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Geotechnical Engineering
Environmental Engineering
Hydrogeology
Materials Testing
Building Science
Rural Development Design
Temporary Shoring Design
Retaining Wall Design
Noise and Vibration Studies

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April 23, 2024
File: PG7051-LET.01

Mr. Farzin Fararooni
10 Garrison Street
Ottawa, Ontario
K1Y 2T8

Attention: **Mr. Farzin Fararooni**

Subject: **Geotechnical Investigation**
Proposed Low-Rise Apartment Building
10 Garrison Street – Ottawa, Ontario

Dear Sir,

Further to your request and authorization, Paterson Group (Paterson) completed a geotechnical investigation for the proposed low-rise apartment building to be located at the aforementioned site. This report presents our findings and recommendations from a geotechnical perspective for the proposed project.

Based on the available drawings, it is understood that the proposed low-rise apartment building will consist of a three-storey building with one basement level. Associated walkways, landscaped areas are also anticipated as part of the development. The development is anticipated to be municipally serviced.

Paterson completed a geotechnical investigation to determine the subsoil and groundwater conditions at this site by means of test holes and provide geotechnical recommendations pertaining to design of the proposed development including construction considerations which may affect the design at the subject site.

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.

1.0 Field Investigation

The field program for the current geotechnical investigation was carried out on March 25, 2024. At that time, a total of two (2) hand augers were excavated to a maximum depth of 1.3 m below the existing ground surface using a 2-m long stainless-steel hand auger. It should be noted that one hand auger was advanced three times to confirm the refusal depth. All fieldwork was conducted under the full-time supervision of Paterson personnel under the direction of a senior engineer.

It should be noted that Paterson reviewed historical borehole information from sites drilled within the immediate surrounding area to compare the findings of this report with the existing data.

The test hole locations were distributed to provide general coverage of the site, taking into consideration existing site features and utilities. The test hole locations and ground surface elevation at each test hole location were surveyed by Paterson using a high-precision 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 PG7051-1 – Test Hole Location Plan, attached to the current report.

2.0 Field Observations

Surface Conditions

The subject site is currently occupied by a single-story residential building with one basement level, with an associated driveway and garage. A small stone block retaining wall, large mature trees, landscaped areas and a concrete patio are also present throughout the subject site.

The site is bordered to the north by Garrison Street, to the east and south by residential dwellings, and to the west by a low-rise commercial building. The ground surface across the subject site is relatively flat with a gradual slope from a geodetic elevation of 65.3 m at the rear to 64.8 m at the front and is approximately 0.5 m above grade from Garrison Street.

Subsurface Conditions

Overburden

Generally, the subsurface profile at the test hole locations consists of topsoil underlain by 0.2 to 0.5 m of fill material, consisting of brown silty sand with gravel and trace topsoil, organics and clay and plastic debris. The fill was observed to be underlain by glacial till consisting of compact, brown silty sand with gravel. Weathered bedrock was observed at HA 1B-24 at a depth of 0.2 to 0.28 m.

Refusal to hand augering was encountered at all hand auger locations between 0.3 m below the existing ground surface at the rear of the site and 1.3 m below the existing ground surface at the front of the site on an inferred bedrock surface.

Bedrock

Weathered bedrock was observed at a depth of 0.2 m below the existing ground surface at hand auger HA1B-24. Based on nearby subsurface test holes conducted by Paterson Group, the bedrock consists of grey limestone with weathering and fracturing in the upper 3 to 5 m.

Based on available geological mapping, the bedrock consists of interbedded limestone and dolomite of the Gull River Formation with an overburden thickness ranging from approximately 1 to 5 m.

Nearby Borehole Coverage

Based on historical boreholes completed by this firm within the immediate surrounding area, similar subsurface conditions were encountered with a slightly deeper bedrock surface ranging from 1 to 2.5 m below the existing grade.

Groundwater

Groundwater observations were recorded in the hand auger holes during the current geotechnical investigation. All test holes were noted to be dry at the time of our investigation. Based on our observations and nearby test hole data, the long-term groundwater table is anticipated to occur below the bedrock surface, at depths lower than the anticipated founding depth. Groundwater levels are subject to seasonal fluctuations. Therefore, the groundwater levels could vary at the time of construction.

3.0 Geotechnical Assessment

From a geotechnical perspective, the subject site is suitable for the proposed development. It is expected that the proposed building will be founded on conventional shallow footings placed on a clean, surface-sounded bedrock bearing surface.

Due to the shallow overburden thickness and anticipated founding level, bedrock removal will be required for the proposed building excavation. Bedrock removal may also be required for installation of site services, depending on the depth of the proposed utilities.

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

Due to the absence of a silty clay deposit within the subject site, the proposed development will not be subjected to a permissible grade raise restriction or tree planting setbacks.

Site Grading and Preparation

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 completely removed from the proposed building perimeter. Under paved areas, existing construction remnants, such as foundation walls should be excavated to a minimum of 1 m below final grade.

Due to the depth of bedrock and the anticipated founding level for the proposed building, all existing overburden material and construction debris should be excavated from within the proposed building footprint.

Bedrock Removal

Bedrock removal can be accomplished by hoe ramming where the bedrock is weathered and/or where only small quantities of the bedrock need to be removed. Sound bedrock may be removed by line drilling in conjunction with 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 proximity of the blasting operations should be completed 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 velocity (measured at the structures) should not exceed 25 mm/s during the blasting program to reduce the risks of damage to the existing structures.

The blasting operations should be planned and conducted under the supervision of a licensed professional engineer who is an experienced blasting consultant.

Vibration Considerations

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

The following construction equipment could be a source of vibrations: piling rig, hoe ram, compactor, dozer, crane, truck traffic, etc. Vibrations, whether caused by blasting operations or by construction operations, could be the cause of the source of detrimental vibrations on the nearby buildings and structures. Therefore, it is recommended that all vibrations be limited.

Two parameters are used to determine the permissible vibrations, namely, 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).

It should be noted that these guidelines are for today’s construction standards. Considering that these guidelines are above perceptible human level and, in some cases, could be very disturbing to some people, it is recommended that a pre-construction survey be completed to minimize the risks of claims during or following the construction of the proposed building.

Fill Placement

Fill used for grading beneath the proposed buildings, where required, should consist of clean imported granular fill, such as Ontario Provincial Standard Specifications (OPSS) Granular A, Granular B Type II or blast rock fill approved by the geotechnical consultant.

This material should be tested and approved prior to delivery to the site. The fill should be placed in lifts no greater than 300 mm thick and compacted using suitable compaction equipment for the lift thickness. Fill placed beneath the buildings and paved areas should be compacted to at least 98% of the material's standard Proctor maximum dry density (SPMDD).

Non-specified existing fill, along with site-excavated soil, can be used as general landscaping fill where settlement of the ground surface is of minor concern. This material should be spread in thin lifts and at least compacted by the tracks of the spreading equipment to minimize voids. If this material is to be used to build up the subgrade level for areas to be paved, it should be compacted in thin lifts to at least 95% of the material's SPMDD.

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. 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 should be assessed by Paterson at the time of construction. Site-generated blast rock fill should be compacted using a suitably sized smooth drum vibratory roller when considered for placement.

Under winter conditions, if snow and ice are present within the blast rock fill below future basement slabs, then settlement of the fill should be expected and support of a future basement slab and/or temporary supports for slab pours will be negatively impacted and could undergo settlement during spring and summer time conditions. The geotechnical consultant should complete periodic inspections during fill placement to ensure that snow and ice quantities are minimized.

Foundation Design

Bearing Resistance Values

Conventional, shallow footings placed on an undisturbed, compact glacial till, can be designed using a bearing resistance value at SLS of **200 kPa** and a bearing resistance value at ULS of **300 kPa**, incorporating a geotechnical resistance factor of 0.5.

Footings placed on clean, surface sounded or weathered limestone bedrock can be designed using a factored bearing resistance value at ultimate limit states (ULS) of **500 kPa**, incorporating a geotechnical resistance factor of 0.5.

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.

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

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. The bedrock bearing surface should be reviewed and approved at the time of excavation by Paterson.

Footings supported on an acceptable bedrock bearing surface and designed for the bearing resistance values provided herein, will be subjected to negligible 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 glacial till, 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.

Adequate lateral support is provided to a sound bedrock bearing medium when a plane extending horizontally and vertically from the footing perimeter at a minimum of 1H:6V (or shallower) passes only through sound bedrock or a material of the same or higher capacity as the bedrock, such as concrete. A heavily fractured, weathered bedrock bearing medium, will require a lateral support zone of 1H:1V (or shallower).

Design for Earthquake

The site class for seismic site response can be taken as **Class C**. A higher seismic site class, such as Class A or B, may be achievable. However, a site-specific shear wave velocity test is required 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.

Soils underlying the subject site are not susceptible to liquefaction. Reference should be made to the latest revision of the Ontario Building Code 2012 for a full discussion of the earthquake design requirements.

Basement Floor Slab Construction

With the removal of all topsoil and fill, containing significant amounts of deleterious or organic materials, the bedrock medium approved by Paterson personnel at the time of excavation will be considered an acceptable subgrade surface on which to commence backfilling for basement slab construction. It is recommended that the upper 200 mm of sub-slab fill is recommended to consist of 19 mm clear crushed stone.

Any soft areas in the basement slab 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, is recommended for backfilling below the floor slab. All backfill material within the footprint of the proposed building should be placed in maximum 300 mm thick loose layers and compacted to a minimum of 98% of the SPMDD.

Basement Wall

There are several combinations of backfill materials and retained soils that could be applicable for the basement walls of the proposed building. 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 (effective unit weight 13 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). For bedrock, K_o is equal to 0.05.
γ = 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 (ΔP_{AE}).

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

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

The peak ground acceleration, (a_{max}), for the Ottawa area is 0.32g according to OBC 2012. Note that the vertical seismic coefficient is assumed to be zero.

The earth force component (P_o) under seismic conditions can be calculated using $P_o = 0.5\ K_o \cdot \gamma \cdot H2$, 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 forces calculated are unfactored. For the ULS case, the earth loads should be factored as live loads, as per OBC 2012.

Pavement Structure (If Applicable)

For design purposes, the following pavement structures, presented on the following page, are recommended for the design of car only parking areas, and access lanes and heavy truck parking areas.

Table 1 - Recommended Pavement Structure – Car Only Parking Areas

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

Table 2 - Recommended Pavement Structure – Access Lanes & Heavy Truck Parking Areas

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

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

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

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.

4.0 Design and Construction Precautions

Foundation Drainage and Backfill

Foundation Drainage

It is recommended that a perimeter foundation drainage system be provided for the proposed residential building. The system should consist of a 150 mm diameter perforated and corrugated plastic pipe, surrounded on all sides by 150 mm of 19 mm clear crushed stone, and placed at the footing level around the exterior perimeter of the structure. The pipe should have a positive outlet, such as a gravity connection to the storm sewer or sump pit (if applicable).

A full drainage system design can be provided by Paterson upon the completion of the architectural and structural design drawings for the proposed development.

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

Concrete Sidewalks Adjacent to Building

To avoid differential settlements within the proposed sidewalks adjacent to the proposed building(s), it is recommended that the upper 600 mm of backfill placed below the concrete sidewalks adjacent to the building footprints to consist of non-frost susceptible material such as OPSS Granular A or Granular B Type II. The granular material should be placed in maximum 300 mm loose lifts and compacted to a minimum of 98% of the material's SPMDD using suitable compaction equipment. The subgrade material should be shaped to promote positive drainage towards the building's perimeter drainage system.

Consideration should be given to placing a layer of rigid insulation below the granular fill layer, which can be designed by Paterson once design drawings are finalized.

Further, consideration can be given to installing a 150 mm diameter perforated, corrugated plastic pipe surrounded on all sides by 150 mm of 19 mm clear crushed stone at the interface of the soil subgrade and the granular sidewalk base. If a drainage pipe is provided at the top of the soil subgrade layer, the granular backfill thickness below the sidewalk may be reduced to 300 mm.

Sump Pit and Elevator Pit Waterproofing (If Applicable)

It is important to note that the building's sump pit should be considered for waterproofing, if proposed. Design details can be provided by Paterson once the design drawings are available for the elevator and sump pits.

Protection of Footings Against Frost Action

Perimeter footings of heated structures are required to be insulated against the deleterious effect of frost action. A minimum of 1.5 m thick soil cover should be provided for adequate frost protection of heated structures, or an equivalent combination of soil cover and foundation insulation.

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

Excavation Side Slopes

The side slopes of excavations in the overburden and weathered bedrock should either be cut back at acceptable slopes or should be retained by shoring systems from the start of the excavation until the structure is backfilled. It is expected that sufficient room will be available for the greater part of the excavation to be undertaken by open-cut methods.

Unsupported Excavations

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

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

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

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

Bedrock Stabilization

Excavation side slopes in weathered bedrock can be carried out using almost vertical side walls. 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 or to provide a stable base for the overburden shoring system.

Depending on the excavation depth, horizontal rock anchors may be required at specific locations to prevent pop-outs of the bedrock, especially in areas where bedrock fractures are conducive to the failure of the bedrock surface.

The requirement for horizontal rock anchors should be evaluated during the excavation operations and should be discussed with Paterson during the design stage.

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.

A minimum of 150 mm of OPSS Granular A should be placed for bedding for sewer or water pipes when placed on a soil 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 obvert of the pipe, 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 and compacted to 98% of the SPMDD.

It should generally be possible to re-use the site materials above the cover material if the operations are carried out in dry weather conditions.

Where hard surface areas are considered above the trench backfill, the trench backfill material within the frost zone (about 1.8 m below finished grade) and above the cover material should match the soils exposed at the trench walls to minimize differential frost heaving.

The trench backfill should be placed in maximum 225 mm thick loose lifts and compacted to a minimum of 95% of the material's SPMDD. All cobbles larger than 200 mm in their longest direction should be segregated from re-use as trench backfill.

Groundwater Control

It is anticipated that groundwater infiltration into the excavations should be low and controllable using open sumps. The contractor should be prepared to direct water away from all bearing surfaces and subgrades to prevent disturbance to the founding medium.

Groundwater Control for Building Construction

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 of 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.

Impacts on Neighbouring Structures

Based on the subsurface conditions encountered at the subject site, it is anticipated that the adjacent structures are founded on bedrock or the glacial till deposit. Therefore, no adverse effects from short-term and/or long-term dewatering are expected or the surrounding structures. However, it is recommended that Paterson review the excavation plan prior to commencement of field work, once available.

Winter Construction

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

The subsurface soil 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.

Corrosion Potential and Sulphates

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 low to slightly aggressive corrosive environment.

Protection Against Potentially Expansive Weathered Bedrock

Upon being exposed to air and moisture, mechanical weathering from ice, water, rain, wind or thermal activity may cause the carbonate bedrock (dolomitic limestone) to weather further, resulting in expansion of the existing joints and fissures as well as spalling.

The expansion process can be retarded when air (i.e., oxygen) is prevented from contact with the limestone and dolostone bedrock and/or the ambient temperature is maintained below 20°C, and/or the bedrock is confined by pressures in excess of 70 kPa. The latter restriction on the heaving process is probably the major reason why damage to structures has, for the greater part, been confined to slabs-on-grade rather than footings.

Based on the hand auger test holes within the subject site and nearby subsurface test holes, weathered limestone and dolostone may be encountered at the subject site. To reduce the long term deterioration of the bedrock, exposure of the bedrock surface to oxygen should be kept as low as possible.

Consideration should be given to the placement of a 50 mm thick concrete mud slab, consisting of a minimum of 17 MPa lean concrete, placed on the exposed bedrock surface within a 48-hour period of being exposed.

An alternative option for protecting the bedrock from deterioration is placing a minimum 300 mm thick layer of granular fill, such as OPSS Granular A or B Type II, over the exposed surface within a 48-hour period after exposure.

The excavated sides of the exposed bedrock should be sprayed with a bituminous emulsion to seal bedrock from exposure to air and dewatering.

6.0 Recommendations

It is recommended that the following be carried out by Paterson once details of the proposed building have been prepared:

☐ Review detailed grading and servicing plans from a geotechnical perspective.

☐ Review of detailed plans pertaining to excavation, foundation drainage and waterproofing details, including for sump pit(s), if applicable.

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

☐ Review and inspection of the installation of the foundation drainage systems.

☐ Review of the bedrock surface at the time of excavation.

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

☐ Observation of driving and re-striking of all pile foundations.

☐ 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 must 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 request, following the completion of a satisfactory materials testing and observation program by the geotechnical consultant.

7.0 Statement of Limitations

The recommendations made in this report are in accordance with our present understanding of the project. Our recommendations should be reviewed when the project drawings and specifications are complete.

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

The present report applies only to the project described in this document. Use of this report for purposes other than those described herein or by person(s) other than Mr. Farzin Fararooni, or his agents, is not authorized without review by Paterson for the applicability of our recommendations to the alternative use of the report.

We trust that this information satisfies your requirements.

Paterson Group Inc.

Owen R. Canton, B.Eng.

LICENSED PROFESSIONAL ENGINEER
Apr. 23, 2024
F. I. ABOU-SEIDO
100156744
PROVINCE OF ONTARIO

Faisal I. Abou-Seido, P.Eng.

Attachments:

☐ Soil Profile and Test Data Sheets
☐ Symbols and Terms
☐ Analytical Testing Results
☐ Figure 1 – Key Plan
☐ Drawing PG7051-1 – Test Hole Location Plan

Report Distribution:

☐ Mr. Farzin Fararooni (e-mail copy)
☐ Paterson Group

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9 Auriga Drive, Ottawa, Ontario K2E 7T9

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Apartment Building - 10 Garrison Street
Ottawa, Ontario

EASTING: 364291.064 **NORTHING:** 5029003.443 **ELEVATION:** 65.23
DATUM: Geodetic
REMARKS:
BORINGS BY: Hand Auger **DATE:** March 25, 2024

FILE NO. PG7051
HOLE NO. HA 1-24

SAMPLE DESCRIPTION	STRATA PLOT	SAMPLE				DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone ○ Water Content % 20 40 60 80	PIEZOMETER CONSTRUCTION
		TYPE	NUMBER	% RECOVERY	N VALUE or RQD				
Ground Surface						0	65.23		
TOPSOIL with organics 0.05	■								
FILL: Brown silty sand with gravel, trace clay pipe, topsoil and organcis 0.50	▨	G	1						
End of Borehole Practical refusal to hand augering at 0.50m depth (HA dry upon completion)									

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

patersongroup Consulting Engineers

9 Auriga Drive, Ottawa, Ontario K2E 7T9

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Apartment Building - 10 Garrison Street
Ottawa, Ontario

EASTING: 364290.133 **NORTHING:** 5029005.785 **ELEVATION:** 65.18

DATUM: Geodetic

REMARKS:

BORINGS BY: Hand Auger **DATE:** March 25, 2024

FILE NO. PG7051

HOLE NO. HA 1A-24

SAMPLE DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone ○ Water Content % 20 40 60 80	PIEZOMETER CONSTRUCTION
Ground Surface						0	65.18		
TOPSOIL with organics 0.10	■								
FILL: Brown silty sand with gravel, trace clay pipe, topsoil, organcis and plastic 0.50	▨	G	1						
GLACIAL TILL: Compact, brown silty sand with gravel 0.70	^	G	2						
End of Borehole Practical refusal to hand augering at 0.70m depth (HA dry upon completion)									

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

patersongroup Consulting Engineers
9 Auriga Drive, Ottawa, Ontario K2E 7T9

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Apartment Building - 10 Garrison Street
Ottawa, Ontario

EASTING: 364292.232 **NORTHING:** 5029000.69 **ELEVATION:** 65.27
DATUM: Geodetic
REMARKS:
BORINGS BY: Hand Auger **DATE:** March 25, 2024

FILE NO. PG7051
HOLE NO. HA 1B-24

SAMPLE DESCRIPTION	STRATA PLOT	SAMPLE				DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone ○ Water Content % 20 40 60 80	PIEZOMETER CONSTRUCTION
		TYPE	NUMBER	% RECOVERY	N VALUE or RQD				
Ground Surface						0	65.27		
TOPSOIL with organics 0.05	■								
FILL: Brown silty sand with gravel, trace topsoil, organcis and plastic 0.20	▩	G	1						
WEATHERED ROCK 0.28	▤	G	2						
End of Borehole Practical refusal to hand augering at 0.28m depth (HA dry upon completion)									

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

patersongroup Consulting Engineers

9 Auriga Drive, Ottawa, Ontario K2E 7T9

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
Prop. Apartment Building - 10 Garrison Street
Ottawa, Ontario

EASTING: 364285.28 **NORTHING:** 5029020.503 **ELEVATION:** 64.82

DATUM: Geodetic

REMARKS:

BORINGS BY: Hand Auger **DATE:** March 25, 2024

FILE NO. PG7051

HOLE NO. HA 2-24

SAMPLE DESCRIPTION	STRATA PLOT	SAMPLE TYPE	SAMPLE NUMBER	SAMPLE % RECOVERY	SAMPLE N VALUE or RQD	DEPTH (m)	ELEV. (m)	Pen. Resist. Blows/0.3m ● 50 mm Dia. Cone ○ Water Content % 20 40 60 80	PIEZOMETER CONSTRUCTION
Ground Surface						0	64.82		
TOPSOIL with organics 0.25	■								
FILL: Brown silty sand, trace gravel, topsoil and organcis 0.40	▨	G	1						
GLACIAL TILL: Compact, brown silty sand with gravel	^	G	2						
	^	G	3			1	63.82		
1.30	^	G	4						
End of Borehole Practical refusal to hand augering at 1.30m depth (HA dry upon completion)									

20 40 60 80 100

Shear Strength (kPa)

▲ Undisturbed △ Remoulded

SYMBOLS AND TERMS

SOIL DESCRIPTION

Behavioural properties, such as structure and strength, take precedence over particle gradation in describing soils. Terminology describing soil structure are as follows:

Desiccated	-	having visible signs of weathering by oxidation of clay minerals, shrinkage cracks, etc.
Fissured	-	having cracks, and hence a blocky structure.
Varved	-	composed of regular alternating layers of silt and clay.
Stratified	-	composed of alternating layers of different soil types, e.g. silt and sand or silt and clay.
Well-Graded	-	Having wide range in grain sizes and substantial amounts of all intermediate particle sizes (see Grain Size Distribution).
Uniformly-Graded	-	Predominantly of one grain size (see Grain Size Distribution).

The standard terminology to describe the strength of cohesionless soils is the relative density, usually inferred from the results of the Standard Penetration Test (SPT) 'N' value. The SPT N value is the number of blows of a 63.5 kg hammer, falling 760 mm, required to drive a 51 mm O.D. split spoon sampler 300 mm into the soil after an initial penetration of 150 mm.

Relative Density	'N' Value	Relative Density %
Very Loose	<4	<15
Loose	4-10	15-35
Compact	10-30	35-65
Dense	30-50	65-85
Very Dense	>50	>85

The standard terminology to describe the strength of cohesive soils is the consistency, which is based on the undisturbed undrained shear strength as measured by the in situ or laboratory vane tests, penetrometer tests, unconfined compression tests, or occasionally by Standard Penetration Tests.

Consistency	Undrained Shear Strength (kPa)	'N' Value
Very Soft	<12	<2
Soft	12-25	2-4
Firm	25-50	4-8
Stiff	50-100	8-15
Very Stiff	100-200	15-30
Hard	>200	>30

SYMBOLS AND TERMS (continued)

SOIL DESCRIPTION (continued)

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

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

ROCK DESCRIPTION

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

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

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

SAMPLE TYPES

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

SYMBOLS AND TERMS (continued)

GRAIN SIZE DISTRIBUTION

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

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

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

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

CONSOLIDATION TEST

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

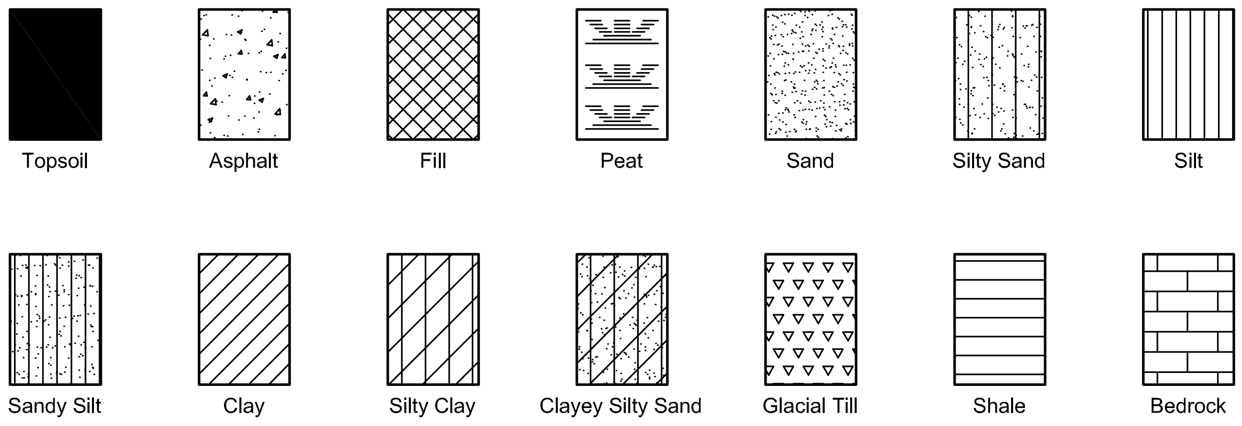
OC Ratio Overconsolidaton ratio = p'_c / p'_o
Void Ratio Initial sample void ratio = volume of voids / volume of solids
Wo - Initial water content (at start of consolidation test)

PERMEABILITY TEST

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

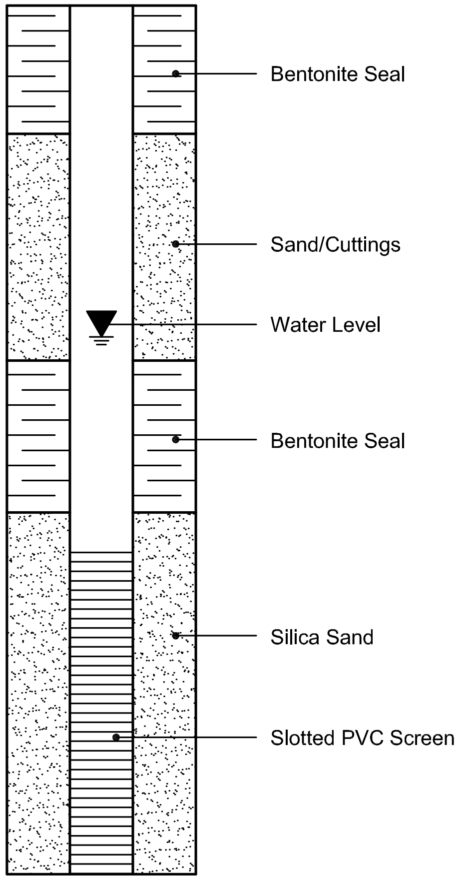
SYMBOLS AND TERMS (continued)

STRATA PLOT

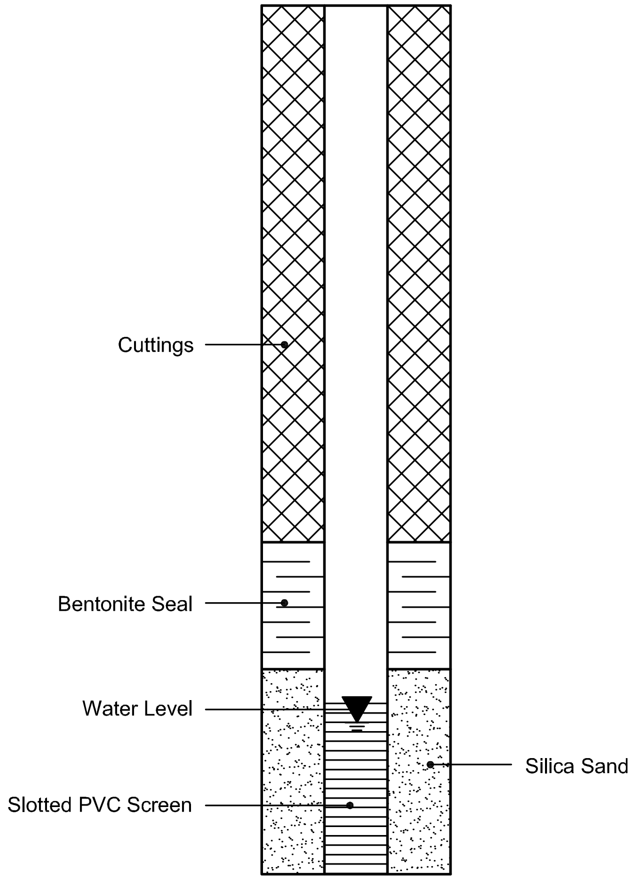


MONITORING WELL AND PIEZOMETER CONSTRUCTION

MONITORING WELL CONSTRUCTION



PIEZOMETER CONSTRUCTION



Certificate of Analysis

Report Date: 03-Apr-2024

Client: **Paterson Group Consulting Engineers (Ottawa)**

Order Date: 27-Mar-2024

Client PO: 59777

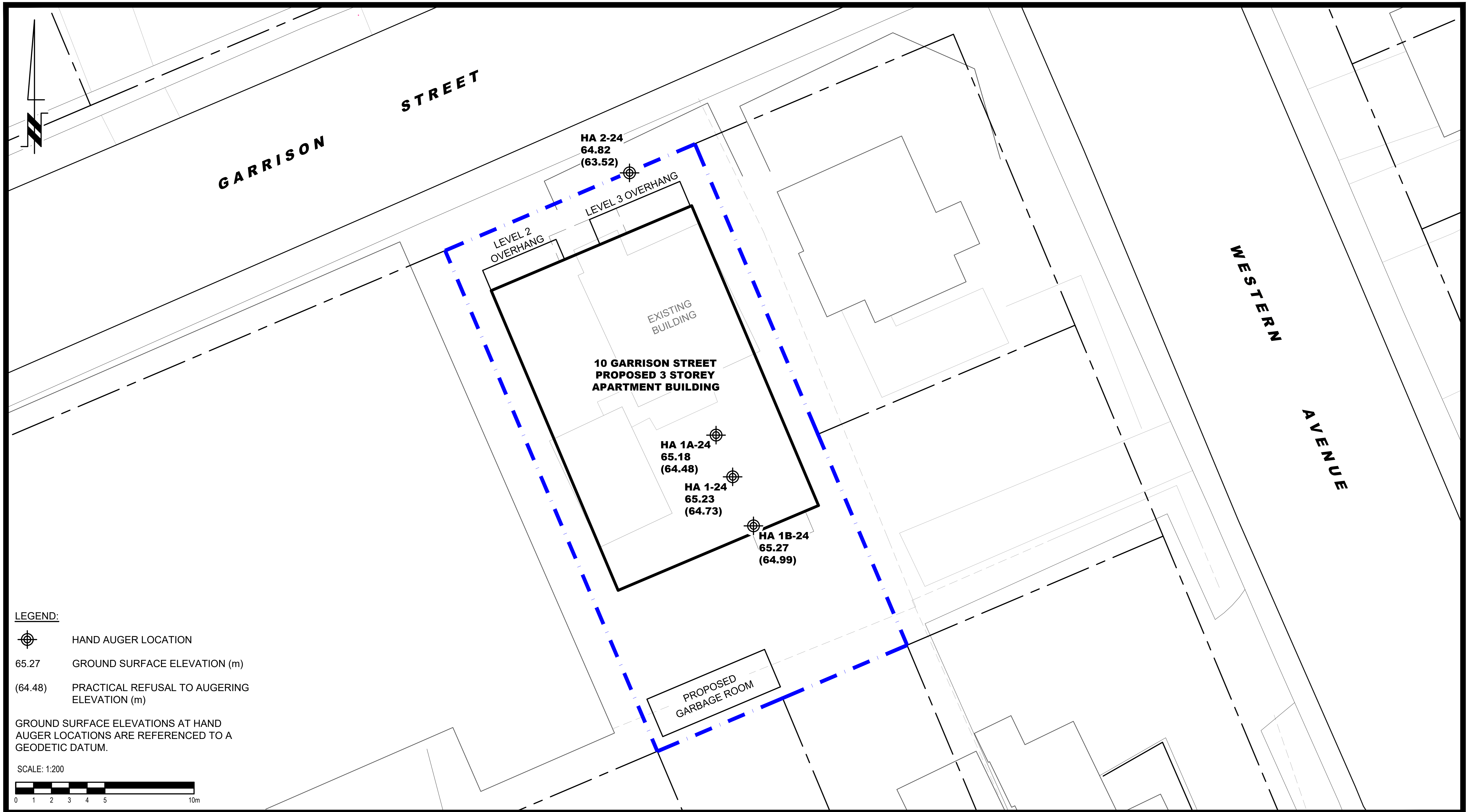
Project Description: PG7051

	Client ID:	HA2-24-G3	-	-	-		
	Sample Date:	25-Mar-24 09:00	-	-	-	-	-
	Sample ID:	2413323-01	-	-	-		
	Matrix:	Soil	-	-	-		
	MDL/Units						
Physical Characteristics							
% Solids	0.1 % by Wt.	85.2	-	-	-	-	-
General Inorganics							
pH	0.05 pH Units	7.39	-	-	-	-	-
Resistivity	0.1 Ohm.m	67.6	-	-	-	-	-
Anions							
Chloride	10 ug/g	<10	-	-	-	-	-
Sulphate	10 ug/g	<10	-	-	-	-	-

FIGURE 1

KEY PLAN

PATERSON GROUP



LEGEND:

⌖	HAND AUGER LOCATION
65.27	GROUND SURFACE ELEVATION (m)
(64.48)	PRACTICAL REFUSAL TO AUGERING ELEVATION (m)

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

SCALE: 1:200

PATERSON GROUP

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

NO.	REVISIONS	DATE	INITIAL

MR. FARZIN FARAROONI
GEOTECHNICAL INVESTIGATION
PROPOSED LOW-RISE APARTMENT BUILDING
10 GARRISON STREET

OTTAWA, ONTARIO

Title:

TEST HOLE LOCATION PLAN

Scale: 1:200
Date: 03/2024
Drawn by: ZS
Report No.: PG7051-LET.01
Checked by: OC
Dwg. No.: PG7051-1
Approved by: FA
Revision No.:

11x17

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