

Geotechnical  
Engineering

Environmental  
Engineering

Hydrogeology

Geological  
Engineering

Materials Testing

Building Science

Noise and Vibration  
Studies

## Geotechnical Investigation

Proposed Development  
249, 251, 255 Richmond Road and  
372 Tweedsmuir Avenue  
Ottawa, Ontario

Prepared For

2828727 Ontario Inc.

### Paterson Group Inc.

Consulting Engineers  
154 Colonnade Road South  
Ottawa (Nepean), Ontario  
Canada K2E 7J5

Tel: (613) 226-7381  
Fax: (613) 226-6344  
[www.patersongroup.ca](http://www.patersongroup.ca)

September 24, 2021

Report: PG5946-1

## Table of Contents

|   | <b>PAGE</b> |
|---|-------------|
| <b>1.0 Introduction .....</b>                         | <b>1</b>    |
| <b>2.0 Proposed Development.....</b>                  | <b>1</b>    |
| <b>3.0 Method of Investigation .....</b>              | <b>2</b>    |
| 3.1 Field Investigation .....                         | 2           |
| 3.2 Field Survey .....                                | 3           |
| 3.3 Laboratory Review .....                           | 3           |
| 3.4 Analytical Testing .....                          | 4           |
| <b>4.0 Observations .....</b>                         | <b>5</b>    |
| 4.1 Surface Conditions .....                          | 5           |
| 4.2 Subsurface Profile .....                          | 5           |
| 4.3 Groundwater .....                                 | 6           |
| <b>5.0 Discussion .....</b>                           | <b>7</b>    |
| 5.1 Geotechnical Assessment .....                     | 7           |
| 5.2 Site Grading and Preparation .....                | 7           |
| 5.3 Foundation Design .....                           | 10          |
| 5.4 Design for Earthquakes .....                      | 10          |
| 5.5 Basement Slab .....                               | 10          |
| 5.6 Basement Wall .....                               | 11          |
| 5.7 Rock Anchor Design.....                           | 12          |
| 5.8 Pavement Design.....                              | 15          |
| <b>6.0 Design and Construction Precautions.....</b>   | <b>17</b>   |
| 6.1 Foundation Drainage and Backfill .....            | 17          |
| 6.2 Protection of Footings Against Frost Action ..... | 18          |
| 6.3 Excavation Side Slopes .....                      | 18          |
| 6.4 Pipe Bedding and Backfill .....                   | 20          |
| 6.5 Groundwater Control .....                         | 21          |
| 6.6 Winter Construction.....                          | 22          |
| 6.7 Corrosion Potential and Sulphate .....            | 22          |
| <b>7.0 Recommendations .....</b>                      | <b>23</b>   |
| <b>8.0 Statement of Limitations.....</b>              | <b>24</b>   |

## **Appendices**

- Appendix 1**      Soil Profile and Test Data Sheets  
                         Symbols and Terms  
                         Analytical Test Results
- Appendix 2**      Figure 1 - Key Plan  
                         Drawing PG5946-1 - Test Hole Location Plan

## 1.0 Introduction

Paterson Group (Paterson) was commissioned by 2828727 Ontario Inc. to conduct a geotechnical investigation for the site that is located on 249, 251, 255 Richmond Road and 372 Tweedsmuir Avenue in the City of Ottawa (refer to Figure 1 - Key Plan in Appendix 2 of this report).

The objective of the geotechnical investigation was to:

- Determine the subsoil and groundwater conditions at this site by means of test holes.
- Provide geotechnical recommendations pertaining to 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 Development

Based on the available drawings, it is understood that the proposed development will consist of a 9-storey building with three underground parking levels to cover the majority of the site. Associated access lanes, hardscaped areas, and walkways are also anticipated as part of the development. It is expected that the proposed building will be municipally serviced.

## **3.0 Method of Investigation**

### **3.1 Field Investigation**

#### **Field Program**

The field program for the current geotechnical investigation was carried out on August 6, 2021 and consisted of advancing a total of three (3) boreholes to a maximum depth of 7.7 m below existing ground surface. The test hole locations were distributed in a manner to provide general coverage of the subject site and taking into consideration underground utilities and site features. The test hole locations are shown on Drawing PG5946-1 - Test Hole Location Plan included in Appendix 2.

The test holes were completed using a low clearance drill rig operated by a two-person crew. All fieldwork was conducted under the full-time supervision of Paterson personnel under the direction of a senior engineer. The drilling procedure consisted of drilling to the required depths at the selected locations, and sampling and testing the overburden.

#### **Sampling and In Situ Testing**

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

Rock samples were recovered from borehole BH 1-21 using a core barrel and diamond drilling techniques. The bedrock samples were classified on site, placed in hard cardboard core boxes, and transported to Paterson's laboratory.

The depths at which rock core samples were recovered from the boreholes are presented as RC on the Soil Profile and Test Data sheets in Appendix 1.

The recovery value and a Rock Quality Designation (RQD) value were calculated for each drilled section of bedrock and are presented on the borehole logs. The recovery value is the length of the bedrock sample recovered over the length of the drilled section. The RQD value is the total length of intact rock pieces longer than 100 mm over the length of the core run. The values indicate the bedrock quality.

The subsurface conditions observed in the test holes were recorded in detail in the field. The soil profiles are logged on the Soil Profile and Test Data sheets in Appendix 1 of this report.

### **Groundwater**

A monitoring well was installed in BH 1-21 to permit monitoring of the groundwater level subsequent to the completion of the sampling program.

Groundwater level measurements and observations are discussed in Section 4.3 and are presented in the Soil Profile and Test Data sheets in Appendix 1.

### **Sample Storage**

All samples will be stored in the laboratory for a period of one (1) 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 Paterson to provide general coverage of the proposed development, taking into consideration the existing site features and underground utilities. The test hole locations and ground surface elevation at each test hole location were surveyed by Paterson using a handheld GPS and referenced to a geodetic datum. The location of the test holes and ground surface elevation at each test hole location are presented on Drawing PG5946-1 - Test Hole Location Plan in Appendix 2.

## **3.3 Laboratory Review**

Soil samples were recovered from the subject site and visually examined in our laboratory to review the results of the field logging. Soil samples will be stored for a period of one month after this report is completed, unless otherwise directed.

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

## **4.0 Observations**

### **4.1 Surface Conditions**

The subject site is relatively flat and is currently occupied by several commercial and one residential building. A two-storey commercial building occupies the southeast portion, a one-storey commercial building occupies the central and west portion, and a single-family residential dwelling with associated driveway and backyard occupies the northern portion of the site. At-grade asphaltic concrete parking occupies the remaining southwestern portion of the site.

The site is bordered by two residential buildings to the north, Tweedsmuir Avenue followed by a one storey commercial building to the east, Richmond Road followed by a gas station to the south and by a low-rise commercial building to the west.

### **4.2 Subsurface Profile**

Generally, the soil profile at the test hole locations consists of an asphaltic concrete and fill layer followed by dense to very dense glacial till deposit overlying bedrock. The fill material consists of brown silty sand or clay with crushed stone, and trace coal and wood. The glacial till deposit encountered below the fill was observed to consist of compact to very dense brown silty sand with gravel, cobbles and boulders. Refusal to augering was encountered in BH 2-21 and BH 3-21 at an approximate depth of 2.2 m. Bedrock was cored in BH 1-21 at a depth of 2.9m below ground surface, with an average RQD value ranging from 85 to 100%. This is indicative of a good to excellent quality bedrock at the location of the drilled boreholes.

Reference should be made to the Soil Profile and Test Data sheets in Appendix 1 for the details of the soil profile encountered at each test hole location.

#### **Bedrock**

Based on available geological mapping and augur refusal/coring, the bedrock in the subject area consists of interbedded limestone and dolomite of the Gull River formation, with an overburden drift thickness of 2 to 3 m depth.



### 4.3 Groundwater

Groundwater levels were measured during the current investigation on August 26, 2021 within the new and existing monitoring wells. The measured groundwater levels are presented in Table 1 below. The long-term groundwater table is expected to range between 5.0 to 7.0 m below existing grade.

| <b>Table 1 – Summary of Groundwater Levels</b>  |                                     |                                   |                      |                       |
|---|-------------------------------------|-----------------------------------|----------------------|-----------------------|
| <b>Current Investigation</b>  |                                     |                                   |                      |                       |
| <b>Test Hole Number</b>   | <b>Ground Surface Elevation (m)</b> | <b>Measured Groundwater Level</b> |                      | <b>Dated Recorded</b> |
|   |                                     | <b>Depth (m)</b>                  | <b>Elevation (m)</b> |                       |
| BH 1-21   | 66.76                               | 6.35                              | 60.41                | August 26, 2021       |
| <b>Existing Monitoring wells – by others</b>  |                                     |                                   |                      |                       |
| MW 17-1   | 67.79                               | 6.72                              | 61.07                |                       |
| MW 17-2   | 67.62                               | 6.17                              | 61.45                |                       |
| MW 17-3   | 67.88                               | 7.56                              | 60.32                |                       |
| MW 17-4   | 67.35                               | 8.42                              | 58.93                |                       |
| <b>Note:</b> The ground surface elevation at the borehole location was surveyed using a handheld GPS using a geodetic datum. Elevations for monitoring wells were provided by others. |                                     |                                   |                      |                       |

It should be noted that groundwater levels are subject to seasonal fluctuations. Therefore, the groundwater levels could vary at the time of construction.

## **5.0 Discussion**

### **5.1 Geotechnical Assessment**

From a geotechnical perspective, the subject site is considered suitable for the proposed development. Due to the presence of three levels of underground parking, it is anticipated that conventional shallow foundations placed on the clean surface sounded bedrock bearing surface will be suitable to support the proposed buildings.

It is anticipated that bedrock removal will be required to complete the underground parking levels of the proposed building. Line drilling and controlled blasting are recommended where large quantities of bedrock need to be removed. The blasting operations should be planned and carried out under the guidance of a professional engineer with experience in blasting operations.

Based on the anticipated excavation depth and the nature of the overburden, a temporary excavation support will be required along the upper portion of the excavation of the subject site. The design of the temporary shoring system needs to adequately support the existing building along the west side of the site, which is in close proximity with the proposed excavation.

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

### **5.2 Site Grading and Preparation**

#### **Stripping Depth**

Due to the anticipated founding level for the proposed building, all existing overburden material will be excavated from within the proposed building footprint. Bedrock removal will be required for the majority of the site for construction of the parking garage levels.

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. If encountered, existing foundation walls and other construction debris should be entirely removed from within the building perimeters. Under paved areas, existing construction remnants such as foundation walls should be excavated to a minimum of 1 m below final grade.

## **Bedrock Removal**

Bedrock removal can be accomplished by hoe ramming where only a small quantity of bedrock needs to be removed. Sound bedrock may be removed by line drilling and controlled blasting and/or hoe ramming.

Prior to considering blasting operations, the blasting effects on the existing services, buildings, and other structures should be addressed. A pre-blast or pre-construction survey of the existing structures located in the proximity of the blasting operations should be carried out prior to commencing site activities. The extent of the survey should be determined by the blasting consultant and should be sufficient to respond to any inquiries or claims related to the blasting operations.

As a general guideline, peak particle velocities (measured at the structures) should not exceed 25 mm/s during the blasting program to reduce the risks of damage to the existing surrounding structures. The blasting operations should be planned and conducted under the supervision of a licensed professional engineer who is also an experienced blasting consultant.

Excavation side slopes in sound bedrock can be carried out using near vertical sidewalls. A minimum 1 m horizontal ledge should be left between the bottom of the overburden excavation and the top of the bedrock surface to provide an area to allow for potential sloughing. The 1 m horizontal ledge set back can be eliminated with a shoring program which has drilled piles extending below the proposed founding elevation.

## **Vibration Considerations**

Construction operations could cause vibrations, and possibly, sources of nuisance to the community. Therefore, means to reduce the vibration levels as much as possible should be incorporated in the construction operations to maintain a cooperative environment with the residents.

The following construction equipment could cause vibrations: piling equipment, hoe ram, compactor, dozer, crane, truck traffic, etc. The construction of the shoring system with soldier piles or sheet piling will require these pieces of equipment. Vibrations caused by blasting or construction operations could cause detrimental vibrations on the adjoining buildings and structures. Therefore, it is recommended that all vibrations be limited.

Two parameters determine the recommended vibration limit, the maximum peak particle velocity and the frequency. For low frequency vibrations, the maximum allowable peak particle velocity is less than that for high frequency vibrations. As a guideline, the peak particle velocity should be less than 15 mm/s between frequencies of 4 to 12 Hz, and 50 mm/s above a frequency of 40 Hz (interpolate between 12 and 40 Hz).

These guidelines are for current construction standards. Considering there are several sensitive buildings in close proximity to the subject site, consideration to lowering these guidelines is recommended. These guidelines are above perceptible human level and, in some cases, could be very disturbing to some people, a pre-construction survey is recommended to minimize the risks of claims during or following the construction of the proposed building.

### **Bedrock Excavation Face Reinforcement**

A bedrock stabilization system consisting of a combination of horizontal rock anchors and/or chain link fencing connected to the excavation face may be required at specific locations to prevent bedrock pop-outs. This system is usually considered where bedrock fractures are conducive to the failure of the bedrock surface. The requirement for horizontal rock anchors will be evaluated during the excavation operations.

### **Fill Placement**

Fill placed 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. The imported fill material should be tested and approved prior to delivery. The fill should be placed in maximum 300 mm thick loose lifts and compacted by suitable compaction equipment. Fill placed beneath the building should be compacted to a minimum of 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.

If excavated rock is to be used as fill, it should be suitably fragmented to produce a well-graded material with a maximum particle size of 300 mm. This material should be used structurally only to build up the subgrade for pavements. Where the fill is open-graded, a blinding layer of finer granular fill and/or a woven geotextile may be required to prevent adjacent finer materials from migrating into the voids, with associated loss of ground and settlements. This can be assessed at the time of construction.

## 5.3 Foundation Design

### Bearing Resistance Values

Footings placed on a clean, surface sounded bedrock surface can be designed using a bearing resistance value at ultimate limits states (ULS) of **3,000 kPa**. A geotechnical factor of 0.5 was applied to the above noted bearing resistance value.

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

### Settlement

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

### Lateral Support

The bearing medium under footing-supported structures is required to be provided with adequate lateral support with respect to excavations and different foundation levels. Adequate lateral support is provided to a sound bedrock bearing medium when a plane extending down and out from the bottom edge of the footing at a minimum of 1H:6V (or flatter) passes only through sound bedrock or a material of the same or higher capacity as the bedrock, such as concrete.

## 5.4 Design for Earthquakes

The site class for seismic site response can be taken as **Class C** for foundations constructed at the subject site. A higher site class, such as Class A or B may be provided for foundations placed on or near the bedrock surface. However, the higher site class will need to be confirmed by a site-specific seismic shear wave velocity test. The soils underlying the subject site are not susceptible to liquefaction. Reference should be made to the latest revision of the 2012 Ontario Building Code for a full discussion of the earthquake design requirements.

## 5.5 Basement Slab

With the removal of all topsoil and deleterious fill within the footprint of the proposed building, the bedrock surface will be considered an acceptable subgrade upon which to commence backfilling for floor slab construction.

A subfloor drainage system, consisting of lines of perforated drainage pipe subdrains connected to a positive outlet, should be provided in the clear stone backfill under the lower basement floor. Pipe spacing requirements should be determined at the time of excavation when the groundwater infiltration can be better assessed.

An engineered fill such as an OPSS Granular A or Granular B Type II compacted to 98% of its SPMDD could be placed around the proposed footings. The upper 200 mm below the basement floor slab should consist of a 19 mm clear crushed stone. Alternatively, excavated limestone bedrock could be used as select subgrade material around the proposed building footings, provided the excavated bedrock is suitably crushed to 50 mm in its longest dimension and approved by the Paterson at the time of placement.

In consideration of the groundwater conditions encountered during the investigation, a subfloor drainage system, consisting of lines of perforated drainage pipe subdrains connected to a positive outlet, should be provided in the clear stone backfill under the lower basement floor. Pipe spacing requirements should be determined at the time of excavation when the groundwater infiltration can be better assessed

## 5.6 Basement Wall

It is understood that the basement walls are to be poured against a water suppression system, which will be placed against the temporary shoring system and/or exposed bedrock face. Below the bedrock surface, a nominal coefficient for at-rest earth pressure of 0.05 is recommended in conjunction with a bulk unit weight of 24.5 kN/m<sup>3</sup> (effective 15.5 kN/m<sup>3</sup>). A seismic earth pressure component will not be applicable for the foundation wall, which is to be poured against the bedrock face. It is expected that the seismic earth pressure will be transferred to the underground floor slab, which should be designed to accommodate these pressures. A hydrostatic pressure should be added for the portion below groundwater level.

Where the soil is to be retained, 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 dry unit weight of 20 kN/m<sup>3</sup>. The applicable effective unit weight of the retained soil can be estimated as 13 kN/m<sup>3</sup>, where applicable. A hydrostatic pressure should be added to the total static earth pressure when calculating the effective unit weight.

### Lateral Earth Pressures

The static horizontal earth pressure ( $p_o$ ) can be calculated using 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)
- $\gamma$  = unit weight of fill of the applicable retained soil (kN/m<sup>3</sup>)
- $H$  = height of the wall (m)

An additional pressure having 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 Earth Pressures

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

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

$$a_c = (1.45 - a_{max}/g)a_{max}$$

$$\gamma = \text{unit weight of fill of the applicable retained soil (kN/m}^3\text{)}$$

$$H = \text{height of the wall (m)}$$

$$g = \text{gravity, 9.81 m/s}^2$$

The peak ground acceleration, ( $a_{max}$ ), for the Ottawa area is 0.281 g according to OBC 2012. Note that the vertical seismic coefficient is assumed to be zero.

The earth force component ( $P_o$ ) under seismic conditions can be calculated using

$$P_o = 0.5 K_o \gamma H^2, \text{ where } K_o = 0.5 \text{ for the soil conditions noted above.}$$

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 Rock Anchor Design

The geotechnical design of grouted rock anchors in limestone bedrock is based upon two possible failure modes. The rock anchor can fail either by shear failure along the grout/rock interface or by pullout at 60 to 90 degree cone of rock with the apex of the cone near the middle of the bonded length of the anchor. Interaction may develop between the failure cones of anchors that are relatively close to one another resulting in a total group capacity smaller than the sum of the individual anchor load capacity.



A third failure mode of shear failure along the grout/steel interface should be reviewed by a qualified structural engineer to ensure all typical failure modes have been reviewed. Typical rock anchor suppliers, such as Dywidag Systems International (DSI Canada) or Williams Form Engineering, have qualified personnel on staff to recommend appropriate rock anchor size and materials.

Anchors in close proximity to each other are recommended to be grouted at the same time to ensure any fractures or voids are completely in-filled and grout fluid does not flow from one hole to an adjacent empty one.

Anchors can be of the “passive” or the “post-tensioned” type, depending on whether the anchor tendon is provided with post-tensioned load or not, prior to servicing. To resist seismic uplift pressures, a passive rock anchor system is adequate. However, a post-tensioned anchor will absorb the uplift load pressure with less deflection than a passive anchor.

Regardless of whether an anchor is of the passive or the post tensioned type, it is recommended that the anchor is provided with a fixed anchor length at the anchor base, which will provide the anchor capacity, and a free anchor length between the rock surface and the top of the bonded length. As the depth at which the apex of the shear failure cone develops midway along the bonded length, a fully bonded anchor would tend to have a much shallower cone, and therefore less geotechnical resistance, than one where the bonded length is limited to the bottom part of the overall anchor.

Permanent anchors should be provided with corrosion protection. As a minimum, this requires that the entire drill hole be filled with cementitious grout. The free anchor length is provided by installing a sleeve to act as a bond break, with the sleeve filled with grout. Double corrosion protection can be provided with factory assembled systems, such as those available from Dywidag Systems International or Williams Form Engineering Corp.

### **Grout to Rock Bond**

Generally, the unconfined compressive strength of limestone ranges between 75 and 100 MPa, which is stronger than most routine grouts. A factored tensile grout to rock bond resistance value at ULS of **1.0 MPa**, incorporating a resistance factor of 0.3, should be provided. A minimum grout strength of 40 MPa is recommended.

### **Rock Cone Uplift**

The rock anchor capacity depends on the dimensions of the rock anchors and the anchorage system configuration. Based on existing bedrock information, a **Rock Mass Rating (RMR) of 72** was assigned to the bedrock, and Hoek and Brown parameters (**m and s**) were taken as **0.575 and 0.00293**, respectively.



## Recommended Grouted Rock Anchor Lengths

Parameters used to calculate grouted rock anchor lengths are provided in Table 2.

| <b>Table 2 - Parameters used in Rock Anchor Review</b>                       |                                  |
|--|----------------------------------|
| Grout to Rock Bond Strength - Factored at ULS                                | 1.0 MPa                          |
| Compressive Strength - Grout   | 40 MPa                           |
| Rock Mass Rating (RMR) - Good quality Limestone<br>Hoek and Brown parameters | 72<br>m=0.575 and s=0.00293      |
| Unconfined compressive strength - Limestone                                  | 75 MPa                           |
| Unit weight - Submerged Bedrock  | 15 kN/m <sup>3</sup>             |
| Apex angle of failure cone   | 60°                              |
| Apex of failure cone   | mid-point of fixed anchor length |

The fixed anchor length will depend on the diameter of the drill holes. Recommended anchor lengths are provided in Table 3. The factored tensile resistance values provided are based on a single anchor with no group influence effects.

| <b>Table 3 - Recommended Rock Anchor Lengths - Grouted Rock Anchor</b> |                           |                        |                     |   |
|--|---------------------------|------------------------|---------------------|---|
| <b>Diameter of Drill Hole (mm)</b>                                     | <b>Anchor Lengths (m)</b> |                        |                     | <b>Factored Tensile Resistance (kN)</b> |
|  | <b>Bonded Length</b>      | <b>Unbonded Length</b> | <b>Total Length</b> |   |
| 75   | 1.7                       | 0.7                    | 2.4                 | 450                                     |
|  | 2.2                       | 0.7                    | 2.9                 | 600                                     |
|  | 2.5                       | 0.8                    | 3.3                 | 750                                     |
|  | 2.8                       | 1.0                    | 3.8                 | 900                                     |
| 125  | 1.0                       | 1.0                    | 2.0                 | 450                                     |
|  | 1.3                       | 1.1                    | 2.4                 | 600                                     |
|  | 1.6                       | 1.2                    | 2.8                 | 750                                     |
|  | 1.9                       | 1.2                    | 3.1                 | 900                                     |

It is recommended that the anchor drill hole diameter be within 1.5 to 2 times the rock anchor tendon diameter and the anchor drill holes be inspected by Paterson personnel and should be flushed clean prior to grouting. The use of a grout tube to place grout from the bottom up in the anchor holes is further recommended. The geotechnical capacity of each rock anchor should be proof tested at the time of construction. More information on testing can be provided upon request. Compressive strength testing is recommended to be completed for the rock anchor grout. A set of grout cubes should be tested for each day grout is prepared.

## 5.8 Pavement Design

For design purposes, it is recommended that the rigid pavement structure for the lower level of the underground parking structure should consist of Category C2, 32 MPa concrete at 28 days with air entrainment of 5 to 8%. The recommended rigid pavement structure is further presented in Table 4 below. The flexible pavement structure presented in Table 5 should be used for at grade access lanes and heavy loading parking areas overlying the podium deck.

| <b>Table 4 - Recommended Rigid Pavement Structure - Lower Parking Level</b>        |   |
|--|---|
| <b>Thickness (mm)</b>  | <b>Material Description</b>                 |
| 150  | <b>32 MPa Concrete</b>                      |
| 300  | <b>BASE - OPSS Granular A Crushed Stone</b> |
| <b>SUBGRADE</b> Fill or OPSS Granular B Type I or II material placed over bedrock. |   |

To control cracking due to shrinking of the concrete floor slab, it is recommended that strategically located saw cuts be used to create control joints within the concrete floor slab of the lower underground parking level. The control joints are generally recommended to be located at the center of the column lines and spaced at approximately 24 to 36 times the slab thickness (for example, a 0.15 m thick slab should have control joints spaced between 3.6 and 5.4 m). The joints should be cut between 25 and 30% of the thickness of the concrete floor slab and completed as early as 4 hours after the concrete has been poured during warm temperatures and up to 12 hours during cooler temperatures.

| <b>Table 5 - Recommended Asphalt Pavement Structure - Access Lanes and Heavy Loading Parking Areas</b> |  |
|--|--|
| <b>Thickness (mm)</b>  | <b>Material Description</b>                              |
| 40   | <b>Wear Course - Superpave 12.5 Asphaltic Concrete</b>   |
| 50   | <b>Binder Course - Superpave 19.0 Asphaltic Concrete</b> |
| 150  | <b>BASE - OPSS Granular A Crushed Stone</b>              |
| 300  | <b>SUBBASE - OPSS Granular B Type II</b>                 |
| <b>SUBGRADE - OPSS Granular B Type II overlying the Concrete Podium Deck.</b>                          |  |

Minimum Performance Graded (PG) 58-34 asphalt cement should be used for this project. The pavement granular base and subbase should be placed in maximum 300 mm thick lifts and compacted to a minimum of 99% of the material's SPMDD using suitable vibratory equipment, noting that excessive compaction can result in subgrade softening.

The upper 300 mm of the bedrock surface should be reviewed and approved by Paterson prior to placing the base and subbase materials. Care should be exercised to ensure that the bedrock subgrade does not have depressions that will trap water.

## **6.0 Design and Construction Precautions**

### **6.1 Foundation Drainage and Backfill**

#### **Water Suppression System and Foundation Drainage**

It is understood that the proposed structure will occupy the entire boundary of the subject site. It is expected that insufficient room will be available for exterior backfill along these walls and, therefore, the foundation wall will be blind poured against a foundation drainage/waterproofing system placed directly against the temporary shoring system and a suitably prepared bedrock surface. It is suggested that this system be constructed as follows:

- Temporary shoring system and/or bedrock vertical faces should be prepared to receive a waterproofing membrane, such as lined bentonite sheets, and drainage board for the underground parking structure. The bedrock surface will be prepared by grinding bedrock face high points and in-filling bedrock face cavities or using shotcrete to smooth out angular sections depending on the manufacturer's requirements of the proposed waterproofing membrane.
- A waterproofing membrane will be applied to the temporary shoring system and prepared vertical bedrock surface from ground surface to the founding elevation. The waterproofing membrane should also be extended horizontally below the proposed footings a minimum of 600 mm away from the face of the excavation. The membrane will serve as a water infiltration suppression system. The membrane will also be placed along the horizontal surface beneath the perimeter footings to provide a better seal at the vertical and horizontal interface.
- A composite drainage layer will be placed from finished grade to the bottom of the foundation wall. It is recommended that the composite drainage system (such as Delta Drain 6000 or equivalent) extend down to the bottom of the foundation wall. It is expected that 150 mm diameter sleeves placed at 3 m centers be cast in the foundation wall at the footing interface to allow the infiltration of water to flow to an interior perimeter drainage pipe. The perimeter drainage pipe should direct water to the sump pit(s) within the lower basement area.

#### **Underfloor Drainage**

Underfloor drainage will be required to control water infiltration for the lower basement area. For preliminary design purposes, we recommend that 150 mm diameter perforated PVC pipes be placed at every bay opening. The spacing of the underfloor drainage system should be confirmed at the time of completing the excavation when water infiltration can be better assessed.

## **Foundation Backfill**

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

## **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 1.5 m thick soil cover (or insulation equivalent) should be provided in this regard.

Other exterior unheated footings, such as those for isolated exterior piers and retaining walls, are more prone to deleterious movement associated with frost action. These should be provided with a minimum 2.1 m thick soil cover (or insulation equivalent).

The footings located along parking garage entrance may require protection against frost action depending on the founding depth. Unheated structures, such as the access ramp wall footings, may be required to be insulated against the deleterious effect of frost action. A minimum of 2.1 m of soil cover alone, or a minimum of 0.6 m of soil cover, in conjunction with foundation insulation, should be provided.

## **6.3 Excavation Side Slopes**

The side slopes of excavations in the overburden materials should be either cut back at acceptable slopes or should be retained by shoring systems from the start of the excavation until the structure is backfilled. However, for most of the site, insufficient room will be available to permit the building excavation to be constructed by open-cut methods (i.e., unsupported excavations).

### **Unsupported Side Slopes**

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

In bedrock, almost vertical side slopes can be used provided that all loose rock and blocks with unfavorable weak planes are removed or stabilized.

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.

### Temporary Shoring

Temporary shoring may be required for the overburden soil to complete the required excavations where insufficient room is available for open cut methods. The shoring requirements designed by a structural engineer specializing in those works will depend on the depth of the excavation, the proximity of the adjacent structures and the elevation of the adjacent building foundations and underground services. The design and implementation of these temporary systems will be the responsibility of the excavation contractor and their design team. Inspections and approval of the temporary system will also be the responsibility of the designer. Geotechnical information provided below is to assist the designer in completing a suitable and safe shoring system. The designer should take into account the impact of a significant precipitation event and designate design measures to ensure that a precipitation will not negatively impact the shoring system or soils supported by the system. Any changes to the approved shoring design system should be reported immediately to the owner’s structural design prior to implementation.

The temporary shoring system could consist of a soldier pile and lagging system or steel sheet piles. Any additional loading due to street traffic, construction equipment, adjacent structures and facilities, etc., should be included to the earth pressures described below. This system could be cantilevered, anchored or braced. The shoring system is recommended to be adequately supported to resist toe failure, if required, by means of extending the piles into the bedrock through pre-augered holes, if a soldier pile and lagging system is the preferred method. The earth pressures acting on the temporary shoring system may be calculated with the following parameters.

| <b>Table 6 – Soils Parameter for Shoring System Design</b> |               |
|--|---------------|
| <b>Parameters</b>  | <b>Values</b> |
| Active Earth Pressure Coefficient ( $K_a$ )                | 0.33          |
| Passive Earth Pressure Coefficient ( $K_p$ )               | 3             |
| At-Rest Earth Pressure Coefficient ( $K_o$ )               | 0.5           |
| Unit Weight ( $\gamma$ ), kN/m <sup>3</sup>                | 20            |
| Submerged Unit Weight ( $\gamma$ ), kN/m <sup>3</sup>      | 13            |

The active earth pressure should be calculated where wall movements are permissible while the at-rest pressure should be calculated if no movement is permissible. The dry unit weight should be calculated above the groundwater level while the effective unit weight should be calculated below the groundwater level.

The hydrostatic groundwater pressure should be included to the earth pressure distribution wherever the effective unit weight is calculated for earth pressures. If the groundwater level is lowered, the dry unit weight for the soil/bedrock should be calculated full weight, with no hydrostatic groundwater pressure component.

For design purposes, the minimum factor of safety of 1.5 should be calculated.

### **Underpinning of Adjacent Structures**

Founding conditions of the adjacent structure along the west boundary of the proposed building should be assessed and underpinning requirements should be evaluated.

## **6.4 Pipe Bedding and Backfill**

Bedding and backfill materials should be in accordance with the most recent Material Specifications and Standard Detail Drawings from the Department of Public Works and Services, Infrastructure Services Branch of the City of Ottawa. At least 300 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 or Granular B Type II with a maximum size of 25 mm. The bedding and cover materials should be placed in maximum 225 mm thick lifts compacted to 99% of the material's standard Proctor maximum dry density.

It should generally be possible to re-use the upper portion of the dry to moist (not wet) glacial till above the cover material if the excavation and filling operations are carried out in dry weather conditions. Any stones greater than 200 mm in their longest dimension should be removed from these materials prior to placement.

Well fractured bedrock should be acceptable as backfill for the lower portion of the trenches when the excavation is within bedrock provided the rock fill is placed only from at least 300 mm above the top of the service pipe and that all stones are 300 mm or smaller in their longest dimension.

The backfill material within the frost zone (about 1.8 m below finished grade) should match the soils exposed at the trench walls to reduce potential differential frost heaving. The backfill should be placed in maximum 225 mm thick loose lifts and compacted to a minimum of 95% of the material's SPMDD.



## **6.5 Groundwater Control**

### **Groundwater Control for Building Construction**

Based on our observations, it is anticipated that groundwater infiltration into the excavations should be low to moderate and controllable using open sumps. Pumping from open sumps should be sufficient to control the groundwater influx through the sides of shallow excavations. 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.

### **Permit to Take Water**

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

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

### **Long-term Groundwater Control**

Any groundwater encountered along the buildings' perimeter or sub-slab drainage system will be directed to the proposed buildings' cistern/sump pit. Provided the proposed groundwater infiltration control system is properly implemented and approved by the geotechnical consultant at the time of construction, the expected long-term groundwater flow should be low (i.e., less than 25,000 L/day/building) with peak periods noted after rain events. A more accurate estimate can be provided at the time of construction, once groundwater infiltration levels are observed. The long-term groundwater flow is anticipated to be controllable using conventional open sumps.

### **Impacts on Neighbouring Properties**

A local groundwater lowering is anticipated under short-term conditions due to construction of the proposed building. Based on the existing groundwater level, the extent of any significant groundwater lowering will take place within a limited range of the proposed building. Based on the proximity of neighbouring buildings and minimal zone impacted by the groundwater lowering, the proposed development will not negatively impact the neighbouring structures.



Due to the proposed waterproofing to be installed along the perimeter of the proposed building, no issues are expected with respect to groundwater lowering that would cause long term adverse effects to adjacent structures surrounding the proposed building.

## **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.

## **6.7 Corrosion Potential and Sulphate**

The results of analytical testing show that the sulphate content is less than 0.1%. This result is indicative that Type 10 Portland cement (normal cement) would be appropriate for this site. The chloride content and the pH of the sample indicate that they are not significant factors in creating a corrosive environment for exposed ferrous metals at this site, whereas the resistivity is indicative of a non-aggressive to a slightly aggressive corrosive environment.

## 7.0 Recommendations

It is a requirement for the foundation design data provided herein to be applicable that the following material testing and observation program be performed by the geotechnical consultant.

- Review of the geotechnical aspects of the excavating program, prior to construction.
- Observation of all bearing surfaces prior to the placement of concrete.
- Inspection of the perimeter and underfloor drainage system, and the waterproofing of basement walls and elevator pit.
- Sampling and testing of the concrete and fill materials.
- 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.

All excess soils, with the exception of engineered crushed stone fill, generated by construction activities that will be transported on-site or off-site should be handled as per *Ontario Regulation 406/19: On-Site and Excess Soil Management*.

A report confirming that these works have been conducted in general accordance with our recommendations could be issued upon the completion of a satisfactory inspection program by the geotechnical consultant.

## 8.0 Statement of Limitations

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

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 immediate notification to permit reassessment of our recommendations.

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

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 2828727 Ontario Inc. or their agents is not authorized without review by Paterson for the applicability of our recommendations to the alternative use of the report.

### Paterson Group Inc.

Maha K. Saleh, Provisional P.Eng.



David J. Gilbert, P.Eng

### Report Distribution:

- 2828727 Ontario Inc (email copy)
- Paterson Group (1 copy)

# APPENDIX 1

SOIL PROFILE AND TEST DATA SHEETS

SYMBOLS AND TERMS

ANALYTICAL TESTING RESULTS

DATUM Geodetic

REMARKS

BORINGS BY CME-55 Low Clearance Drill

DATE August 6, 2021

FILE NO. **PG5946**

HOLE NO. **BH 1-21**

| SOIL DESCRIPTION  | STRATA PLOT | SAMPLE |        |            |                | DEPTH (m) | ELEV. (m) | Pen. Resist. Blows/0.3m<br>● 50 mm Dia. Cone |    |    |    | Monitoring Well Construction |  |
|---|-------------|--------|--------|------------|----------------|-----------|-----------|--|----|----|----|------------------------------|--|
|   |             | TYPE   | NUMBER | RECOVERY % | N VALUE or RQD |           |           | ○ Water Content %                            |    |    |    |                              |  |
| GROUND SURFACE  |             |        |        |            |                |           |           | 20   | 40 | 60 | 80 |                              |  |
| Asphaltic concrete  | 0.13        |        |        |            |                | 0         | 66.76     |  |    |    |    |                              |  |
| <b>FILL:</b> Brown silty sand with crushed stone  | 0.91        | AU     | 1      |            |                |           |           |  |    |    |    |                              |  |
|   |             | SS     | 2      | 50         | 50+            | 1         | 65.76     |  |    |    |    |                              |  |
| <b>GLACIAL TILL:</b> Very dense, brown silty sand with gravel, cobbles and boulders, trace clay |             | SS     | 3      | 100        | 50+            | 2         | 64.76     |  |    |    |    |                              |  |
|   |             | SS     | 4      | 94         | 50+            |           |           |  |    |    |    |                              |  |
|   | 2.92        | RC     | 1      | 100        | 100            | 3         | 63.76     |  |    |    |    |                              |  |
|   |             | RC     | 2      | 97         | 85             | 4         | 62.76     |  |    |    |    |                              |  |
| <b>BEDROCK:</b> Good to excellent quality, grey silty dolostone interbedded with grey limestone |             | RC     | 3      | 100        | 88             | 5         | 61.76     |  |    |    |    |                              |  |
|   |             | RC     | 4      | 100        | 100            | 6         | 60.76     |  |    |    |    |                              |  |
|   |             |        |        |            |                | 7         | 59.76     |  |    |    |    |                              |  |
| End of Borehole<br>(GWL @ 6.35m - August 16, 2021)  | 7.70        |        |        |            |                |           |           |  |    |    |    |                              |  |

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

DATUM Geodetic

REMARKS

BORINGS BY CME-55 Low Clearance Drill

DATE August 6, 2021

FILE NO. **PG5946**

HOLE NO. **BH 2-21**

| SOIL DESCRIPTION   | STRATA PLOT | SAMPLE |        |            |                | DEPTH (m) | ELEV. (m) | Pen. Resist. Blows/0.3m<br>● 50 mm Dia. Cone |    |    |    | Monitoring Well Construction |
|--|-------------|--------|--------|------------|----------------|-----------|-----------|--|----|----|----|------------------------------|
|  |             | TYPE   | NUMBER | RECOVERY % | N VALUE or RQD |           |           | ○ Water Content %                            |    |    |    |                              |
| GROUND SURFACE   |             |        |        |            |                |           |           | 20   | 40 | 60 | 80 |                              |
| Asphaltic concrete<br>FILL: Brown silty sand with crushed stone                                      | 0.10        | AU     | 1      |            |                | 0         | 67.46     |  |    |    |    |                              |
| FILL: Brown silty sand with gravel, trace wood and coal  | 0.76        | SS     | 2      | 42         | 12             | 1         | 66.46     |  |    |    |    |                              |
| GLACIAL TILL: Compact, brown silty sand with gravel, cobbles and boulders                            | 1.52        | SS     | 3      | 50         | 13             | 2         | 65.46     |  |    |    |    |                              |
| End of Borehole<br><br>Practical refusal to augering at 2.23m depth.<br><br>(BH dry upon completion) | 2.23        |        |        |            |                |           |           |  |    |    |    |                              |

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

## SOIL PROFILE AND TEST DATA

Geotechnical Investigation  
249, 251, 255 Richmond Road & 372 Tweedsmuir Ave.  
Ottawa, Ontario

DATUM Geodetic

FILE NO. **PG5946**

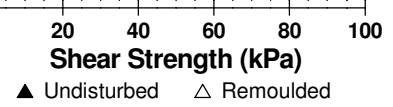
REMARKS

HOLE NO. **BH 3-21**

BORINGS BY CME-55 Low Clearance Drill

DATE August 6, 2021

| SOIL DESCRIPTION   | STRATA PLOT | SAMPLE |        |            |                | DEPTH (m) | ELEV. (m) | Pen. Resist. Blows/0.3m<br>● 50 mm Dia. Cone |    |    |    | Monitoring Well Construction |
|--|-------------|--------|--------|------------|----------------|-----------|-----------|--|----|----|----|------------------------------|
|  |             | TYPE   | NUMBER | RECOVERY % | N VALUE or RQD |           |           | 20   | 40 | 60 | 80 |                              |
| <b>GROUND SURFACE</b>  |             |        |        |            |                |           |           |  |    |    |    |                              |
| Asphaltic concrete<br>FILL: Brown silty sand with crushed stone                                      | 0.10        | AU     | 1      |            |                | 0         | 66.83     |  |    |    |    |                              |
| FILL: Hard to very stiff, brown silty clay, trace gravel   | 0.76        | SS     | 2      | 42         | 10             | 1         | 65.83     |  |    |    |    |                              |
| GLACIAL TILL: Dense, brown silty sand with gravel, cobbles and boulders                              | 1.68        | SS     | 3      | 42         | 35             | 2         | 64.83     |  |    |    |    |                              |
| End of Borehole<br><br>Practical refusal to augering at 2.23m depth.<br><br>(BH dry upon completion) | 2.23        |        |        |            |                |           |           |  |    |    |    |                              |



# 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.

| <b>RQD %</b> | <b>ROCK QUALITY</b>  |
|--------------|--|
| 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<br>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 = $(D_{30})^2 / (D_{10} \times D_{60})$  |
| Cu  | - | Uniformity coefficient = $D_{60} / D_{10}$   |

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   |   | Overconsolidation 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)

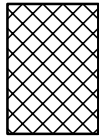
### STRATA PLOT



Topsoil



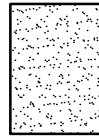
Asphalt



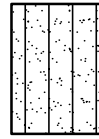
Fill



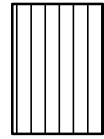
Peat



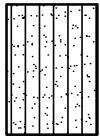
Sand



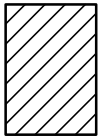
Silty Sand



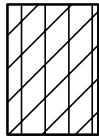
Silt



Sandy Silt



Clay



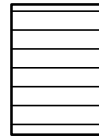
Silty Clay



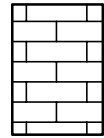
Clayey Silty Sand



Glacial Till



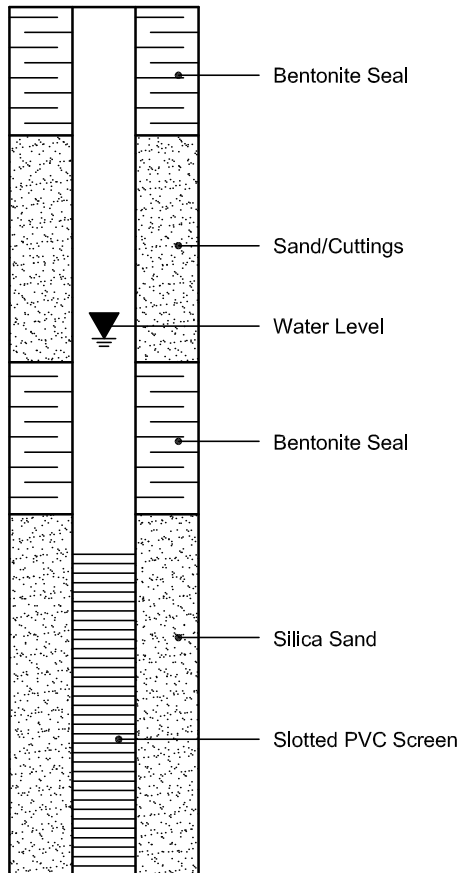
Shale



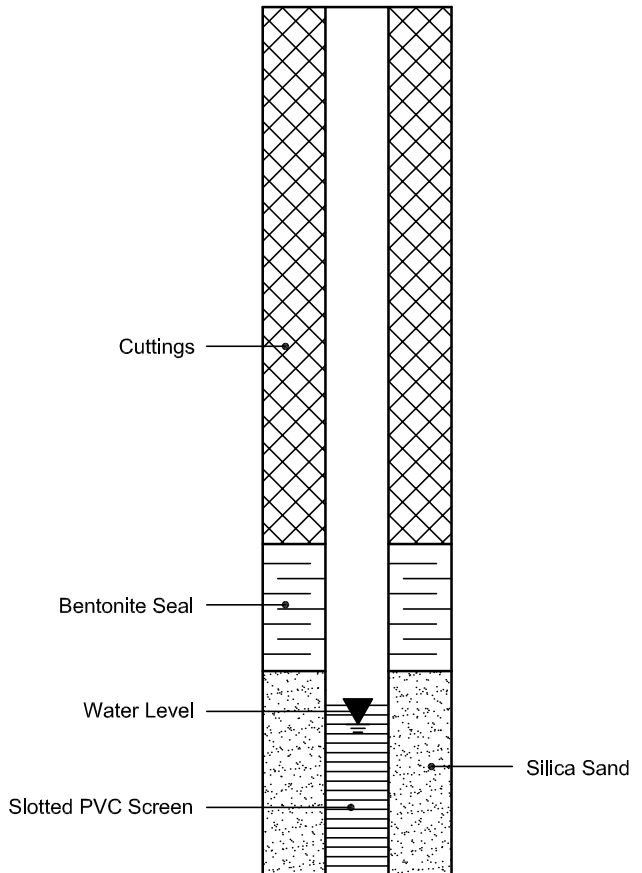
Bedrock

### MONITORING WELL AND PIEZOMETER CONSTRUCTION

#### MONITORING WELL CONSTRUCTION



#### PIEZOMETER CONSTRUCTION



# Log of Borehole MW17-1

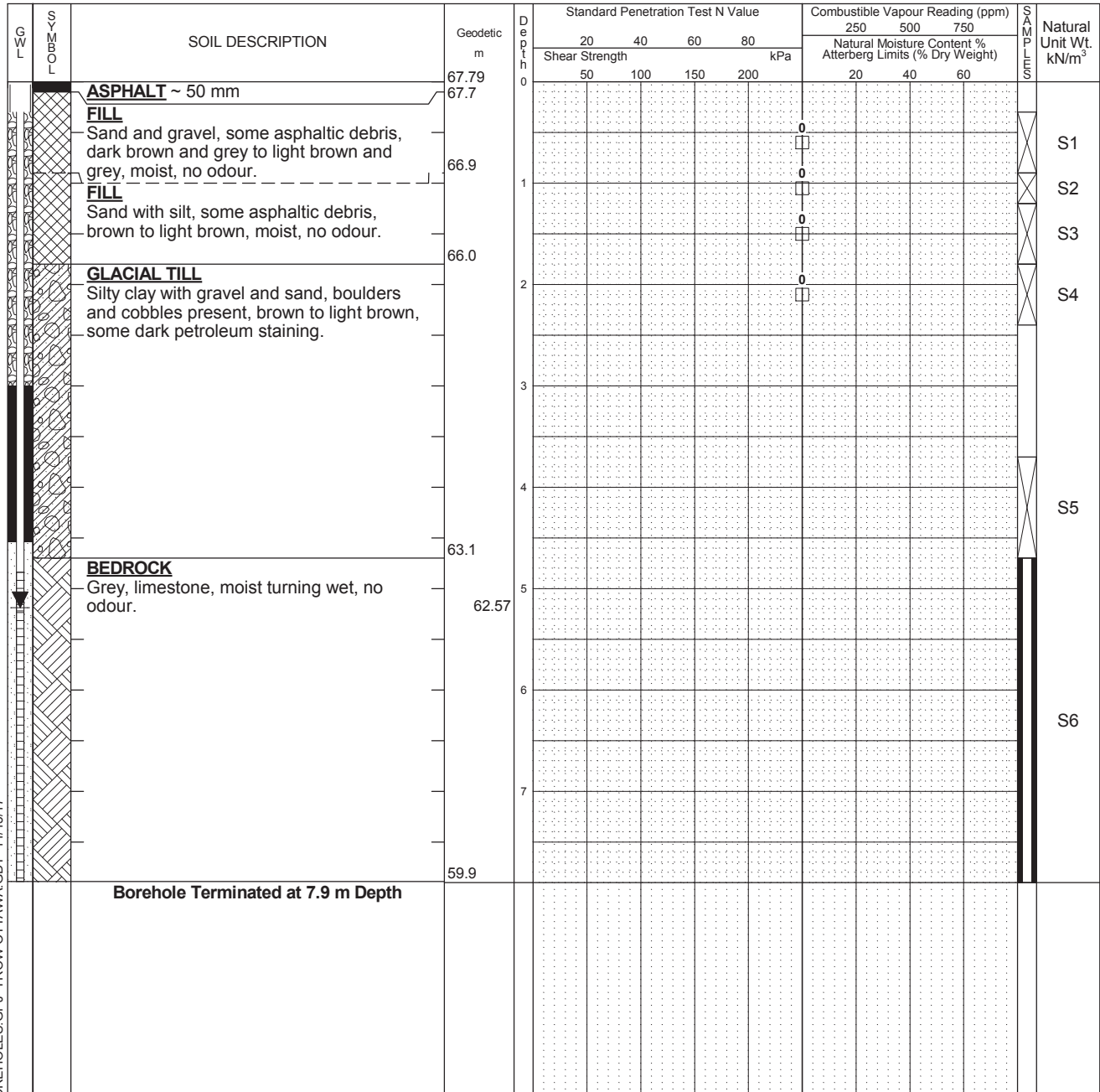


Project No: OTT-00241482-B0  
 Project: Supplemental Phase II ESA  
 Location: 255 Richmond Road, Ottawa, Ontario

Figure No. 3  
 Page. 1 of 1

Date Drilled: August 4th, 2017  
 Drill Type: Geoprobe 420M  
 Datum: Geodetic  
 Logged by: JO Checked by: MGM

Split Spoon Sample   
 Auger Sample   
 SPT (N) Value   
 Dynamic Cone Test   
 Shelby Tube   
 Shear Strength by Vane Test   
 Combustible Vapour Reading   
 Natural Moisture Content   
 Atterberg Limits   
 Undrained Triaxial at % Strain at Failure   
 Shear Strength by Penetrometer Test



LOG OF BOREHOLE LOGS OF BOREHOLES.GPJ TROW OTTAWA.GDT 11/15/17

NOTES:  
 1. Borehole data requires interpretation by exp. before use by others  
 2. A flushmount monitoring well with a 32 mm slotted standpipe was installed in the borehole upon completion.  
 3. Field work was supervised by an exp representative.  
 4. See Notes on Sample Descriptions  
 5. This Figure is to read with exp. Services Inc. report OTT-00241482-B0

| WATER LEVEL RECORDS |                 |                  |
|---------------------|-----------------|------------------|
| Elapsed Time        | Water Level (m) | Hole Open To (m) |
| 6 days              | 7.1             |                  |
| 95 days             | 5.9             |                  |
| 102 days            | 5.2             |                  |

| CORE DRILLING RECORD |           |        |       |
|----------------------|-----------|--------|-------|
| Run No.              | Depth (m) | % Rec. | RQD % |
|                      |           |        |       |

# Log of Borehole MW17-2



Project No: OTT-00241482-B0  
 Project: Supplemental Phase II ESA  
 Location: 255 Richmond Road, Ottawa, Ontario  
 Date Drilled: October 16th, 2017  
 Drill Type: Geoprobe 420M  
 Datum: Geodetic  
 Logged by: JO Checked by: MGM

Figure No. 4  
 Page. 1 of 1

- Split Spoon Sample
- Auger Sample
- SPT (N) Value
- Dynamic Cone Test
- Shelby Tube
- Shear Strength by Vane Test
- Combustible Vapour Reading
- Natural Moisture Content
- Atterberg Limits
- Undrained Triaxial at % Strain at Failure
- Shear Strength by Penetrometer Test

| GWL | SOIL DESCRIPTION   | Geodetic m | Depth | Standard Penetration Test N Value |    |    |    | Combustible Vapour Reading (ppm) |     |     | Natural Unit Wt. kN/m <sup>3</sup> |     |
|-----|--|------------|-------|-----------------------------------|----|----|----|----------------------------------|-----|-----|------------------------------------|-----|
|     |  |            |       | Shear Strength kPa                |    |    |    | Natural Moisture Content %       |     |     |                                    |     |
|     |  |            |       | 20                                | 40 | 60 | 80 | 250                              | 500 | 750 |                                    |     |
|     | <b>FILL</b><br>Sand and gravel, some asphaltic and concrete debris, brown and grey, moist, no odour.                       | 67.62      | 0     |                                   |    |    |    | 10                               |     |     |                                    | S1  |
|     | <b>FILL</b><br>Sand with silt, some concrete debris, brown with grey, moist, no odour.                                     | 66.7       | 1     |                                   |    |    |    | 10                               |     |     |                                    | S2  |
|     |  |            | 2     |                                   |    |    |    | 0                                |     |     |                                    | S3A |
|     | <b>GLACIAL TILL</b><br>Silty clay with sand and gravel, boulders and cobbles present, brown turning grey, moist, no odour. | 64.5       | 3     |                                   |    |    |    | 5                                |     |     |                                    | S4  |
|     |  |            | 4     |                                   |    |    |    | 100                              |     |     |                                    | S3B |
|     |  |            | 5     |                                   |    |    |    | 95                               |     |     |                                    | S5  |
|     |  |            | 6     |                                   |    |    |    | 95                               |     |     |                                    | S6  |
|     |  |            | 7     |                                   |    |    |    | 5                                |     |     |                                    | S7  |
|     |  | 61.1       | 8     |                                   |    |    |    | 170                              |     |     |                                    | S8  |
|     |  |            | 9     |                                   |    |    |    | 0                                |     |     |                                    | S9  |
|     | <b>Borehole Terminated at 7.6 m Depth</b>  |            |       |                                   |    |    |    |                                  |     |     |                                    |     |

LOG OF BOREHOLE LOGS OF BOREHOLES.GPJ TROW OTTAWA.GDT 11/15/17

- NOTES:
- Borehole data requires interpretation by exp. before use by others
  - A flushmount monitoring well with a 32 mm slotted standpipe was installed in the borehole upon completion.
  - Field work was supervised by an exp representative.
  - See Notes on Sample Descriptions
  - This Figure is to read with exp. Services Inc. report OTT-00241482-B0

| WATER LEVEL RECORDS |                 |                  |
|---------------------|-----------------|------------------|
| Elapsed Time        | Water Level (m) | Hole Open To (m) |
| 17 days             | 7.2             |                  |
| 24 days             | 6.5             |                  |

| CORE DRILLING RECORD |           |        |       |
|----------------------|-----------|--------|-------|
| Run No.              | Depth (m) | % Rec. | RQD % |
|                      |           |        |       |

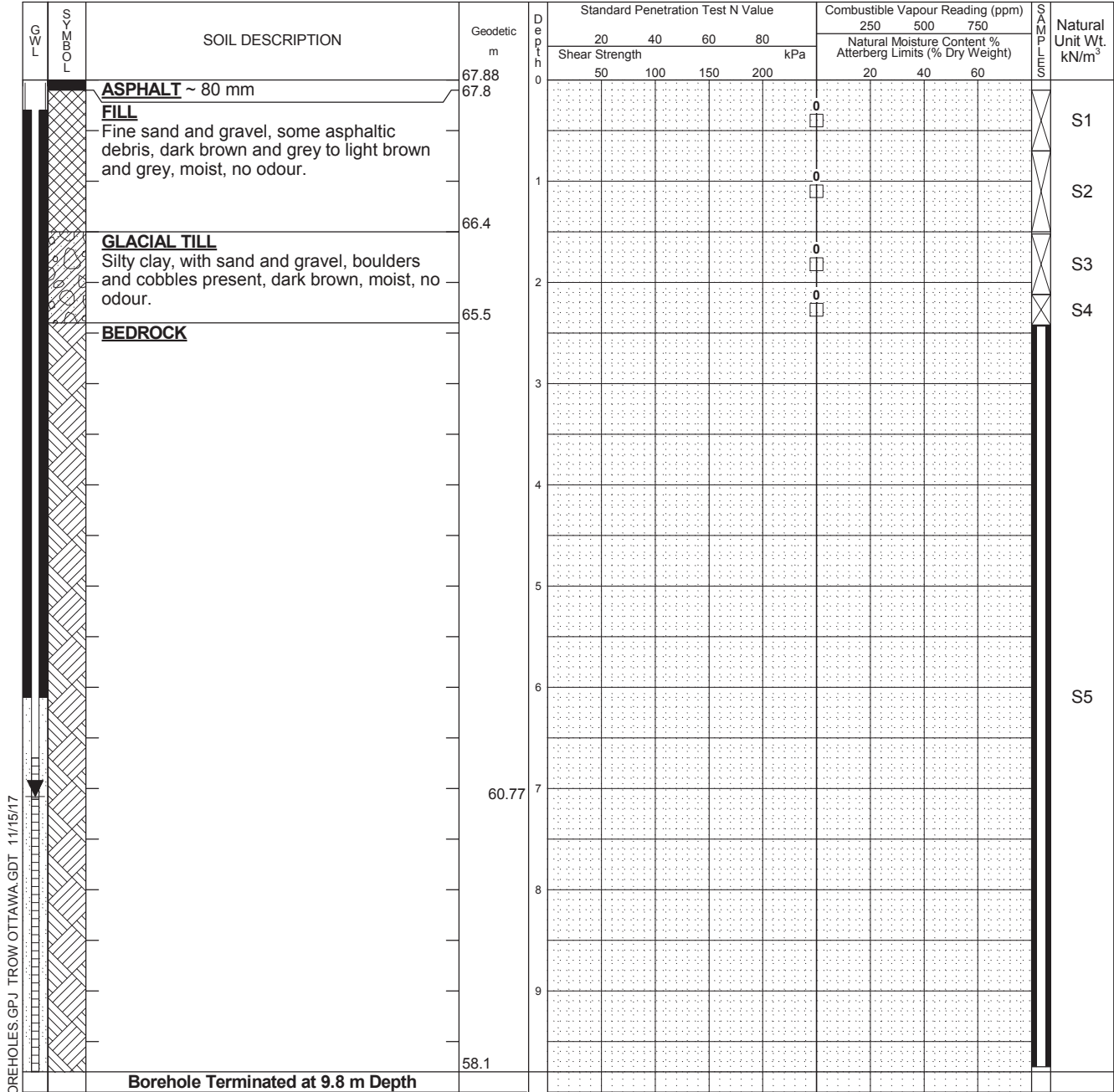
# Log of Borehole MW17-3



Project No: OTT-00241482-B0  
 Project: Supplemental Phase II ESA  
 Location: 255 Richmond Road, Ottawa, Ontario  
 Date Drilled: October 16th, 2017  
 Drill Type: Geoprobe 420M  
 Datum: Geodetic  
 Logged by: JO Checked by: MGM

Figure No. 5  
 Page. 1 of 1

Split Spoon Sample  Combustible Vapour Reading   
 Auger Sample  Natural Moisture Content   
 SPT (N) Value  Atterberg Limits   
 Dynamic Cone Test  Undrained Triaxial at % Strain at Failure   
 Shelby Tube  Shear Strength by Penetrometer Test   
 Shear Strength by Vane Test



NOTES:  
 1. Borehole data requires interpretation by exp. before use by others  
 2. A flushmount monitoring well with a 32 mm slotted standpipe was installed in the borehole upon completion.  
 3. Field work was supervised by an exp representative.  
 4. See Notes on Sample Descriptions  
 5. This Figure is to read with exp. Services Inc. report OTT-00241482-B0

| WATER LEVEL RECORDS |                 |                  |
|---------------------|-----------------|------------------|
| Elapsed Time        | Water Level (m) | Hole Open To (m) |
| 17 days             | 6.6             |                  |
| 24 days             | 7.1             |                  |

| CORE DRILLING RECORD |           |        |       |
|----------------------|-----------|--------|-------|
| Run No.              | Depth (m) | % Rec. | RQD % |
|                      |           |        |       |

LOG OF BOREHOLE LOGS OF BOREHOLES.GPJ TROW OTTAWA.GDT 11/15/17

# Log of Borehole MW17-4



Project No: OTT-00241482-B0

Figure No. 6

Project: Supplemental Phase II ESA

Page. 1 of 2

Location: 255 Richmond Road, Ottawa, Ontario

Date Drilled: October 16th, 2017

Split Spoon Sample

Combustible Vapour Reading

Drill Type: Geoprobe 420M

Auger Sample

Natural Moisture Content

SPT (N) Value

Atterberg Limits

Datum: Geodetic

Dynamic Cone Test

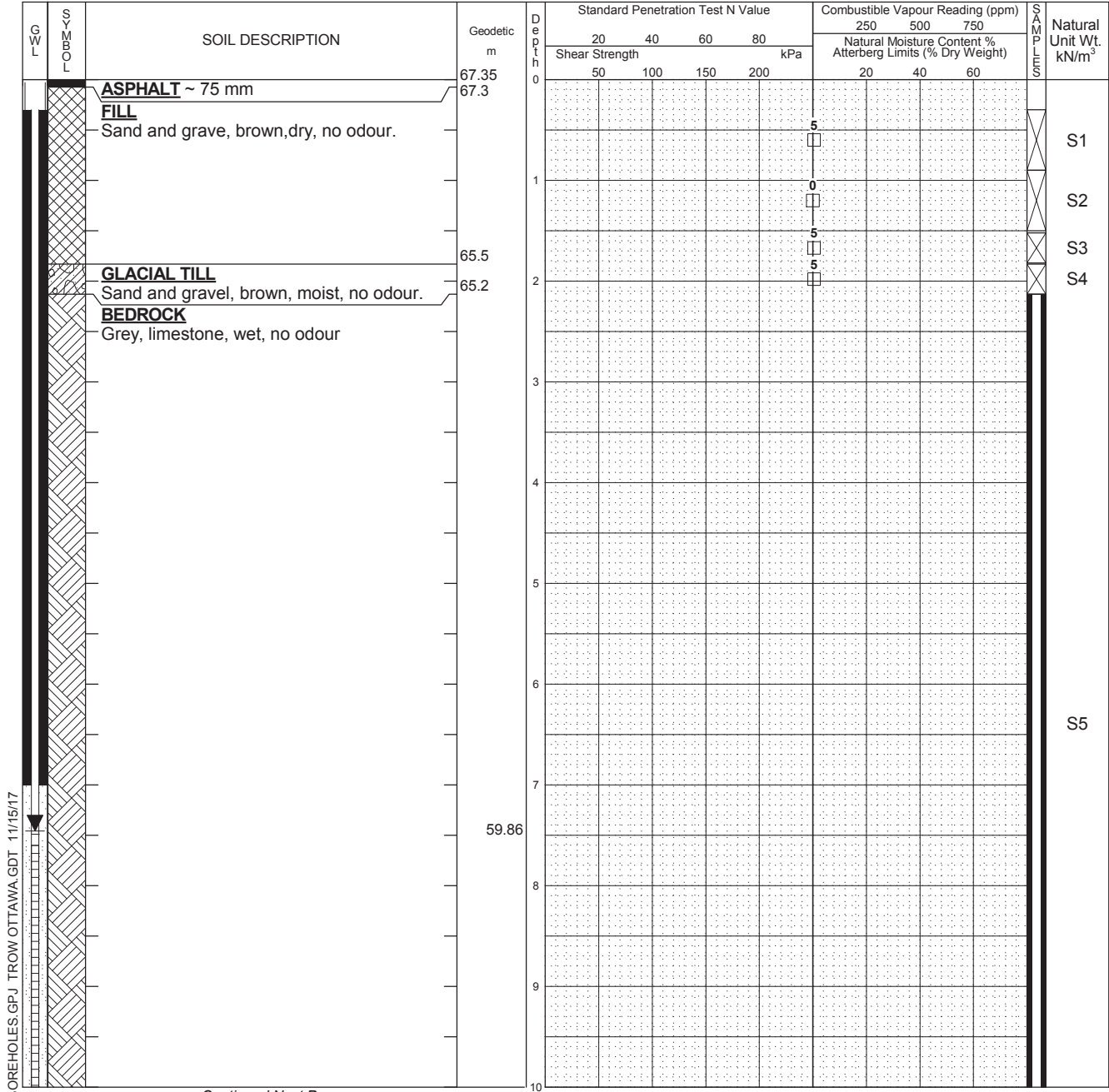
Undrained Triaxial at % Strain at Failure

Shelby Tube

Shear Strength by Penetrometer Test

Logged by: JO Checked by: MGM

Shear Strength by Vane Test



Continued Next Page

LOG OF BOREHOLE LOGS OF BOREHOLES.GPJ TROW OTTAWA.GDT 11/15/17

NOTES:  
 1. Borehole data requires interpretation by exp. before use by others  
 2. A flushmount monitoring well with a 32 mm slotted standpipe was installed in the borehole upon completion.  
 3. Field work was supervised by an exp representative.  
 4. See Notes on Sample Descriptions  
 5. This Figure is to read with exp. Services Inc. report OTT-00241482-B0

| WATER LEVEL RECORDS |                 |                  |
|---------------------|-----------------|------------------|
| Elapsed Time        | Water Level (m) | Hole Open To (m) |
| 17 days             | 6.8             |                  |
| 24 days             | 7.5             |                  |

| CORE DRILLING RECORD |           |        |       |
|----------------------|-----------|--------|-------|
| Run No.              | Depth (m) | % Rec. | RQD % |
|                      |           |        |       |

# Log of Borehole MW17-4



Project No: OTT-00241482-B0

Figure No. 6

Project: Supplemental Phase II ESA

Page. 2 of 2

| G<br>W<br>L | S<br>O<br>I<br>L<br>D<br>E<br>S<br>C<br>R<br>I<br>P<br>T<br>I<br>O<br>N | Geodetic<br>m | D<br>e<br>p<br>t<br>h<br>m | Standard Penetration Test N Value |     |     |     | Combustible Vapour Reading (ppm)                              |     |     | Natural<br>Unit Wt.<br>kN/m <sup>3</sup> |
|-------------|---|---------------|----------------------------|-----------------------------------|-----|-----|-----|---|-----|-----|--|
|             |   |               |                            | 20                                | 40  | 60  | 80  | 250   | 500 | 750 |  |
|             |   |               |                            | Shear Strength<br>kPa             |     |     |     | Natural Moisture Content %<br>Atterberg Limits (% Dry Weight) |     |     |  |
|             |   |               |                            | 50                                | 100 | 150 | 200 | 20  | 40  | 60  |  |
|             | <b>BEDROCK</b><br>Grey, limestone, wet, no odour ( <i>continued</i> )   | 57.35         | 10                         |                                   |     |     |     |   |     |     |  |
|             | <b>Borehole Terminated at 10.67 m Depth</b>                             | 56.7          |                            |                                   |     |     |     |   |     |     |  |

LOG OF BOREHOLE LOGS OF BOREHOLES.GPJ TROW OTTAWA.GDT 11/15/17

NOTES:  
 1. Borehole data requires interpretation by exp. before use by others  
 2. A flushmount monitoring well with a 32 mm slotted standpipe was installed in the borehole upon completion.  
 3. Field work was supervised by an exp representative.  
 4. See Notes on Sample Descriptions  
 5. This Figure is to read with exp. Services Inc. report OTT-00241482-B0

| WATER LEVEL RECORDS |                 |                  |
|---------------------|-----------------|------------------|
| Elapsed Time        | Water Level (m) | Hole Open To (m) |
| 17 days             | 6.8             |                  |
| 24 days             | 7.5             |                  |

| CORE DRILLING RECORD |           |        |       |
|----------------------|-----------|--------|-------|
| Run No.              | Depth (m) | % Rec. | RQD % |
|                      |           |        |       |



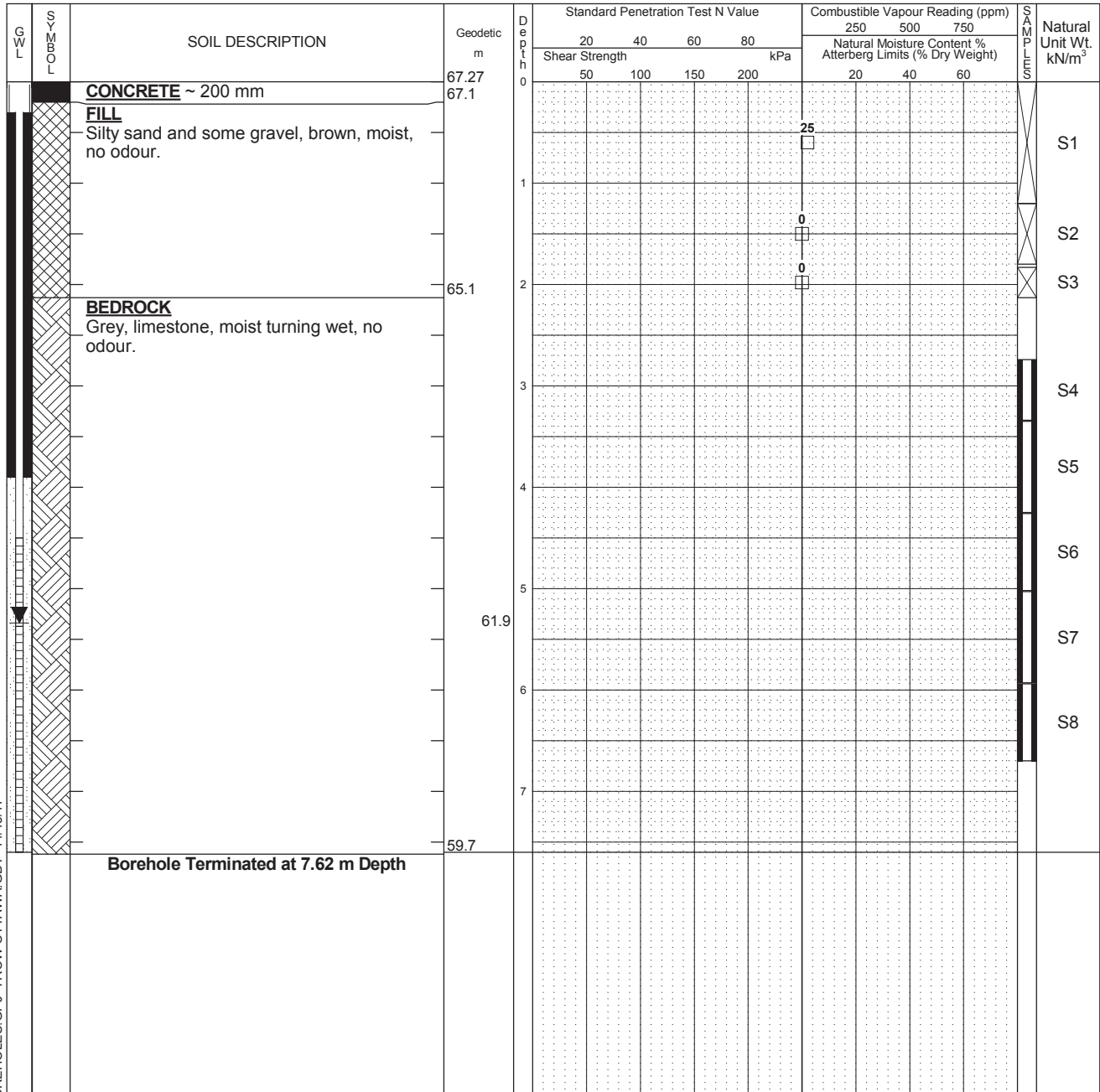
# Log of Borehole MW17-5



Project No: OTT-00241482-B0  
 Project: Supplemental Phase II ESA  
 Location: 255 Richmond Road, Ottawa, Ontario  
 Date Drilled: October 23rd, 2017  
 Drill Type: Geoprobe 420M  
 Datum: Geodetic  
 Logged by: JO Checked by: MGM

Figure No. 7  
 Page. 1 of 1

- Split Spoon Sample
- Auger Sample
- SPT (N) Value
- Dynamic Cone Test
- Shelby Tube
- Shear Strength by Vane Test
- Combustible Vapour Reading
- Natural Moisture Content
- Atterberg Limits
- Undrained Triaxial at % Strain at Failure
- Shear Strength by Penetrometer Test



LOG OF BOREHOLE LOGS OF BOREHOLES.GPJ TROW OTTAWA.GDT 11/15/17

NOTES:  
 1. Borehole data requires interpretation by exp. before use by others  
 2. A flushmount monitoring well with a 32 mm slotted standpipe was installed in the borehole upon completion.  
 3. Field work was supervised by an exp representative.  
 4. See Notes on Sample Descriptions  
 5. This Figure is to read with exp. Services Inc. report OTT-00241482-B0

| WATER LEVEL RECORDS |                 |                  |
|---------------------|-----------------|------------------|
| Elapsed Time        | Water Level (m) | Hole Open To (m) |
| 10 days             | 4.4             |                  |
| 17 days             | 5.4             |                  |

| CORE DRILLING RECORD |           |        |       |
|----------------------|-----------|--------|-------|
| Run No.              | Depth (m) | % Rec. | RQD % |
|                      |           |        |       |

# Log of Borehole MW17-6



Project No: OTT-00241482-B0  
 Project: Supplemental Phase II ESA  
 Location: 255 Richmond Road, Ottawa, Ontario  
 Date Drilled: October 23rd, 2017  
 Drill Type: Geoprobe 420M  
 Datum: Geodetic  
 Logged by: JO Checked by: MGM

Figure No. 8  
 Page. 1 of 1

- Split Spoon Sample
- Auger Sample
- SPT (N) Value
- Dynamic Cone Test
- Shelby Tube
- Shear Strength by Vane Test
- Combustible Vapour Reading
- Natural Moisture Content
- Atterberg Limits
- Undrained Triaxial at % Strain at Failure
- Shear Strength by Penetrometer Test

| GWL | SOIL LOG | SOIL DESCRIPTION   | Geodetic m | Depth | Standard Penetration Test N Value |  |  |  | Combustible Vapour Reading (ppm)                              |  |  | Natural Unit Wt. kN/m <sup>3</sup> |
|-----|----------|--|------------|-------|-----------------------------------|--|--|--|---|--|--|------------------------------------|
|     |          |  |            |       | 20 40 60 80                       |  |  |  | 250 500 750   |  |  |                                    |
|     |          |  |            |       | Shear Strength kPa                |  |  |  | Natural Moisture Content %<br>Atterberg Limits (% Dry Weight) |  |  |                                    |
|     |          | <b>CONCRETE ~ 200 mm</b>   | 67.27      | 0     |                                   |  |  |  |   |  |  |                                    |
|     |          | <b>FILL</b><br>Silty sand and some gravel, brown, moist, no odour. | 67.1       | 0     |                                   |  |  |  |   |  |  | S1                                 |
|     |          |  |            | 1     |                                   |  |  |  |   |  |  | S2                                 |
|     |          |  |            | 2     |                                   |  |  |  |   |  |  | S3                                 |
|     |          | <b>BEDROCK</b><br>Grey, limestone, moist turning wet, no odour.    | 65.1       | 2     |                                   |  |  |  |   |  |  | S4                                 |
|     |          |  |            | 3     |                                   |  |  |  |   |  |  | S5                                 |
|     |          |  |            | 4     |                                   |  |  |  |   |  |  | S6                                 |
|     |          |  |            | 5     |                                   |  |  |  |   |  |  | S7                                 |
|     |          |  | 61.84      | 6     |                                   |  |  |  |   |  |  | S8                                 |
|     |          |  |            | 7     |                                   |  |  |  |   |  |  | S9                                 |
|     |          | <b>Borehole Terminated at 7.82 m Depth</b>                         | 59.5       | 7     |                                   |  |  |  |   |  |  |                                    |

LOG OF BOREHOLE LOGS OF BOREHOLES.GPJ TROW OTTAWA.GDT 11/15/17

**NOTES:**  
 1. Borehole data requires interpretation by exp. before use by others  
 2. A flushmount monitoring well with a 32 mm slotted standpipe was installed in the borehole upon completion.  
 3. Field work was supervised by an exp representative.  
 4. See Notes on Sample Descriptions  
 5. This Figure is to read with exp. Services Inc. report OTT-00241482-B0

| WATER LEVEL RECORDS |                 |                  |
|---------------------|-----------------|------------------|
| Elapsed Time        | Water Level (m) | Hole Open To (m) |
| 9 days              | 4.6             |                  |
| 18 days             | 5.4             |                  |

| CORE DRILLING RECORD |           |        |       |
|----------------------|-----------|--------|-------|
| Run No.              | Depth (m) | % Rec. | RQD % |
|                      |           |        |       |

# Log of Borehole MW17-7



Project No: OTT-00241482-B0  
 Project: Supplemental Phase II ESA  
 Location: 255 Richmond Road, Ottawa, Ontario

Figure No. 9  
 Page. 1 of 1

Date Drilled: October 6th, 2017  
 Drill Type: Geoprobe 420M  
 Datum: Geodetic  
 Logged by: JO Checked by: MGM

Split Spoon Sample   
 Auger Sample   
 SPT (N) Value   
 Dynamic Cone Test   
 Shelby Tube   
 Shear Strength by Vane Test   
 Combustible Vapour Reading   
 Natural Moisture Content   
 Atterberg Limits   
 Undrained Triaxial at % Strain at Failure   
 Shear Strength by Penetrometer Test

| GWL | SOIL LOG | SOIL DESCRIPTION  | Geodetic m | Depth | Standard Penetration Test N Value |    |    |    | Combustible Vapour Reading (ppm) |     |     | Natural Unit Wt. kN/m <sup>3</sup> |    |
|-----|----------|---|------------|-------|-----------------------------------|----|----|----|----------------------------------|-----|-----|------------------------------------|----|
|     |          |   |            |       | Shear Strength kPa                |    |    |    | Natural Moisture Content %       |     |     |                                    |    |
|     |          |   |            |       | 20                                | 40 | 60 | 80 | 250                              | 500 | 750 |                                    |    |
|     |          | <b>FILL</b><br>Fine sand and gravel, some asphaltic debris, dark brown and grey to light brown and grey, moist, no odour. | 66.83      | 0     |                                   |    |    |    |                                  |     |     |                                    | S1 |
|     |          | <b>GLACIAL TILL</b><br>Silty sand, clay and gravel, brown, moist, no odour.   | 65.3       | 1     |                                   |    |    |    |                                  |     |     |                                    | S2 |
|     |          | <b>BEDROCK</b>  | 64.5       | 2     |                                   |    |    |    |                                  |     |     |                                    | S3 |
|     |          |   |            | 3     |                                   |    |    |    |                                  |     |     |                                    | S4 |
|     |          |   |            | 4     |                                   |    |    |    |                                  |     |     |                                    |    |
|     |          |   |            | 5     |                                   |    |    |    |                                  |     |     |                                    |    |
|     |          |   |            | 6     |                                   |    |    |    |                                  |     |     |                                    |    |
|     |          |   |            | 7     |                                   |    |    |    |                                  |     |     |                                    |    |
|     |          | <b>Borehole Terminated at 7.62 m Depth</b>  | 59.2       |       |                                   |    |    |    |                                  |     |     |                                    |    |

LOG OF BOREHOLE LOGS OF BOREHOLES.GPJ TROW OTTAWA.GDT 11/15/17

NOTES:  
 1. Borehole data requires interpretation by exp. before use by others  
 2. A flushmount monitoring well with a 32 mm slotted standpipe was installed in the borehole upon completion.  
 3. Field work was supervised by an exp representative.  
 4. See Notes on Sample Descriptions  
 5. This Figure is to read with exp. Services Inc. report OTT-00241482-B0

| WATER LEVEL RECORDS |                 |                  |
|---------------------|-----------------|------------------|
| Elapsed Time        | Water Level (m) | Hole Open To (m) |
| 17 days             | 3.8             |                  |
| 24 days             | 5.5             |                  |

| CORE DRILLING RECORD |           |        |       |
|----------------------|-----------|--------|-------|
| Run No.              | Depth (m) | % Rec. | RQD % |
|                      |           |        |       |

Certificate of Analysis

Report Date: 20-Aug-2021

Client: Paterson Group Consulting Engineers

Order Date: 17-Aug-2021

Client PO: 32696

Project Description: PG5946

|                     |                 |   |   |   |
|---------------------|-----------------|---|---|---|
| <b>Client ID:</b>   | BH1-21 SS4      | - | - | - |
| <b>Sample Date:</b> | 06-Aug-21 09:00 | - | - | - |
| <b>Sample ID:</b>   | 2134258-01      | - | - | - |
| <b>MDL/Units</b>    | Soil            | - | - | - |

**Physical Characteristics**

|          |              |      |   |   |   |
|----------|--------------|------|---|---|---|
| % Solids | 0.1 % by Wt. | 90.2 | - | - | - |
|----------|--------------|------|---|---|---|

**General Inorganics**

|             |               |      |   |   |   |
|-------------|---------------|------|---|---|---|
| pH          | 0.05 pH Units | 7.92 | - | - | - |
| Resistivity | 0.10 Ohm.m    | 55.0 | - | - | - |

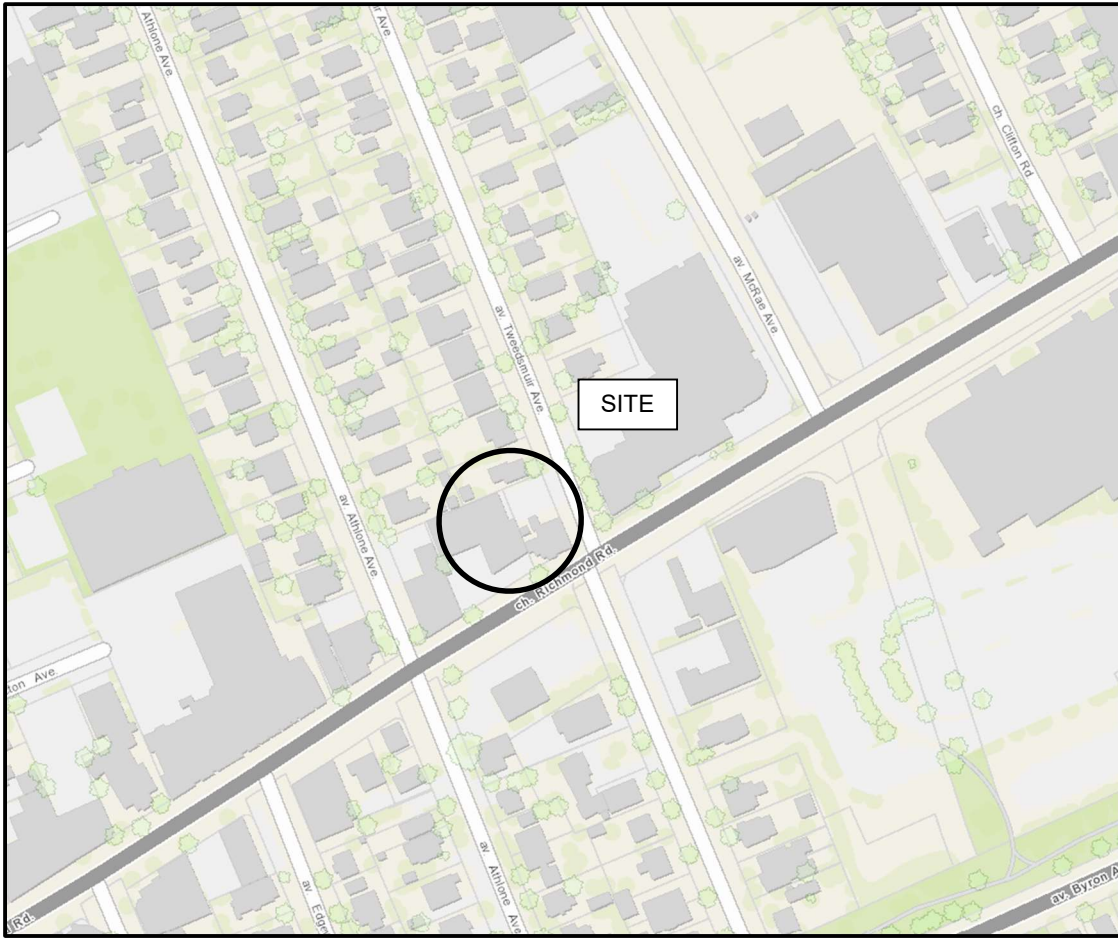
**Anions**

|          |            |    |   |   |   |
|----------|------------|----|---|---|---|
| Chloride | 5 ug/g dry | 32 | - | - | - |
| Sulphate | 5 ug/g dry | 34 | - | - | - |

# APPENDIX 2

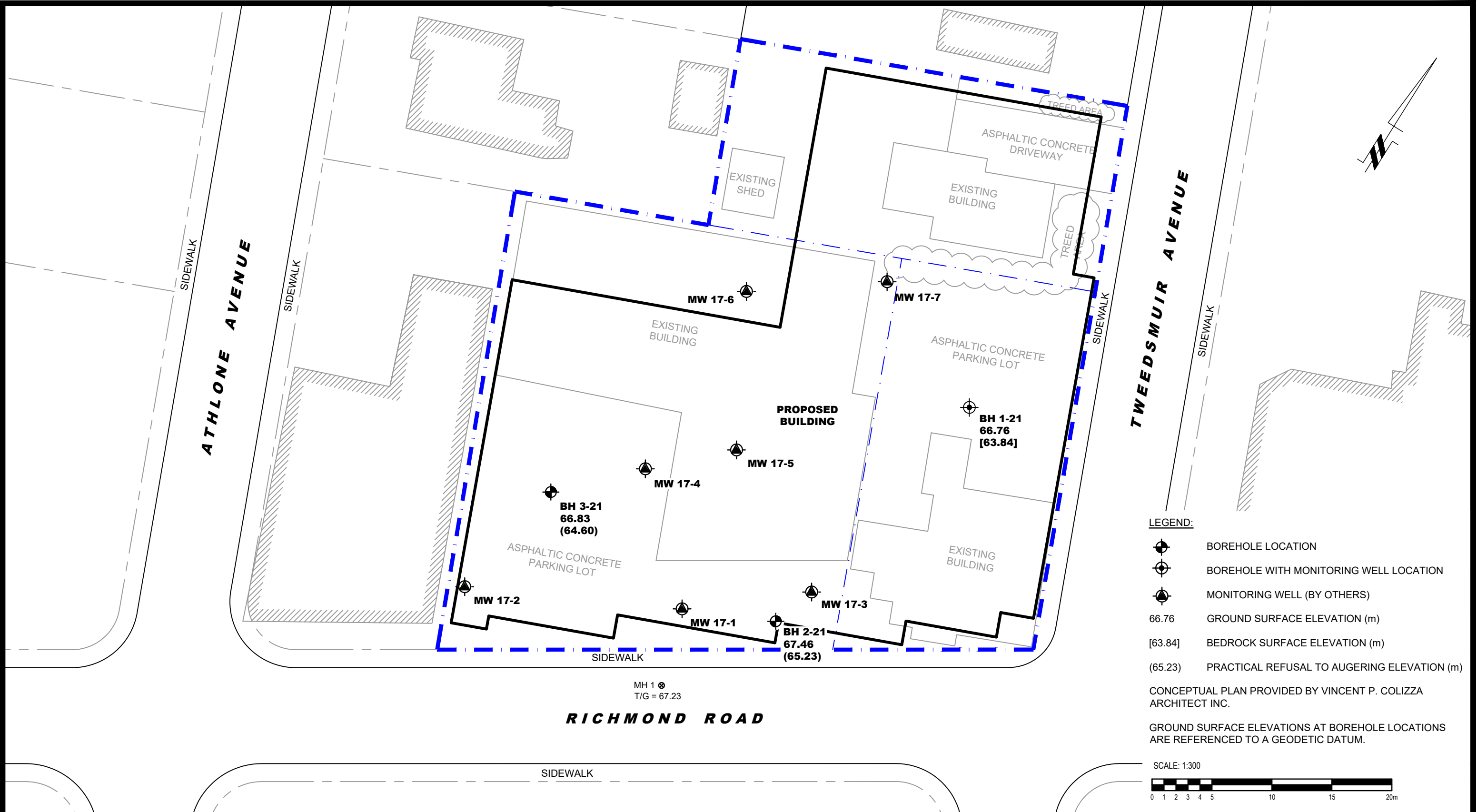
FIGURE 1 – KEY PLAN

DRAWING PG5946-1 – TEST HOLE LOCATION PLAN



**FIGURE 1**

**KEY PLAN**



**patersongroup**  
consulting engineers

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

| NO. | REVISIONS | DATE | INITIAL |
|-----|-----------|------|---------|
|     |           |      |         |
|     |           |      |         |
|     |           |      |         |

2828727 ONTARIO INC. C/O YOUNG STREET CAPITAL  
**GEOTECHNICAL INVESTIGATION  
 PROPOSED DEVELOPMENT**  
 OTTAWA, 249, 251, 255 RICHMOND ROAD & 372 TWEEDSMUIR AVENUE ONTARIO  
 Title: **TEST HOLE LOCATION PLAN**

Scale: 1:300  
 Drawn by: JM  
 Checked by: MS  
 Approved by: DJG

Date: 08/2021  
 Report No.: PG5946-1  
 Dwg. No.: **PG5946-1**  
 Revision No.: