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October 17, 2018
File: PG4335-LET.01 Revision 1

384 Frank Street Ltd.
2277 Prospect Avenue
Ottawa, Ontario
K1H 7G2

Attention: **Mr. Fernando Matos**

Subject: **Geotechnical Investigation**
Proposed Multi-Storey Building
384 Frank Street - Ottawa

Dear Sir,

Further to your request, Paterson Group (Paterson) was commissioned to conduct a geotechnical investigation for the proposed Multi-Storey building to be located at the aforementioned site. The following report presents our findings and recommendations.

The proposed development consists of a three (3) storey residential building with one basement level. It is also expected that access lanes and hard landscaped areas are to be constructed for the proposed development. The existing residential buildings occupying the subject site will be demolished to accommodate the proposed residential development.

1.0 Field Investigation

The field program for our geotechnical investigation was carried out on November 10, 2017. At that time, a total of three (3) boreholes were completed across the subject site to a maximum depth of 7.3 m below existing ground surface. The borehole locations were determined in the field by Paterson personnel taking into consideration site features and existing underground utilities.

The boreholes were put down using a truck-mounted auger drill rig operated by a two person crew. All fieldwork was conducted under the full-time supervision of personnel from Paterson's geotechnical division under the direction of a senior engineer. The testing procedure for the boreholes consisted of augering to the required depths and at the selected locations and sampling the overburden.

The location and ground surface elevation at the borehole locations were surveyed by Paterson field personnel. Ground surface elevations at the borehole locations were referenced to a temporary benchmark (TBM) consisting of the top of spindle of a fire hydrant located at the northeast corner of the Frank Street and Bank Street intersection. A geodetic elevation of 72.05 m was provided for the TBM by Annis, O'Sullivan, Vollebekk Ltd. The locations and ground surface elevations of the boreholes and the TBM are shown on Drawing PG4335-1 - Test Hole Location Plan attached to the present letter report.

2.0 Field Observations

The subject site is currently occupied by a two storey residential dwelling with associated parking and a laneway. The ground surface at the subject site is generally flat and at grade with Frank Street. An existing mid-rise building was noted to be in close proximity to the existing residential dwelling along the east property line.

Generally, the soil profile encountered at the borehole locations consists of a pavement structure comprised of an asphaltic concrete overlying a crushed stone fill material with silty sand. The pavement structure is underlain by a brown silty sand fill with trace gravel, cobbles, topsoil and construction debris. A native loose silty sand layer was encountered below the fill layer followed by a stiff, grey silty clay deposit. Practical refusal to DCPT was observed at a depth of 16.9 m at BH 2-17. Reference should be made to the Soil Profile and Test Data sheets attached to the present letter for specific details of the soil profile encountered at the borehole locations.

Based on geological mapping, shale bedrock from the Billings Formation is present in this area with an overburden thickness of 15 to 25 m.

Groundwater level readings were taken by Paterson personnel in the monitoring wells at all borehole locations on November 17, 2017. Groundwater level readings are presented in the Soil Profile and Test Data sheets attached to this report. It should be noted that groundwater levels are subject to seasonal fluctuations. Therefore, the groundwater level could vary at the time of construction.

3.0 Geotechnical Assessment

The subject site is considered satisfactory from a geotechnical perspective for the proposed building. It is anticipated that the proposed building will be founded on conventional footings placed on an undisturbed, stiff silty clay bearing surface. Consideration may be given to placing the proposed building on a raft foundation

Site Preparation and Fill Placement

Topsoil, asphalt and deleterious fill, such as those containing organic materials, should be stripped from under the proposed 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 m below final grade.

Fill used for grading beneath the proposed building footprint, unless otherwise specified, should consist of clean imported granular fill, such as Ontario Provincial Standard Specifications (OPSS) Granular A or Granular B Type II. The fill should be tested and approved prior to delivery to the site. It 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 proposed buildings and paved areas should be compacted to at least 98% of its 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. These materials should be spread in thin lifts and at least compacted by the tracks of the spreading equipment to minimize voids. If these materials are to be used to build up the subgrade level for areas to be paved, they should be compacted in thin lifts to a minimum density of 95% of their respective SPMDD. Non-specified existing fill and site-excavated soils are not suitable for use as backfill against foundation walls unless used in conjunction with a composite drainage blanket.

Foundation Design

Conventional Shallow Footings

Strip footings, up to 3 m wide, and pad footings, up to 6 m wide, placed over an undisturbed, stiff silty clay bearing surface can be designed using bearing resistance value at serviceability limit states (SLS) of **125 kPa** and a factored bearing resistance value at ultimate limit states (ULS) of **200 kPa**. A geotechnical resistance factor of 0.5 was applied to the reported bearing resistance values at ULS.

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 prior to the placement of concrete for footings. The bearing resistance value given for footings at SLS will be subjected to potential post construction total and differential settlements of 25 and 20 mm, respectively.

Raft Foundation

If the above bearing resistance values are insufficient for the proposed building, consideration may be given to placing the proposed building on a raft foundation.

Based on the following assumptions for the raft foundation, the proposed building can be designed using the above parameters and a total and differential settlement of 25 and 15 mm, respectively. It is expected that the base of the slab is located at or below 4 m depth, the long term groundwater level will be at or below 4 m depth, the raft slab is impervious and the basement walls will be provided with a perimeter foundation drainage system.

The amount of settlement of the raft slab will be dependent on the sustained raft contact pressure. A bearing resistance value at SLS (contact pressure) of **150 kPa** can be used. The loading conditions for the contact pressure are based on sustained loads, that are generally taken to be 100% Dead Load and 50% Live Load. The factored bearing resistance (contact pressure) at ULS can be taken as **225 kPa**. A geotechnical resistance factor of 0.5 was applied to the bearing resistance value at ULS.

The modulus of subgrade reaction was calculated to be **6 MPa/m** for a contact pressure of **150 kPa**. The design of the raft foundation is required to consider the relative stiffness of the reinforced concrete slab and the supporting bearing medium.

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 soil bearing medium when a plane extending horizontally and vertically from the footing perimeter at a minimum of 1.5H:1V, passing through in situ soil or engineered fill of equal or higher capacity as the soil.

Permissible Grade Raise

Due to the high building loads anticipated and the undrained shear strength testing values noted within the silty clay deposit encountered at the test hole locations, a permissible grade raise restriction of **1 m** is recommended for grading in close proximity of the proposed building.

Design for Earthquakes

The site class for seismic site response can be taken as **Class D** for the foundations considered at the subject site. The 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 Slab

With the removal of all topsoil and deleterious materials, within the footprint of the proposed building, the native soil surface approved by the geotechnical consultant at the time of construction is considered to be an acceptable subgrade surface on which to commence backfilling for the floor slab construction.

Any soft areas should be removed and backfilled with appropriate backfill material. OPSS Granular B Type II is recommended for backfilling below the floor slab. It is recommended that the upper 200 mm of sub-slab fill should consist of 19 mm clear crushed stone. All backfill material within the proposed building footprints should be placed in maximum 200 mm thick loose lifts and compacted to a minimum of 98% of the SPMDD.

Basement Wall

There are several applicable combinations of backfill materials and retaining soils for the basement walls of the subject structure. However, the conditions should be designed by assuming the retaining soil consists of a material with an angle of internal friction of 30 degrees and a dry unit weight of 20 kN/m^3.

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

Static Earth Pressures

The static horizontal earth pressure (P_o) should be calculated by a triangular earth pressure distribution equal to $K_o \gamma H$ where:

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

Seismic Earth Pressures

The seismic earth pressure (ΔP_{AE}) should be calculated using the earth pressure distribution equal to $0.375a_c\,\gamma H^2/g$ 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 total earth pressure (P_{AE}) is considered to act at a height, h, (m) from the base of the wall. Where:

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

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

Pavement Structure

For design purposes, the pavement structure presented in the following tables could be used for the design of access lanes.

Table 1 - 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
400	**SUBBASE** - OPSS Granular B Type II
SUBGRADE - Either fill, in situ soil, or OPSS Granular B Type I or II material placed over in situ soil or fill	

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

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

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

4.0 Design and Construction Precautions

Foundation Drainage and Backfill

It is recommended that a perimeter foundation drainage system be provided for the proposed building. The system should consist of a 150 mm diameter, geotextile-wrapped, perforated, corrugated, plastic pipe, surrounded on all sides by 150 mm of 19 mm clear crushed stone, placed at the footing level around the exterior perimeter of the buildings. The pipe should have a positive outlet, such as a gravity connection to the storm sewer.

Backfill against the exterior sides of the foundation walls should consist of free-draining non frost susceptible granular materials. The greater part of the site excavated materials will be frost susceptible and, as such, are not recommended for re-use as backfill against the foundation walls, unless used in conjunction with a 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.

Underfloor Drainage

Underfloor drainage may be required to control water accumulation during spring melt and after heavy rain events due to the low permeability of the underlying silty clay subgrade. For preliminary design purposes, we recommend that 150 mm diameter perforated pipes be placed at 6 m centres. The need for the underfloor drainage system and the spacing should be confirmed at the time of completing the excavation when water infiltration/accumulation can be better assessed.

Concrete Sidewalks Adjacent to Building

To avoid differential settlements within the proposed sidewalks adjacent to the proposed building, it is recommended that the upper 600 mm of backfill placed below the concrete sidewalks to consist of free draining, non-frost susceptible material such as, Granular A, Granular B Type II or any equivalent material, approved by the geotechnical consultant at the time of construction. The site excavated material, in most cases, is considered frost susceptible. The granular material should be placed in maximum 300 mm loose lifts and compacted to 95% 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 pipe.

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 (or equivalent) should be provided.

Exterior unheated footings, such as isolated exterior piers, are more prone to deleterious movement associated with frost action than the exterior walls of the structure proper and require additional protection, such as soil cover of 2.1 m or a combination of soil cover and foundation insulation.

Excavation Side Slopes

At this site, temporary shoring is anticipated to be required to complete the required excavations. However, it is recommended that where sufficient room is available, open cut excavation in combination with temporary shoring can be used.

Unsupported Side Slopes

The side slopes of excavations in the soil and fill overburden materials should either be excavated at acceptable slopes or should be retained by shoring systems from the beginning of the excavation until the structure is backfilled. Insufficient room is expected for majority of the excavation to be constructed by open-cut methods (i.e. unsupported excavations).

The excavation side slopes above the groundwater level extending to a maximum depth of 3 m should be excavated at 1H:1V or shallower. The shallower slope is required for excavation below groundwater level. The subsurface soils are considered to be 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.

A trench box is recommended to protect personnel working in trenches with steep or vertical sides. Services are expected to be installed by “cut and cover” methods and excavations should not remain open for extended periods of time.

Temporary Shoring

The design and approval of the temporary shoring system will be the responsibility of the shoring contractor and the shoring designer who is a licensed professional engineer and is hired by the shoring contractor. It is the responsibility of the shoring contractor to ensure that the temporary shoring system is in compliance with safety requirements, designed to avoid any damage to adjacent structures and include dewatering control measures. In the event that subsurface conditions differ from the approved design during the actual installation, it is the responsibility of the shoring contractor to commission the required experts to re-assess the design and implement the required changes. Furthermore, the design of the temporary shoring system should take into consideration a full hydrostatic condition which can occur during significant precipitation events.

The temporary shoring system could consist of a soldier pile and lagging system or interlocking steel sheet piling. Any additional loading due to street traffic, construction equipment, adjacent structures and facilities, etc., should be included to the earth pressures described below. These systems 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.

Table 2 - Soil Parameters

Parameters	Values
Active Earth Pressure Coefficient (K_a)	0.33
Passive Earth Pressure Coefficient (K_p)	3
At-Rest Earth Pressure Coefficient (K_o)	0.5
Dry Unit Weight (γ), kN/m^3	20
Effective Unit Weight (γ), kN/m^3	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 are calculated for earth pressures. If the groundwater level is lowered, the dry unit weight for the soil 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

If the footings of the proposed building are anticipated to undermine the footings of the neighbouring building, underpinning of this structure may be required and should be designed by an engineer specialized in these works. 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.

Prior to construction, it is recommended that test pits be completed along the foundation walls of the neighbouring building to evaluate the existing underside of footing elevations for underpinning design requirements.

Pipe Bedding and Backfill

The pipe bedding for sewer and water pipes should consist of at least 150 mm of OPSS Granular A material. The material should be placed in maximum 300 mm thick lifts and compacted to a minimum of 95% of its SPMDD. The bedding material should extend at least to the spring line of the pipe.

The cover material, which should consist of OPSS Granular A, should extend from the spring line of the pipe to at least 300 mm above the obvert of the pipe. The material should be placed in maximum 300 mm thick lifts and compacted to a minimum of 95% of its SPMDD.

It should generally be possible to re-use the moist (not wet) brown silty clay above the cover material if the excavation and filling operations are carried out in dry weather conditions. Wet silty clay materials will be difficult to re-use, as the high water contents make compacting impractical without an extensive drying period.

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

To reduce long-term lowering of the groundwater level at this site, clay seals should be provided in the service trenches which are within the silty clay layer. The seals should be at least 1.5 m long (in the trench direction) and should extend from trench wall to trench wall. Generally, the seals should extend from the frost line and fully penetrate the bedding, subbedding and cover material. The barriers should consist of relatively dry and compactable brown silty clay placed in maximum 225 mm thick loose layers and compacted to a minimum of 95% of the material's SPMDD. The clay seals should be placed at the site boundaries and at strategic locations at no more than 60 m intervals in the service trenches.

Groundwater Control

It is anticipated that groundwater infiltration into the excavations should be low and controllable using open sumps. Pumping from open sumps should be sufficient to control the groundwater influx through the sides of the shallow excavation. 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.

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

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

Impacts on Neighbouring Properties

Based on our observations, no groundwater lowering is anticipated under short-term conditions due to construction of the proposed building. The neighbouring structures are expected to be founded within the silty clay deposit. Issues are not expected with respect to groundwater lowering that would cause long term damage to adjacent structures surrounding the proposed building.

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.

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 low corrosive environment.

5.0 Recommendations

It is a requirement for the design data provided herein to be applicable that an acceptable materials testing and observation program, including the aspects shown below, be performed by the geotechnical consultant.

- ❑ Observation of all bearing surfaces prior to the placement of concrete.
- ❑ Sampling and testing of the concrete and fill materials used.
- ❑ Periodic observation of the condition of unsupported excavation side slopes in excess of 3 m in height, if applicable.
- ❑ Observation of all subgrades prior to backfilling.
- ❑ Field density tests to determine the level of compaction achieved.
- ❑ Sampling and testing of the bituminous concrete including mix design reviews.

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

6.0 Statement of Limitations

The recommendations provided in the report are in accordance with Paterson's present understanding of the project. Paterson request 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 the recommendations.

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

The present report applies only to the project described in the report. The use of the report for purposes other than those described herein or by person(s) other than 384 Frank Street Ltd. or their agents are not authorized without review by Paterson.

Paterson Group Inc.

LICENSED PROFESSIONAL ENGINEER
Oct. 17, 2018
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Faisal I. Abou-Seido, P.Eng.

David J. Gilbert, P.Eng.

Attachments

- ❑ Soil Profile and Test Data Sheets
- ❑ Analytical Testing Results
- ❑ Figure 1 - Key Plan
- ❑ Drawing PG4335-1 - Test Hole Location Plan

Report Distribution

- ❑ 384 Frank Street Ltd. (3 copies)
- ❑ Paterson Group (1 copy)

patersongroup Consulting Engineers

154 Colonnade Road South, Ottawa, Ontario K2E 7J5

SOIL PROFILE AND TEST DATA

Geotechnical Investigation
384 Frank Street
Ottawa, Ontario

DATUM Top of spindle of the fire hydrant located at the northeast corner of Frank Street and Bank Street. Geodetic Elevation: 72.05 m

REMARKS

BORINGS BY Geoprobe

DATE November 10, 2017

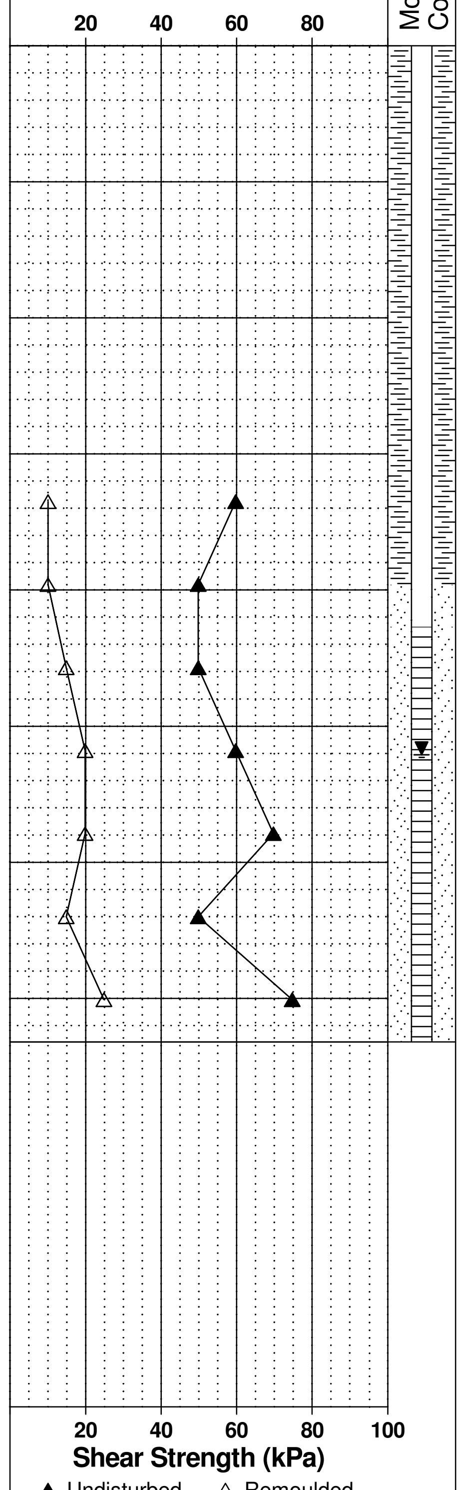
FILE NO. PG4335

HOLE NO. BH 1-17

SOIL DESCRIPTION	Depth to base (m)	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD
GROUND SURFACE					
Asphaltic concrete	0.08				
FILL: Crushed stone with silty sand	0.38	SS	1	39	
FILL: Dark brown silty sand, trace topsoil, gravel and brick fragments	1.07	SS	2	50	6
Compact, brown **SILTY SAND**	1.83	SS	3	50	10
Compact, brown **SILTY SAND** trace gravel	2.29	SS	4	54	12
Stiff, brown **SILTY CLAY** - grey by 2.4m depth	7.32	SS	5	25	2
		SS	6	100	P
		SS	7	100	P
		SS	8	100	P
		SS	9	100	P
		SS	10	67	P
		SS	11	100	P
		SS	12	0	P
End of Borehole (GWL @ 5.21m - Nov. 17, 2017)					

DEPTH (m)	ELEV. (m)
0	71.02
1	70.02
2	69.02
3	68.02
4	67.02
5	66.02
6	65.02
7	64.02

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



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Geotechnical Investigation
384 Frank Street
Ottawa, Ontario

DATUM Top of spindle of the fire hydrant located at the northeast corner of Frank Street and Bank Street. Geodetic Elevation: 72.05 m

REMARKS

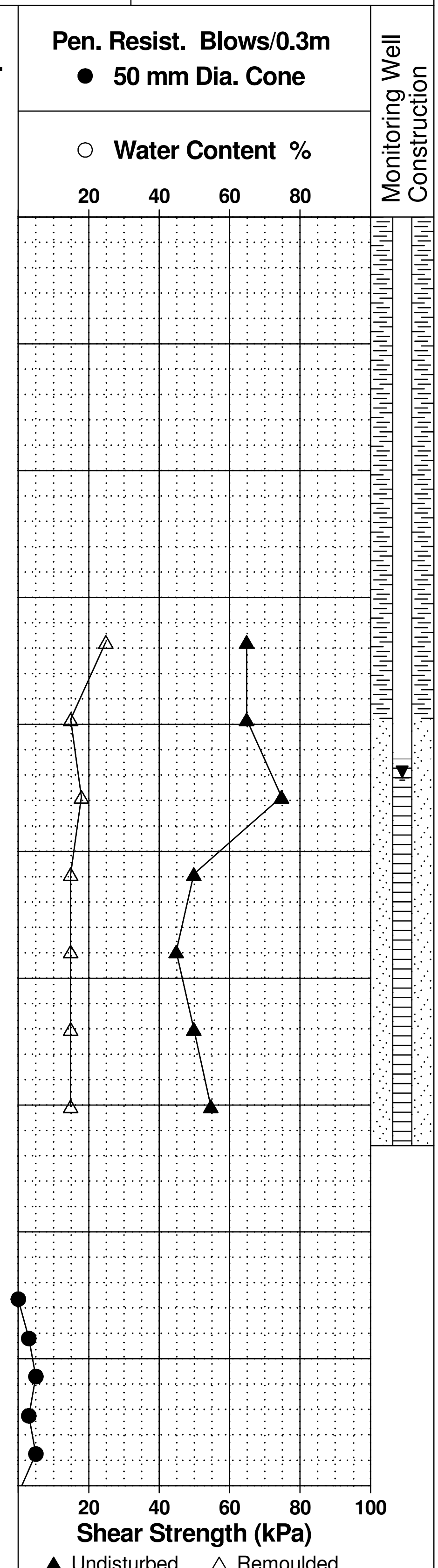
BORINGS BY Geoprobe

DATE November 10, 2017

FILE NO. PG4335

HOLE NO. BH 2-17

SOIL DESCRIPTION	Depth to base (m)	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	71.33
Asphaltic concrete	0.05						
FILL: Crushed stone with silty sand	0.23	SS	1	0	2		
FILL: Dark brown silty sand, trace gravel, clay and brick fragments	1.22	SS	2	8	5	1	70.33
Loose, brown **SILTY SAND**	2.29	SS	3	17	4		
		SS	4	38	4	2	69.33
Brown **SILTY SAND** trace gravel	2.44						
Stiff, grey **SILTY CLAY**	7.32	SS	5	100	2	3	68.33
		SS	6	33	P		
		SS	7	75	P	4	67.33
		SS	8	83	P		
		SS	9	100	P	5	66.33
		SS	10	100	P	6	65.33
		SS	11	100	P		
		SS	12	100	P	7	64.33
Dynamic Cone Penetration Test commenced at 7.32m depth.						8	63.33
						9	62.33
						10	61.33



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384 Frank Street
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DATUM Top of spindle of the fire hydrant located at the northeast corner of Frank Street and Bank Street. Geodetic Elevation: 72.05 m

REMARKS

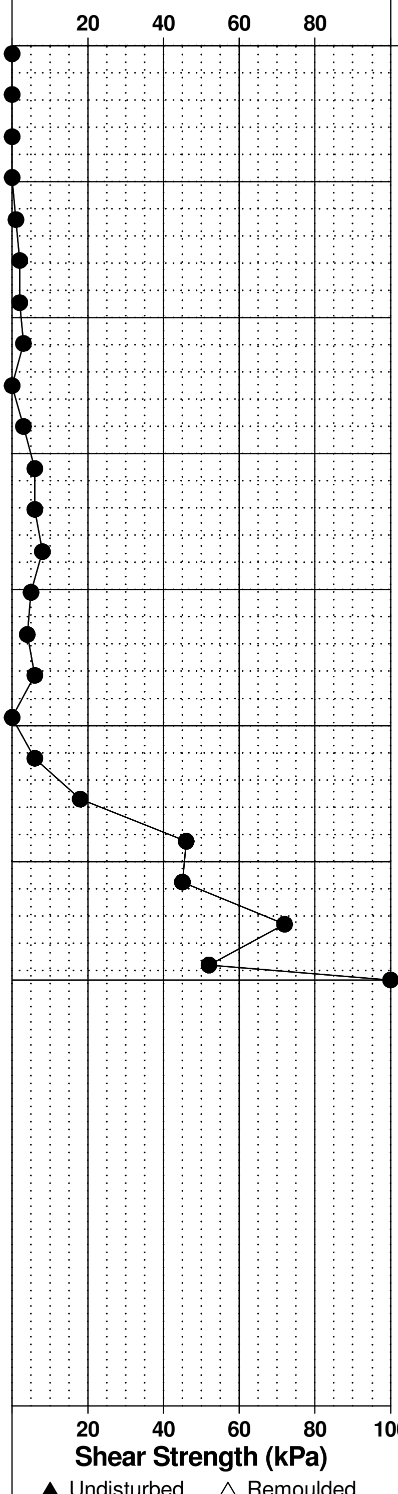
BORINGS BY Geoprobe

DATE November 10, 2017

FILE NO. PG4335

HOLE NO. BH 2-17

SOIL 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 %	Monitoring Well Construction
GROUND SURFACE						10	61.33		
						11	60.33		
						12	59.33		
						13	58.33		
						14	57.33		
						15	56.33		
						16	55.33		
16.87									
End of Borehole Practical DCPT refusal at 16.87m depth (GWL @ 4.42m - Nov. 17, 2017)									



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SOIL PROFILE AND TEST DATA

Geotechnical Investigation
384 Frank Street
Ottawa, Ontario

DATUM Top of spindle of the fire hydrant located at the northeast corner of Frank Street and Bank Street. Geodetic Elevation: 72.05 m

REMARKS

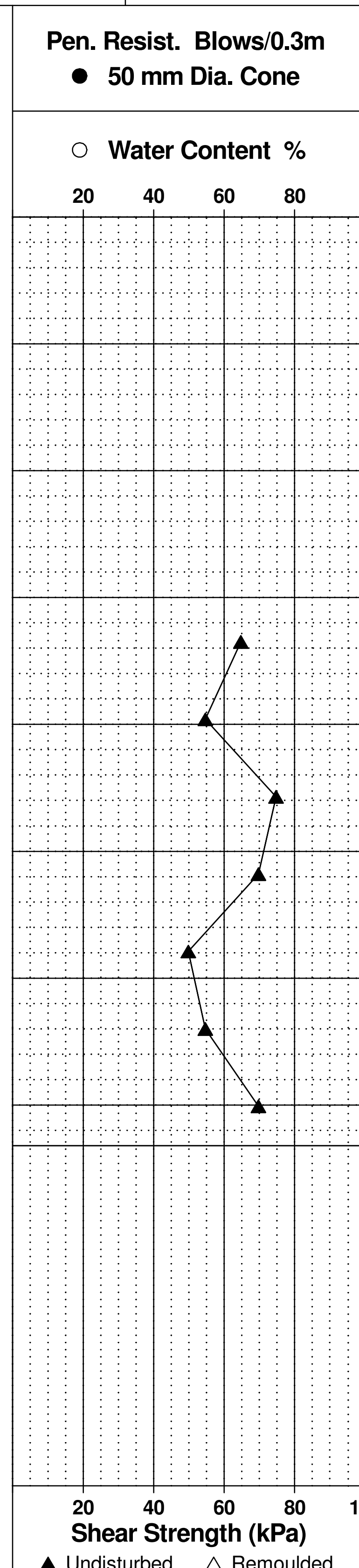
BORINGS BY Geoprobe

DATE November 10, 2017

FILE NO. PG4335

HOLE NO. BH 3-17

SOIL DESCRIPTION	Layer bottom depth (m)	SAMPLE TYPE	NUMBER	% RECOVERY	N VALUE or RQD	DEPTH (m)	ELEV. (m)
GROUND SURFACE						0	71.09
Asphaltic concrete	0.08						
FILL: Dark brown silty sand and gravel	0.30	SS	1	6	4		
Loose, brown **SILTY SAND**	1.83	SS	2	8	4	1	70.09
		SS	3	50	6		
Loose, brown **SILTY SAND**, trace gravel	2.44	SS	4	8	9	2	69.09
Loose, brown **SILTY SAND**	2.74	SS	5	54	4		
Stiff, grey **SILTY CLAY**, trace sand	7.32	SS	6	100	P	3	68.09
		SS	7	100	P	4	67.09
		SS	8	100	P		
		SS	9	100	P	5	66.09
		SS	10	100	P	6	65.09
		SS	11	100	P		
		SS	12	100	P	7	64.09
End of Borehole							
(GWL @ 6.11m - Nov. 17, 2017)							



Monitoring Well Construction

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

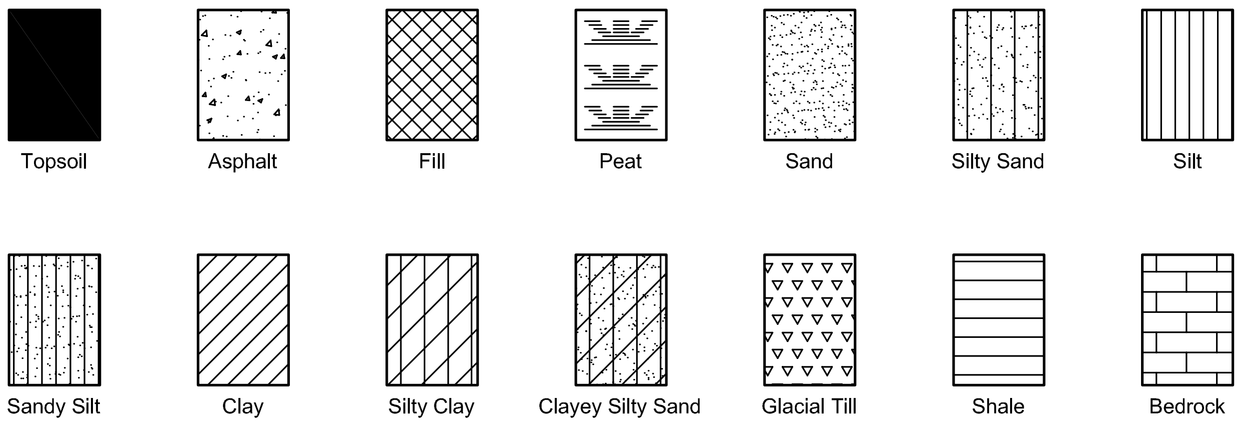
p'_o	-	Present effective overburden pressure at sample depth
p'_c	-	Preconsolidation pressure of (maximum past pressure on) sample
Ccr	-	Recompression index (in effect at pressures below p'_c)
Cc	-	Compression index (in effect at pressures above p'_c)
OC Ratio		Overconsolidaton ratio = p'_c / p'_o
Void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

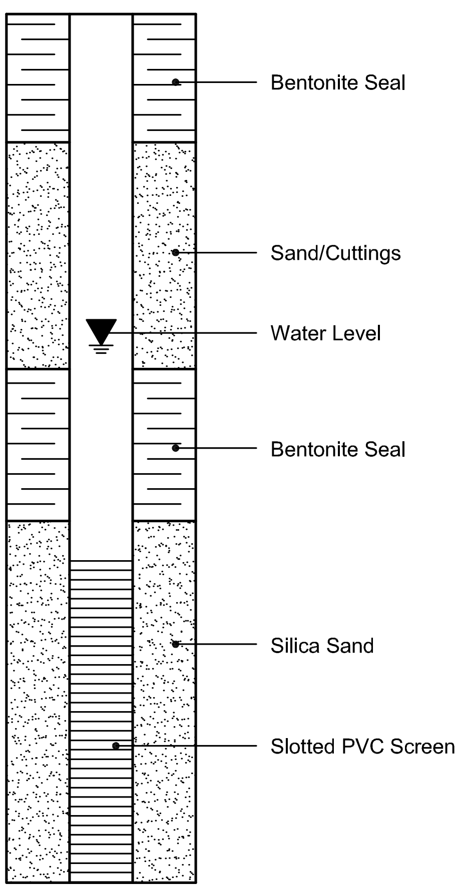
SYMBOLS AND TERMS (continued)

STRATA PLOT

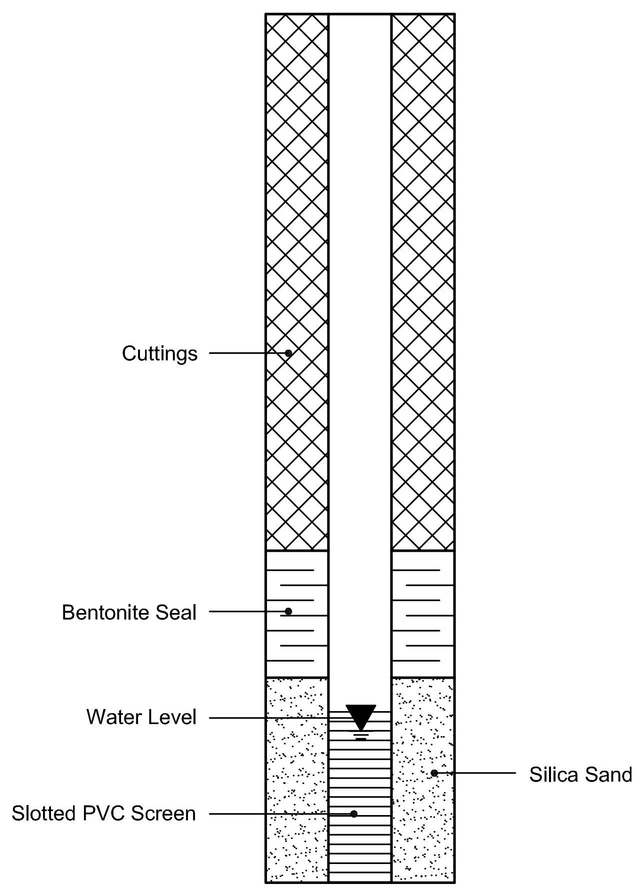


MONITORING WELL AND PIEZOMETER CONSTRUCTION

MONITORING WELL CONSTRUCTION



PIEZOMETER CONSTRUCTION



PARACEL
LABORATORIES LTD.

Order #: 1747083

Certificate of Analysis

Client: Paterson Group Consulting Engineers

Client PO: 22728

Report Date: 24-Nov-2017

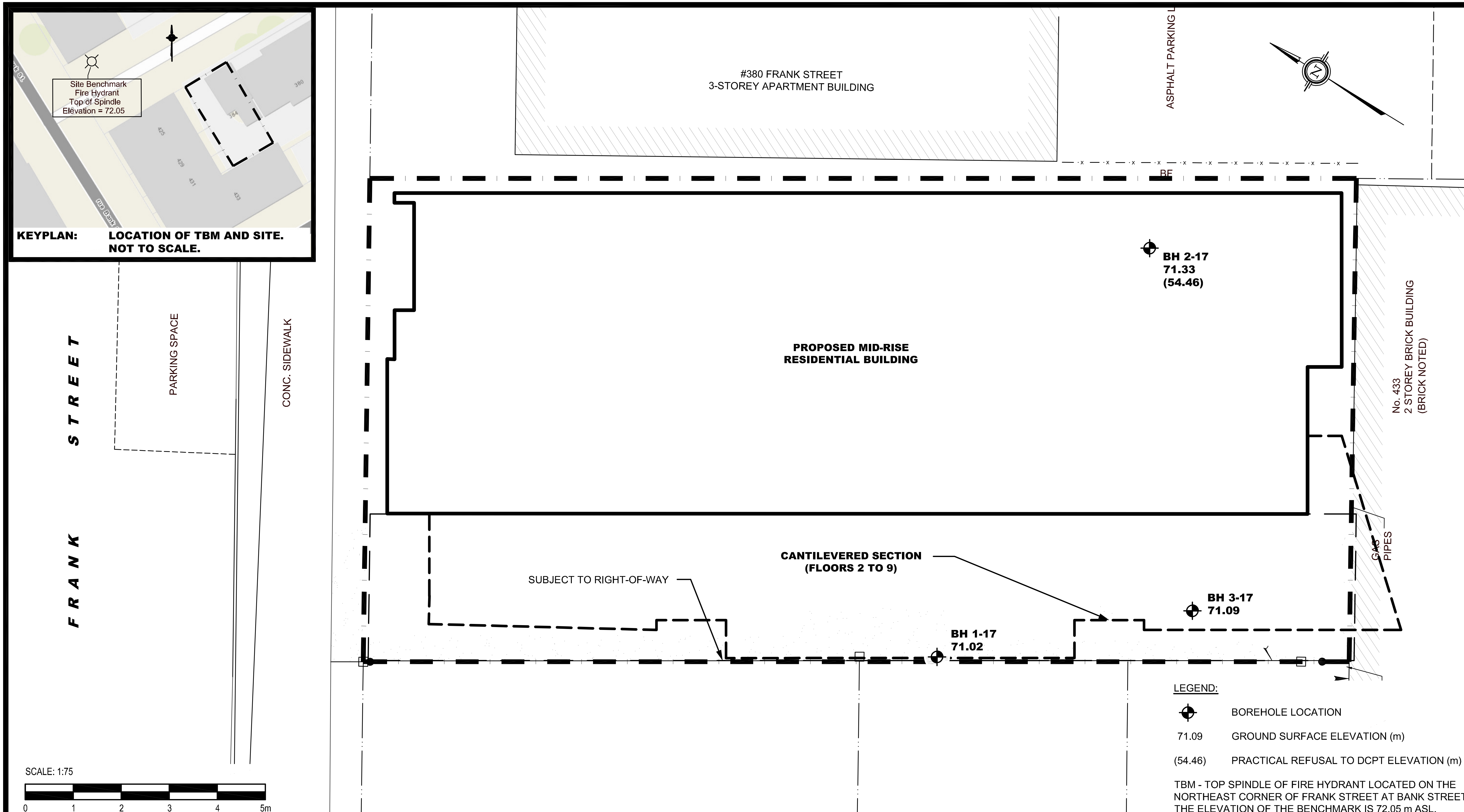
Order Date: 20-Nov-2017

Project Description: PG4335

	Client ID:	BH2-SS4	-	-	-
	Sample Date:	10-Nov-17	-	-	-
	Sample ID:	1747083-01	-	-	-
	MDL/Units	Soil	-	-	-
Physical Characteristics					
% Solids	0.1 % by Wt.	90.1	-	-	-
General Inorganics					
pH	0.05 pH Units	7.39	-	-	-
Resistivity	0.10 Ohm.m	141	-	-	-
Anions					
Chloride	5 ug/g dry	9	-	-	-
Sulphate	5 ug/g dry	12	-	-	-

<u>FIGURE 1</u>

KEY PLAN



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NO.	REVISIONS	DATE	INITIAL
1	BASE PLAN UPDATED	18/10/2018	FA

384 FRANK STREET LTD.

GEOTECHNICAL INVESTIGATION
PROP. MID-RISE RESIDENTIAL BUILDING - 384 FRANK STREET
OTTAWA, ONTARIO

Title:
TEST HOLE LOCATION PLAN

Scale:	1:75	Date:	11/2017
Drawn by:	AG	Report No.:	PG4335-1
Checked by:	NZ	Dwg. No.:	PG4335-1
Approved by:	DJG	Revision No.:	1

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