Geotechnical Engineering

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Materials Testing

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Geotechnical Investigation

Proposed Residence Building
1125 Colonel By Drive
Ottawa, Ontario

Prepared For

Carleton University
c/o ZW Group

November 21, 2014

Report PG3292-2

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APPENDICES

1.0 INTRODUCTION

Paterson Group (Paterson) was commissioned by ZW Group acting on behalf of Carleton University to conduct a geotechnical investigation for the proposed residence building to be located at 1125 Colonel By Drive in the City of Ottawa, Ontario (refer to Figure 1 - Key Plan in Appendix 2 of this report).

The objectives of the current investigation were to:

- ❏ Determine the subsoil and groundwater conditions at this site by means of test pits and boreholes.
- ❏ Provide geotechnical recommendations for the design of the proposed development including construction considerations which may affect the design.

The following report has been prepared specifically and solely for the aforementioned project which is described herein. It contains our findings and includes geotechnical recommendations pertaining to the design and construction of the subject development as they are understood at the time of writing this report.

2.0 PROPOSED PROJECT

It is understood that the proposed development consists of a multi-storey building with up to 20 storeys. It is our understanding the proposed building will be constructed with a basement level and will be tied into the tunnel system at Carleton University. The courtyard portion will also be lowered from the existing grade to the level just below the basement floor slab at an elevation of 62.7 m.

Associated at grade parking areas, access lanes and landscaped areas are also anticipated as part of the development.

Furthermore, it is our understanding that a pedestrian tunnel will constructed to connect the proposed residential building to the current tunnel system.

3.0 METHOD OF INVESTIGATION

3.1 Field Investigation

Field Program

The field program for the supplemental geotechnical investigation was carried out on November 5 and 6, 2014. At that time a total of 7 boreholes and 5 test pits were completed to a maximum depth of 6.7 m. The field program for the previous geotechnical investigation was carried out on July 25, and 28, 2014. At that time a total of 6 boreholes were advanced to a maximum depth of 9.8 m. In addition, 4 test pits were excavated to a maximum depth of 6.5 m on August 7, 2014.

The test holes were distributed in a manner to provide general coverage of the proposed structure taking into consideration of site features and underground utilities. The test holes locations are illustrated on Drawing PG3292-2 - Test Hole Location Plan included in Appendix 2.

The boreholes were completed using a track-mounted auger drill rig operated by a two person crew. The test pits were completed using a hydraulic shovel supplied by Dufresne Piling or Drummonds. 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 or excavating to the required depths at the selected locations and sampling and testing the overburden.

Sampling and In Situ Testing

Soil samples were collected from the boreholes using a 50 mm diameter split-spoon (SS) sampler or auger flights. The soils samples (grab samples) recovered from the test pits were recovered from the excavation sidewalls. All soil samples were visually inspected and initially classified on site. The split-spoon, auger and grab samples were placed in sealed plastic bags and transported to the our laboratory for examination and classification. The depths at which the split-spoon, auger and grab samples were recovered from the test holes are shown as SS, AU and G, 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) at BH 6. 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 borehole 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 polyethylene standpipes were installed in all boreholes to permit monitoring of the groundwater levels subsequent to the completion of the sampling program. Open hole groundwater levels were noted in the test pits at the time of the field program.

Sample Storage

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

3.2 Field Survey

The test hole locations were selected by Vincent P. Colliza Architects Inc. They were determined in the field and surveyed by Paterson personnel. The ground surface elevation at each test hole location was referenced to a temporary benchmark (TBM), consisting of the finished floor slab of the existing residence building located to the south of the subject site. A geodetic elevation of 65.6 m was provided for the TBM on the drawing provided by Vincent P. Colizza Architects Inc. The location of the TBM, test holes and the ground surface elevations at the test hole locations are presented on Drawing PG3292-2 - Test Hole Location Plan in Appendix 2.

3.3 Laboratory Testing

Soil samples were recovered from the subject site and visually examined in our laboratory to review the results of the field logging.

3.4 Analytical Testing

One 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 samples. The results are presented in Appendix 1 and are discussed further in Subsection 6.7.

4.0 OBSERVATIONS

4.1 Surface Conditions

Generally, the central and east portion of the subject site is currently occupied by an existing asphaltic concrete automobile parking area. The west portion slopes approximately 3 m down from the parking area into a low-lying vegetated area covered with fill, mulch, grass and some brush.

The site is bordered to the south by the existing 5 to 6 storey residence building, to the north and east by asphaltic car parking and to the west by vacant treed property followed by Colonel By Drive.

4.2 Subsurface Profile

Overburden

Generally, the subsurface profile at the test hole locations consists of a pavement structure or topsoil overlying fill material varying in thickness between 1.9 and 5 m. The existing fill material is overlying a firm to hard silty clay deposit and/or compact to dense sand and gravel deposit (possibly a glacial till). TP 3 to TP 9, which were extended within the lower west portion of the subject site, consist of a layer of topsoil overlying a silty sand and silty clay layer followed by a compact to dense sand and gravel deposit.

Bedrock

Specific details of the soil profile at each test hole location are presented on the Soil Profile and Test Data sheets provided in Appendix 1. Based on available geological mapping, bedrock in the area of the subject site consists of interbedded silty dolostone, limestone, shale and fine-grained quartz sandstone of the Gull River Formation. The overburden drift thickness is estimated to be between 10 to 15 m depth. Practical auger or DCPT refusal depths can be found in Table 1 below.

Table 1 Practical Refusal to Augering or DCPT			
Borehole Number	**Elevation (m)**	**Depth to refusal (m)**	**Refusal Elevation (m)**
BH 1	66.12	5.54	60.58
BH 2	65.58	9.5	56.08
BH 3	65.97	8.15	57.82
BH 4	65.44	7.64	57.8
BH 5	62.73	6.12	56.61
BH 6	65.61	12.12	53.49
BH 9	65.19	5.36	59.83
BH 10	65.3	5.21	60.09
BH 11	65.52	4.7	60.82
BH 12	65.65	4.67	60.98

4.3 Groundwater

Groundwater levels were measured in the flexible standpipes on August 5, 2014 and November 12, 2014. The results are presented in Table 2 on the following page. The groundwater levels obtained in August at the subject site were considered elevated at that time due to the normal water levels in the Rideau Canal located near the subject site. It should be noted that surface water can become trapped within the backfilled borehole, which can lead to higher than normal groundwater readings.

The long term groundwater level can also be estimated based on the recovered soil sample's moisture level and consistency. Based on these observations, the long term groundwater table is anticipated to be at a geodetic elevation of 60.5 to 61.5 m. It should be further noted that the groundwater level could vary at the time of construction and with fluctuations within the Rideau Canal.

Table 2 - Measured Groundwater Levels

Test Hole Number	Ground Surface Elevation (m)	Water Level		Date
		Depth (m)	Elevation (m)	
BH 1	66.12	5.16	60.96	August 5, 2014
BH 2	65.58	4.86	60.72	August 5, 2014
BH 3	65.97	5.13	60.84	August 5, 2014
BH 4	65.44	4.75	60.69	August 5, 2014
BH 5	62.73	1.88	60.85	August 5, 2014
BH6	65.61	4.64	60.97	August 5, 2014
BH 7	64.25	Dry	--	November 12, 2014
BH 8	64.01	1.54	62.47	November 12, 2014
BH 9	65.19	1.68	63.51	November 12, 2014
BH 10	65.30	5.03	60.27	November 12, 2014
BH 11	65.52	3.83	61.69	November 12, 2014
BH 12	65.65	Dry	--	November 12, 2014
BH 13	65.33	5.26	60.07	November 12, 2014

Note: The ground surface elevation at each test hole location was referenced to a temporary benchmark (TBM), consisting of the finished floor slab of the existing residence building located to the south of the subject site. A geodetic elevation of 65.60 m was provided for the TBM on the drawing provided by Vincent P. Colizza Architects Inc.

5.0 DISCUSSION

5.1 Geotechnical Assessment

The subject site is satisfactory for the proposed hi-rise structure. Since the building will have a basement level throughout, excavated fill materials will be used to raise the low-lying areas on the western portion. Concrete filled trenches will be used to transfer the footing loads to the dense sand-gravel deposit in areas where the dense sand-gravel deposit is not encountered at founding depth. Foundations will consist of conventional spread footings founded directly on either the dense sand-gravel deposit or lean concrete filled trenches extending to the dense sand-gravel deposit.

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

5.2 Site Grading and Preparation

Stripping Depth

Only topsoil and deleterious fill, such as those containing organic materials, should be stripped from under the proposed building and other settlement sensitive structures. For the most part, the existing fill will be left in place and will be used to support the floor slab.

Fill Placement

The excavated fill from the basement area will be evaluated and, where acceptable, will be reused to backfill the low-lying western portion of the site. Segregation of poor quality fill may be required. Based on the test pit observations, the fill material appears to be satisfactory. The material will be placed in 300 mm lifts and will be compacted to 98% of the material's standard Proctor maximum dry density (SPMDD). Furthermore, trench excavations for footings will also produce excavated fill that can be re-used on site for in-filling the low lying areas and in landscaped areas.

Where additional fill is required to raise the site to below the proposed underside of the sub-floor granular materials, an OPSS Granular B Type II can be used for this purpose as engineered fill. The engineered fill should be placed in maximum 300 mm loose lifts and compacted to 98% of the material's SPMDD.

5.3 Foundation Design

Shallow Foundation

It should be noted that footings placed on an undisturbed, dense sand-gravel deposit (possibly glacial till) bearing surface or on a lean concrete filled trench extending to the dense sand-gravel deposit can be designed using a bearing resistance value at SLS of **250 kPa** and a factored bearing resistance value at ULS of **400 kPa**.

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

The bearing medium under footing-supported structures is required to be provided with adequate lateral support with respect to excavations and different foundation levels. Adequate lateral support is provided to an overburden bearing medium 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 or engineered fill of the same or higher capacity as the soil.

Lean Concrete Filled Trenches

For the slab-on-grade area of the building where the dense sand-gravel deposit is deeper than the proposed founding elevation, consideration will be given to excavating vertical trenches to expose the underlying dense sand-gravel deposit surface and backfilling with lean concrete (**17 MPa** 28-day compressive strength). Typically, the excavation side walls will be used as the form to support the concrete. The additional width of the concrete poured against an undisturbed trench sidewall will suffice in providing a direct transfer of the footing load to the underlying dense sand-gravel deposit.

The trench excavation should be at least 150 mm wider than all sides of the footing at the base of the excavation. Once the trench excavation is approved by the geotechnical engineer, lean concrete can be poured up to the proposed founding elevation.

5.4 Design for Earthquakes

A seismic shear wave velocity test was completed for the subject site to accurately determine the applicable seismic site classification for the proposed building based on Table 4.1.8.4.A of the Ontario Building Code 2012. The shear wave velocity test was completed by Paterson personnel. Two seismic shear wave velocity profiles from the on site testing are presented in Appendix 2.

Field Program

The seismic shear wave test was completed along the north property boundary, as presented in Drawing PG3292-1 - Test Hole Location Plan in Appendix 2. Paterson field personnel placed 24 horizontal geophones in a straight line in roughly an east-west orientation. 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 2 m intervals and were connected by a geophone spread cable to a Geode 24 Channel seismograph.

The seismograph was connected to a 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 strikes an I-Beam seated into the ground surface, which creates a polarized shear wave. The hammer shots are repeated between four to eight 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, as well as 3, 4.5 and 20 m away from the first and last geophone.

The test method completed by Paterson are guided by the standard test procedures outlined 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 completed by 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 below the structures 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 by 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. Based on testing results, bedrock is generally present at 15 to 16 m depth below the existing pavement structure.

Based on the test results, the overburden and bedrock seismic shear wave velocities are 184 m/s and 1,820 m/s, respectively. The Vs_{30} was calculated using the standard equation for average shear wave velocity from the Ontario Building Code (OBC) 2012. It is our understanding that typical foundations will be bearing on shallow footings placed on the dense glacial till at an approximate geodetic elevation of 61.5 m.

$$V_{s30} = \frac{Depth_{OfInterest}(m)}{\sum\left(\frac{(Depth_i(m))}{Vs_i(m/s)}\right)}$$

$$V_{s30} = \frac{30m}{\left(\frac{11.5m}{184m/s} + \frac{18.5m}{1{,}820m/s}\right)}$$

$$V_{s30} = 413m/s$$

Based on the seismic test results, the average shear wave velocity, Vs_{30}, for foundations at the subject site is 413 m/s. Therefore, a **Site Class C** is applicable for design of the proposed building, as per Table 4.1.8.4.A of the OBC 2012. The soils underlying the subject site are not considered to be susceptible to liquefaction.

5.5 Basement Slab Construction

With the removal of all topsoil and deleterious materials, within the footprint of the proposed building, the existing fill, free of organics and deleterious materials, can be left in place provided the existing fill is proof rolled and the sub-slab fill thickness is increased to a minimum 300 mm in basement areas and 500 mm in non-basement areas.

The existing material below the existing pavement structure, free of organics and deleterious material, approved by the geotechnical consultant may be used to build up the lower west portion of the subject site below the finished concrete floor slab. The existing mulch and organics within the landscaping area should be removed prior to the placement of fill.

The upper 500 mm of sub-slab fill should consist of an OPSS Granular A material for slab-on-grade and 300 mm for basement slab construction. All backfill material within the footprint of the proposed building should be placed in maximum 300 mm thick loose lifts and compacted to at least 98% of the material's SPMDD.

Any soft areas should be removed and backfilled with appropriate backfill material prior to placing any fill. OPSS Granular B Type I or II, with a maximum particle size of 50 mm, are recommended for backfilling below the floor slab. All backfill material within the footprint of the proposed buildings should be placed in maximum 300 mm thick loose layers and compacted to at least 98% of its SPMDD.

5.6 Basement Wall

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

It is expected that the foundation wall will be provided with a perimeter drainage system; therefore, the retained soils should be considered drained. For the undrained conditions, the applicable effective (undrained) unit weight of the retained soil can be taken as 13 kN/m^3. A hydrostatic pressure should be added to the total static earth pressure when using the effective unit weight. The total earth pressure (P_{AE}) includes both the static earth pressure component (P_o) and the seismic component (ΔP_{AE}).

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

Static Conditions

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

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

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

Seismic Conditions

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

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

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

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

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

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

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

5.7 Pavement Structure

Car only parking, heavy truck parking areas, and access lanes are anticipated at this site. The proposed pavement structures are presented in Tables 3 and 4.

Table 3 - Recommended Pavement Structure - Car Only Parking Areas

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

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

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

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

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

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.

6.0 DESIGN AND CONSTRUCTION PRECAUTIONS

6.1 Foundation Drainage and Backfill

Perimeter Drainage and Backfill

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

Backfill against the exterior sides of the foundation walls should consist of free-draining non frost susceptible granular materials. The greater part of the site excavated materials will be frost susceptible and, as such, are not recommended for re-use as backfill against the foundation walls, unless used in conjunction with a composite drainage system, such as Miradrain G100N or Delta Drain 6000. Imported granular materials, such as clean sand or OPSS Granular B Type I granular material, should be used for backfill material.

Underfloor Drainage

It is anticipated that underfloor drainage will be required to control water infiltration in the basement portion and for the tunnel connection. For preliminary design purposes, we recommend that 150 mm diameter perforated PVC pipes be placed at 6 to 8 m centres and connected to the exterior perimeter drainage system with 150 mm diameter sleeves through the footings.

The spacing of the underfloor drainage system should be confirmed at the time of completing the excavation when water infiltration can be better assessed.

6.2 Protection of Footings Against Frost Action

Perimeter footings of heated structures are required to be insulated 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 in this regard.

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

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

Excavated soil should not be stockpiled directly at the top of excavations and heavy equipment should be kept away from the excavation sides.

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

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

6.4 Pipe Bedding and Backfill

At least 150 mm of OPSS Granular A should be used for pipe bedding for sewer and water pipes. The bedding should extend to the spring line of the pipe. Cover material, from the spring line to at least 300 mm above the obvert of the pipe should consist of OPSS Granular A. The bedding and cover materials should be placed in maximum 225 mm thick lifts compacted to a minimum of 95% of the material’s SPMDD.

Generally, it should be possible to re-use the native soils or existing fill, free of organics and deleterious materials, above the cover material if the excavation and filling operations are carried out in dry weather conditions.

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.

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.

It is expected that the flow of groundwater into the excavation will be low to moderate through the sides of the excavation. However, it is expected that the groundwater inflow will be controllable using open sumps and pumps.

A temporary MOE permit to take water (PTTW) will be required for this project if more than 50,000 L/day are to be pumped during the construction phase. At least 3 to 4 months should be allowed for completion of the application and issuance of the permit by the MOE.

6.6 Winter Construction

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

The subsoil conditions at this site consist of frost susceptible materials. In the presence of water and freezing conditions, ice could form within the soil mass. Heaving and settlement upon thawing could occur.

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

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

7.0 RECOMMENDATIONS

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

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

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

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

❏ Observation of all subgrades prior to backfilling.

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

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

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

8.0 STATEMENT OF LIMITATIONS

The recommendations provided in this report are in accordance with our present understanding of the project. We request permission to review our recommendations when the grading plan, drawings and specifications are completed.

A geotechnical investigation of this nature is a limited sampling of a site. The recommendations are based on information gathered at the specific test locations and can only be extrapolated to an undefined limited area around the test locations. Should any conditions at the site be encountered which differ from those at the test locations, we request notification immediately in order to permit reassessment of our recommendations.

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

Paterson Group Inc.

David J. Gilbert, P.Eng.

Carlos P. Da Silva, P.Eng.

LICENSED PROFESSIONAL ENGINEER
Nov. 21/14
C. P. DA SILVA
PROVINCE OF ONTARIO

Report Distribution

- ZW Group (3 copies)
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APPENDIX 1

SOIL PROFILE AND TEST DATA SHEETS

SYMBOLS AND TERMS

BOREHOLES BY OTHERS

patersongroup Consulting Engineers

154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residence Building - Carleton University
Colonel By Drive, Ottawa, Ontario

DATUM TBM - Door sill on the east end of Leeds Residence. Geodetic elevation = 65.59m.

FILE NO. PG3292

REMARKS

HOLE NO. BH 1

BORINGS BY CME 55 Power Auger **DATE** July 25, 2014

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	66.12
FILL: Mulch (0.15)		AU	1				
FILL: Brown silty sand to silty clay, trace crushed stone		SS	2	29	19	1	65.12
(1.68)		SS	3	29	20		
FILL: Brown silty sand, some crushed stone						2	64.12
		SS	4	21	4		
- with clay by 2.1m depth						3	63.12
		SS	5	25	14		
		SS	6	42	9	4	62.12
(4.42)							
GLACIAL TILL: Dense, brown silty sand with gravel, cobbles, boulders, trace clay		SS	7	58	30	5	61.12
(5.54)		SS	8	100	50+		
End of Borehole							
Practical refusal to augering at 5.54m depth							
(GWL @ 5.16m-August 5, 2014)							

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

○ Water Content %

20 40 60 80

Piezometer Construction

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

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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residence Building - Carleton University
Colonel By Drive, Ottawa, Ontario

DATUM TBM - Door sill on the east end of Leeds Residence. Geodetic elevation = 65.59m.

FILE NO. PG3292

REMARKS

HOLE NO. BH 2

BORINGS BY CME 55 Power Auger **DATE** July 25, 2014

SOIL DESCRIPTION	Depth to base (m)	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	65.58
Asphaltic concrete	0.05	AU	1				
FILL: Brown silty sand with gravel		SS	2	17	4	1	64.58
	2.00	SS	3	42	4		
FILL: Grey silty clay with gravel, some brick, trace sand		SS	4	100	3	2	63.58
	3.10						
Black **SILTY CLAY,** trace sand, gravel and organics	3.81	SS	5	75	8	3	62.58
GLACIAL TILL: Compact to dense, brown silty sand with gravel, cobbles and boulders, trace clay		SS	6	83	61	4	61.58
		SS	7	50	13	5	60.58
		SS	8	50	8		
		SS	9	60	50+	6	59.58
		SS	10	0	50+	7	58.58
		SS	11	100	16	8	57.58
		SS	12	67	37		
	9.50	SS	13	100	50+	9	56.58

End of Borehole

Practical refusal to augering at 9.50m depth

(GWL @ 4.86m-August 5, 2014)

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

○ Water Content %

20 40 60 80

Piezometer Construction

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

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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residence Building - Carleton University
Colonel By Drive, Ottawa, Ontario

DATUM TBM - Door sill on the east end of Leeds Residence. Geodetic elevation = 65.59m.

FILE NO. PG3292

REMARKS

HOLE NO. BH 3

BORINGS BY CME 55 Power Auger

DATE July 25, 2014

SOIL DESCRIPTION	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE					0	65.97
FILL: Brown silty clay wtih sand, trace crushed stone and mulch	AU	1				
	SS	2	50	7	1	64.97
1.68						
FILL: Brown silty sand, some crushed stone	SS	3	42	22	2	63.97
	SS	4	4	4		
	SS	5	0	3	3	62.97
3.81						
GLACIAL TILL: Compact to dense, brown silty sand with gravel, cobbles and boulders, trace clay	SS	6	46	6	4	61.97
	SS	7	50	31	5	60.97
	SS	8	58	54	6	59.97
	SS	9	42	7		
	SS	10	46	28	7	58.97
	SS	11	37	46	8	57.97
8.15						

End of Borehole

Practical refusal to augering at 8.15m depth

(GWL @ 5.13m-August 5, 2014)

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

○ Water Content %

20 40 60 80

Piezometer Construction

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

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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residence Building - Carleton University
Colonel By Drive, Ottawa, Ontario

DATUM TBM - Door sill on the east end of Leeds Residence. Geodetic elevation = 65.59m.

FILE NO. PG3292

REMARKS

HOLE NO. BH 4

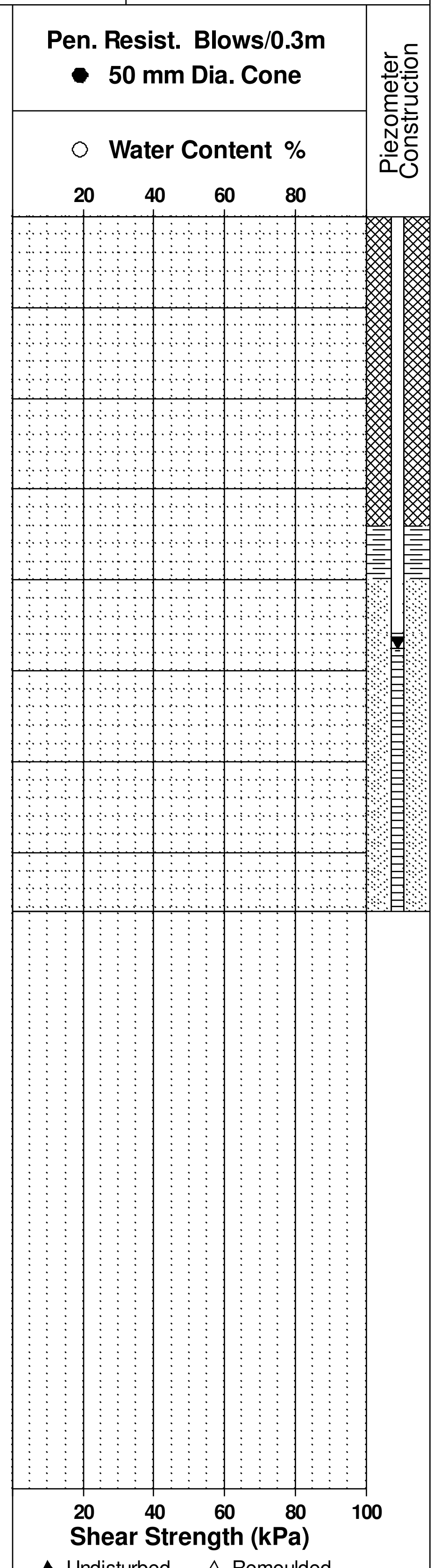
BORINGS BY CME 55 Power Auger

DATE July 28, 2014

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	65.44
Asphaltic concrete (0.05)		AU	1				
FILL: Brown sand with gravel, trace silt (1.42)		SS	2	0	50+	1	64.44
FILL: Grey-brown silty clay with sand and gravel (3.10)		SS	3	67	5	2	63.44
		SS	4	25	4	3	62.44
GLACIAL TILL: Compact to dense, brown silty sand, some gravel, cobbles and boulders, trace clay (7.64)		SS	5	8	8		
		SS	6	83	57	4	61.44
		SS	7	88	59	5	60.44
		SS	8	33	68	6	59.44
		SS	9	42	13		
		SS	10	25	37	7	58.44
End of Borehole		SS	11	0	50+		

Practical refusal to augering at 7.64m depth

(GWL @ 4.75m-August 5, 2014)



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residence Building - Carleton University
Colonel By Drive, Ottawa, Ontario

DATUM TBM - Door sill on the east end of Leeds Residence. Geodetic elevation = 65.59m.

FILE NO. PG3292

REMARKS

HOLE NO. BH 5

BORINGS BY CME 55 Power Auger

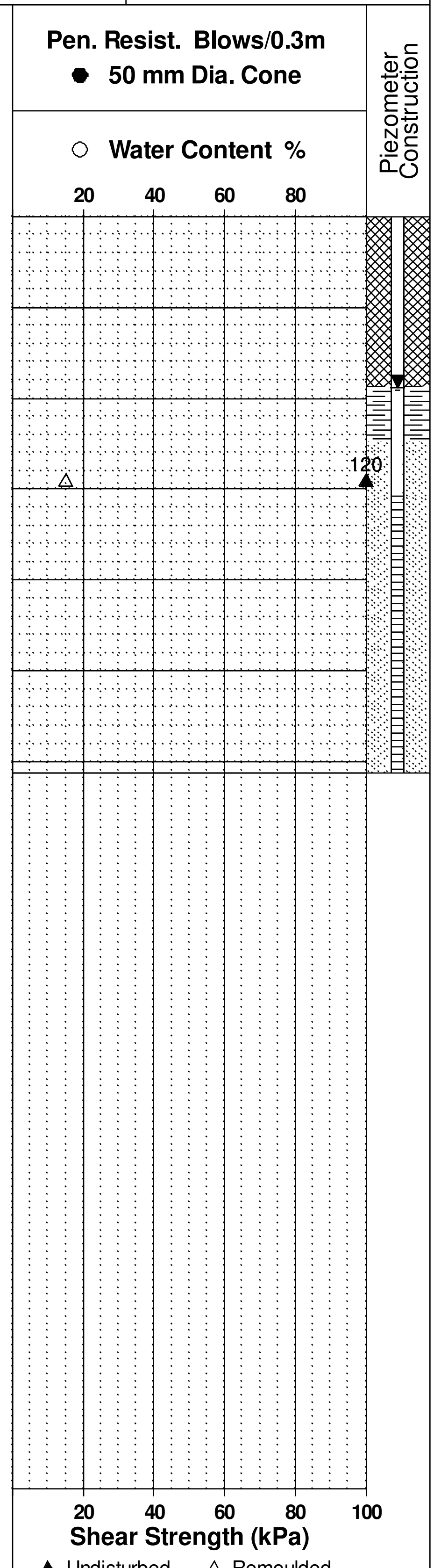
DATE July 25, 2014

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	62.73
TOPSOIL — 0.20							
FILL: Brown silty sand, some clay, trace organics		AU	1				
		SS	2	17	16	1	61.73
— 1.88		SS	3	46	5		
Grey-brown **SILTY CLAY,** trace sand						2	60.73
— 2.80		SS	4	100			
GLACIAL TILL: Compact to dense, brown silty sand with gravel, cobbles and boulders, trace clay						3	59.73
		SS	5	42	7		
		SS	6	58	52	4	58.73
		SS	7	46	60	5	57.73
		SS	8	40	64		
— 6.12		SS	9		50+	6	56.73

End of Borehole

Practical refusal to augering at 6.12m depth

(GWL @ 1.88m-August 5, 2014)



Piezometer Construction

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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residence Building - Carleton University
Colonel By Drive, Ottawa, Ontario

DATUM TBM - Door sill on the east end of Leeds Residence. Geodetic elevation = 65.59m.

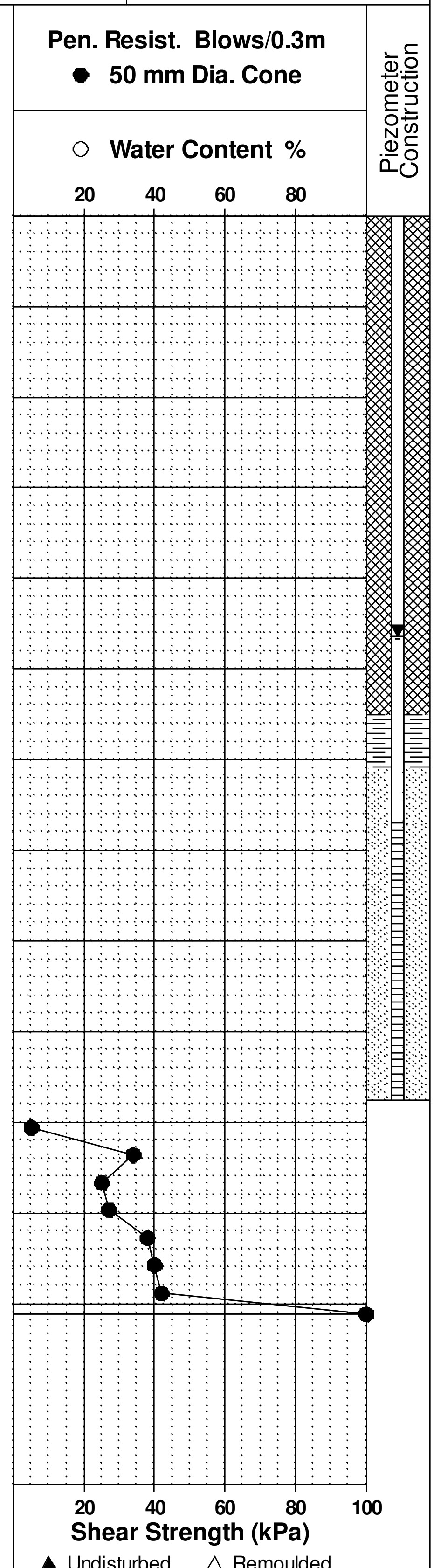
FILE NO. PG3292

REMARKS

HOLE NO. BH 6

BORINGS BY CME 55 Power Auger **DATE** July 28, 2014

SOIL DESCRIPTION	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE					0	65.61
Asphaltic concrete 0.08						
FILL: Crushed stone 0.60	AU	1				
FILL: Brown to grey silty clay with gravel, some sand	SS	2	75	15	1	64.61
	SS	3	50	6	2	63.61
3.10	SS	4	67	4	3	62.61
Grey **SILTY CLAY,** trace sand	SS	5	100	1		
4.62	SS	6	100	31	4	61.61
GLACIAL TILL: Dense to compact, brown silty sand with gravel, cobbles and boulders, trace clay	SS	7	100	50+	5	60.61
	SS	8	73	50+	6	59.61
	SS	9	42	13	7	58.61
	SS	10	58	9	8	57.61
	SS	11	17	18	9	56.61
	SS	12	50	7		
9.75	SS	13	42	16		
Dynamic Cone Penetration Test commenced at 9.75m depth.					10	55.61
Inferred **GLACIAL TILL**					11	54.61
12.12					12	53.61
End of Borehole						
Practical DCPT refusal at 12.12m depth						
(GWL @ 4.64m-August 5, 2014)						



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residence Building - Carleton University
Colonel By Drive, Ottawa, Ontario

DATUM TBM - Door sill on the east end of Leeds Residence. Geodetic elevation = 65.59m.

FILE NO. PG3292

REMARKS

HOLE NO. BH 7

BORINGS BY CME 55 Power Auger DATE November 5, 2014

SOIL DESCRIPTION	Layer depth (m)	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	64.25
TOPSOIL	0.05	AU	1				
FILL: Brown silty sand with gravel, some cobbles	1.52	SS	2	42	48	1	63.25
FILL: Brown silty clay with sand, brick and shale	2.44	SS	3	33	11	2	62.25
FILL: Brown silty sand with gravel, some cobbles - brick pieces from 3.5 to 3.7m depth	4.27	SS	4	42	32	3	61.25
		SS	5	25	6	4	60.25
		SS	6	42	6		
Stiff, grey **SILTY CLAY,** trace sand	5.26	SS	7	92	4	5	59.25
GLACIAL TILL: Grey clayey sand with silt	5.94	SS	8	42	4		
End of Borehole (BH dry - Nov. 12, 2014)							

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

○ Water Content %

20 40 60 80

Piezometer Construction

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

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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residence Building - Carleton University
Colonel By Drive, Ottawa, Ontario

DATUM TBM - Door sill on the east end of Leeds Residence. Geodetic elevation = 65.59m.

FILE NO. PG3292

REMARKS

HOLE NO. BH 8

BORINGS BY CME 55 Power Auger

DATE November 5, 2014

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	64.01
TOPSOIL 0.20		AU	1				
FILL: Brown silty sand with gravel, some clay		SS	2	25	7	1	63.01
		SS	3	25	8	2	62.01
		SS	4	50	15		
3.45		SS	5	25	50+	3	61.01
GLACIAL TILL: Brown silty sand with gravel, cobbles and boulders 4.11		SS	6	100	50+	4	60.01
End of Borehole							
(GWL @ 1.54m-Nov. 12, 2014)							

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

○ Water Content %

20 40 60 80

Piezometer Construction

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

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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residence Building - Carleton University
Colonel By Drive, Ottawa, Ontario

DATUM TBM - Door sill on the east end of Leeds Residence. Geodetic elevation = 65.59m.

FILE NO. PG3292

REMARKS

HOLE NO. BH 9

BORINGS BY CME 55 Power Auger

DATE November 5, 2014

SOIL DESCRIPTION	Strata depth (m)	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD
GROUND SURFACE					
TOPSOIL	0.15	AU	1		
FILL: Brown silty sand with gravel, some shale		SS	2	33	30
	2.29	SS	3	50	47
Grey **SILTY CLAY,** some gravel, trace sand		AU	4		
	3.96	SS	5	67	2
GLACIAL TILL: Very dense, brown silty sand with gavel, cobbles, boulders, trace clay		SS	6	58	31
		SS	7	60	50+
	5.36	SS	8	0	50+

End of Borehole

Practical refusal to augering at 5.36m depth

(GWL @ 1.68m-Nov. 12, 2014)

DEPTH (m)	ELEV. (m)
0	65.19
1	64.19
2	63.19
3	62.19
4	61.19
5	60.19

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

○ Water Content %

20 40 60 80

Piezometer Construction

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

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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residence Building - Carleton University
Colonel By Drive, Ottawa, Ontario

DATUM TBM - Door sill on the east end of Leeds Residence. Geodetic elevation = 65.59m.

FILE NO. PG3292

REMARKS

HOLE NO. BH10

BORINGS BY CME 55 Power Auger **DATE** November 5, 2014

SOIL DESCRIPTION	Depth of base (m)	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD
GROUND SURFACE					
Asphaltic concrete	0.08				
FILL: Crushed stone	0.18	AU	1		
FILL: Brown silty sand with gravel	2.59	SS	2	50	38
		SS	3	50	13
		SS	4	46	8
GLACIAL TILL: Grey silty clay, some sand and gravel	3.81	SS	5	83	7
GLACIAL TILL: Dense, brown silty sand with gravel, cobbles, boulders, shale	5.21	SS	6	58	43
		SS	7	29	50+

End of Borehole

Practical refusal to augering at 5.21m depth

(GWL @ 5.03m-Nov. 12, 2014)

DEPTH (m)	ELEV. (m)
0	65.30
1	64.30
2	63.30
3	62.30
4	61.30
5	60.30

Pen. Resist. Blows/0.3m
● 50 mm Dia. Cone
○ Water Content %
20 40 60 80

Piezometer Construction

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

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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residence Building - Carleton University
Colonel By Drive, Ottawa, Ontario

DATUM TBM - Door sill on the east end of Leeds Residence. Geodetic elevation = 65.59m.

FILE NO. PG3292

REMARKS

HOLE NO. BH11

BORINGS BY CME 55 Power Auger **DATE** November 5, 2014

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	65.52
Asphaltic concrete 0.08		AU	1				
FILL: Crushed stone 0.66							
FILL: Grey silty clay, some sand and gravel		SS	2	58	11	1	64.52
		SS	3	62	4	2	63.52
		SS	4	50	3	3	62.52
3.71							
GLACIAL TILL: Brown silty sand, some gravel, cobbles and boulders		SS	6	50	30	4	61.52
4.70		SS	7	60	50+		

End of Borehole

Practical refusal to augering at 4.70m depth

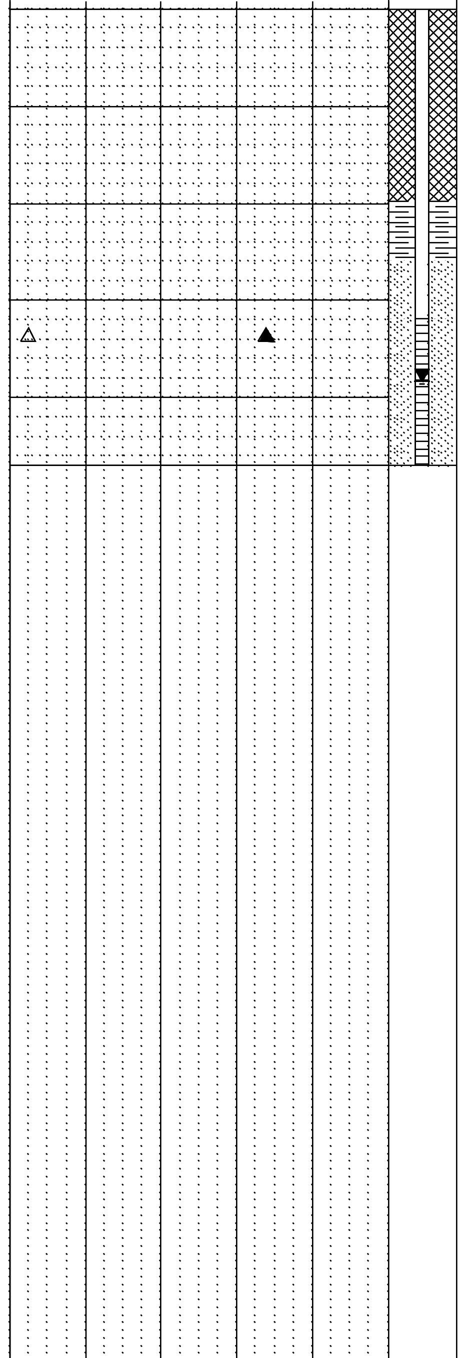
(GWL @ 3.83m-Nov. 12, 2014)

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

○ Water Content %

20 40 60 80

Piezometer Construction



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

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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residence Building - Carleton University
Colonel By Drive, Ottawa, Ontario

DATUM TBM - Door sill on the east end of Leeds Residence. Geodetic elevation = 65.59m.

FILE NO. PG3292

REMARKS

HOLE NO. BH12

BORINGS BY CME 55 Power Auger

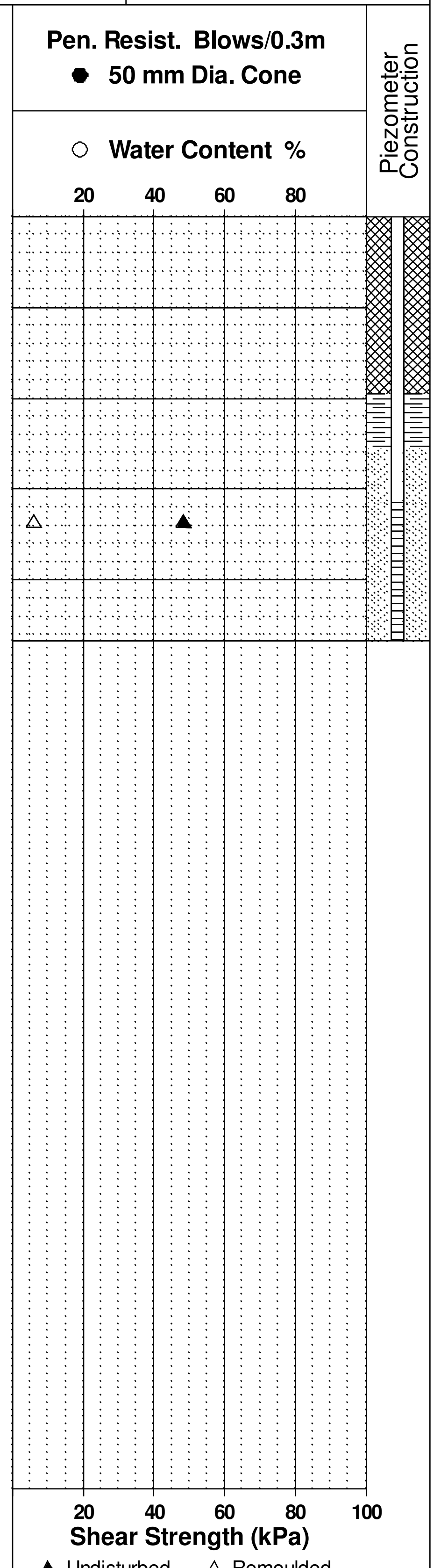
DATE November 5, 2014

SOIL DESCRIPTION	Strata depth (m)	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	65.65
Asphaltic concrete	0.05	AU	1				
FILL: Brown silty sand, some gravel		SS	2	42	27	1	64.65
- some brick by 1.3m depth	1.52						
FILL: Grey silty clay, some sand and gravel		SS	3	29	13	2	63.65
		SS	4	75	4	3	62.65
	3.81					4	61.65
TOPSOIL	4.27	SS	5	50	8		
GLACIAL TILL: Dense, brown silty sand with gravel, cobbles and boulders	4.67	SS	6	100	50+		

End of Borehole

Practical refusal to augering at 4.67m depth

(BH dry - Nov. 12, 2014)



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residence Building - Carleton University
Colonel By Drive, Ottawa, Ontario

DATUM TBM - Door sill on the east end of Leeds Residence. Geodetic elevation = 65.59m.

FILE NO. PG3292

REMARKS

HOLE NO. BH13

BORINGS BY CME 55 Power Auger

DATE November 5, 2014

SOIL DESCRIPTION	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE					0	65.33
Asphaltic concrete 0.05	AU	1				
FILL: Brown crushed stone with silty sand 1.52	SS	2	25	8	1	64.33
FILL: Brown silty clay with gravel	SS	3	50	7	2	63.33
	SS	4	54	2		
3.60	SS	5	50	4	3	62.33
TOPSOIL 3.66						
GLACIAL TILL: Brown silty sand with gravel, cobbles and boulders	SS	6	57	50+	4	61.33
	SS	7	50	38	5	60.33
	SS	8	33	12	6	59.33
6.70	SS	9	58	19		
End of Borehole						
(GWL @ 5.26m-Nov. 12, 2014)						

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

○ Water Content %

20 40 60 80

Piezometer Construction

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

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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residence Building - Carleton University
Colonel By Drive, Ottawa, Ontario

DATUM TBM - Door sill on the east end of Leeds Residence. Geodetic elevation = 65.59m.

FILE NO. PG3292

REMARKS

HOLE NO. TP 1

BORINGS BY Hydraulic Shovel **DATE** August 7, 2014

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	65.82
TOPSOIL (to 0.30)							
FILL: Brown silty clay with sand, trace wood (0.30 – 1.40)		G	1			1	64.82
FILL: Brown silty sand, some clay and boulders (1.40 – 5.00)		G	2			2	63.82
						3	62.82
						4	61.82
GLACIAL TILL: Compact to dense, brown silty sand with gravel, cobbles and boulders, trace clay (5.00 – 6.50)		G	3			5	60.82
						6	59.82
End of Test Pit (6.50)							

End of Test Pit

(Groundwater infiltration at 6.2m depth)

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

○ Water Content %
20 40 60 80

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

Piezometer Construction

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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residence Building - Carleton University
Colonel By Drive, Ottawa, Ontario

DATUM TBM - Door sill on the east end of Leeds Residence. Geodetic elevation = 65.59m.

FILE NO. PG3292

REMARKS

HOLE NO. TP 2

BORINGS BY Hydraulic Shovel **DATE** August 7, 2014

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone / ○ Water Content % (20, 40, 60, 80)	Piezometer Construction
GROUND SURFACE						0	65.97		
TOPSOIL 0.20									
FILL: Brown silty clay, some sand, trace wood, gravel and cobbles 1.10		G	1			1	64.97		
FILL: Brown silty sand, some clay 4.50		G	2			2	63.97		
						3	62.97		
						4	61.97		
TOPSOIL 4.60									
GLACIAL TILL: Compact to dense, brown silty sand with gravel, cobbles, boulders, trace clay 5.50		G	3			5	60.97		
End of Test Pit									

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

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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residence Building - Carleton University
Colonel By Drive, Ottawa, Ontario

DATUM TBM - Door sill on the east end of Leeds Residence. Geodetic elevation = 65.59m.

FILE NO. PG3292

REMARKS

HOLE NO. TP 3

BORINGS BY Hydraulic Shovel **DATE** August 7, 2014

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone / ○ Water Content % (20 40 60 80)	Piezometer Construction
GROUND SURFACE						0	62.29		
TOPSOIL — 0.30									
Brown **SILTY SAND,** some clay — 0.60									
Grey **SILTY CLAY** — 0.70									
GLACIAL TILL: Compact to dense, grey-brown silty sand with gravel, cobbles, boulders, trace clay — 1.50		G	1			1	61.29		
End of Test Pit									

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

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154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residence Building - Carleton University
Colonel By Drive, Ottawa, Ontario

DATUM TBM - Door sill on the east end of Leeds Residence. Geodetic elevation = 65.59m.

FILE NO. PG3292

REMARKS

HOLE NO. TP 4

BORINGS BY Hydraulic Shovel **DATE** August 7, 2014

SOIL DESCRIPTION	Depth to base (m)	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone / ○ Water Content %	Piezometer Construction
GROUND SURFACE							0	62.20		
TOPSOIL	0.30									
Brown **SILTY SAND**	0.50									
Dark grey **SILTY SAND,** some gravel and cobbles	0.90						1	61.20		
Hard, brown **SILTY CLAY**	1.50		G	1						
GLACIAL TILL: Dark brown silty sand with gravel, cobbles, boulders, trace clay	2.00						2	60.20		
End of Test Pit										

Water Content % axis: 20 40 60 80

Shear Strength (kPa): 20 40 60 80 100

▲ Undisturbed △ Remoulded

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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residence Building - Carleton University
Colonel By Drive, Ottawa, Ontario

DATUM TBM - Door sill on the east end of Leeds Residence. Geodetic elevation = 65.59m.

FILE NO. PG3292

REMARKS

HOLE NO. TP 5

BORINGS BY Hydraulic Shovel

DATE November 6, 2014

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone / ○ Water Content %	Piezometer Construction
GROUND SURFACE						0	61.68		
TOPSOIL 0.30		G	1						
FILL: Grey silty sand, trace clay		G	2			1	60.68		
						2	59.68		
2.60		G	3						∇
GLACIAL TILL: Brown silty sand with gravel, cobbles, trace clay 3.00		G	4			3	58.68		
End of Test Pit (Groundwater infiltration at 2.3m depth)									

Water Content %: 20 40 60 80

Shear Strength (kPa): 20 40 60 80 100

▲ Undisturbed △ Remoulded

patersongroup Consulting Engineers

154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residence Building - Carleton University
Colonel By Drive, Ottawa, Ontario

DATUM TBM - Door sill on the east end of Leeds Residence. Geodetic elevation = 65.59m.

FILE NO. PG3292

REMARKS

HOLE NO. TP 6

BORINGS BY Hydraulic Shovel

DATE November 6, 2014

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	61.76
TOPSOIL 0.45							
FILL: Brown silty sand with crushed stone, trace clay 1.70		G	1			1	60.76
FILL: Brown silty sand with cobbles and boulders 2.10		G	2			2	59.76
GLACIAL TILL: Brown silty sand with gravel, cobbles and bouldes 3.00		G	3				
		G	4			3	58.76
End of Test Pit							
(Groundwater infiltration at 2.4m depth)							

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

○ Water Content %
20 40 60 80

Piezometer Construction

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

patersongroup Consulting Engineers

154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residence Building - Carleton University
Colonel By Drive, Ottawa, Ontario

DATUM TBM - Door sill on the east end of Leeds Residence. Geodetic elevation = 65.59m.

FILE NO. PG3292

REMARKS

HOLE NO. TP 7

BORINGS BY Hydraulic Shovel

DATE November 6, 2014

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone / ○ Water Content %	Piezometer Construction
GROUND SURFACE						0	61.73		
TOPSOIL 0.30		G	1						
FILL: Grey-brown silty sand with clay, gravel and cobbles 2.10		G	2			1	60.73		
		G	3			2	59.73		
GLACIAL TILL: Grey silty sand with gravel, cobbles and boulders 3.00						3	58.73		∇
End of Test Pit (Groundwater infiltration at 2.3m depth)									

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

patersongroup Consulting Engineers 154 Colonnade Road South, Ottawa, Ontario K2E 7J5	**SOIL PROFILE AND TEST DATA** **Geotechnical Investigation** **Proposed Residence Building - Carleton University** **Colonel By Drive, Ottawa, Ontario**

DATUM TBM - Door sill on the east end of Leeds Residence. Geodetic elevation = 65.59m.

FILE NO. PG3292

REMARKS

HOLE NO. TP 8

BORINGS BY Hydraulic Shovel **DATE** November 6, 2014

SOIL DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone / ○ Water Content %	Piezometer Construction
GROUND SURFACE						0	61.79		
TOPSOIL 0.30		G	1						
FILL: Grey-brown silty sand with clay - some gravel, cobbles and boulders by 1.3m depth 2.40		G	2			1	60.79		
		G	3			2	59.79		
		G	4						
Grey **SILTY SAND** 2.60									▽
GLACIAL TILL: Grey silty sand with gravel, cobbles, boulders, trace clay 3.00		G	5						
End of Test Pit (Groundwater infiltration at 2.7m depth)									

Pen. Resist. / Water Content scale: 20 40 60 80

Shear Strength (kPa): 20 40 60 80 100

▲ Undisturbed △ Remoulded

patersongroup Consulting Engineers

154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Proposed Residence Building - Carleton University
Colonel By Drive, Ottawa, Ontario

DATUM TBM - Door sill on the east end of Leeds Residence. Geodetic elevation = 65.59m.

FILE NO. PG3292

REMARKS

HOLE NO. TP 9

BORINGS BY Hydraulic Shovel

DATE November 6, 2014

SOIL DESCRIPTION	Depth to base (m)	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	61.80
TOPSOIL	0.30						
FILL: Brown silty sand with gravel, clay and cobbles	1.40	G	1			1	60.80
Grey-brown **SILTY CLAY** with sand seams	1.60	G	2				
GLACIAL TILL: Grey silty clay with gravel	3.00	G	3			2	59.80
End of Test Pit						3	58.80

(Groundwater infiltration at 2.7m depth)

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

○ Water Content %

20 40 60 80

Piezometer Construction

20 40 60 80 100

Shear Strength (kPa)

▲ Undisturbed △ Remoulded

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

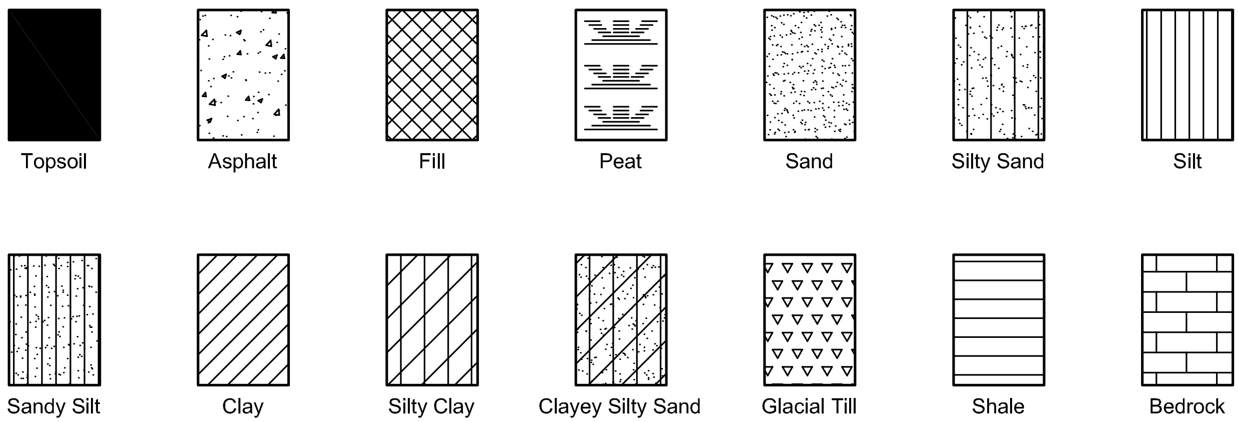
p'_o	-	Present effective overburden pressure at sample depth
p'_c	-	Preconsolidation pressure of (maximum past pressure on) sample
Ccr	-	Recompression index (in effect at pressures below p'_c)
Cc	-	Compression index (in effect at pressures above p'_c)
OC Ratio		Overconsolidaton ratio = p'_c / p'_o
Void 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.

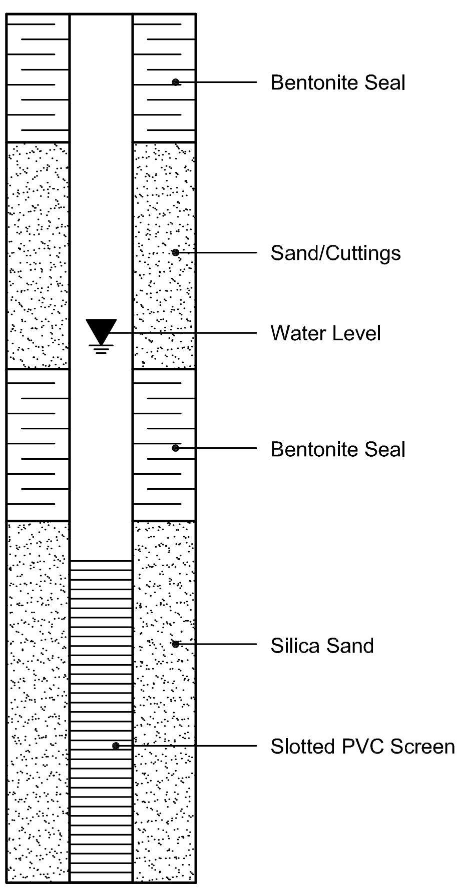
SYMBOLS AND TERMS (continued)

STRATA PLOT

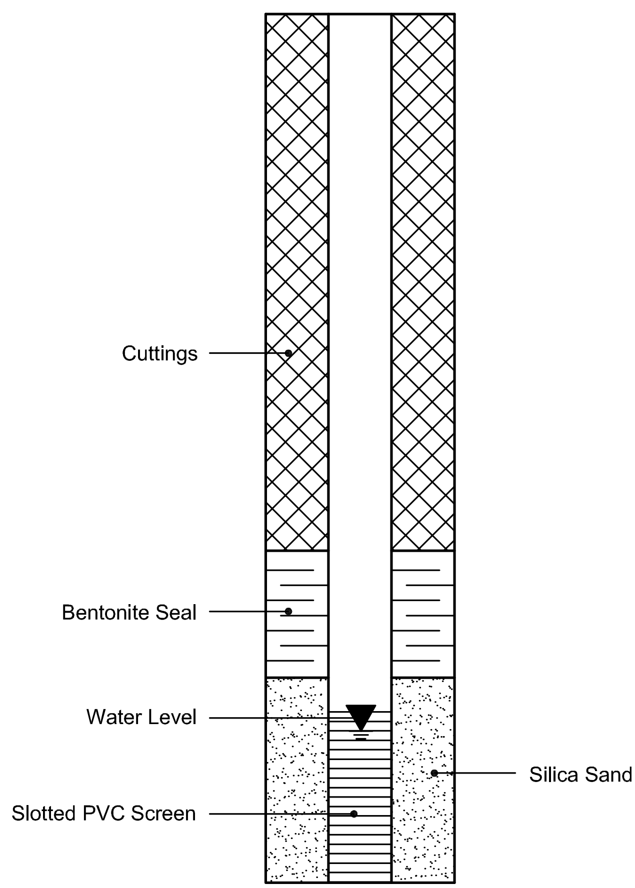


MONITORING WELL AND PIEZOMETER CONSTRUCTION

MONITORING WELL CONSTRUCTION



PIEZOMETER CONSTRUCTION



SPL Consultants Limited
Geotechnical Environmental Materials Hydrogeology

LOG OF BOREHOLE 12-1

PROJECT: Carleton University Northern Property Development
CLIENT: Carleton University
PROJECT LOCATION: Parking Lots P-6 and P-7
DATUM: Geodetic
BH LOCATION: See Borehole Location Plan

DRILLING DATA
Method: Hollow Stem Auger/Coring
Diameter: 203mm/N size core
Date: Dec/11/2012

REF. NO.: 1405-710/720
ENCL NO.:

(m) ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" BLOWS 0.3 m	ELEVATION	WATER CONTENT (%) / LIMITS	NATURAL UNIT WT (kN/m^3)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
62.0								
61.8 / 0.0	Silty Clay, some organics, brown, damp, soft (Fill)							
0.2	Clayey Silt, trace organics, brown, damp, soft-firm	1	SS	2				
61.2 / 0.8	Silty Clay, trace organics, moist, stiff-very stiff	2	SS	6	61	62	17.1	
60.5 / 1.5	Silty Clay, grey, moist, stiff	3	SS	6	60		16.8	
		4	SS	5		54	16.9	
		5	SS	2	59	49, 43	17.3	
					58			
57.4 / 4.6	Silt, some sand, trace clay, grey, wet, firm	6	SS	6	57			
55.9 / 6.1	Silty Sand and Gravel, trace clay, wet, loose (Till)	7	SS	5	56 / 55			28 37 35
54.4 / 7.6	Silty Sand, some gravel, trace clay, wet, loose (Till) - Auger Refusal at 9.0 m. Switched to coring	8	SS	8	54			18 60 22
53.0 / 9.0	Dense Sandy Till with cobbles and boulders (Till)	RC 1	CORE		53			

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH (kPa): ○ UNCONFINED + FIELD VANE & Sensitivity ● QUICK TRIAXIAL × LAB VANE; 50 100 150 200 250
PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30
POCKET PEN. (Cu) (kPa)

Continued Next Page

GROUNDWATER ELEVATIONS
Shallow/ Single Installation ▽ ▼ Deep/Dual Installation ▽ ▼

GRAPH NOTES: $+^3, \times^3$: Numbers refer to Sensitivity; ○ ε=3% Strain at Failure

SPL Consultants Limited
Geotechnical Environmental Materials Hydrogeology

LOG OF BOREHOLE 12-1

PROJECT: Carleton University Northern Property Development
CLIENT: Carleton University
PROJECT LOCATION: Parking Lots P-6 and P-7
DATUM: Geodetic
BH LOCATION: See Borehole Location Plan

DRILLING DATA
Method: Hollow Stem Auger/Coring
Diameter: 203mm/N size core
Date: Dec/11/2012

REF. NO.: 1405-710/720
ENCL NO.:

(m) ELEV / DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS/0.3 m	GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100); SHEAR STRENGTH (kPa) ○ UNCONFINED + FIELD VANE & Sensitivity ● QUICK TRIAXIAL × LAB VANE (50 100 150 200 250)	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L; WATER CONTENT (%) (10 20 30)	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (Mg/m^3)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	Dense Sandy Till with cobbles and boulders (Till)(Continued)		RC 2	CORE			51					
49.8 / 12.2	Limestone, fresh moderately closely bedded, grey TCR = 57% SCR = 57% RQD = 57%		RC 3	CORE			50 49					
48.7 / 13.3	Shaley Limestone, fresh to slighly weathered, very close to closely bedded with closely spaced horizontal joints TCR = 80% SCR = 70% RQD = 60%		RC 4	CORE			48					
47.2 / 14.8	Shaley Limestone, fresh to slighly weathered, very close to closely bedded with closely spaced horizontal joints TCR = 85% SCR = 85% RQD = 79%		RC 5	CORE			47 46					
45.7 / 16.3	END OF BOREHOLE											

GROUNDWATER ELEVATIONS
Shallow/ Single Installation ▽ ▼ Deep/Dual Installation ▽ ▼

GRAPH NOTES: $+^3, \times^3$: Numbers refer to Sensitivity ○ ε=3% Strain at Failure

SPL SOIL LOG CARLETON UNIVERSITY NORTH PROPERTY DEVELOPMENT.GPJ SPL.GDT 8/2/13

SPL Consultants Limited
Geotechnical Environmental Materials Hydrogeology

LOG OF BOREHOLE 12-2

PROJECT: Carleton University Northern Property Development
CLIENT: Carleton University
PROJECT LOCATION: Parking Lots P-6 and P-7
DATUM: Geodetic
BH LOCATION: See Borehole Location Plan

DRILLING DATA
Method: Hollow Stem Auger/Coring
Diameter: 203mm/N size core
Date: Dec/02/2012

REF. NO.: 1405-710/720
ENCL NO.:

(m) ELEV DEPTH	DESCRIPTION	NUMBER	TYPE	"N" BLOWS 0.3 m	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
65.6					
[illegible]	Asphalt				20 62 18
	Sand and Gravel, brown, frozen, very dense (Fill)	1	SS	50/ 5"	
64.8 / 0.8	Sandy Silt, trace wood, trace organics, grey, moist, soft-stiff (Fill)	2	SS	9	
64.1 / 1.5	Silty Clay, grey, moist, stiff (Fill)	3	SS	4	
63.3 / 2.3	Silty Clay, grey with black mottling, moist, stiff (Fill)	4	SS	2	
			VANE		33 36 31
61.7 / 3.9	Silty Sand and Gravel, brown, moist, dense-very dense	5	SS	30	
		6	SS	66	
59.5 / 6.1	Gravelly Sand, trace silt, grey, wet, compact	7	SS	23	24 61 5
58.0 / 7.6	Sand and Gravel, brown, wet, compact	8	SS	9	41 58 1
56.5 / 9.1	Sand and Gravel with cobbles/boulders, brown, wet, very dense	9	SS	61	56 41 3

GROUND WATER CONDITIONS: Sand; Bentonite; W. L. 200.0 m Dec 13, 2012; Sand; Screen; Sand; Bentonite

ELEVATION: 65, 64, 63, 62, 61, 60, 59, 58, 57, 56

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH (kPa): UNCONFINED; + FIELD VANE & Sensitivity; ● QUICK TRIAXIAL; × LAB VANE: 50 100 150 200 250
Field vane: 4.2

PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L
WATER CONTENT (%): 10 20 30
Liquid limit: 55

POCKET PEN. (Cu) (kPa) | NATURAL UNIT WT (Mg/m³)

Continued Next Page

GROUNDWATER ELEVATIONS
Shallow/ Single Installation ▽ ▼ Deep/Dual Installation

GRAPH NOTES: $+^3, \times^3$: Numbers refer to Sensitivity; ○ ε=3% Strain at Failure

SPL Consultants Limited
Geotechnical Environmental Materials Hydrogeology

LOG OF BOREHOLE 12-2

PROJECT: Carleton University Northern Property Development
CLIENT: Carleton University
PROJECT LOCATION: Parking Lots P-6 and P-7
DATUM: Geodetic
BH LOCATION: See Borehole Location Plan

DRILLING DATA
Method: Hollow Stem Auger/Coring
Diameter: 203mm/N size core
Date: Dec/02/2012

REF. NO.: 1405-710/720
ENCL NO.:

(m) ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" BLOWS/0.3 m	GROUND WATER CONDITIONS	ELEVATION	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
55.3	- Auger refusal at 10.3 m. Switched to coring						
10.3 / 54.9	Dense Sandy Till with boulders and cobble (Till)	RC 1	CORE			55	7 88 5
10.7 / 54.2	Sand, trace gravel, trace silt, brown, wet, dense (Till)	10	SS	36			
11.4 / 52.5	Dense sandy Till with Cobbles and Boulders (Till)	RC 2	CORE			54	
		RC 3	CORE		Slough	53	
13.1 / 51.0	Limestone with shale partings. Fresh to slightly weathered. Very closely bedded with close to very closely spaced horizontal joints. Dark grey. TCR = 95% SCR = 80% RQD = 76%	RC 4	CORE			52	
14.6 / 49.4	Limestone with shale partings. Fresh close to very closely bedded with close to moderately closely spaced joints. Grey. TCR = 100% SCR = 85% RQD = 63%	RC 5	CORE			51, 50	
16.2	END OF BOREHOLE						

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH (kPa): UNCONFINED; + FIELD VANE & Sensitivity; QUICK TRIAXIAL; × LAB VANE; 50 100 150 200 250
PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L; WATER CONTENT (%) 10 20 30
POCKET PEN. (Cu) (kPa); NATURAL UNIT WT (kN/m^3)

Waterlevels:

Date	Depth
Dec 4th, 2012	4.6 m
Dec 13th, 2012	4.7 m

SPL SOIL LOG CARLETON UNIVERSITY NORTH PROPERTY DEVELOPMENT.GPJ SPL.GDT 8/2/13

GROUNDWATER ELEVATIONS
Shallow/ Single Installation ▽ ▼ Deep/Dual Installation ▽ ▼

GRAPH NOTES: +3, ×3: Numbers refer to Sensitivity; ○ ε=3% Strain at Failure

LOG OF BOREHOLE BH13-1

PROJECT: Carleton University Residence Building
CLIENT: Carleton University
PROJECT LOCATION: Ottawa, Ontario
DATUM: Geodetic
BH LOCATION: See Borehole Location Plan

DRILLING DATA
Method: CME55-Hollow stem augers
Diameter: 200 mm
Date: Nov/27/2013

REF. NO.: 1985-710
ENCL NO.:

ELEV (m) / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" BLOWS/0.3 m	GROUND WATER CONDITIONS	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
65.6						
65.6 / 0.0	**Asphalt:** 40 mm					
65.4 / 0.2	**SAND AND GRAVEL:** 200 mm (FILL)	1	SS	26		35 42 (23)
	SILTY SAND TO SANDY SILT: trace gravel, some shale pieces, compact, dark black to grey, moist (FILL)	2	SS	25		
		3	SS	9		14 46 (40)
63.8 / 1.8	**SILTY CLAY:** some organics, some clay lumps, some shale pieces, firm, grey, moist (FILL)	4	SS	8		
62.3 / 3.3	**ORGANICS:** some wood pieces, rootlets, soft, black, moist	5	SS	7	Cuttings	
62.1 / 3.5	**SAND AND GRAVEL:** trace silt, some shale pieces, compact to very dense, greyish brown, moist	6	SS	74	W. L. 60.4 m	48 41 (11)
		7	SS	17		
58.0 / 7.6	**SAND:** trace silt, some gravel, compact, grey, wet	8	SS	13	Bentonite; Sand	
56.5 / 9.1	**SILTY SAND:** some cobbles and boulders, some gravel, compact to very dense, grey, wet (TILL)	9	SS	31		

Elevation scale: 65, 64, 63, 62, 61, 60, 59, 58, 57, 56

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH (kPa): ○ UNCONFINED + FIELD VANE & Sensitivity ● QUICK TRIAXIAL × LAB VANE; 25 50 75 100 125
PLASTIC LIMIT W_P, NATURAL MOISTURE CONTENT W, LIQUID LIMIT W_L
WATER CONTENT (%): 25 50 75
POCKET PEN. (Cu) (kPa)
NATURAL UNIT WT (kN/m³)

Continued Next Page

GROUNDWATER ELEVATIONS
Shallow/ Single Installation ▽ ▼ Deep/Dual Installation ▽ ▼

GRAPH NOTES: $+^3, \times^3$: Numbers refer to Sensitivity ○ ε=3% Strain at Failure

SPL Consultants Limited
Geotechnical Environmental Materials Hydrogeology

LOG OF BOREHOLE BH13-1

PROJECT: Carleton University Residence Building
CLIENT: Carleton University
PROJECT LOCATION: Ottawa, Ontario
DATUM: Geodetic
BH LOCATION: See Borehole Location Plan

DRILLING DATA
Method: CME55-Hollow stem augers
Diameter: 200 mm
Date: Nov/27/2013

REF. NO.: 1985-710
ENCL NO.:

(m) ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLES NUMBER	TYPE	"N" BLOWS/0.3 m	GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20 40 60 80 100) / SHEAR STRENGTH (kPa) (UNCONFINED, QUICK TRIAXIAL, FIELD VANE & Sensitivity, LAB VANE) 25 50 75 100 125	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT w / LIQUID LIMIT W_L — WATER CONTENT (%) 25 50 75	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m³)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	SILTY SAND: some cobbles and boulders, some gravel, compact to very dense, grey, wet (TILL)(Continued)				Screen						
						55					
		10	SS	50 blows / 100 mm							
						54					
53.4 12.2	**GRAVELLY SAND:** some cobbles and boulders, compact to dense, grey, wet (TILL)	1	CORE			53					
52.2 13.4	**BEDROCK:** Limestone with shale partings, fresh, close to very closely bedded TCR = 100% RQD = 50%	2	CORE		Cuttings	52 51					
	TCR = 100% RQD = 66%	3	CORE			50					
49.1 16.5	**END OF BOREHOLE** Notes: 1) Auger refusal encountered at 12.1 m below surface 2) Coring started at 12.1 m in the gravelly sand till layer and continued into bedrock										

SPL SOIL LOG-OTTAWA 1985-710.GPJ SPL.GDT 17/12/13

GROUNDWATER ELEVATIONS
Shallow/ Single Installation ▽ ▼ Deep/Dual Installation ▽ ▼

GRAPH NOTES $+^3, \times^3$: Numbers refer to Sensitivity ○ ε=3% Strain at Failure

SPL Consultants Limited
Geotechnical Environmental Materials Hydrogeology

LOG OF BOREHOLE BH13-2

PROJECT: Carleton University Residence Building
CLIENT: Carleton University
PROJECT LOCATION: Ottawa, Ontario
DATUM: Geodetic
BH LOCATION: See Borehole Location Plan

DRILLING DATA
Method: CME55-Hollow stem augers
Diameter: 200 mm
Date: Nov/27/2013

REF. NO.: 1985-710
ENCL NO.:

(m) ELEV DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" BLOWS 0.3 m	GROUND WATER CONDITIONS	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
65.6						
65.6 0.0	Asphalt: 40 mm					
65.4 0.2	SAND AND GRAVEL: 200 mm (FILL)					
	SILTY SAND : trace gravel, some shale pieces, dark black to grey, moist, compact (FILL)	1	SS	13		
		2	SS	hit gravel	Cuttings	
63.8 1.8	SILTY CLAY: some organics, shale pieces, firm, grey, moist (FILL)	3	SS	4		
		4	SS	2	Bentonite	
61.1 4.5	SAND AND GRAVEL: trace silt, some shale pieces, compact, greyish brown, moist	5	SS	50 blows/ 150 mm	Sand	
		6	SS	32	Screen	
58.0 7.6	SILTY SAND: some cobbles and boulders, some gravel, compact, grey, wet (TILL)	7	SS	31		
		8	SS	20		29 47 (24)

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH (kPa): UNCONFINED; + FIELD VANE & Sensitivity; QUICK TRIAXIAL; × LAB VANE — 25 50 75 100 125
PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L
WATER CONTENT (%): 25 50 75
POCKET PEN. (Cu) (kPa)
NATURAL UNIT WT (KN/m³)
ELEVATION: 65, 64, 63, 62, 61, 60, 59, 58, 57, 56

Continued Next Page

GROUNDWATER ELEVATIONS
Shallow/ Single Installation ▽ ▼ Deep/Dual Installation ▽ ▼

GRAPH NOTES: + 3, × 3: Numbers refer to Sensitivity ○ ε=3% Strain at Failure

SPL Consultants Limited
Geotechnical Environmental Materials Hydrogeology

LOG OF BOREHOLE BH13-2

PROJECT: Carleton University Residence Building
CLIENT: Carleton University
PROJECT LOCATION: Ottawa, Ontario
DATUM: Geodetic
BH LOCATION: See Borehole Location Plan

DRILLING DATA
Method: CME55-Hollow stem augers
Diameter: 200 mm
Date: Nov/27/2013

REF. NO.: 1985-710
ENCL NO.:

(m) ELEV / DEPTH	SOIL PROFILE: DESCRIPTION	SAMPLES: NUMBER	TYPE	"N" BLOWS / 0.3 m	GROUND WATER CONDITIONS	ELEVATION	NATURAL MOISTURE CONTENT (%)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	SILTY SAND: some cobbles and boulders, some gravel, compact, grey, wet (TILL)(Continued)							
						55		
		9	SS	34	Cuttings			
						54		
53.5 / 12.1	**GRAVELLY SAND TILL:** some boulders, compact, grey, wet							
		10	SS	23		53		
						52		
		11	SS	50 blows / 100 mm				
51.4 / 14.2	**END OF BOREHOLE** Notes: 1) Borehole terminated at 14.2 m on auger refusal							

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH (kPa): UNCONFINED; + FIELD VANE & Sensitivity; QUICK TRIAXIAL; × LAB VANE; 25 50 75 100 125
PLASTIC LIMIT W_P — NATURAL MOISTURE CONTENT W — LIQUID LIMIT W_L; WATER CONTENT (%) 25 50 75
POCKET PEN. (Cu) (kPa)
NATURAL UNIT WT (kN/m³)

SPL SOIL LOG-OTTAWA 1985-710.GPJ SPL.GDT 17/12/13

GROUNDWATER ELEVATIONS
Shallow/ Single Installation ▽ ▼ Deep/Dual Installation ▽ ▼

GRAPH NOTES: $+^3, \times^3$: Numbers refer to Sensitivity; ○ ε=3% Strain at Failure

SPL Consultants Limited
Geotechnical Environmental Materials Hydrogeology

LOG OF BOREHOLE BH13-3

PROJECT: Carleton University Residence Building
CLIENT: Carleton University
PROJECT LOCATION: Ottawa, Ontario
DATUM: Geodetic
BH LOCATION: See Borehole Location Plan

DRILLING DATA
Method: CME55-Hollow stem augers
Diameter: 200 mm
Date: Nov/28/2013

REF. NO.: 1985-710
ENCL NO.:

(m) ELEV / DEPTH	SOIL PROFILE DESCRIPTION	SAMPLE NUMBER	TYPE	"N" BLOWS/0.3 m	ELEVATION	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
65.6						
65.6 / 0.0	**Asphalt:** 40 mm					
65.4 / 0.2	**SAND AND GRAVEL:** 200 mm (FILL)	1	SS	25		
	SILTY SAND (FILL): trace gravel, some shale pieces, dark black to grey, moist, compact				65	
		2	SS	8		
		3	SS	2	64	
63.8 / 1.8	**SILTY CLAY:** some organics, shale pieces, firm, grey, moist					
	- some organics, wood, rootlets below 2.2 m	4	SS	5	63	
		5	SS	14	62	
61.1 / 4.5	**SAND AND GRAVEL:** trace silt, some shale pieces, compact, greyish brown, moist,	6	SS	51	61	40 43 (17)
					60	
	- some cobbles, wet, grey below 6.1 m	7	SS	67	59	
58.0 / 7.6	**SAND:** trace gravel, compact, brown, wet	8	SS	23	58	
					57	
	- greyish brown below 9.1 m	9	SS	14	56	0 87 (13)

DYNAMIC CONE PENETRATION RESISTANCE PLOT: 20 40 60 80 100
SHEAR STRENGTH (kPa): ○ UNCONFINED + FIELD VANE & Sensitivity ● QUICK TRIAXIAL × LAB VANE; 25 50 75 100 125
PLASTIC LIMIT W_P NATURAL MOISTURE CONTENT W LIQUID LIMIT W_L
WATER CONTENT (%): 25 50 75
POCKET PEN. (Cu) (kPa)
NATURAL UNIT WT (kN/m^3)
GROUND WATER CONDITIONS
STRATA PLOT

Continued Next Page

GROUNDWATER ELEVATIONS
Shallow/ Single Installation ▽ ▼ Deep/Dual Installation ▽ ▼

GRAPH NOTES: $+^3, \times^3$: Numbers refer to Sensitivity ○ ε=3% Strain at Failure

LOG OF BOREHOLE BH13-3

PROJECT: Carleton University Residence Building
CLIENT: Carleton University
PROJECT LOCATION: Ottawa, Ontario
DATUM: Geodetic
BH LOCATION: See Borehole Location Plan

DRILLING DATA
Method: CME55-Hollow stem augers
Diameter: 200 mm
Date: Nov/28/2013

REF. NO.: 1985-710
ENCL NO.:

(m) ELEV / DEPTH	DESCRIPTION	STRATA PLOT	NUMBER	TYPE	"N" BLOWS / 0.3 m	GROUND WATER CONDITIONS	ELEVATION	DYNAMIC CONE PENETRATION RESISTANCE PLOT (20, 40, 60, 80, 100) / SHEAR STRENGTH (kPa) (25, 50, 75, 100, 125) ○ UNCONFINED + FIELD VANE & Sensitivity ● QUICK TRIAXIAL × LAB VANE	PLASTIC LIMIT W_P / NATURAL MOISTURE CONTENT W / LIQUID LIMIT W_L — WATER CONTENT (%) (25, 50, 75)	POCKET PEN. (Cu) (kPa)	NATURAL UNIT WT (kN/m^3)	REMARKS AND GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
	SAND: trace gravel, compact, brown, wet(Continued)											
	- some gravel below 10.6 m						55					
			10	SS	26				○			
							54					
							53					
							52					
51.1 / 14.5	**END OF BOREHOLE** Notes: 1) Borehole terminated at 14.5 m on auger refusal											

GROUNDWATER ELEVATIONS
Shallow/ Single Installation ▽ ▼ Deep/Dual Installation ▽ ▼

GRAPH NOTES
$+^3, \times^3$: Numbers refer to Sensitivity
○ ε=3% Strain at Failure

APPENDIX 2

FIGURE 1 - KEY PLAN

FIGURES 2 AND 3 - SEISMIC SHEAR WAVE VELOCITY PROFILES

DRAWING PG3292-2 - TEST HOLE LOCATION PLAN

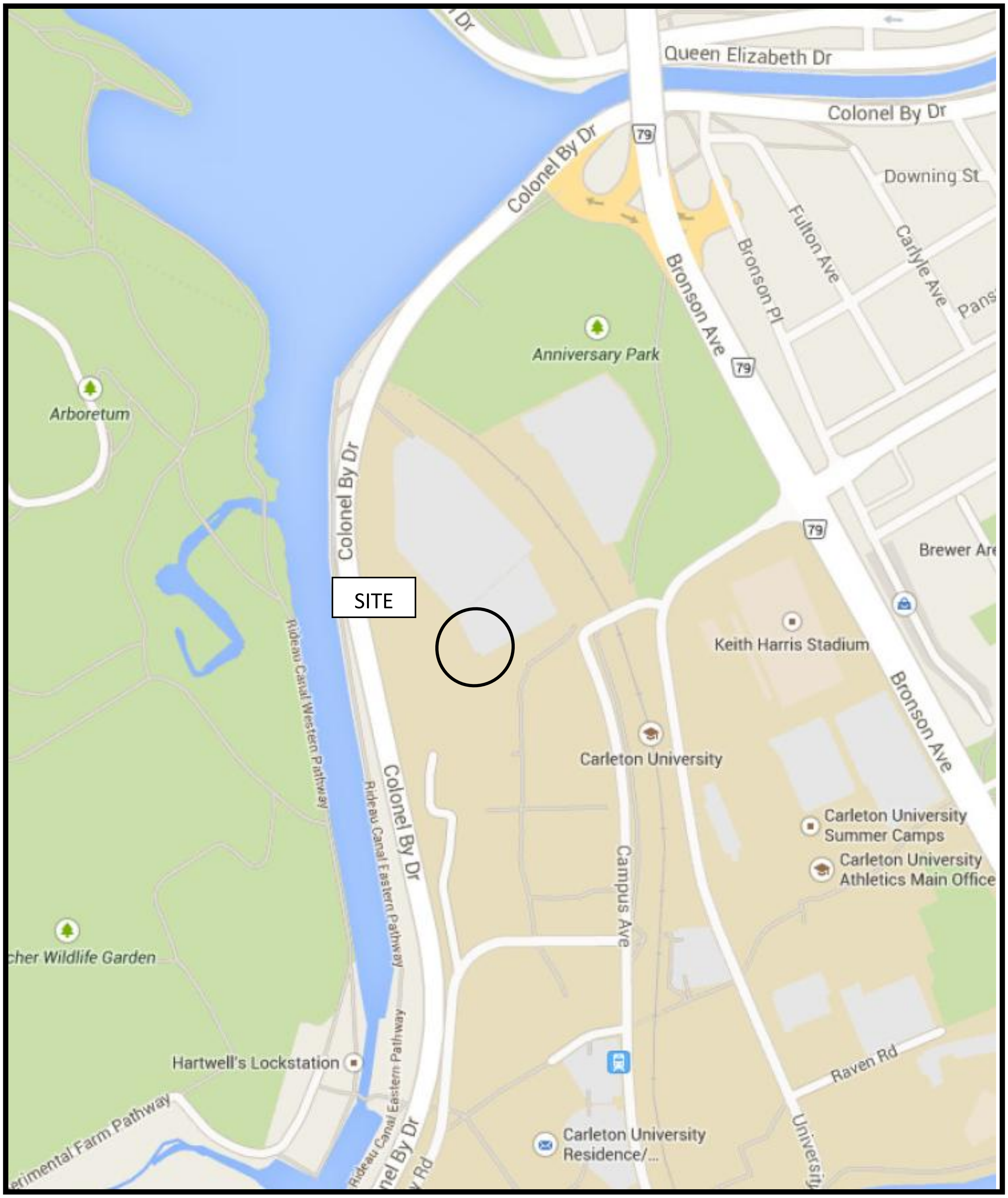


FIGURE 1

KEY PLAN

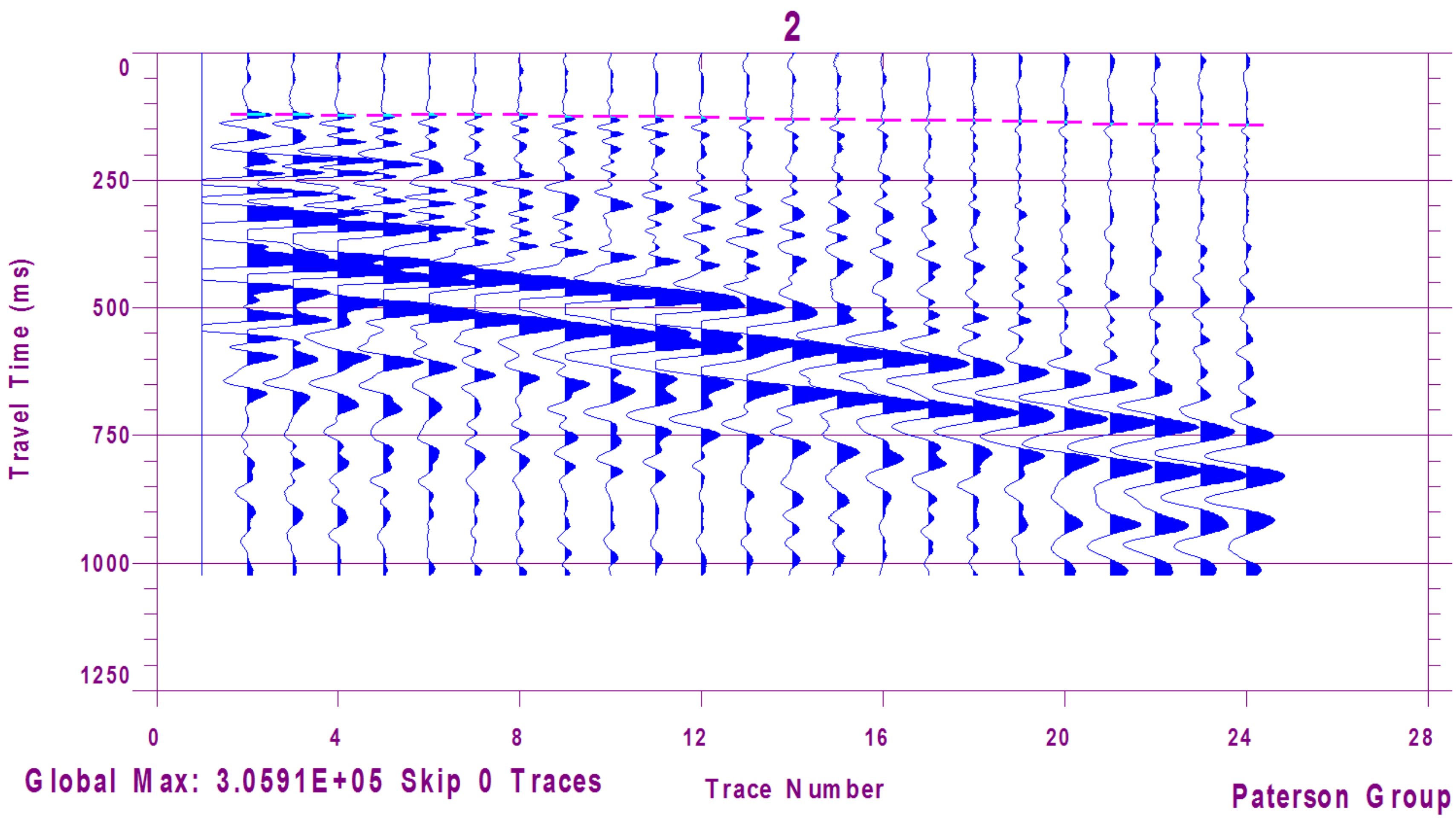


Figure 2 – Shear Wave Velocity Profile at Shot Location – 30 m

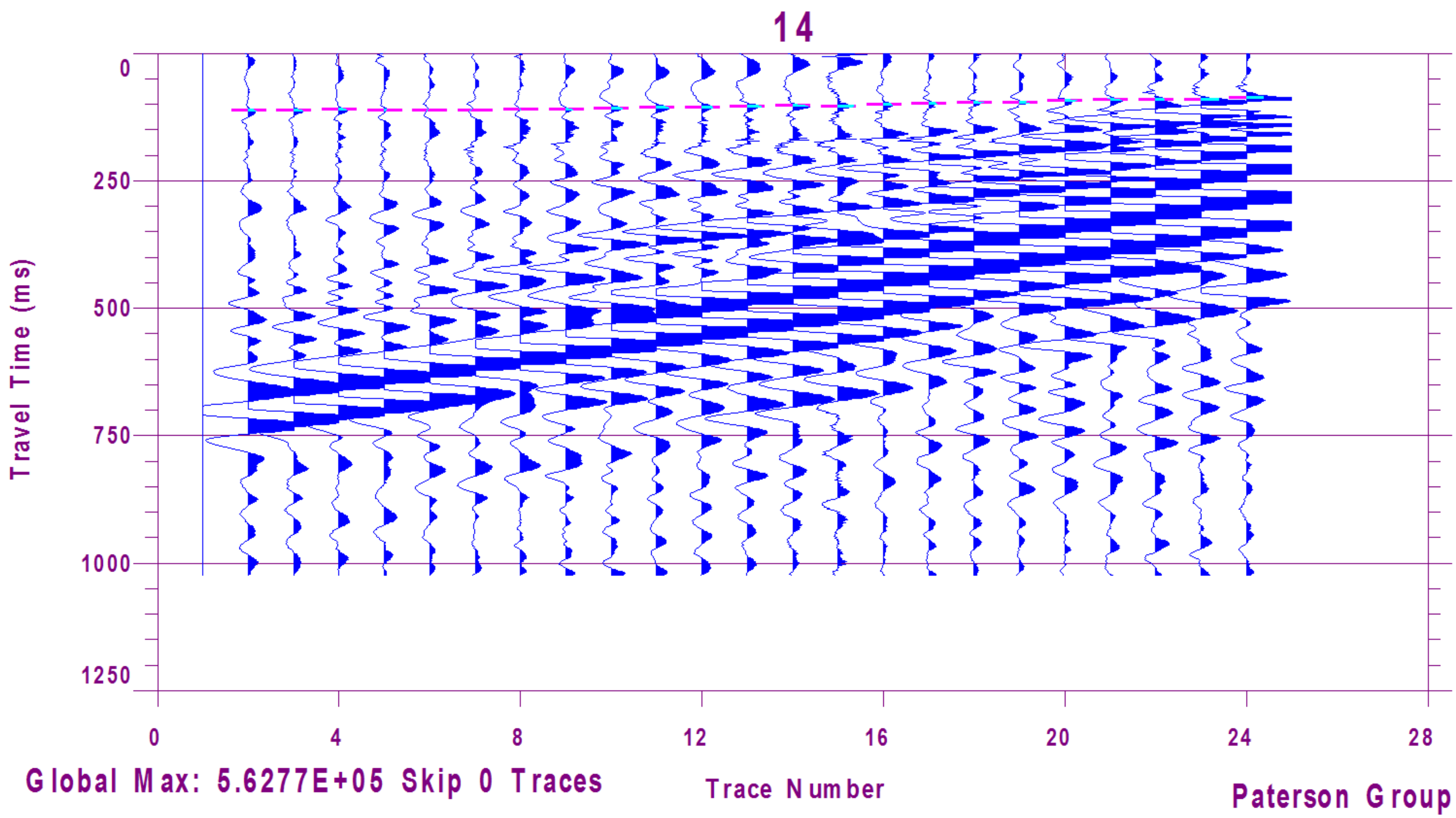
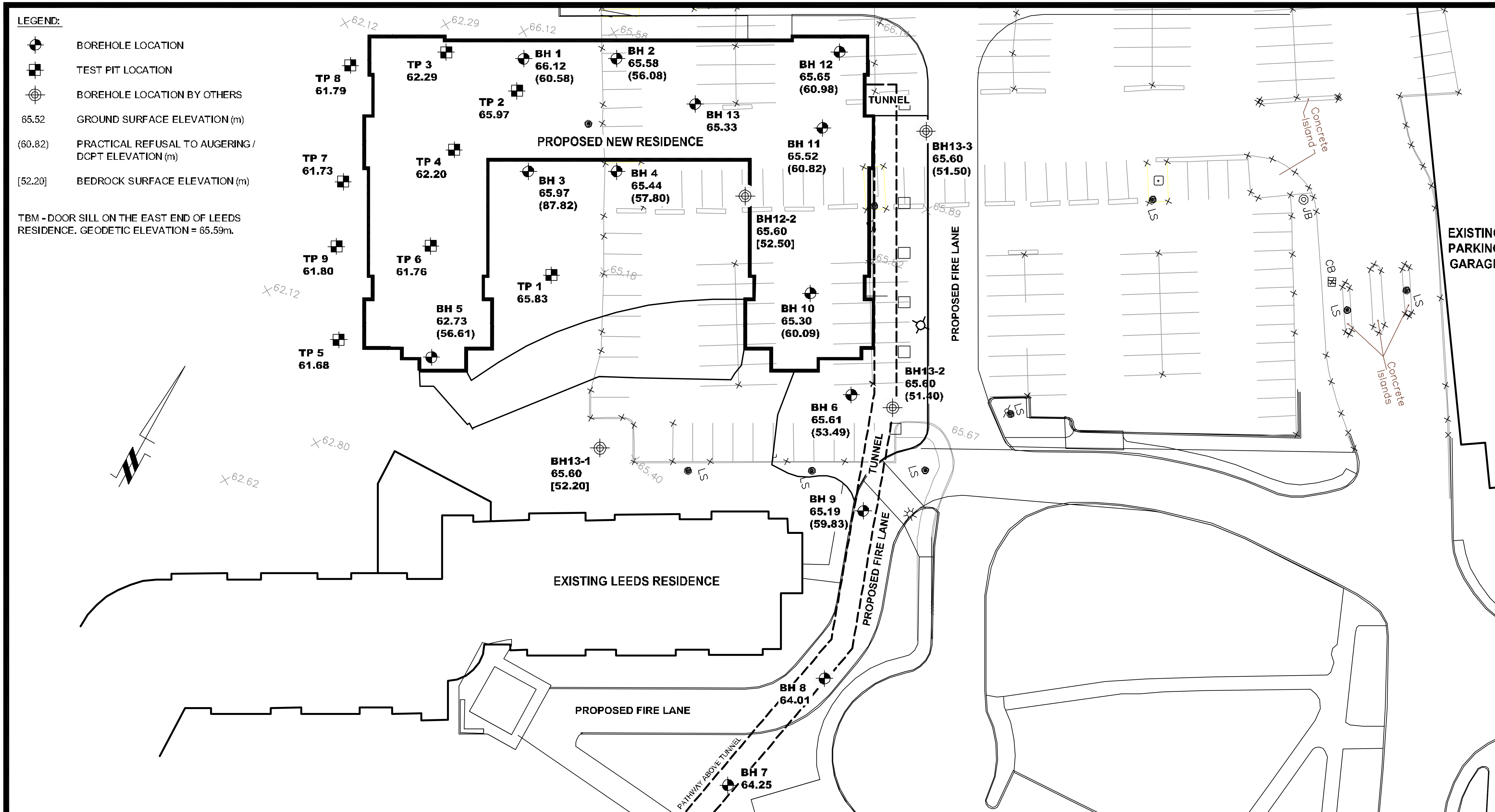


Figure 3 – Shear Wave Velocity Profile at Shot Location 66 m



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NO.	REVISIONS	DATE	INITIAL

CARLETON UNIVERSITY c/o ZW GROUP

GEOTECHNICAL INVESTIGATION

PROPOSED RESIDENCE BUILDING & TUNNEL - 1125 COLONEL BY DRIVE

OTTAWA, ONTARIO

Title:

TEST HOLE LOCATION PLAN

Scale: 1:500	Date: 11/2014
Checked by: SB	Report No.: PG3292-2
Approved by: DJG	Drawing No.:
Drawn by: MPG	PG3292-2

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