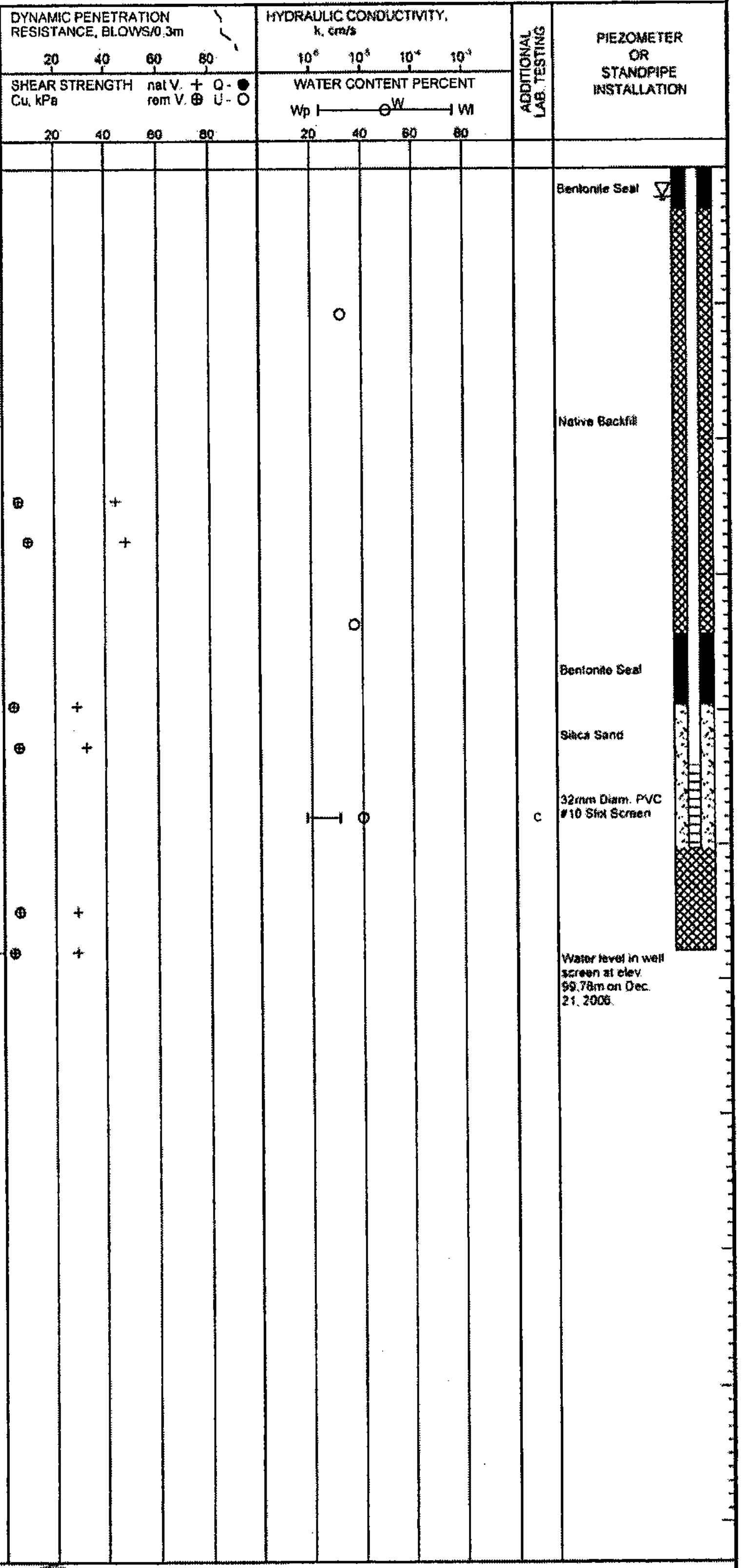
BORING DATE: Dec. 12, 2006

DATUM: Local

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV. / DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.3m	ADDITIONAL LAB. TESTING
0		GROUND SURFACE	100.00				
	Power Auger 200mm Diam. (Hollow Stem)	Brown sandy TOPSOIL	0.00				
		Stiff brown layered SANDY SILT and SILTY CLAY	99.69 0.31				
1				1	50 DO	2	
		Firm grey brown SILTY CLAY, some sand (Weathered Crust)	98.63 1.37				
2				2	50 DO	PH	
3		Firm grey SILTY CLAY with black streaking	97.00 3.00	3	50 DO	PH	
4							
5				4	73 TP	PH	C
6		End of Borehole	94.21 5.79				
7							
8							
9							
10							



DEPTH SCALE

1 : 50

Golder Associates

LOGGED: J.A.S.

CHECKED: J.A.S.

MIS-BHS 001 06-1120-392.GPJ GLDR_CAN.GDT 18/1/07 NBHS

PROJECT: 06-1120-392

RECORD OF BOREHOLE: BH 06-5

SHEET 1 OF 1

LOCATION: See Site Plan

BORING DATE: Dec. 13, 2006

DATUM: Local

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	STRATA PLOT	ELEV. DEPTH (m)	SAMPLES NUMBER	TYPE	BLOWS/0.3m	DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m 20 40 60 80 SHEAR STRENGTH Cu, kPa nat V. + Q - ● rem V. ⊕ U - ○ 20 40 60 80	HYDRAULIC CONDUCTIVITY, k, cm/s 10^{-6} 10^{-5} 10^{-4} 10^{-3} WATER CONTENT PERCENT Wp ⊢—○W—⊣ Wl 20 40 60 80	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
		GROUND SURFACE		101.19							
0	Power Auger 200mm Diam (Hollow Stem)	Dark brown sandy TOPSOIL		0.00							
		Compact brown CLAYEY SILT, some sand, gravel (GLACIAL TILL)		100.88 0.31							
1					1	50 DO	16				
2					2	50 DO	22		○		
		Compact grey SANDY SILT, some gravel, trace clay (GLACIAL TILL)		98.60 2.59	3	50 DO	18				
3					4	50 DO	24		○		
4					5	50 DO					
		End of Borehole Auger Refusal		97.08 4.11							
5											
6											
7											
8											
9											
10											

DEPTH SCALE
1 : 50

Golder Associates

LOGGED: N.N.
CHECKED: J.A.S.

PROJECT: 06-1120-392

RECORD OF BOREHOLE: BH 06-6

SHEET 1 OF 1

LOCATION: See Site Plan

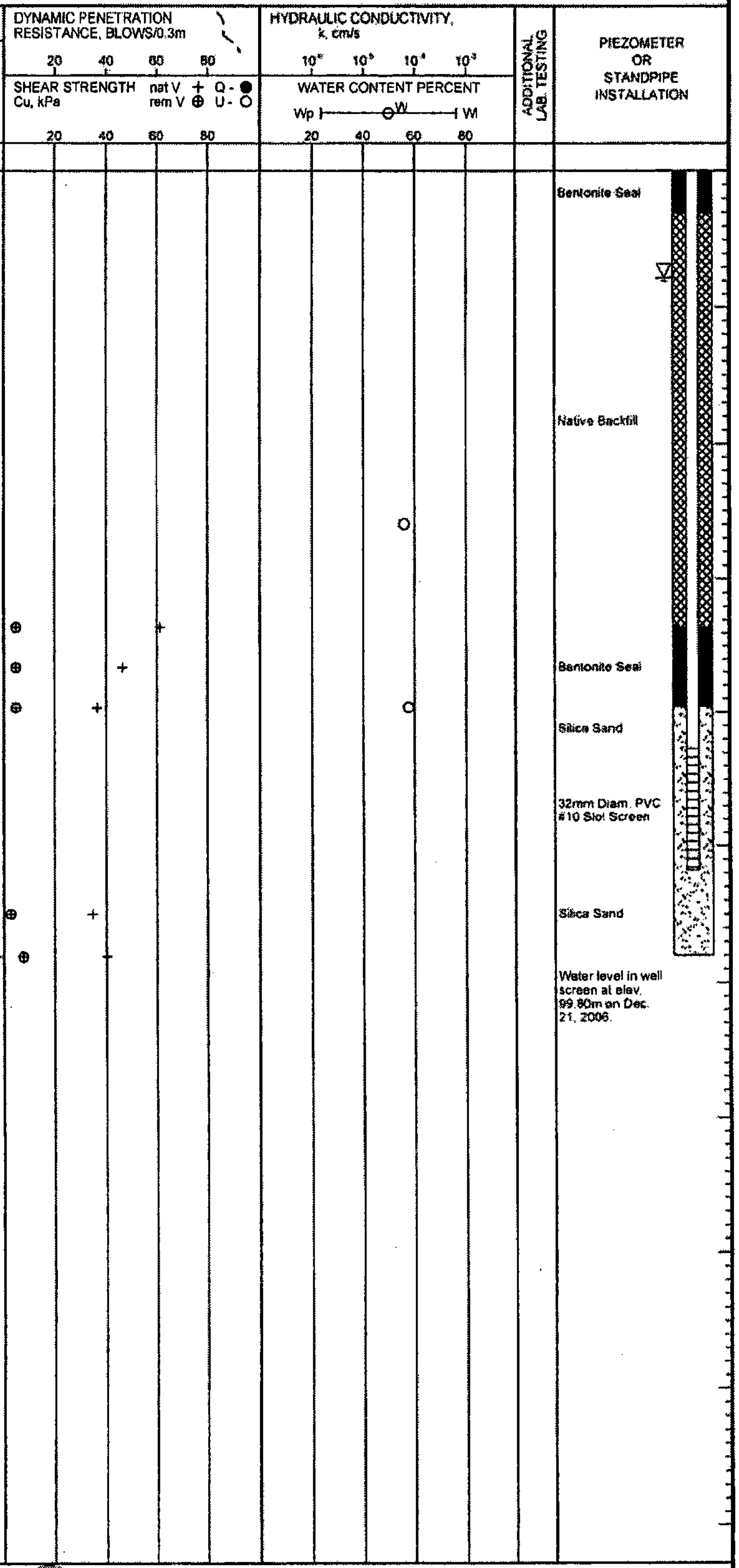
BORING DATE: Dec. 13, 2006

DATUM: Local

SAMPLER HAMMER, 64kg; DROP, 760mm

PENETRATION TEST HAMMER, 64kg; DROP, 760mm

DEPTH SCALE METRES	BORING METHOD	SOIL PROFILE DESCRIPTION	ELEV DEPTH (m)	SAMPLES NUMBER	SAMPLES TYPE	SAMPLES BLOWS/0.3m
		GROUND SURFACE	100.52			
0	Power Auger 200mm Diam. (Hollow Stem)	Brown sandy TOPSOIL	0.00			
		Stiff brown SILTY CLAY and CLAYEY SILT, some sand	100.21 0.31			
1				1	50 DO	2
		Stiff grey brown SILTY CLAY (Weathered Crust)	99.02 1.50			
2				2	50 DO	4
				3	50 DO	2
3		Stiff to firm grey SILTY CLAY	97.52 3.00			
4				4	50 DO	PH
5				5	73 TP	PH
		End of Borehole	94.72 5.80			
6						
7						
8						
9						
10						



Water level in well screen at elev. 99.80m on Dec. 21, 2006.

MIS-BHS 001 06-1120-392.GPJ GLDR_CAN.GDT 11/1/07 NBHS

DEPTH SCALE

1 : 50

Golder Associates

LOGGED: N.N.

CHECKED: J.A.S.

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)

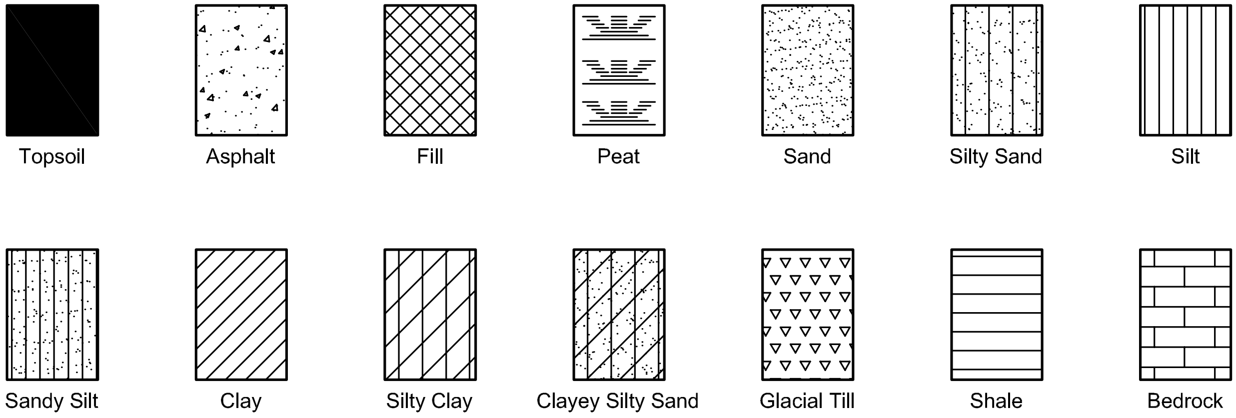
OC Ratio Overconsolidaton ratio = p'_c / p'_o
Void Ratio Initial sample void ratio = volume of voids / volume of solids
Wo - Initial water content (at start of consolidation test)

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.

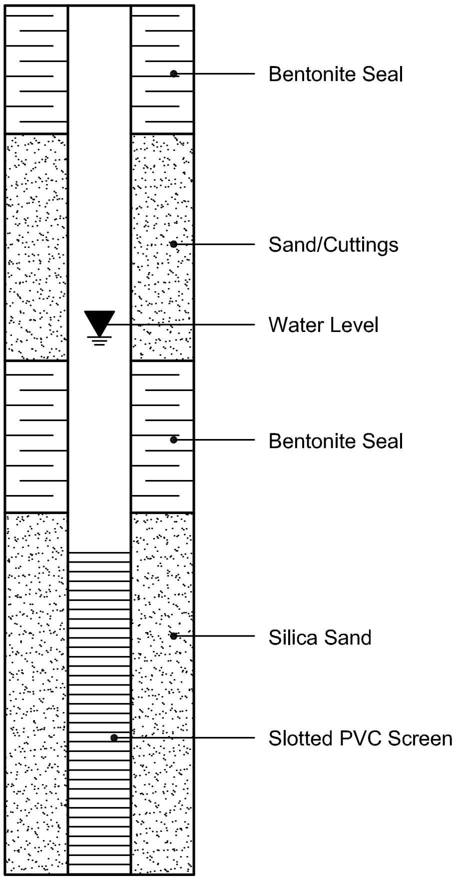
SYMBOLS AND TERMS (continued)

STRATA PLOT

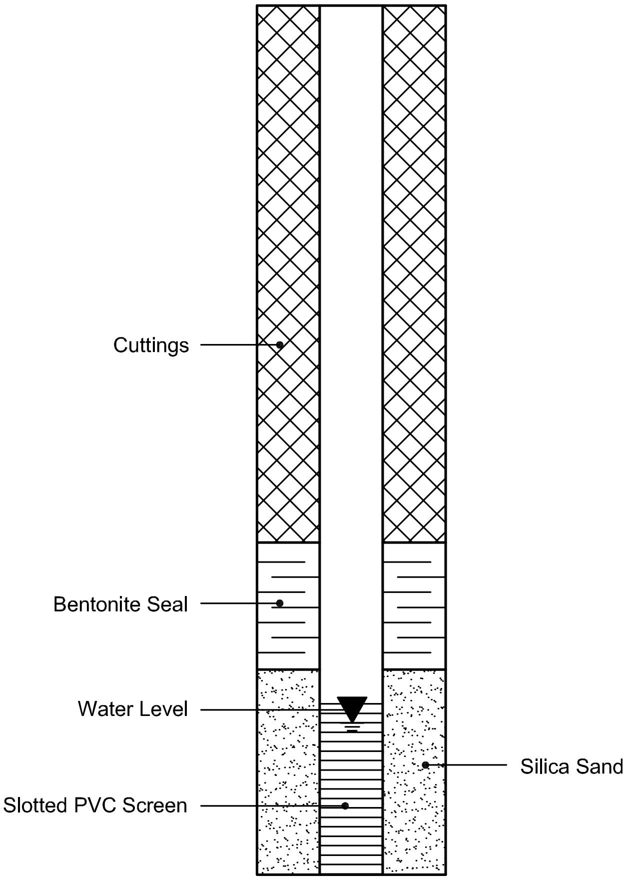


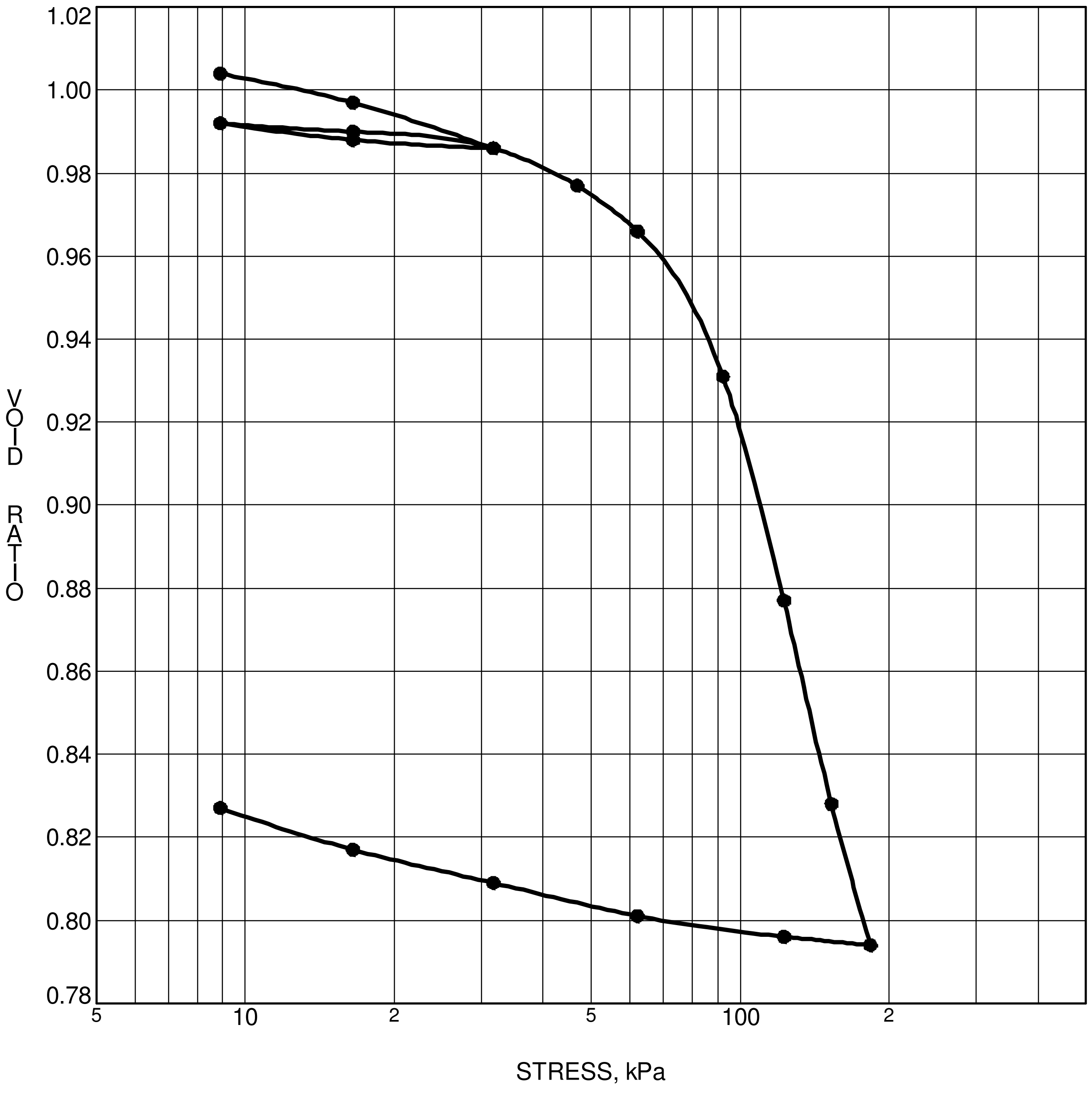
MONITORING WELL AND PIEZOMETER CONSTRUCTION

MONITORING WELL CONSTRUCTION



PIEZOMETER CONSTRUCTION





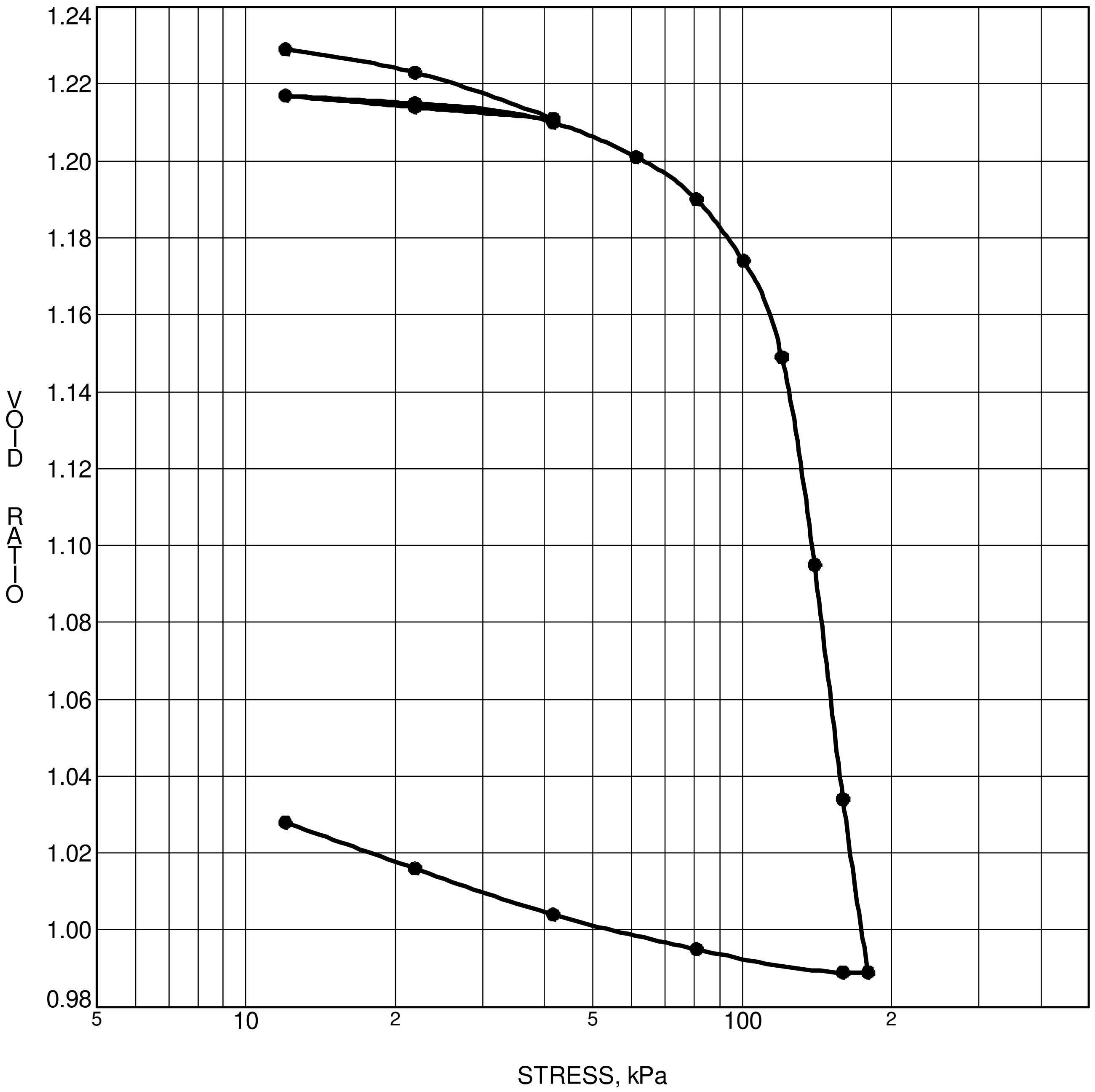
CONSOLIDATION TEST DATA SUMMARY					
Borehole No.	**BH 1**	p'_o	**40** kPa	Ccr	**0.012**
Sample No.	**TW 2**	p'_c	**78** kPa	Cc	**0.471**
Sample Depth	**3.45** m	OC Ratio	**2.0**	Wo	**36.7** %
Sample Elev.	**95.41** m	Void Ratio	**1.01**	Unit Wt.	**18.6** kN/m ^{3}

CLIENT **Monarch Group**
FILE NO. **PG2233**
PROJECT **Supplemental Geotechnical Investigation - West Park Residential Development**
DATE **11/20/2010**

patersongroup **Consulting Engineers**

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

CONSOLIDATION TEST



CONSOLIDATION TEST DATA SUMMARY					
Borehole No.	**BH 2**	p'_o	**54** kPa	Ccr	**0.009**
Sample No.	**TW 2**	p'_c	**113** kPa	Cc	**0.934**
Sample Depth	**5.76** m	OC Ratio	**2.1**	Wo	**45.2** %
Sample Elev.	**93.12** m	Void Ratio	**1.242**	Unit Wt.	**17.5** kN/m ^{3}

CLIENT **Monarch Group**

PROJECT **Supplemental Geotechnical Investigation - West Park Residential Development**

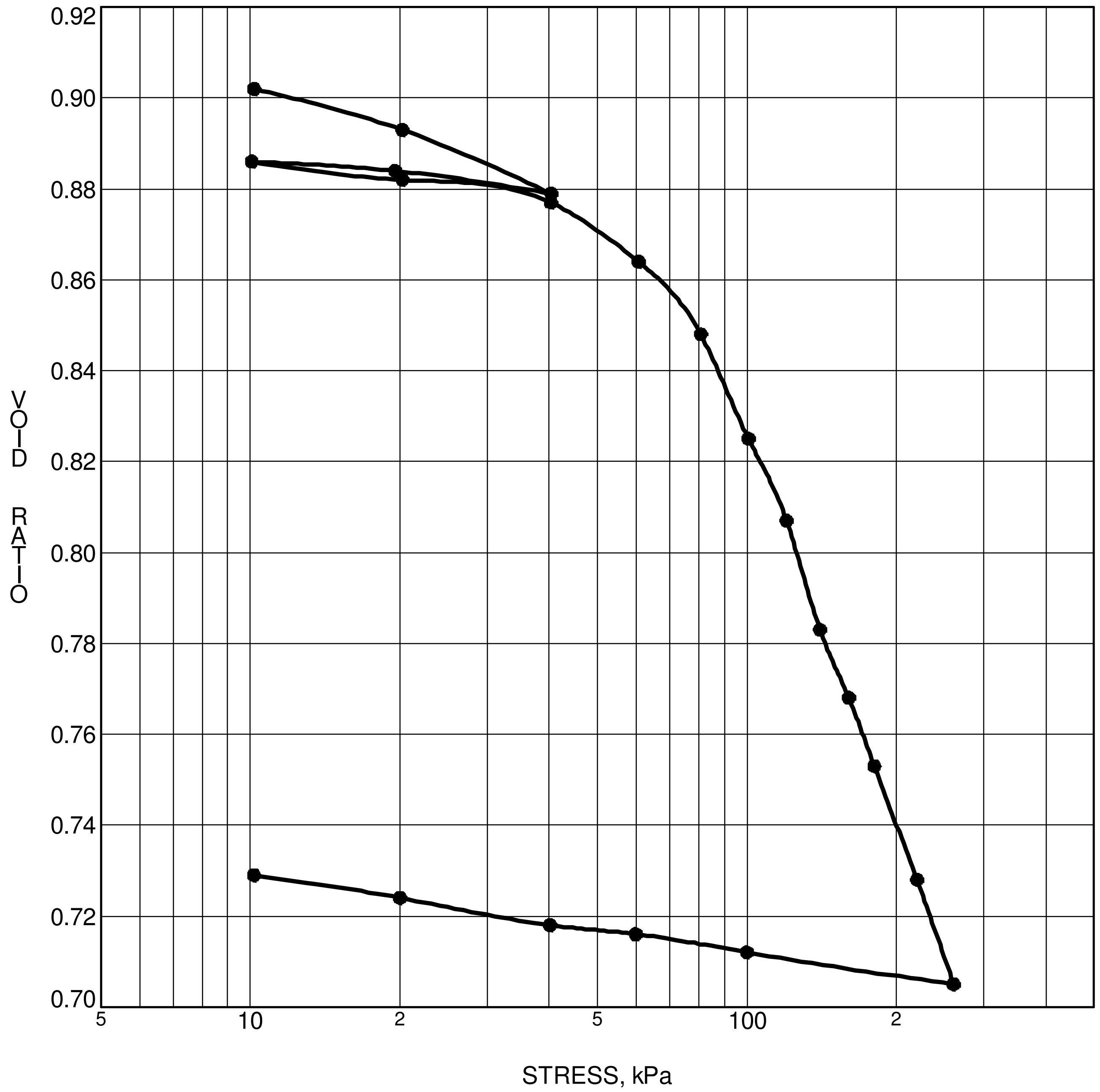
FILE NO. **PG2233**

DATE **11/19/2010**

patersongroup **Consulting Engineers**

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

CONSOLIDATION TEST



CONSOLIDATION TEST DATA SUMMARY					
Borehole No.	**BH 9**	p'_o	**45** kPa	Ccr	**0.015**
Sample No.	**TW 5**	p'_c	**77** kPa	Cc	**0.290**
Sample Depth	**4.19** m	OC Ratio	**1.7**	Wo	**33.3** %
Sample Elev.	**94.17** m	Void Ratio	**0.902**	Unit Wt.	**19.0** kN/m ^{3}

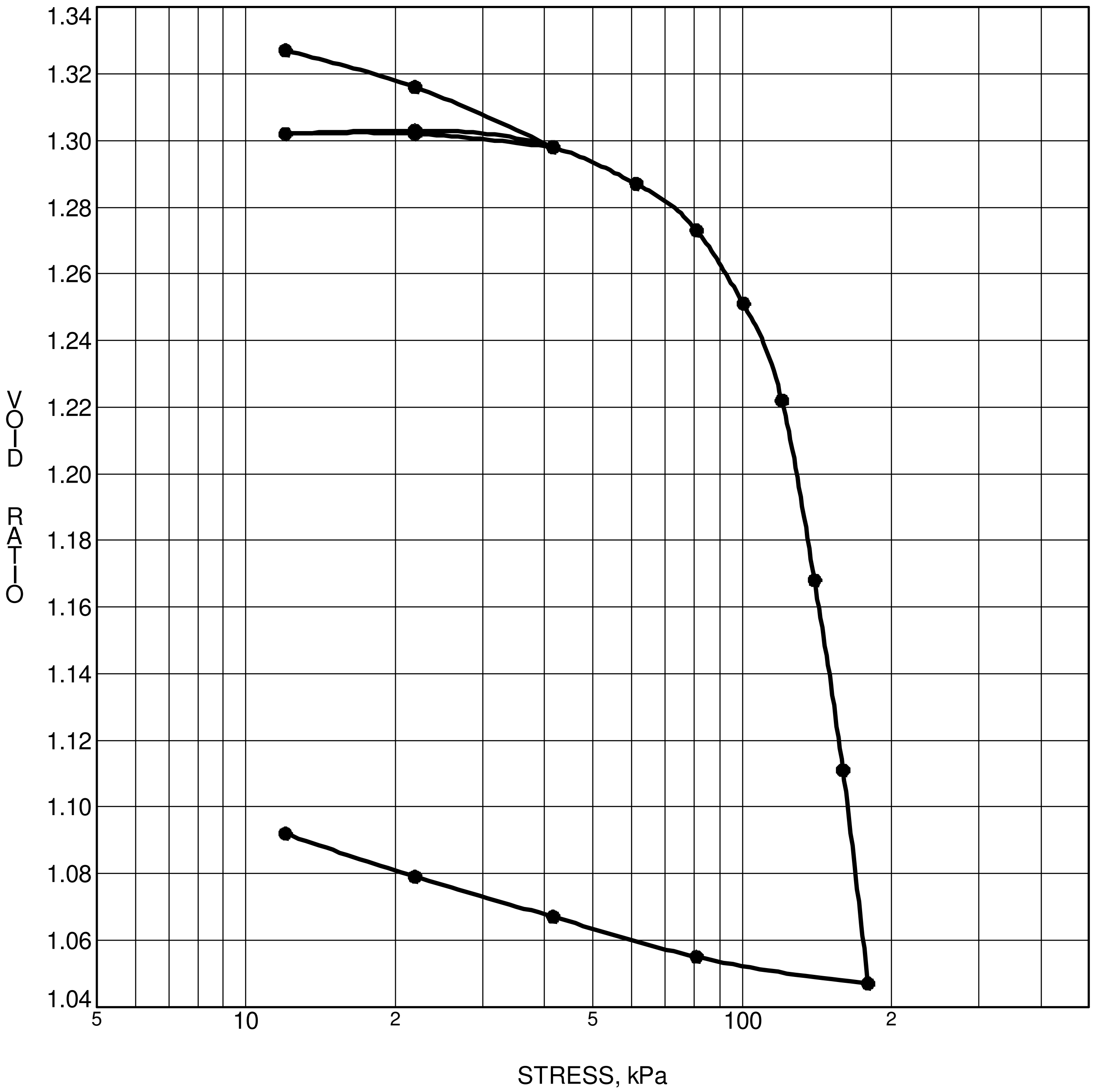
CLIENT **Monarch Group**

FILE NO. **PG2233**

PROJECT **Supplemental Geotechnical Investigation - West Park Residential Development**

DATE **03/18/2011**

CONSOLIDATION TEST



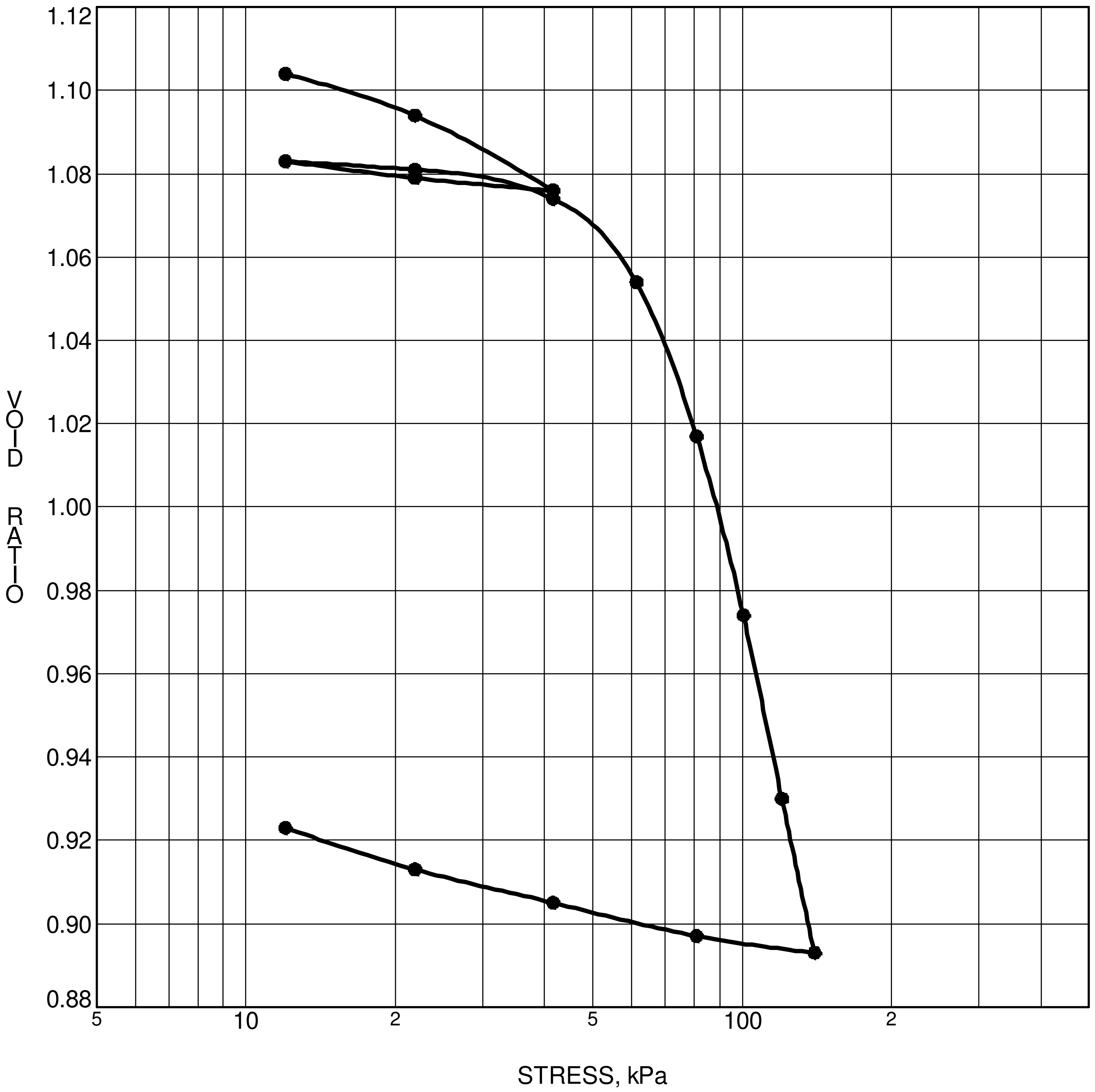
CONSOLIDATION TEST DATA SUMMARY					
Borehole No.	**BH 9**	p'_o	**69** kPa	Ccr	**0.015**
Sample No.	**TW 6**	p'_c	**116** kPa	Cc	**1.104**
Sample Depth	**8.06** m	OC Ratio	**1.7**	Wo	**48.9** %
Sample Elev.	**90.30** m	Void Ratio	**1.327**	Unit Wt.	**17.6** kN/m ^{3}

CLIENT	**Monarch Group**	FILE NO.	**PG2233**
PROJECT	**Supplemental Geotechnical Investigation - West Park Residential Development**	DATE	**03/09/2011**

patersongroup **Consulting Engineers**

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

CONSOLIDATION TEST



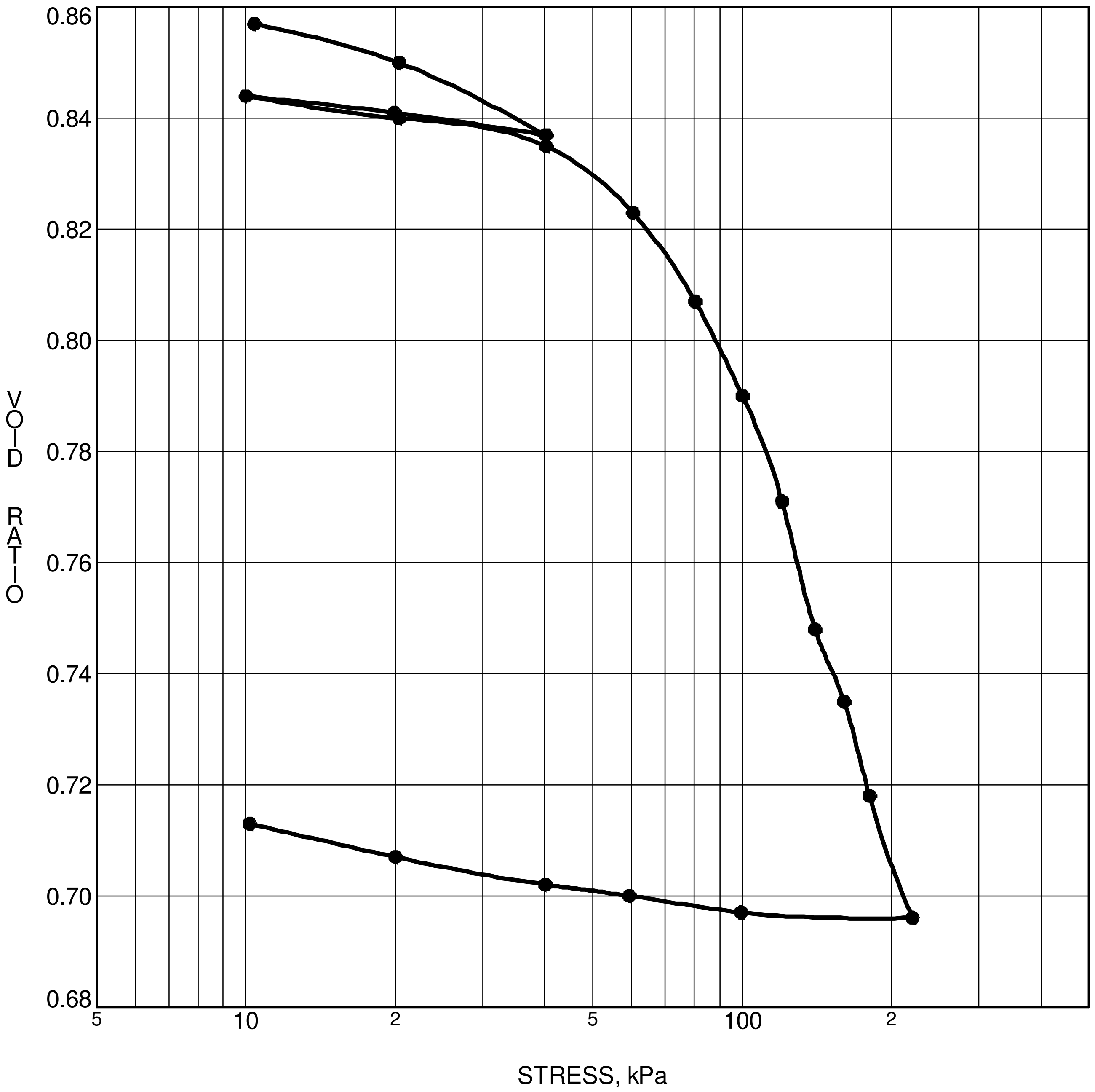
CONSOLIDATION TEST DATA SUMMARY					
Borehole No.	**BH10**	p'_o	**36** kPa	Ccr	**0.015**
Sample No.	**TW 5**	p'_c	**70** kPa	Cc	**0.586**
Sample Depth	**3.30** m	OC Ratio	**1.9**	Wo	**40.6** %
Sample Elev.	**94.81** m	Void Ratio	**1.104**	Unit Wt.	**18.4** kN/m ^{3}

CLIENT	**Monarch Group**	FILE NO.	**PG2233**
PROJECT	**Supplemental Geotechnical Investigation - West Park Residential Development**	DATE	**03/24/2011**

patersongroup **Consulting Engineers**

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

CONSOLIDATION TEST

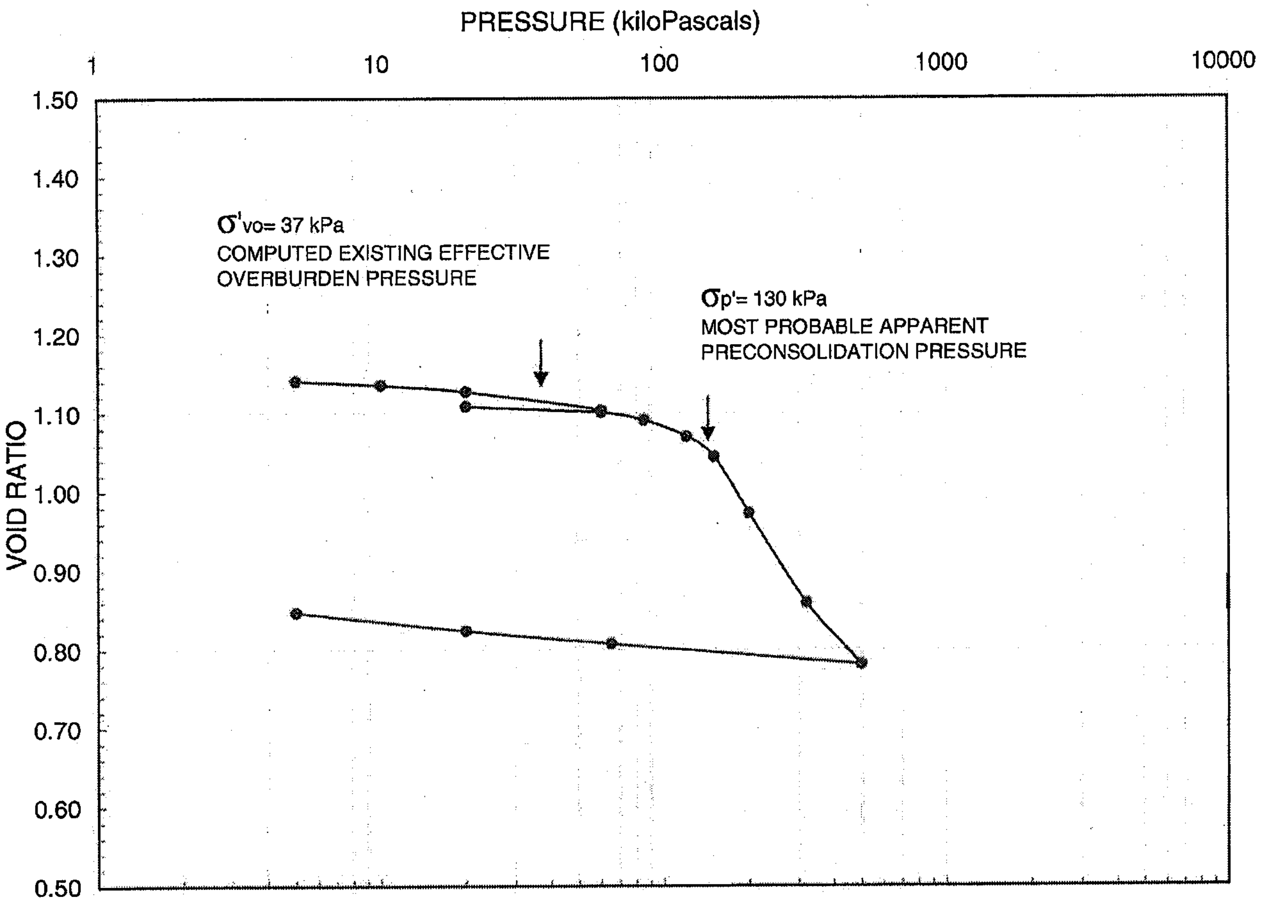


CONSOLIDATION TEST DATA SUMMARY					
Borehole No.	BH12	p'_o	34 kPa	Ccr	0.014
Sample No.	TW 5	p'_c	85 kPa	Cc	0.281
Sample Depth	3.38 m	OC Ratio	2.5	Wo	31.6 %
Sample Elev.	95.05 m	Void Ratio	0.857	Unit Wt.	19.5 kN/m^3

CLIENT **Monarch Group**
FILE NO. **PG2233**
PROJECT **Supplemental Geotechnical Investigation - West Park Residential Development**
DATE **03/10/2011**

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

CONSOLIDATION TEST



LEGEND

Borehole: 06-2 — w_i = 40% — S_o = 98%

Sample: 4 — w_f = 31% — C_c = 0.56

Depth (m): 5.00 — w_l = 31% — C_r = 0.02

w_p = 18% — γ = 18.2 kg/m^3

Golder Associates

SCALE AS SHOWN

DATE 01/11/07

DESIGN NA

CADD NA

CHECK

REVIEW

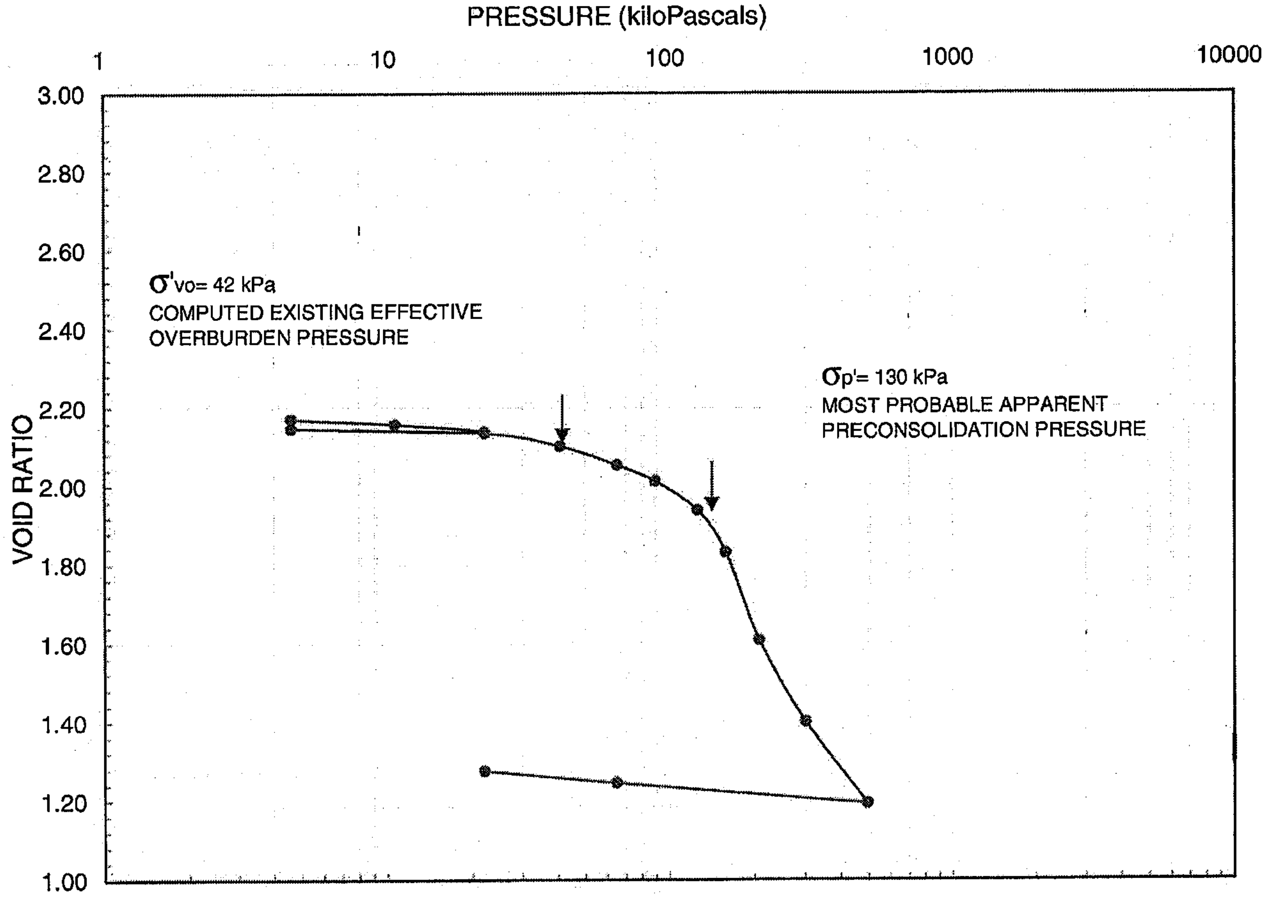
FILE No. Consolidation summary

PROJECT No. 061120392 REV. 0

TITLE

CONSOLIDATION TEST RESULTS

FIGURE 3



LEGEND

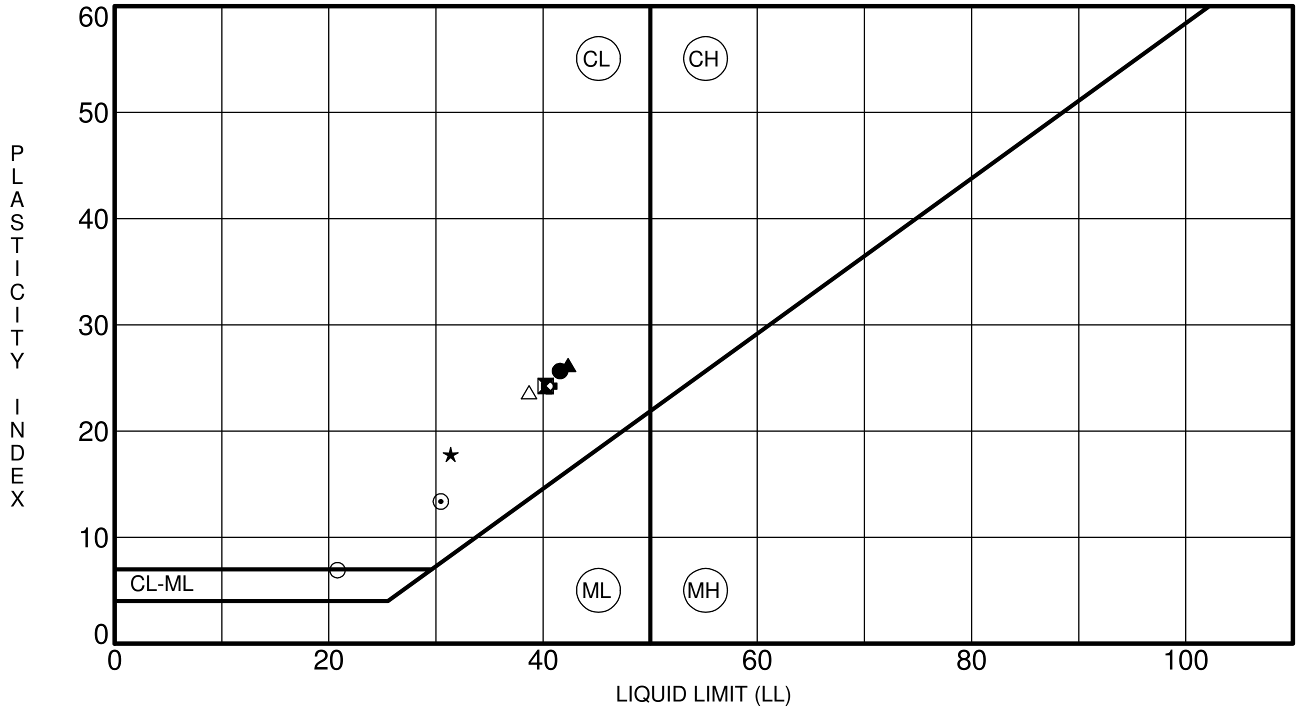
Borehole:	06-7	w_i = 74%	S_o = 95%
Sample:	4	w_f = 47%	C_c = 1.60
Depth (m):	4.8	w_l = 52%	C_r = 0.02
		w_p = 22%	γ= 15.3 kg/m^3

Golder Associates

SCALE AS SHOWN
DATE 01/11/07
DESIGN NA
CADD NA
CHECK
REVIEW

TITLE
CONSOLIDATION TEST RESULTS

FILE No. Consolidation summary
PROJECT No. 61120392 REV. 0
FIGURE 5



Specimen Identification		LL	PL	PI	Fines	Classification
●	**BH 1-17**	**42**	**16**	**26**		**CL - Inorganic clay with low plasticity**
⧗	**BH 2-17**	**40**	**16**	**24**		**CL - Inorganic clay with low plasticity**
▲	**BH 3-17**	**42**	**16**	**26**		**CL - Inorganic clay with low plasticity**
★	**BH 4-17**	**31**	**14**	**18**		**CL - Inorganic clay with low plasticity**
⊙	**BH 5-17**	**30**	**17**	**13**		**CL - Inorganic clay with low plasticity**
✿	**BH 6-17**	**41**	**16**	**24**		**CL - Inorganic clay with low plasticity**
○	**BH 7-17**	**21**	**14**	**7**		**CL - Inorganic clay with low plasticity**
△	**BH 8-17**	**39**	**15**	**24**		**CL - Inorganic clay with low plasticity**

CLIENT **Mattamy Homes**

FILE NO. **PG4053**

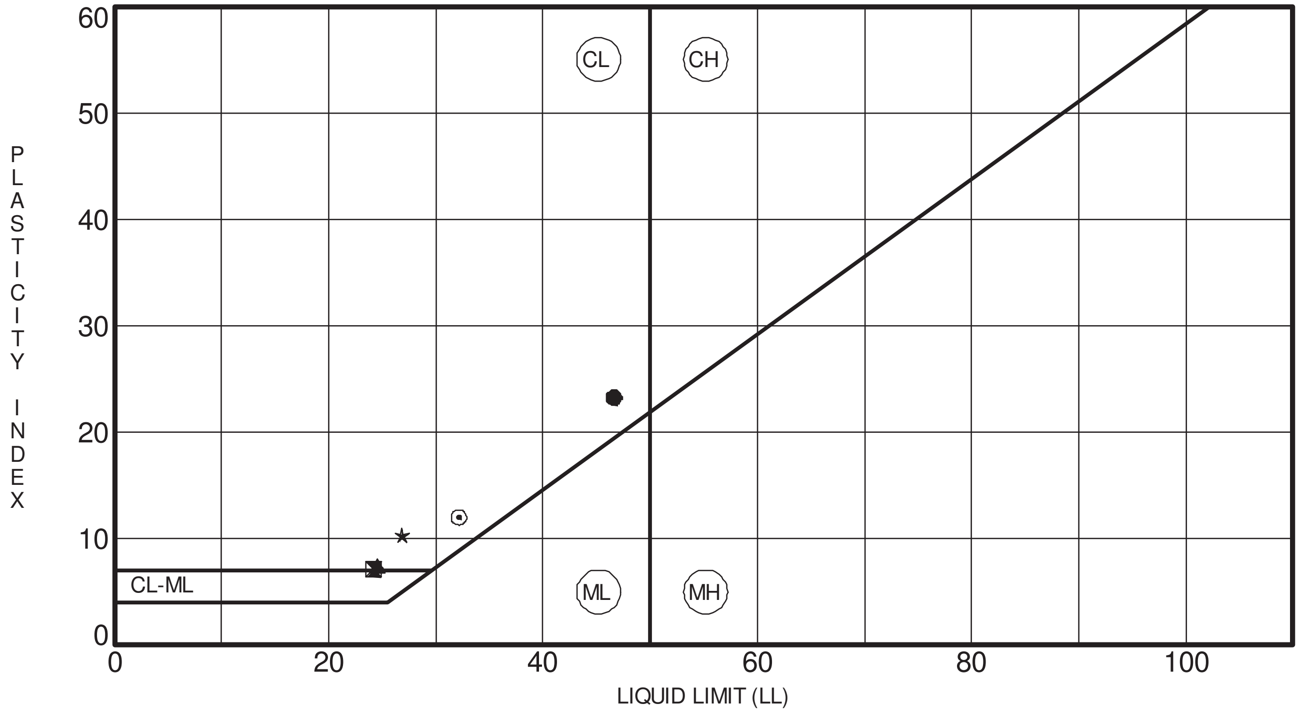
PROJECT **Geotechnical Investigation - Residential Development - Blackstone Phases 4 to 8**

DATE **13 Mar 17**

patersongroup **Consulting Engineers**

154 Colonnade Road South, Ottawa, Ontario K2E 7J5

ATTERBERG LIMITS' RESULTS



	Specimen Identification		LL	PL	PI	Fines	Classification
●	**BH 1**	**TW 3**	**47**	**23**	**23**		**CL-Inorganic clays of low plasticity**
⊠	**BH 2**	**SS 4**	**24**	**17**	**7**		**CL-Inorganic clays of low plasticity**
▲	**BH 2**	**TW 5**	**24**	**17**	**7**		**CL-Inorganic clays of low plasticity**
★	**BH 4A**	**TW 1**	**27**	**17**	**10**		**CL-Inorganic clays of low plasticity**
⊙	**BH19**	**TW 3**	**32**	**20**	**12**		**CL-Inorganic clays of low plasticity**

CLIENT **Monarch Corporation**

FILE NO. **PG1874**

PROJECT **Geotechnical Investigation - Proposed Residential Development - West Park**

DATE **14 Oct 09**

patersongroup **Consulting Engineers**

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

ATTERBERG LIMITS' RESULTS

	Client ID:	BH2-17-SS3	-	-	-
	Sample Date:	24-Mar-17	-	-	-
	Sample ID:	1713073-01	-	-	-
	MDL/Units	Soil	-	-	-
Physical Characteristics					
% Solids	0.1 % by Wt.	75.0	-	-	-
General Inorganics					
pH	0.05 pH Units	7.76	-	-	-
Resistivity	0.10 Ohm.m	90.3	-	-	-
Anions					
Chloride	5 ug/g dry	8	-	-	-
Sulphate	5 ug/g dry	18	-	-	-

APPENDIX 2

FIGURE 1 - KEY PLAN

FIGURES 2 AND 3 - SHEAR WAVE VELOCITY PROFILES

DRAWING PG4053-1 - TEST HOLE LOCATION PLAN

DRAWING PG4053-2 - PERMISSIBLE GRADE RAISE PLAN

DRAWING PG4053-3 - SEISMIC SITE CLASSIFICATION PLAN

FIGURE 1

KEY PLAN

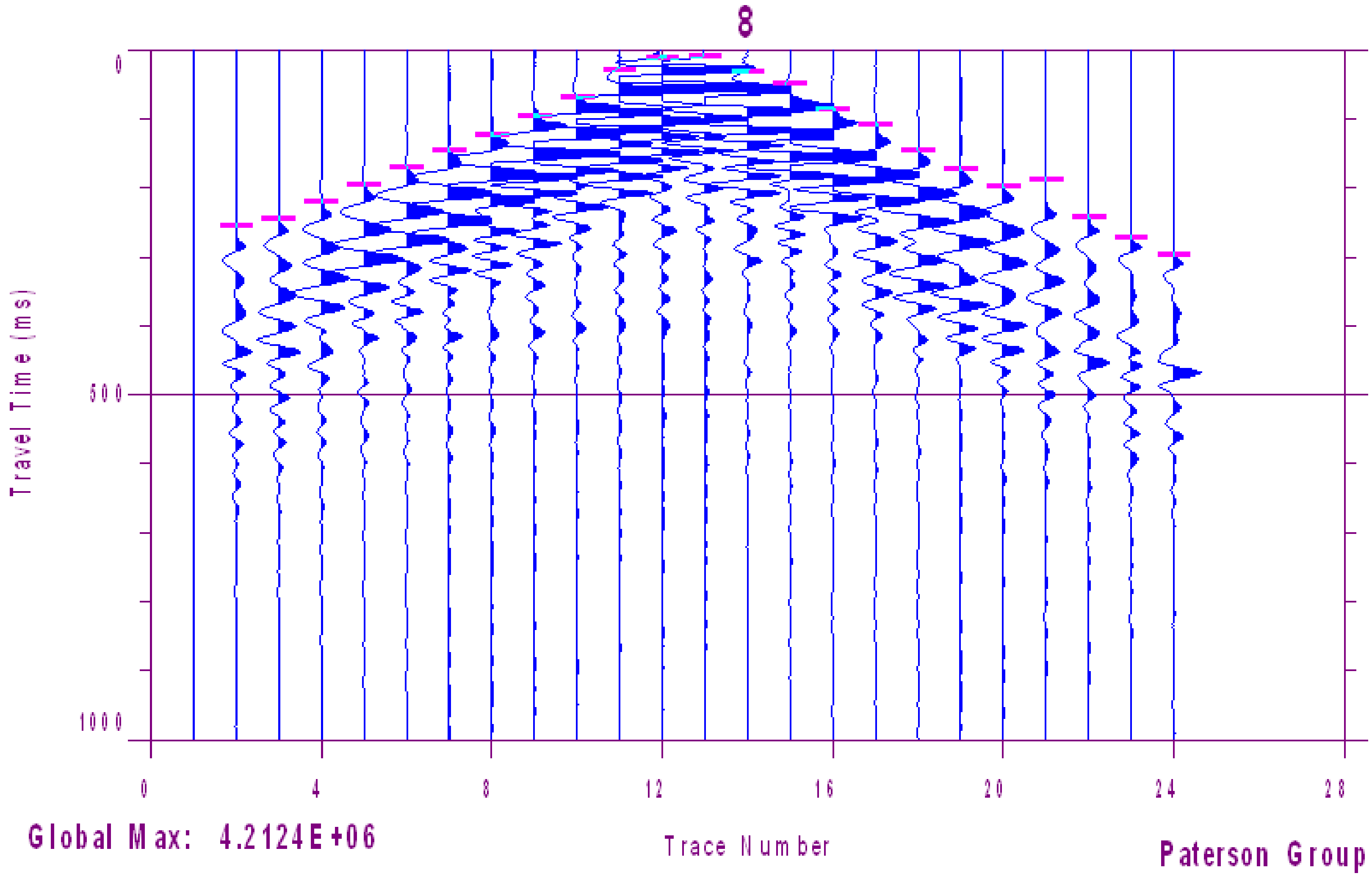


Figure 2 – Shear Wave Velocity Profile at Shot Location 34.5 m

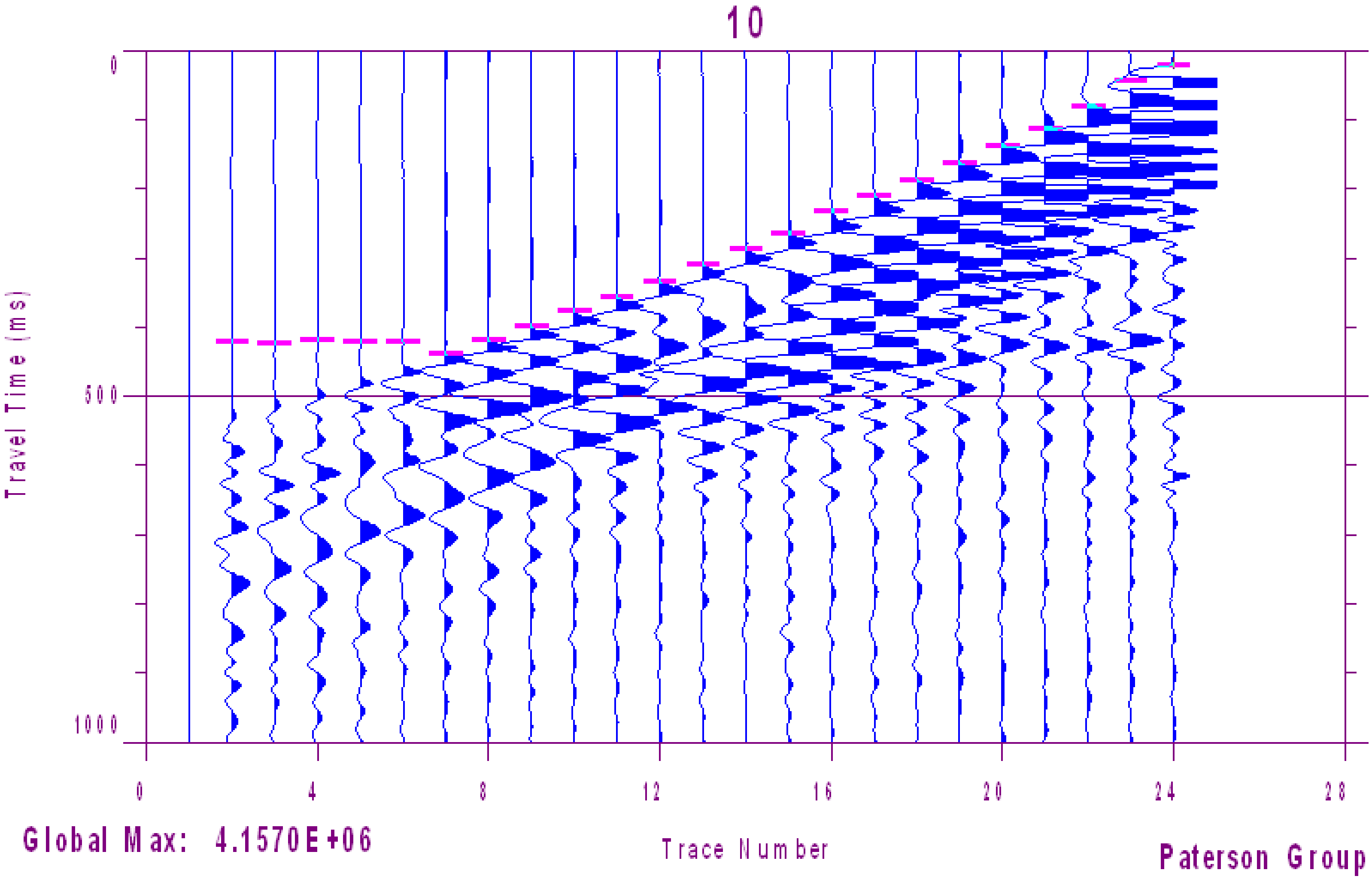
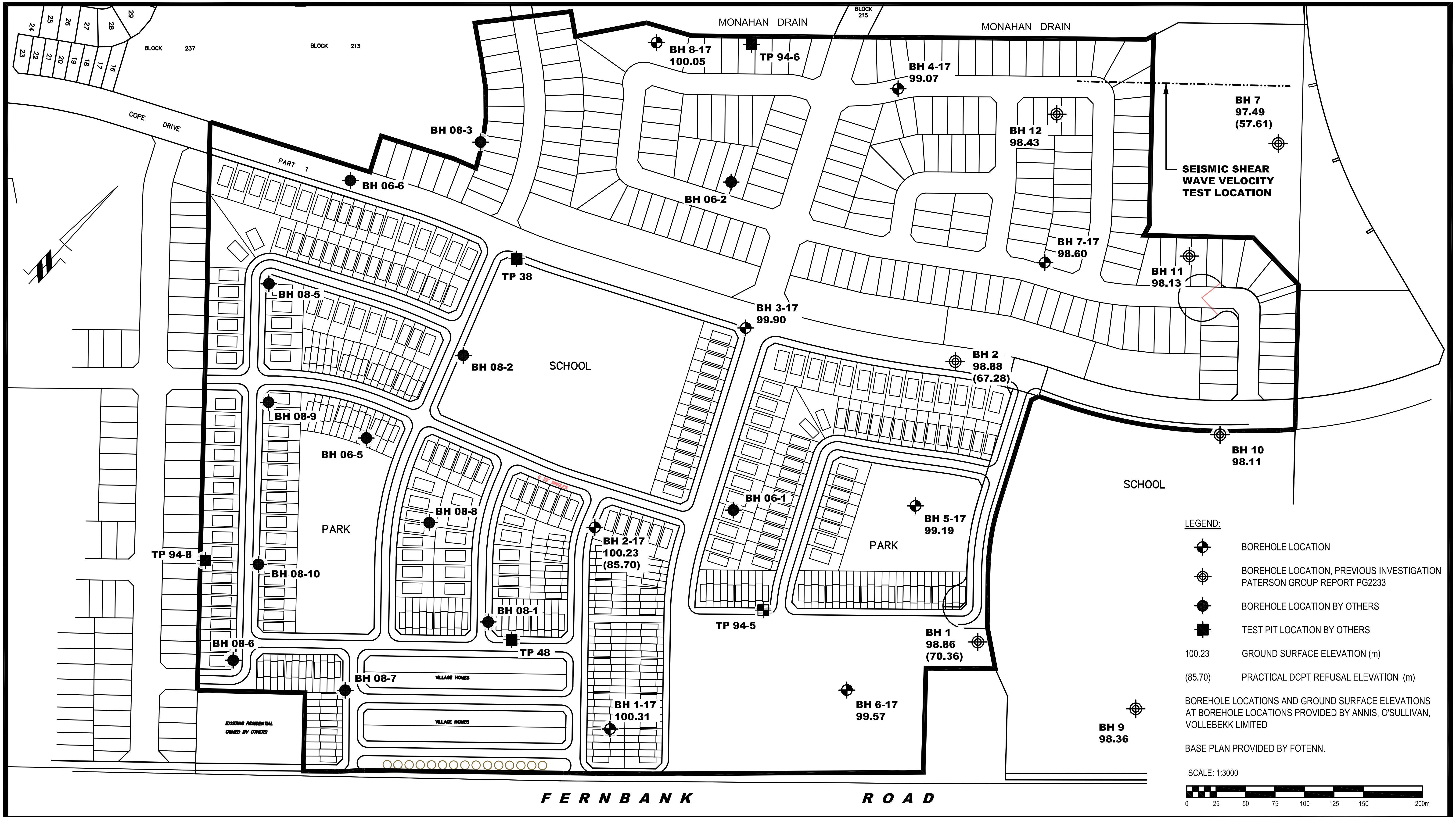


Figure 3 – Shear Wave Velocity Profile at Shot Location 72 m



LEGEND:

⊕	BOREHOLE LOCATION
⊕	BOREHOLE LOCATION, PREVIOUS INVESTIGATION PATERSON GROUP REPORT PG2233
●	BOREHOLE LOCATION BY OTHERS
■	TEST PIT LOCATION BY OTHERS
100.23	GROUND SURFACE ELEVATION (m)
(85.70)	PRACTICAL DCPT REFUSAL ELEVATION (m)

BOREHOLE LOCATIONS AND GROUND SURFACE ELEVATIONS AT BOREHOLE LOCATIONS PROVIDED BY ANNIS, O'SULLIVAN, VOLLEBEKK LIMITED

BASE PLAN PROVIDED BY FOTENN.

patersongroup
consulting engineers

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

NO.	REVISIONS	DATE	INITIAL
0			

MATTAMY HOMES

GEOTECHNICAL INVESTIGATION
RESIDENTIAL DEVELOPMENT - BLACKSTONE PHASES 4 TO 8

OTTAWA, ONTARIO

Title:

TEST HOLE LOCATION PLAN

Scale: 1:3000	Date: 04/2017
Drawn by: MPG	Report No.: PG4053-1
Checked by: CB	Dwg. No.: PG4053-1
Approved by: DJG	Revision No.: 0

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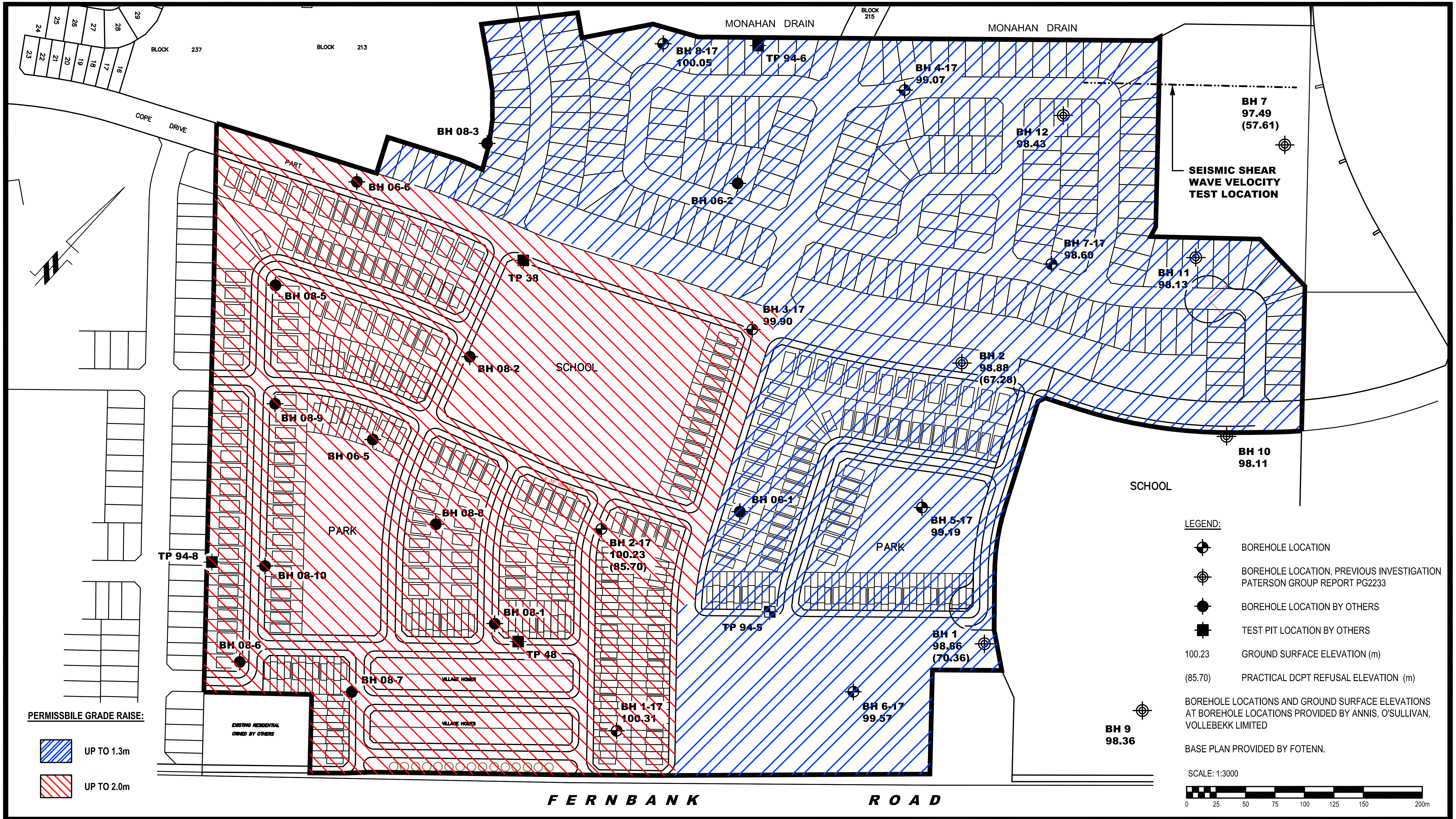

patersongroup
consulting engineers

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

NO.	REVISIONS	DATE	INITIAL
0			

MATTAMY HOMES

GEOTECHNICAL INVESTIGATION
RESIDENTIAL DEVELOPMENT - BLACKSTONE PHASES 4 TO 8
OTTAWA, ONTARIO

Title:

PERMISSIBLE GRADE RAISE PLAN

Scale: 1:3000
Date: 04/2017
Drawn by: MPG
Report No.: PG4053-1
Checked by: CB
Dwg. No.: PG4053-2
Approved by: DJG
Revision No.: 0

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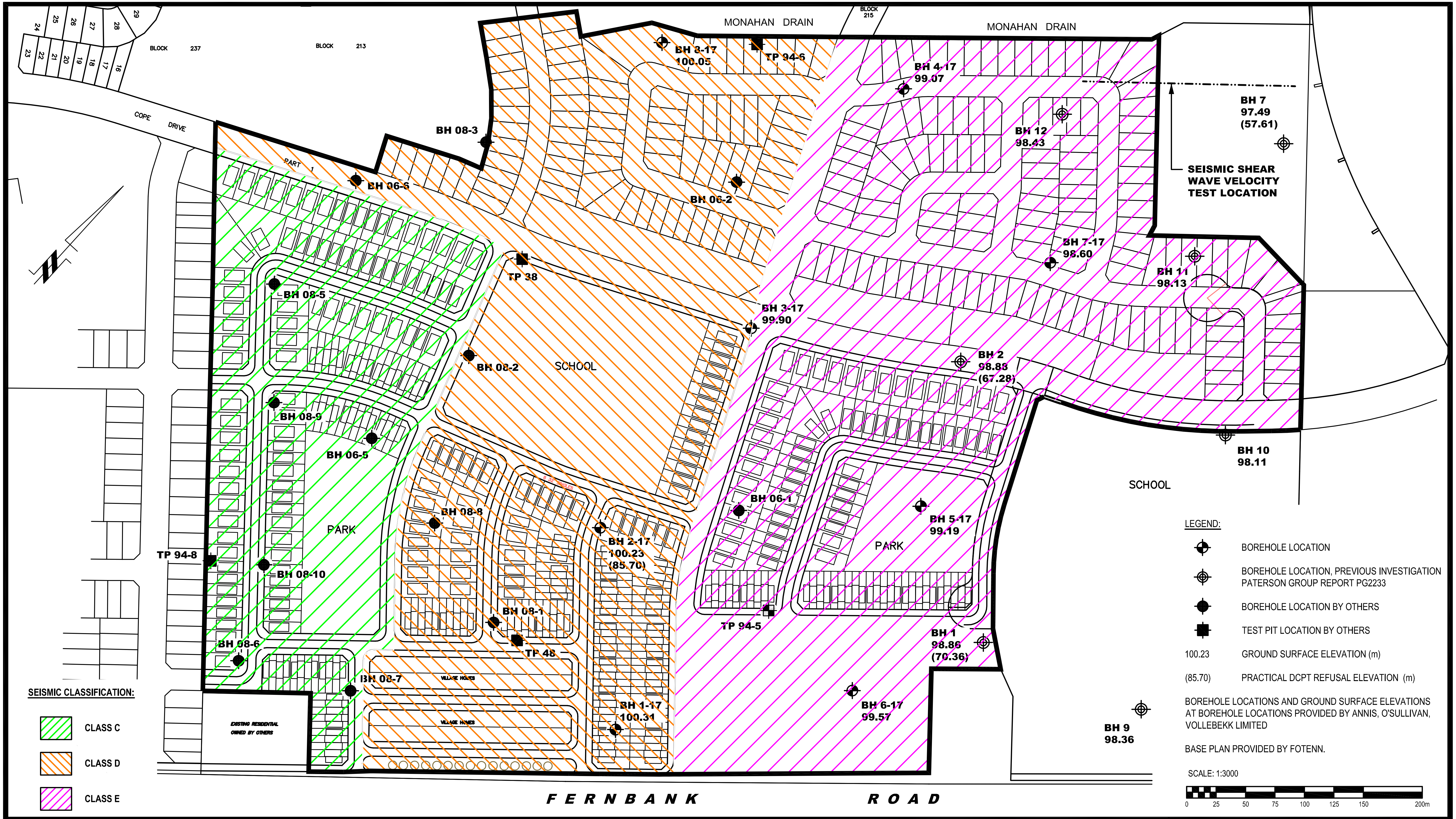

SEISMIC CLASSIFICATION:

- 🟩 CLASS C
- 🟧 CLASS D
- 🟪 CLASS E

LEGEND:

⊕	BOREHOLE LOCATION
⊕	BOREHOLE LOCATION, PREVIOUS INVESTIGATION PATERSON GROUP REPORT PG2233
●	BOREHOLE LOCATION BY OTHERS
■	TEST PIT LOCATION BY OTHERS
100.23	GROUND SURFACE ELEVATION (m)
(85.70)	PRACTICAL DCPT REFUSAL ELEVATION (m)

BOREHOLE LOCATIONS AND GROUND SURFACE ELEVATIONS AT BOREHOLE LOCATIONS PROVIDED BY ANNIS, O'SULLIVAN, VOLLEBEKK LIMITED

BASE PLAN PROVIDED BY FOTENN.

SCALE: 1:3000

0 25 50 75 100 125 150 200m

patersongroup
consulting engineers

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

NO.	REVISIONS	DATE	INITIAL
0			

MATTAMY HOMES

GEOTECHNICAL INVESTIGATION
RESIDENTIAL DEVELOPMENT - BLACKSTONE PHASES 4 TO 8

OTTAWA, ONTARIO

Title:

SEISMIC SITE CLASSIFICATION PLAN

Scale: 1:3000	Date: 04/2017
Drawn by: MPG	Report No.: PG4053-1
Checked by: CB	Dwg. No.: PG4053-3
Approved by: DJG	Revision No.: 0

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