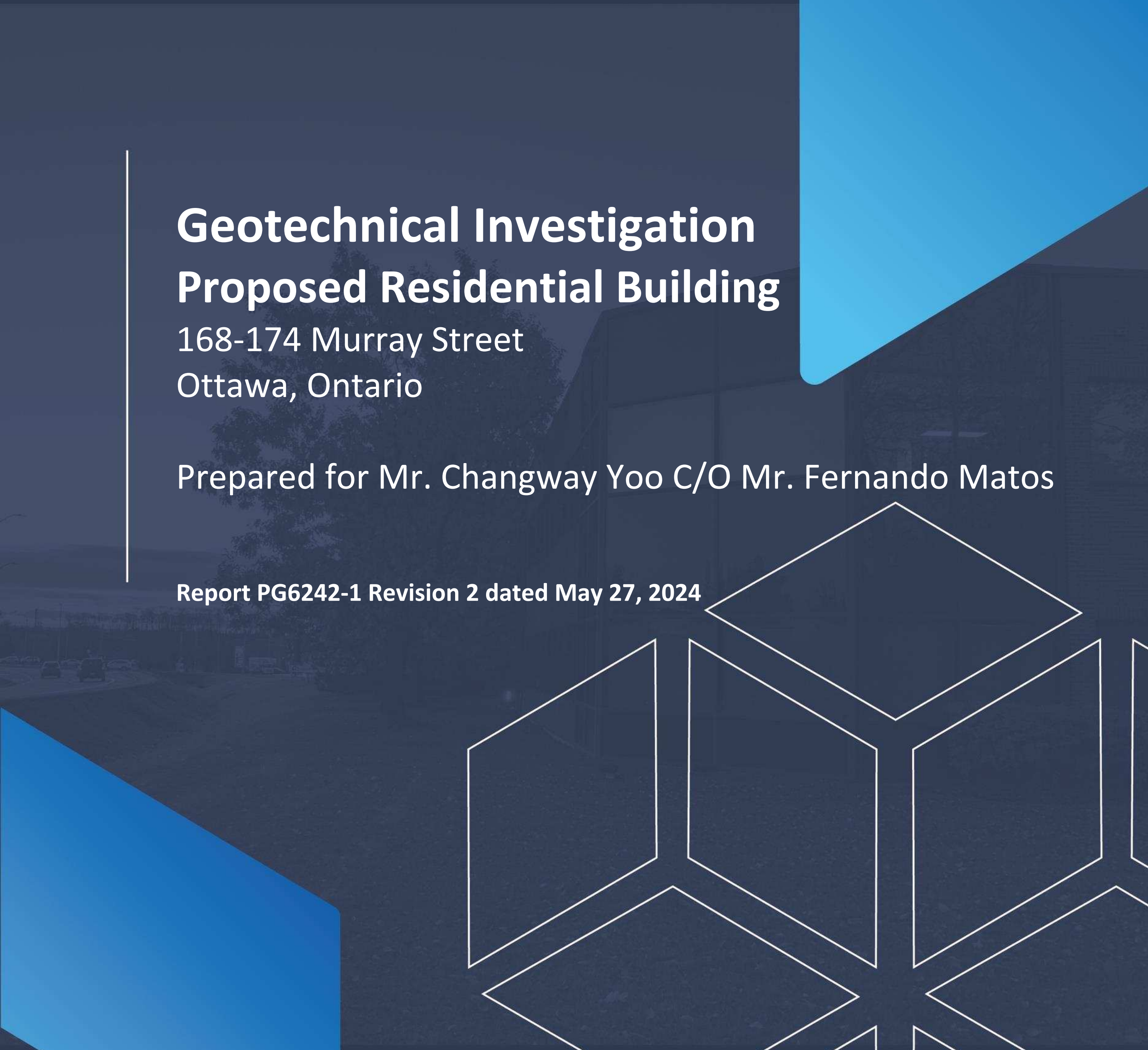

# Geotechnical Investigation
# Proposed Residential Building

168-174 Murray Street
Ottawa, Ontario

Prepared for Mr. Changway Yoo C/O Mr. Fernando Matos

**Report PG6242-1 Revision 2 dated May 27, 2024**

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# 1.0 Introduction

Paterson Group (Paterson) was commissioned by Mr. Changway Yoo to conduct a geotechnical investigation for the proposed residential development to be located at 168-174 Murray Street, Ottawa, Ontario (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 a borehole.

- ☐ Provide geotechnical recommendations pertaining to the design of the proposed development including construction considerations which may affect the design.

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

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

# 2.0 Proposed Development

Based on the available site drawings, it is understood that the proposed development will be comprised of a four-storey residential building, with one basement level. The building is expected to occupy a total footprint of 280 m$^2$. It is understood that the proposed new building will be connected to the existing heritage buildings located at 168 and 172 Murray Street. It is understood that the proposed Underside of Footings (USF) elevation of the building will be lower than the USF elevations of the neighbouring buildings at 168 and 172 Murray Street, thus the neighbouring buildings' foundations must be underpinned to the proposed USF elevation of the subject building. It is further expected that the project will include associated asphalt paved access lanes and landscape areas and the subject site will be municipally serviced.

# 3.0 Method of Investigation

## 3.1 Field Investigation

### Field Program

The field program for the investigation was carried out on June 09, 2022. At that time, one borehole was drilled to a maximum depth of 2.59 m. The borehole location was determined in a manner to provide general coverage of the subject site considering access and utilities. The location of the borehole is shown on Drawing PG6242-1 - Test Hole Location Plan included in Appendix 2.

The boreholes were drilled using a Geoprobe 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 driving a casing to the required depth at the selected location, 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 samples 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.

The subsurface conditions observed in the borehole 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

Borehole BH1-22 was fitted with a flexible polyethylene standpipe to allow groundwater level monitoring. The groundwater level readings were obtained after a suitable stabilization period subsequent to the completion of the field investigation.

Groundwater observations are discussed in Subsection 4.3 and 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 borehole location was selected by Paterson to provide general coverage of the proposed development, taking into consideration the existing site features and underground utilities. The test hole location and ground surface elevation at the borehole location were surveyed by Paterson using a handheld GPS and referenced to a geodetic datum. The location of the borehole and ground surface elevation at the borehole location are presented on Drawing PG6242-1 - Test Hole Location Plan in Appendix 2.

## 3.3 Laboratory Testing

Soil samples were recovered from the subject site and visually examined in our laboratory to review the results of the field logging. 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, one of which was collected from borehole BH 1 22. 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 currently occupied by 2 two-storey residential buildings and is bordered by low rise residential buildings to the south, east and west and Murray Street to the northwest. The existing ground surface across the site is generally level at approximate geodetic elevation 57.8 m.

## 4.2 Subsurface Profile

### Overburden

Generally, the subsurface profile encountered at the test hole location consists of topsoil overlying a brown silty sand fill material, some gravel and brick. A thin layer of topsoil was noted underlaying the sandy fill. A very stiff to stiff brown silty clay, and a compact native brown sandy silt layers were encountered at depths of 1.75 to 2.6 m. A glacial till deposit was encountered underlying the above-noted layers at approximate depths of 2.59 to 4.19 m. The glacial till was generally observed to consist of a compact to dense, grey sandy silt to silty sand, trace clay and gravel. The gravel content in the glacial till deposit was noted to increase with depth. Specific details of the subsurface profile at each test hole location are presented on the Soil Profile and Test Data sheets in Appendix 1.

### Bedrock

Practical refusal of the augers was encountered on the inferred bedrock surface at approximate depth of 4.19 m below the existing ground surface.

Based on available geological mapping, the subject site is located in an area where the bedrock consists of interbedded limestone and shale of the Verulam Formation with an overburden drift thickness of 5 to 10 m depth.

## 4.3 Groundwater

Groundwater levels were recorded at the piezometer location on June 29, 2022. The groundwater level reading is presented in the Soil Profile and Test Data sheets in Appendix 1. The measured groundwater level and observed depth of infiltration are presented in Table 1 below:

**Table 1 – Summary of Groundwater Levels**

| Borehole Number | Ground Surface Elevation (m) | Measured Groundwater Level | | Date Recorded |
|---|---|---|---|---|
| | | Depth (m) | Elevation (m) | |
| BH1-22 | 57.75 | 3.28 | 54.47 | June 29, 2022 |

**Note:** The ground surface elevation at the borehole location was surveyed using a handheld GPS using a geodetic datum.

It should be noted that surface water can become trapped within a backfilled borehole that can lead to higher than typical groundwater level observations.

The Long-term groundwater levels can also be estimated based on the observed colour, consistency, and moisture content of the recovered soil samples. Based on these observations, the long-term groundwater table can be estimated at **2.5 to 3.0 m** below ground surface. Groundwater levels are subject to seasonal fluctuations. Therefore, the groundwater levels could vary at the time of construction. However, groundwater levels are subject to seasonal fluctuations and therefore could differ at the time of construction.

# 5.0 Discussion

## 5.1 Geotechnical Assessment

From a geotechnical perspective, the subject site is suitable for the proposed development. The proposed building is expected to be founded on conventional footings placed on an undisturbed soil surface of silty clay, sandy silt, or glacial till.

A layer of fill and topsoil material was observed extending 1.75 m below existing grade. Fill material and topsoil/organic material should be removed from the building footprint.

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

## 5.2 Site Grading and Preparation

### Stripping Depth

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

Existing foundation walls and other construction debris should be entirely removed from within the proposed building perimeter. Under paved areas, existing construction remnants such as foundation walls should be excavated to a minimum of 1.0 m below finished grade.

### 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 to the site. 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 Terraxx.

## 5.3 Foundation Design

### Bearing Resistance Value (Conventional Shallow Foundation)

Using continuously applied loads, The bearing resistance values at Serviceability Limit States (SLS) and Ultimate Limit States (ULS) are summarized in Table 2.

**Table 2 - Bearing Resistance Values**

| Bearing Surface | Bearing Resistance Values at SLS (kPa) | Factored Bearing Resistance Value at ULS (kPa) |
|---|---|---|
| Very Stiff to Stiff Silty Clay* | 100 | 150 |
| Compact Sandy Silt | 100 | 200 |
| Compact to Dense Glacial Till | 100 | 200 |
| Engineered Fill | 100 | 200 |

**Note:** A geotechnical resistance factor of 0.5 was applied to the above noted bearing resistance values at ULS.

* For footings founded on silty clay, strip footings, up to 3 m wide, and pad footings, up to 5 m wide can be used for design.

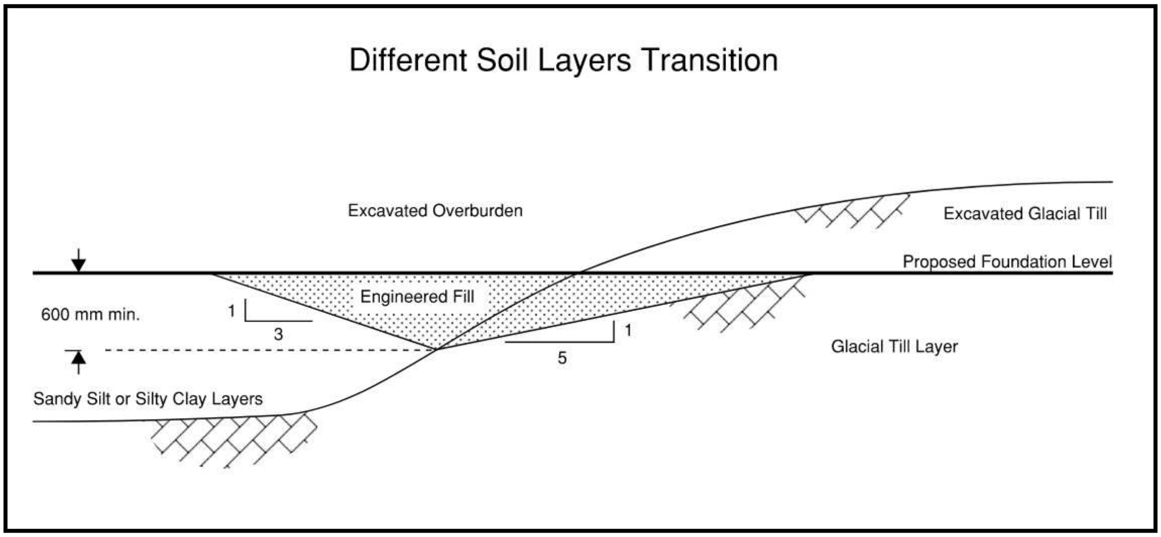
An undisturbed soil bearing surface consists of one from which all topsoil and deleterious materials, such as loose, frozen, or disturbed soil, have been removed, in the dry, prior to the placement of concrete footings.

To allow the underside of footing to remain at the current design elevations and using glacial till bearing resistance values, the footings which are presently proposed within the sandy silt or silty clay layers can be extended down to an adequate stiff silty clay bearing surface. This can be completed by excavating a zero-entry, near vertical trench extending to an undisturbed, compact to dense glacial till bearing surface and backfilled with a minimum **15 MPa** lean concrete up to the design underside of footing elevation.

The sub-excavation required to extend the footings down to the undisturbed, glacial till bearing surface will likely require large quantities of material to be removed due to collapsing of the sandy silt excavation sidewalls. Depending on the differences in elevation of the proposed footings, the proximity of adjacent footings and depth of sub-excavation required, undermining may occur. Refer to the following section for recommendations on lateral support. The bearing surfaces for all footings should be reviewed in the field by Paterson to determine the extent of sub-excavation required at the time of construction.

## Different Soil Layers Transition

Where a building is founded partly on glacial till and partly on silty clay or sandy silt, it is recommended to provide different soil layers transition to reduce the risks of excessive differential settlements. This transition involves profiling the glacial till with a slope of 1.0 vertical to 5.0 horizontal, while the silty clay or sandy silt will be profiled with a slope of 1.0 vertical to 3.0 horizontal, reaching a depth of 600 mm at their point of contact relative to the projected foundation level.



The excavation should be filled with clean imported granular fill, such as Ontario Provincial Standard Specifications (OPSS) Granular A or Granular B Type II placed in maximum 300 mm thick loose lifts and compacted to a minimum of 98% of the standard Proctor maximum dry density (SPMDD). The figure below illustrates a cross-section of a Bedrock/soil transition.

## Settlement

Footings bearing on an undisturbed soil bearing surface and designed using the bearing resistance values provided above will be subjected to potential post-construction total and differential settlements of 25 and 20 mm, respectively.

### Lateral Support

The bearing medium under footing-supported structures is required to be provided with adequate lateral support with respect to excavations and different foundation levels. Adequate lateral support is provided to the in-situ bearing medium soils above the groundwater table when a plane extending down and out from the bottom edge of the footing at a minimum of 1.5H:1V passes only through in situ soil of the same or higher capacity as the bearing medium soil.

## 5.4 Design for Earthquakes

The site class for the seismic site response can be taken as a **Class C** for foundations constructed on the subject site. If a higher seismic site class is required (Class A or Class B), a site-specific seismic shear wave velocity test may be completed to accurately determine the applicable seismic site classification for foundation design of the proposed building, as presented in Table 4.1.8.4.A of the Ontario Building Code (OBC) 2012.

The soils underlying the subject site are not susceptible to liquefaction. Reference should be made to the latest revision of the 2012 OBC for a full discussion of the earthquake design requirements.

## 5.5 Basement Floor Slab

With the removal of all topsoil and deleterious fill containing significant amounts of organic material within the footprint of the proposed building, the existing native material will, reviewed and approved by Paterson, will be considered an acceptable subgrade upon which to commence backfilling for basement slab/floor slab construction. Where the native subgrade is observed to be in a weak state of compaction, proof-rolling by a suitably sized vibratory roller should be completed and approved prior to backfilling.

It is recommended that the upper 200 mm of sub-slab fill consists of 19 mm clear crushed stone. All backfill material within the footprint of the proposed building should be placed in a maximum of 300 mm thick loose layers and compacted to at least 95% of its SPMDD.

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

## 5.6 Basement Wall

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

### 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$^3$)
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:

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

$\gamma$ = unit weight of fill of the applicable retained soil (kN/m$^3$)
H = height of the wall (m)
g = gravity, 9.81 m/s$^2$

The peak ground acceleration, ($a_{max}$), for the Ottawa area, is 0.32 g according to the 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 $P_o = 0.5\ K_o\ \gamma\ H^2$, where $K_o = 0.5$ 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 pressures calculated are unfactored. For the ULS case, the earth loads should be factored as live loads, as per the OBC 2012.

## 5.7 Pavement Design

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

**Table 3 - Recommended Pavement Structure - Car-Only Parking Areas**

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

**Table 4 - Recommended Pavement Structure - Access Lanes**

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

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

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

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

# 6.0 Design and Construction Precautions

## 6.1 Foundation Drainage and Backfill

### Foundation Drainage

It is recommended that a perimeter foundation drainage system be provided for the proposed building. The system should consist of a 150 mm diameter perforated corrugated plastic pipe wrapped in a geosock, surrounded on all sides by 150 mm of 10 mm clear crushed stone, placed at the footing level around the exterior perimeter of the structure. The clear stone layer should be wrapped in a non-woven geotextile. The pipe should have a positive outlet, such as a gravity connection to a storm sewer or sump pump.

### Foundation Backfill

Above the bedrock surface, 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 Miradrain G100N or 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.

## 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 alone, or a combination of soil cover in conjunction with foundation insulation should be provided in this regard.

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

## 6.3 Excavation Side Slopes

### Temporary Side Slopes

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

The excavation side slopes above the groundwater level extending to a maximum depth of 3 m should be cut back at 1H:1V or flatter. The flatter slope is required for excavation below groundwater level. The subsurface soil is considered to be mainly a Type 2 and 3 soil according to the Occupational Health and Safety Act and Regulations for Construction Projects. Excavated soil should not be stockpiled directly at the top of excavations and heavy equipment should maintain safe working distance from the excavation sides.

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

### Impacts on Neighbouring Properties

Due to the proximity of the neighbouring structures, sufficient setback from the property line to excavate side slopes at a 1H:1V or flatter slope to a maximum height of 3 m, may not be available at all sides of the excavation. Temporary shoring system or underpinning of the neighbouring building foundations will have to constructed/completed around different sections of the site, in order to complete the excavation without causing any significant impacts to the neighbouring buildings. Refer to Paterson Group memorandum PG6242-MEMO.02-Grotechnical Excavation Review and Shoring Design, dated November 21, 2023, for detailed recommendations on safely completing the excavation.

### 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. A temporary shoring system has been designed by Paterson to complete the proposed excavation.

The following parameters have been used to calculate the earth pressures acting on the shoring system.

**Table 5 – Soil Parameters for Calculating Earth Pressures Acting on Shoring System**

| Parameter | Value |
|---|---|
| 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$^3$ | 20 |
| Submerged Unit Weight ($\gamma'$), kN/m$^3$ | 13 |

Refer to Paterson Group memorandum PG6242-MEMO.02-Grotechnical Excavation Review and Shoring Design, dated November 21, 2023, for detailed recommendations on proposed shoring system.

### Underpinning of Adjacent Structures

If the footings of the proposed building are anticipated to extend below the underside of footing (USF) elevations and within the lateral support zone of adjacent building foundations at 164, 168 and 172 Murray Street. Thus, underpinning of these structures may be required. The depth of the underpinning will be dependent on the depth of the neighbouring foundations relative to the foundation depths of the proposed building at the subject site. Refer to Paterson Group memorandum PG6242-MEMO.02-Grotechnical Excavation Review and Shoring Design, dated November 21, 2023, for general underpinning recommendations.

## 6.4 Pipe Bedding and Backfill

A minimum of 300 mm of OPSS Granular A should be placed for bedding for sewer or water pipes when placed on bedrock subgrade.  The bedding should extend to the spring line of the pipe. Cover material, from the spring line to a minimum of 300 mm above the pipe obvert should consist of OPSS Granular A (concrete or PSM PVC pipes) or sand (concrete pipe). The bedding and cover materials should be placed in maximum 225 mm thick lifts compacted to a minimum of 95% of the SPMDD.

Where hard surface areas are considered above the trench backfill, the trench backfill material within the frost zone (about 1.8 m below finished grade) should match the soils exposed at the trench walls to reduce the potential differential frost heaving. The trench backfill should be placed in maximum 300 mm thick loose lifts and compacted to a minimum of 95% of the SPMDD.

## 6.5 Groundwater Control

It is anticipated that groundwater infiltration into the excavations should be controllable using open sumps. 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.

### Groundwater Control for Building Construction

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

Our recommendations for the proposed building’s long-term groundwater control are presented in Subsection 6.1. Any groundwater encountered along the building’s perimeter or sub-slab drainage system will be directed to the proposed building’s cistern/sump pit. Provided the proposed groundwater infiltration control system is properly implemented and approved by the geotechnical consultant at the time of construction, it is expected that groundwater flow will be low (i.e.- less than 10,000 L/day) 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. It is anticipated that the groundwater flow will be controllable using conventional open sumps.

## 6.6 Winter Construction

Precautions must be taken if winter construction is considered for this project. In the event of construction during below zero temperatures, the founding stratum should be protected from freezing temperatures by the installation of straw, propane heaters and tarpaulins or other suitable means. 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 difficult activities to complete during freezing conditions without introducing frost in the subgrade or in the excavation walls and bottoms. Precautions should be considered if such activities are to be completed during freezing conditions. Additional information could be provided, if required.

## 6.7 Corrosion Potential and Sulphate

The 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 slightly aggressive corrosive environment.

# 7.0 Recommendations

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

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

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

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

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

☐ Review of the proposed groundwater infiltration control system, if applicable.

☐ Observation of all subgrades prior to backfilling.

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

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

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

All excess soil must be handled as per ***Ontario Regulation 406/19: On-Site and Excess Soil Management*****.**

# 8.0 Statement of Limitations

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

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

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

**Paterson Group Inc.**

LICENSED PROFESSIONAL ENGINEER
May 27, 2024
J. R. VILLENEUVE
100504344
PROVINCE OF ONTARIO

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**Report Distribution:**

❏ Mr. Changway Yoo C/O Mr. Fernando Matos (Email Copy)
❏ Paterson Group (1 Copy)

# APPENDIX 1

SOIL PROFILE AND TEST DATA SHEETS

SYMBOLS AND TERMS

ANALYTICAL TESTING RESULTS

**patersongroup** Consulting Engineers

9 Auriga Drive, Ottawa, Ontario K2E 7T9

# SOIL PROFILE AND TEST DATA

**Geotechnical Investigation**
**Prop. Residential Development - 168-174 Murray St.**
**Ottawa, Ontario**

**DATUM** Geodetic

**REMARKS**

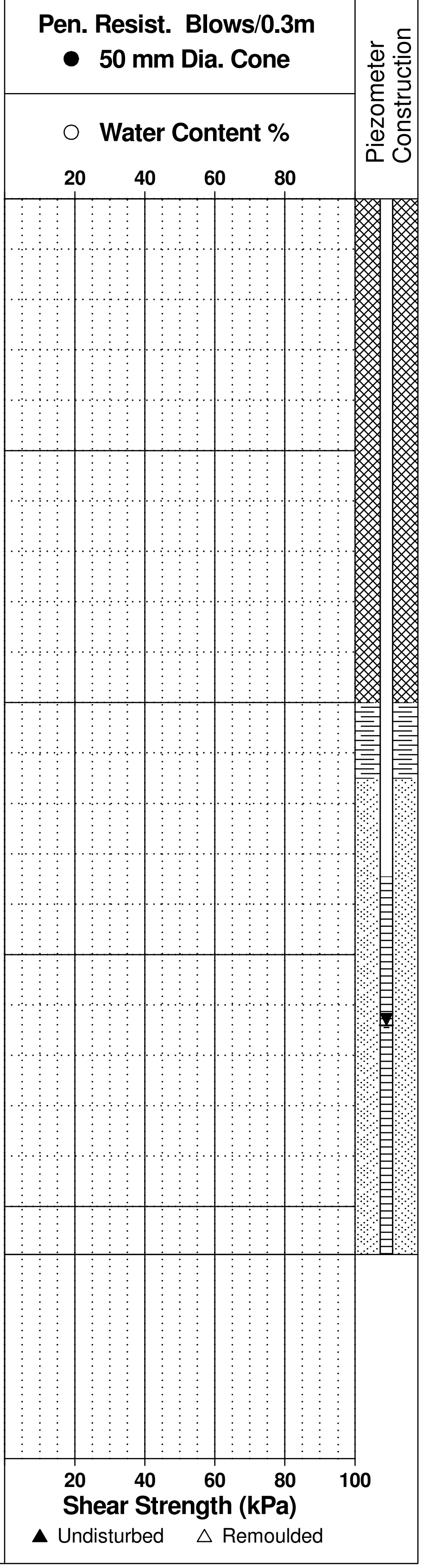
**BORINGS BY** CME-55 Low Clearance Drill

**DATE** June 9, 2022

**FILE NO.** **PG6242**

**HOLE NO.** **BH 1-22**

| SOIL DESCRIPTION | SAMPLE TYPE | SAMPLE NUMBER | SAMPLE % RECOVERY | SAMPLE N VALUE or RQD | DEPTH (m) | ELEV. (m) |
|---|---|---|---|---|---|---|
| **GROUND SURFACE** | | | | | 0 | 57.75 |
| **TOPSOIL** 0.15 | | | | | | |
| **FILL:** Brown silty sand, some gravel, trace topsoil and brick | AU | 1 | | | | |
| | SS | 2 | 25 | 7 | 1 | 56.75 |
| 1.52 | | | | | | |
| **TOPSOIL** 1.75 | | | | | | |
| Very stiff to stiff, brown **SILTY CLAY,** some sand | SS | 3 | 42 | 8 | 2 | 55.75 |
| 2.21 | | | | | | |
| Compact, brown **SANDY SILT** 2.59 | SS | 4 | 58 | 24 | | |
| **GLACIAL TILL:** Compact to dense, grey sandy silt, trace clay and gravel<br>- gravel content increasing with depth | | | | | 3 | 54.75 |
| | SS | 5 | 50 | 33 | | |
| | SS | 6 | 40 | 50+ | 4 | 53.75 |
| 4.19 | | | | | | |
| End of Borehole<br>Practical refusal to augering at 4.19m depth.<br>(GWL @ 3.28m - June 29, 2022) | | | | | | |



# 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 |

## SOIL DESCRIPTION (continued)

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

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

## ROCK DESCRIPTION

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

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

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

## SAMPLE TYPES

| | | |
|---|---|---|
| SS | - | Split spoon sample (obtained in conjunction with the performing of the Standard Penetration Test (SPT)) |
| TW | - | Thin wall tube or Shelby tube |
| PS | - | Piston sample |
| AU | - | Auger sample or bulk sample |
| WS | - | Wash sample |
| RC | - | Rock core sample (Core bit size AXT, BXL, etc.). Rock core samples are obtained with the use of standard diamond drilling bits. |

## SYMBOLS AND TERMS (continued)

## GRAIN SIZE DISTRIBUTION

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

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

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

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

## CONSOLIDATION TEST

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

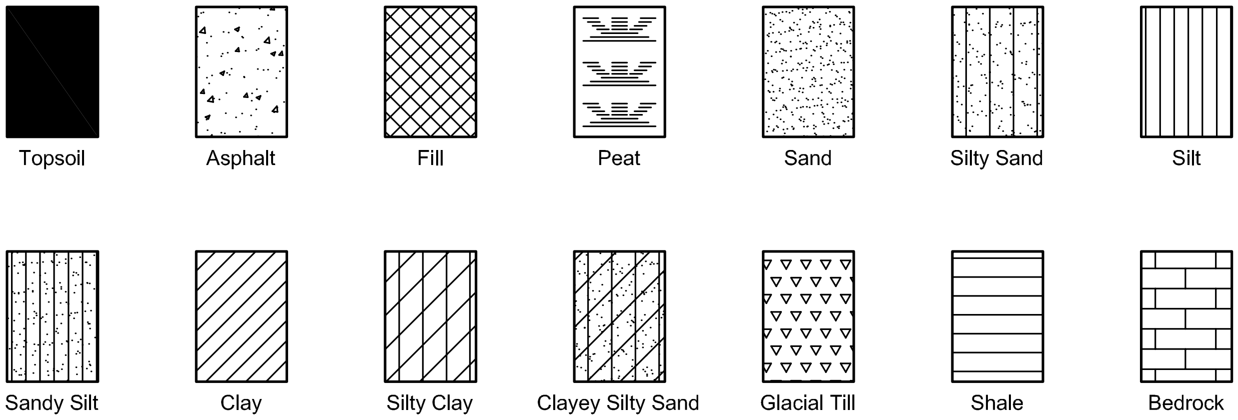
OC Ratio Overconsolidaton ratio = $p'_c / p'_o$
Void Ratio Initial sample void ratio = volume of voids / volume of solids
Wo - Initial water content (at start of consolidation test)

## PERMEABILITY TEST

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

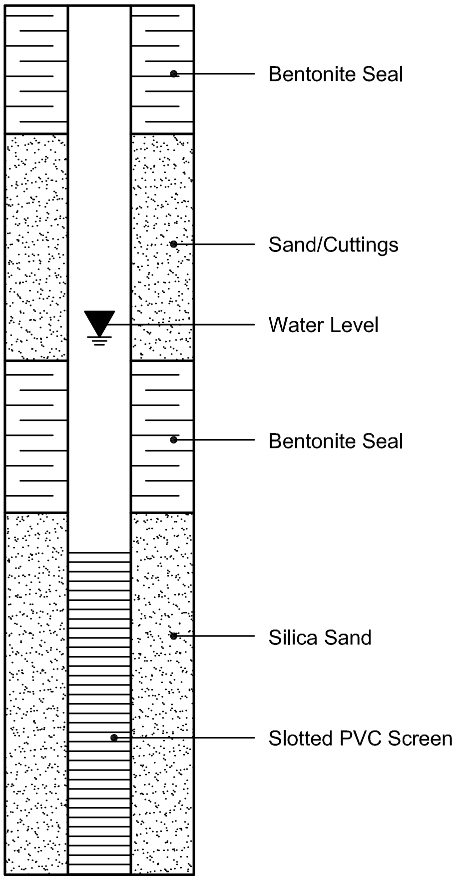
# SYMBOLS AND TERMS (continued)

## STRATA PLOT

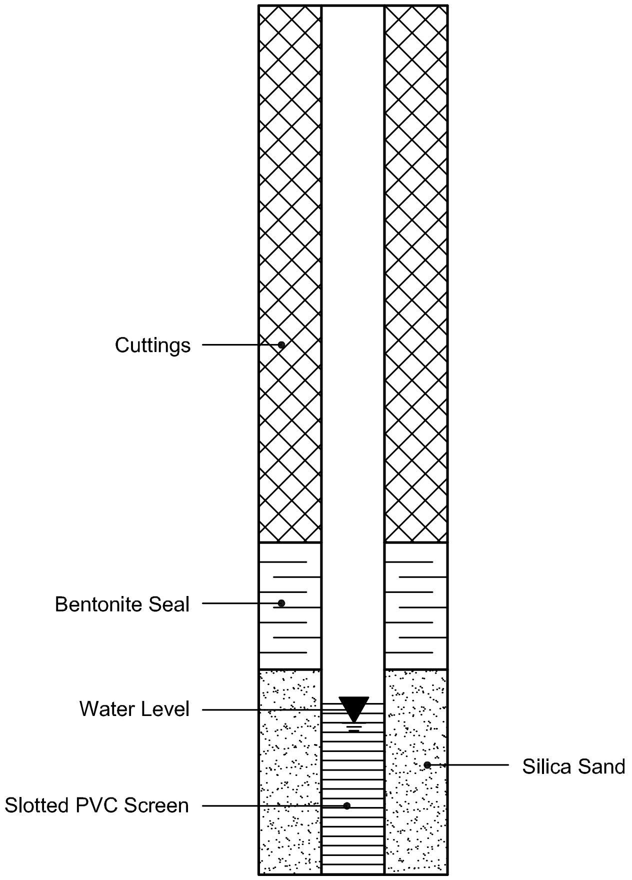


## MONITORING WELL AND PIEZOMETER CONSTRUCTION

### MONITORING WELL CONSTRUCTION



### PIEZOMETER CONSTRUCTION



Certificate of Analysis

**Client: Paterson Group Consulting Engineers**

**Client PO: 54938**

Report Date: 17-Jun-2022

Order Date: 13-Jun-2022

**Project Description: PG6242**

| | | | | | |
|---|---|---|---|---|---|
| | **Client ID:** | BH1-22-SS3-BO1 | - | - | - |
| | **Sample Date:** | 09-Jun-22 09:00 | - | - | - |
| | **Sample ID:** | 2225111-01 | - | - | - |
| | **MDL/Units** | Soil | - | - | - |
| **Physical Characteristics** | | | | | |
| % Solids | 0.1 % by Wt. | 79.1 | - | - | - |
| **General Inorganics** | | | | | |
| pH | 0.05 pH Units | 8.08 | - | - | - |
| Resistivity | 0.10 Ohm.m | 18.3 | - | - | - |
| **Anions** | | | | | |
| Chloride | 5 ug/g dry | 38 | - | - | - |
| Sulphate | 5 ug/g dry | 195 | - | - | - |

# APPENDIX 2

FIGURE 1 - KEY PLAN

DRAWING PG6242-1 - TEST HOLE LOCATION PLAN

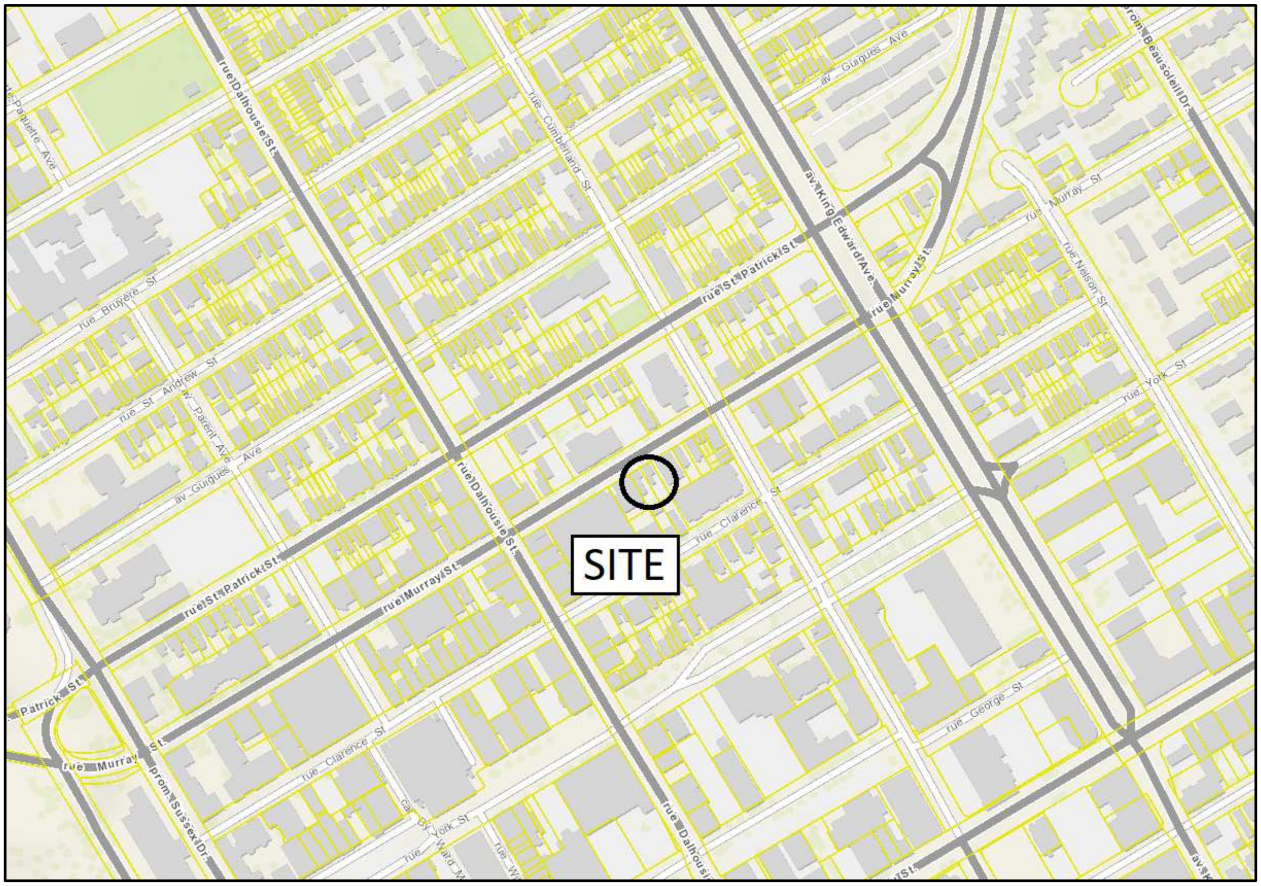
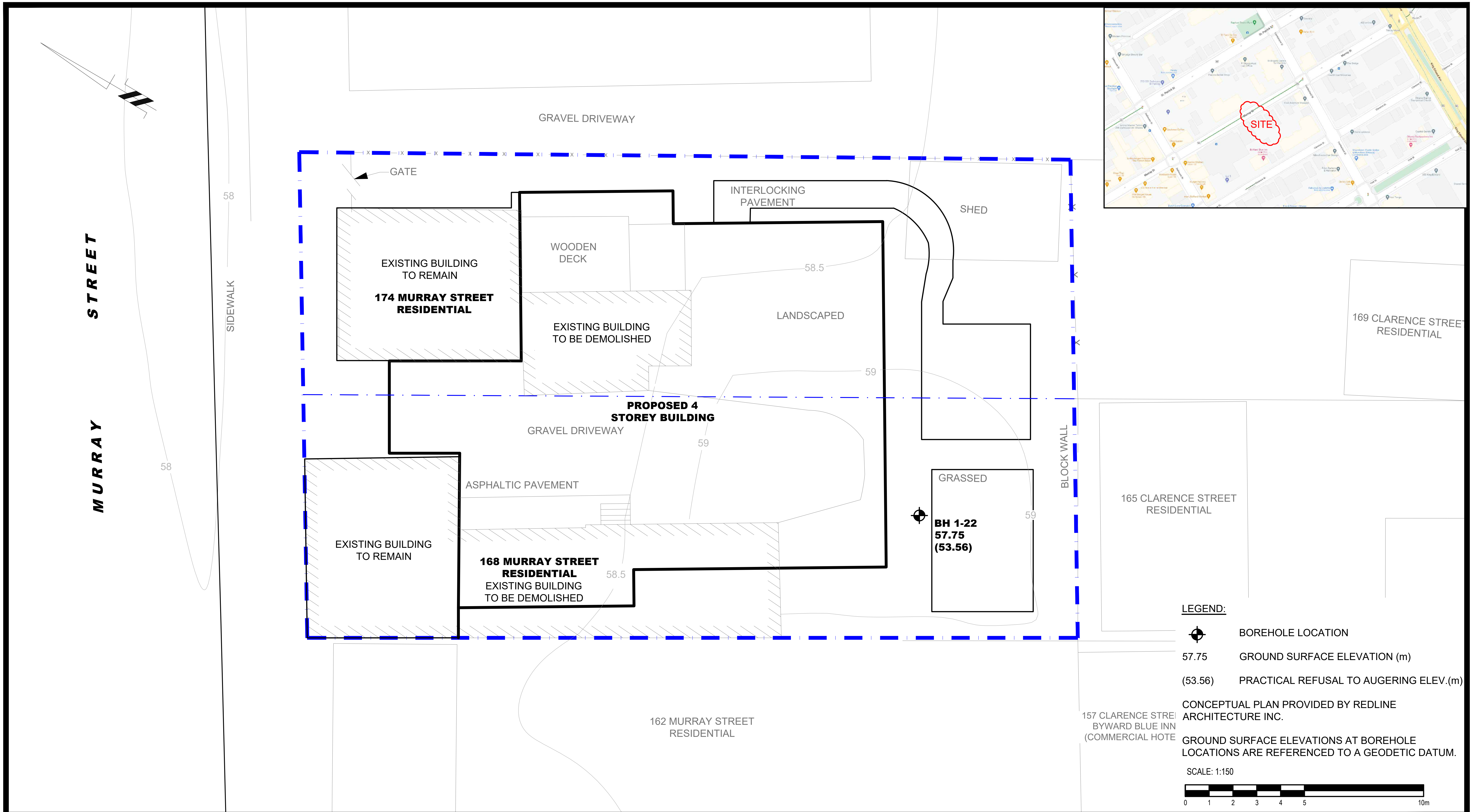


**FIGURE 1**

**KEY PLAN**



LEGEND:

| | |
|---|---|
| ⌖ | BOREHOLE LOCATION |
| 57.75 | GROUND SURFACE ELEVATION (m) |
| (53.56) | PRACTICAL REFUSAL TO AUGERING ELEV.(m) |

CONCEPTUAL PLAN PROVIDED BY REDLINE ARCHITECTURE INC.

GROUND SURFACE ELEVATIONS AT BOREHOLE LOCATIONS ARE REFERENCED TO A GEODETIC DATUM.

SCALE: 1:150

0 1 2 3 4 5 10m

**PATERSON GROUP**

9 AURIGA DRIVE
OTTAWA, ON
K2E 7T9
TEL: (613) 226-7381

| NO. | REVISIONS | DATE | INITIAL |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |
| 1 | ADDED CONCEPTUAL PLAN | 16/05/2024 | YZ |

MR. CHANGWAY YOO C/O MR. FERNANDO MATOS

GEOTECHNICAL INVESTIGATION
PROPOSED RESIDENTIAL DEVELOPMENT
168-174 MURRAY STREET

OTTAWA, ONTARIO

Title:

# TEST HOLE LOCATION PLAN

Scale: 1:150
Date: 06/2022
Drawn by: GK
Report No.: PG6242-1
Checked by: YZ
Dwg. No.: PG6242-1
Approved by: JV
Revision No.:

p:\autocad drawings\geotechnical\pg62xx\pg6242\pg6242-1 test hole location plan (rev.01).dwg

11x17