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Mr. Jeremy Silburt
Senior Consultant, Development
229 Beechwood Holdings Inc. and 241 Beechwood Holding Inc.
c/0 Bintee Development Inc.
226 Argyle Avenue, Suite 300
Ottawa, Ontario K2P 1B9

Project Name:	Updated Geotechnical Investigation Report Proposed Residential Development - 229 to 247 Beechwood Avenue, Ottawa, Ontario
Project Number:	OTT-00238207-A0

EXP Services Inc. (EXP) is pleased to present the updated geotechnical investigation report completed for the proposed residential development to be located at 229-247 Beechwood Avenue, Ottawa, Ontario. Original authorization to proceed with this work was provided by Takyan Developments and the original geotechnical investigation report was submitted on August 9, 2017. Following the issuance of the 2017 geotechnical report, the proposed development has changed and therefore, an updated geotechnical investigation report was required and requested by Smart Living Properties.

Introduction

The site consists of two (2) parcels of land; Parcel A located at 229 and 231-235 Beechwood Avenue (south parcel of land) and Parcel B located at 241, 245 and 247 Beechwood Avenue (north parcel of land) in Ottawa, Ontario. The two (2) parcels of land are currently occupied by single storey residential dwellings which will be demolished to allow the construction of the proposed two (2) new residential buildings identified herein as the north building (247 Beechwood Avenue) and the south building (227 Beechwood Avenue).

Available 2022 architectural drawings indicate that the north building will be three (3) storeys with a penthouse and roof and the south building will be two storeys with a penthouse and roof.   Each building will have one (1) basement level.   Retaining walls are also proposed to be constructed along the western boundary of the site. However, the type of retaining walls were not known at the time of preparing this updated geotechnical investigation report.

Geotechnical related information from the set of design drawings for the proposed residential development are summarized in Table I.

Table I: Design Details of Proposed Buildings

Building Location	Number of Storeys	Underside of Footing Elevation (m)	Basement Floor Elevation (m)	Main Floor Elevation (m)
North Building - 247 Beechwood Avenue	3 Storeys with Basement, Penthouse and Roof	58.40	58.90	61.95
South Building - 229 Beechwood Avenue	2 Storeys with Basement and Roof	57.45	57.95	61.00

The geotechnical investigation was undertaken to:

a.) Establish the geotechnical and groundwater conditions at five (5) boreholes located at the site,

b.) Provide seismic site classification in accordance with the requirements of the 2012 Ontario Building Code (as amended May 2, 2019) and comment on the liquefaction potential of the on-site soils,

c.) Comment on site grade restrictions,

d.) Make recommendations regarding the most suitable type of foundations, founding depth and serviceability limit state (SLS) bearing pressure and factored geotechnical resistance at ultimate limit state (ULS) of the founding strata and comment on the anticipated total and differential settlements for the recommended foundation type,

e.) Provide soil parameters and lateral earth pressure coefficients (for static and seismic (dynamic) conditions) for the design of basement walls and retaining walls,

f.) Discuss slab-on-grade construction and permanent drainage system requirements,

g.) Discuss excavation conditions and de-watering requirements during construction,

h.) Provide pipe bedding requirements,

i.) Comment on backfilling requirements and suitability of the on-site soils for backfilling purposes,

j.) Recommend pavement structure thickness for the parking lots and access roadways; and

k.) Provide recommendations for subsurface concrete requirements and comment on the corrosion potential of the subsurface soil to buried metal structures/members.

The comments and recommendations given in this report are based on the assumption that the above-described design concept will proceed into construction. If changes are made either in the design phase or during construction, this office must be retained to review these modifications. The results of this review may be a modification of our recommendations or it may require additional field or laboratory work to check whether the changes are acceptable from a geotechnical viewpoint.

EXP completed Phase One and Two Environmental Site Assessments (ESAs) of the site in 2017 and completed an update Phase One Environmental Site Assessment (ESA) in 2022. The ESA reports are presented under separate covers.

Site Description

The site is located on the west side of the Beechwood Avenue and Jolliet Avenue intersection in Ottawa, Ontario (Figure 1). The site is bounded by Beechwood Avenue to the east, Corona Avenue to the north, Black Maple Private to the south and existing residences on the west side.

The site consists of two (2) parcels of land identified as Parcel A and Parcel B. Parcel A includes the two (2) properties located at 229 and 231-235 Beechwood Avenue and Parcel B includes the three (3) properties located at 241, 245 and 247 Beechwood Avenue. Parcel A and Parcel B are separated by a city-owned paved laneway located between the two (2) parcels of land. The laneway was formerly known as Carsdale Avenue. Parcel A is currently occupied by two 2-storey residential buildings with storage sheds in the backyards and asphalt driveway/parking lot south of 229 Beechwood Avenue. There is a small parking lot on the north side of 231-235 Beechwood Avenue, which is connected to the city-owned laneway. Parcel B is currently occupied by three 2-storey residential buildings, each with a storage shed in the backyard. There is a small paved parking lot south of 241 Beechwood Avenue that connects to the city-owned laneway. Between 245 and 247 Beechwood Avenue, there is a paved driveway/parking area.

The elevation of the ground surface of the site is set higher than Beechwood Avenue and gradually slopes down in an easterly direction towards Beechwood Avenue. The ground surface elevations at the borehole locations range from Elevation 61.0 m to Elevation 58.7 m.

Procedure

The fieldwork for the geotechnical investigation was undertaken on June 26 and 27, 2017 and comprised the drilling of a total of five (5) boreholes (Borehole Nos. 1 to 5). Borehole Nos. 1 and 2 are located on the south Parcel A (229 Beechwood Avenue) and Borehole Nos. 3 to 5 are located on the north Parcel B (247 Beechwood Avenue). The boreholes extended to auger and sampler refusal and termination depths ranging from 1.8 m to 6.1 m below the existing ground surface. The fieldwork was supervised on a full-time basis by a representative from EXP.

The borehole locations were established on site by EXP. The geodetic elevations of the boreholes were established by EXP and based on the geodetic benchmark defined as the northwest corner of the outdoor concrete slab located on the north side of 231-235 Beechwood Avenue. The geodetic elevation of the benchmark is provided on the survey plan titled, “Part 1, Plan of Lots 10, 11, 12, 24, 25, 26, Part of Rear Passage, Registered Plan 4M-30, City of Ottawa”, dated June 14, 2017 and prepared by Annis, O’Sullivan Vollebekk Ltd. The borehole locations and elevations are shown on the Borehole Location Plan, Figure 2.

Prior to the start of the borehole fieldwork, the borehole locations were cleared of any underground services by USL-1 Cable Locators. Borehole Nos. 1 to 4 were drilled using a CME-55 truck-mounted drill rig equipped with continuous flight hollow-stem augers and rock coring equipment. Borehole No. 5 was advanced by using a portable manual augering equipment set-up. In Borehole Nos. 1 to 4, standard penetration tests (SPTs) were performed in the soil on a continuous basis and at a 0.75 m depth interval with soil samples retrieved by split-barrel sampler. In

Borehole No. 5, auger samples of the soil were collected on a continuous basis. It is noted that Borehole Nos. 3 and 4 were advanced below 2.3 m and 3.0 m depths using the tri-cone drill bit. The bedrock was cored in Borehole No.1 by conventional rock coring method. A careful record of any sudden drops of the core barrel, colour of the wash water and percent of wash water return were recorded during the rock coring operation.

Water levels were measured in the open boreholes on completion of drilling. In addition, 31 mm diameter monitoring wells were installed in in Borehole Nos. 1, 3, 4 and 5 for groundwater level measurements and for the sampling of the groundwater (as part of the updated Phase One ESA). The monitoring wells were installed in accordance with EXP standard practice. The monitoring well installation configuration is documented on the respective borehole log.

The boreholes were logged and representative soil samples were obtained, preserved in plastic bags and identified. Similarly, the bedrock cores were placed in core boxes, identified, visually examined and logged. On completion of the fieldwork, all the soil samples and rock cores were transported to the EXP laboratory in Ottawa where they were visually examined by a senior geotechnical engineer and borehole logs prepared. The engineer also assigned the laboratory testing which consisted of performing natural moisture content determination on all recovered soil samples and grain size analysis on one (1) selected soil sample and unconfined compressive strength test on one (1) selected section of the recovered bedrock cores.

It is noted that the number of boreholes drilled as part of the 2017 geotechnical investigation was limited due to drill-rig access issues; could not access all borehole locations by a standard large machine-type drill rig. Therefore, it is recommended that prior to tendering this project, additional test holes (boreholes and/or test pits) should be completed to collect additional data on the subsurface conditions throughout the site, including the lateral extent and depth of the fill, buried topsoil layer, sand, glacial till and shale bedrock.

Subsurface Soil and Groundwater Conditions

A detailed description of the geotechnical conditions encountered in the boreholes is presented in the borehole logs, Figure Nos. 3 to 7. The borehole logs and related information depict subsurface conditions only at the specific locations and times indicated. Subsurface conditions and water levels at other locations may differ from conditions at the location where sampling was conducted. The passage of time also may result in changes in the conditions interpreted to exist at the location where sampling was conducted.

Boreholes were drilled to provide representation of subsurface conditions as part of a geotechnical exploration program and are not intended to provide evidence of potential environmental conditions. The environmental related conditions are presented in the previously referenced ESA reports.

It should be noted that the soil boundaries indicated on the borehole logs are inferred from non-continuous sampling. These boundaries are intended to reflect approximate transition zones for the purpose of geotechnical design and should not be interpreted as exact planes of geological change. The “Notes on Sample Descriptions” preceding the borehole logs forms an integral part of this report and should be read in conjunction with this report.

A review of the borehole logs indicates the following subsurface soil conditions with depth and groundwater level measurements.

A 125 mm and 180 mm thick surficial topsoil layer was encountered in Borehole Nos. 2 and 5, respectively. A 50 mm and 150 mm thick layer of asphaltic concrete was encountered at ground surface in Borehole Nos. 1, 3 and 4.

The topsoil and asphaltic concrete are underlain by fill in all of the boreholes. The fill extends to depths of 0.8 m to 1.8 m below existing grade (Elevation 58.7 m and Elevation 57.2 m). The fill comprises of a heterogeneous mixture ranging from sand and gravel to sand to sand and silt and contains organic matter, roots and brick fragments. Based on the SPT N-values of 1 to 17, the fill is in a very loose to compact state. The moisture content of the fill is 4 percent to 34 percent.

A 75-mm thick buried topsoil layer was contacted beneath the fill in Borehole No. 3 at a 0.8 m depth (Elevation 58.7 m).

The buried topsoil layer in Borehole No. 3 is underlain by native sand that extends to a 1.5 m depth (Elevation 58.0 m). The sand is in a loose state as indicated by the SPT N-value of 6. The native sand has a natural moisture content of 27 percent.

Glacial till was contacted beneath the native sand in Borehole No. 3and extends to a 2.5 m depth (Elevation 57.0 m). The glacial till consists of a silty sand with gravel and contains cobbles and boulders. Based on the SPT N-value of 39, the glacial till is in a dense state. The natural moisture content of the glacial till is 11 percent.

Grain size analysis was conducted on one (1) sample of the glacial till and the grain size distribution curve is shown in Figure 8. The results of the grain size analysis indicate the glacial till comprises of 22 percent gravel, 38 percent sand and 40 percent fines (silt and clay). Based on a review of the results of the grain size analysis, the glacial till may be classified as a silty sand with gravel (SM) in accordance with the Unified Soil Classification System (USCS).

Possible highly weathered shale bedrock that could be sampled (Borehole No. 1) and augered into by 500 mm (Borehole Nos. 3 and 4) was contacted beneath the fill and glacial till in Borehole Nos. 1, 3 and 4 at 1.5 m to 2.5 m depths (Elevation 58.7 m to Elevation 57.0 m). The possible weathered shale bedrock is approximately 300 mm and 500 mm thick. Borehole Nos. 3 and 4 were advanced below the possible weathered shale bedrock into inferred shale bedrock (below the auger refusal depths of 2.3 m and 3.0 m) using a tri-cone drill bit to a termination depth of 6.1 m below existing grade. In addition, auger and sampler refusal were met in Borehole Nos. 2 and 5 on possible obstructions, inferred cobbles, boulders or bedrock at 1.8 m and 2.4 m depths (Elevation 58.8 m and Elevation 58.6 m).

The presence of the shale bedrock was proven by coring the bedrock in Borehole No. 1. Based on coring operation, shale bedrock was contacted below the possible weathered shale bedrock in Borehole No. 1 at a 1.8 m depth (Elevation 56.9 m).

Based on a review of the published bedrock geology map (Map 1508A, "Generalized Bedrock Geology, Ottawa – Hull, Ontario and Quebec", 1985), the site is located near a transition zone between shale from the Billings formation and limestone from the Eastview or Ottawa formations. The map also indicates the site is located southwest of and in close proximity to the approximate location of a major fault.

Based on a review of the recovered rock cores from Borehole No. 1, the bedrock is shale of the Billings formation. The Total Core Recovery (TCR) is 100 percent and the Rock Quality Designation (RQD) ranges from 0 percent to 34 percent indicating the bedrock is of a very poor quality to poor quality. It is noted that the bedrock was moderately to highly fractured within the investigated depth. It also contains a 130-mm thick dark grey to black silty clay seam at 3.8 m depth approximately below the ground surface and 2.0 m below the bedrock surface. Based on the close proximity of the site to a major fault, there is a possibility that minor faults may be located at or near the site which may account for the very poor quality to poor quality of the bedrock.

The results of the unconfined compressive strength test completed on one (1) section of the recovered bedrock cores from Borehole No. 1 (Run No. 2; 2.7-2.8 m depths) indicates a compressive strength of 56 MPa. Based on the compressive strength test result, the bedrock may be classified as 'strong' in accordance with the 2006 Canadian Foundation Engineering Manual (CFEM), 4th Edition. The unit weight of the bedrock is 25.2 kN/m^3.

The shale bedrock of the Billings formation is prone to deterioration when exposed to the elements. It also heaves due to a complex mechanism caused in part by bio-oxidation of sulphides in the rock, which then reacts with calcite seams to form expanding gypsum. This occurs when oxygen is permitted to enter the rock, usually by the lowering of the groundwater table and is accelerated by the presence of heat.

It is noteworthy to mention that the sampler and auger refusal depths in Borehole Nos. 2 and 5 may have occurred on obstructions, cobbles, boulders or bedrock. Therefore, it is recommended that prior to tendering this project, additional test holes (boreholes and/or test pits) should be completed to collect additional data on the subsurface conditions throughout the site, including the lateral extent and depth (elevation) of the fill, buried topsoil layer, sand, glacial till and the shale bedrock. The information from the additional test holes would have an impact on the project costs. It is best to undertake the additional test holes (boreholes and/or test pits) on completion of the demolition of the existing buildings.

A summary of the groundwater level measurements in the monitoring wells installed in the boreholes is shown in Table II.

Table II: Summary of Groundwater Levels

Borehole No.	Ground Surface Elevation (m)	Date of Groundwater Level Measurement (Number of Days After Drilling)	Depth (m)	Elevation (m)
BH-1	58.70	July 7, 2017 (15 days)	2.8	55.9
BH-3	59.49	July 7, 2017 (14 days)	1.8	57.7
BH-4	60.50	July 7, 2017 (14 days)	1.8	59.5
BH-5	60.63	July 7, 2017 (14 days)	1.0	59.6

Water levels were made in the exploratory boreholes at the times and under the conditions stated in the scope of services. Note that fluctuations in the level of the groundwater may occur due to seasonal variation such as precipitation, snowmelt, rainfall activities, and other factors not evident at the time of measurement and therefore may be at a higher level during wet weather periods.

Seismic Considerations

Seismic Site Classification

The subsurface soil conditions at the site were examined in relation to Section 4.1.8.4 of the 2012 Ontario Building Code (as amended May 2, 2019) and the site classification for seismic site response is estimated to be **Class C**.

A higher site classification for seismic site response may be obtained if a multi-channel analysis of surface waves (MASW) survey is conducted at the site and the underside of the footings are less than 3.0 m from the bedrock surface.

Liquefaction Potential of On-Site Soils

The subsurface soils are not considered to be liquifiable during a seismic event.

Grade Raise Restrictions

The geotechnical investigation revealed the site is underlain by cohesionless fill consisting of sand, sand and silt to sand and gravel, and cohesionless native sand glacial till underlain by shale bedrock and inferred cobbles and/or boulders. Cohesive clayey soils were not encountered in the boreholes. Therefore, there are no grade raise restrictions at the site from a geotechnical perspective.

Review of the site grading plan (Drawing No. C200 dated March 18, 2022, Revision No. 2) prepared by EXP indicates a site grade raise in the order of up to approximately 0.5 m which is in accordance with the recommendations of this updated geotechnical report.

Foundation Considerations

The geotechnical investigation has revealed that the subsurface conditions at the site are suitable for supporting the proposed buildings and retaining walls on strip and spread footings designed to bear on the native glacial till, an engineered fill pad constructed on the glacial till and bedrock or on the shale bedrock. The existing fill in all the boreholes and the buried topsoil and loose sand from Borehole No. 3 are not suitable for supporting the footings and must be excavated and removed from within the footprint of the proposed buildings and retaining walls.

The available set of design drawings indicates that the underside of the footings of the north and south buildings will be set at Elevation 58.40 m and 57.45 m respectively. Review of the available limited borehole data revealed that the north building will be likely founded on the shale bedrock or on the glacial till or on an engineered fill pad constructed on the glacial till or shale bedrock. The south building will be founded on the shale bedrock. It is not recommended to found the footings of a building partly on soil (the glacial till or engineered fill) and partly on the shale bedrock unless a transition zone is provided at the interface of the two founding mediums (the soil and the bedrock). However, in such cases, it would be more feasible to excavate down to the shale bedrock and design the footings for a higher bearing value available in the shale bedrock. This would depend on the elevation of the shale bedrock in other areas of the footprint of the proposed buildings and can be best established on completion of the additional test holes.

It is recommended that in the early stages of the final design process, an additional geotechnical investigation consisting of boreholes and/or test pits should be conducted to further delineate the lateral and vertical (depths) extent throughout the site of the fill, buried topsoil layer, sand, glacial till and shale bedrock.

Footings on Glacial Till or Engineered Fill Pad

The proposed buildings and retaining walls may be supported by strip and spread footings set on an engineered fill pad constructed as noted below, or on the native glacial till and may be designed for a bearing pressure at serviceability limit state (SLS) of 150 kPa and factored geotechnical resistance at ultimate limit state (ULS) of 225 kPa. The factored ULS value includes a geotechnical resistance factor of 0.5. It is noted that glacial till was confirmed in only one (1) borehole and as such may be present elsewhere on site; possibly in the boreholes that met sampler and auger refusal.

Settlements of the footings designed for the recommended SLS bearing pressure value and properly constructed are expected to be within the normally tolerated limits of 25 mm total and 19 mm differential movements.

Engineered Fill Pad Construction

It is noted that following the demolition of the existing buildings and sheds, all construction debris, asphalt, topsoil, fill and disturbed materials should be removed from the footprints of the proposed new buildings and retaining walls down to the native glacial till or shale bedrock. The area of the excavation for the footings should extend to a sufficient distance beyond the limits of the footprints of the proposed new buildings to accommodate a 1.0 m wide bench of engineered fill around the perimeter of the structure, which is thereafter sloped at an inclination of 1H to 1V down to the glacial till or bedrock. The exposed glacial till or shale bedrock subgrade should be examined by a geotechnical engineer.

Following approval of the subgrade for the engineered fill pad, engineered fill required to raise the grades to the underside of the footings and lowest floor slab level should consist of free draining Ontario Provincial Standard Specification (OPSS) Granular B Type II material placed in 300 mm thick lifts and each lift compacted to 100 percent of the Standard Proctor Maximum Dry Density (SPMDD) under the footings and to 98 percent of the SPMDD under the slab on grade (floor slab). The engineered fill should be placed under the full-time supervision of a geotechnician working under the direction of a geotechnical engineer. In-place density tests should be undertaken on each lift of the engineered fill to ensure that it is properly compacted prior to placement of subsequent lift.

Footings designed on engineered fill pads constructed as noted above may be designed for a serviceability limit state (SLS) bearing pressure of 150 kPa and factored geotechnical resistance at ultimate limit state (ULS) of 225 kPa. The factored ULS value includes a geotechnical resistance factor of 0.5.

Settlements of the footings designed for the recommended SLS bearing pressure value and properly constructed are expected to be within the normally tolerated limits of 25 mm total and 19 mm differential movements.

As indicated in the *Subsurface Soil and Groundwater* section of this report, the shale bedrock of the Billings formation has a potential to swell and rapidly deteriorate when exposed to the elements. For the engineered fill pad to be constructed on the shale bedrock subgrade, once the shale bedrock has been exposed, it should be examined by a geotechnical engineer and the approved exposed bedrock surface covered within hours of exposure with the OPSS Granular B Type II engineered fill material.

Footings on Shale Bedrock

The proposed buildings may be supported by strip and spread footings designed to bear on the weathered shale bedrock below any heavily fractured zones and designed for an SLS bearing pressure of 500 kPa and factored geotechnical resistance at ULS of 750 kPa. The factored ULS value includes a geotechnical resistance factor of 0.5. Settlements of the footings founded on the weathered shale bedrock and designed to the recommended SLS bearing pressure are expected to be less than 10 mm.

As indicated in the section above, the shale bedrock of the Billings formation is prone to swelling under certain conditions of heat and humidity. It is also prone to rapid deterioration especially from below the groundwater table when exposed to the elements. Therefore, the bedrock exposed in the footings beds should be cleaned of any soil or deleterious materials, examined by a geotechnical engineer and the approved exposed bedrock covered with a skim coat of concrete within hours of its first exposure. Alternatively, the shale exposed in the sides of the footing trenches may be sealed by spraying gunnite.

All the footing beds should be thoroughly examined by a geotechnical engineer to ensure the shale bedrock is capable of supporting the recommended SLS bearing pressure value and to locate and map any minor fault zones, which may contain concentrated zones of fractured bedrock and may require special foundation treatment. Where fractured rock is encountered in a fault zone, sub-excavation may be undertaken to the underlying more competent bedrock. Alternatively, the footings may be re-designed to a reduced SLS bearing pressure value.

General Comments

In areas where the footings may be founded partly on the bedrock and partly on the engineered fill or glacial till, it is recommended that a transition zone be provided at the interface of the two (2) materials to minimize high load stress concentration and maintain foundation differential settlements between the two (2) founding materials to within the acceptable limits. Transition zone can be provided by excavating the bedrock at a gradient of 10H:7V and backfilling the excavation with OPSS Granular B Type II material compacted to 100 percent SPMDD. The lower SLS bearing pressure value of 150 kPa must be used along the section of the footing founded on the engineered fill or glacial till and along the transition zone.

Footings adjacent to any existing buildings should be designed in such a way that they will not exert any additional loads on the existing footings and subsurface walls.

All footing beds should be examined by a geotechnical engineer to ensure that the founding surfaces are capable of supporting the recommended SLS bearing pressure and that the footing beds have been properly prepared.

A minimum of 1.5 m of earth cover should be provided to all the exterior footings of heated structures to protect them from damage due to frost penetration. Footings of unheated structure should be provided with a cover of 2.1 m if snow would not be cleared from their vicinity. If the snow would be cleared from the vicinity of the footings, they should be provided with 2.4 m of earth cover. Where earth cover is less than the required, an equivalent combination of earth fill and rigid polystyrene insulation (such as Styrofoam HI-40) or rigid insulation should be provided. EXP can provide additional information regarding earth fill/rigid insulation combination of frost protection, if required.

The recommended bearing pressure at SLS and factored geotechnical resistances at ULS have been calculated by Exp from the borehole information for the design stage only. The investigation and comments are necessarily on-going as new information of underground conditions becomes available. For example, more specific information is available with respect to conditions between boreholes when foundation construction is underway. The interpretation between boreholes and the recommendations of this report must therefore be checked through field monitoring provided by an experienced geotechnical engineer to validate the information for use during the construction stage.

Floor Slab and Drainage Requirements

The lowest level floor of the proposed buildings may be constructed as a slabs-on-grade provided they are set on a bed of well compacted 19 mm sized clear stone at least 300 mm thick constructed on a minimum 300 mm thick engineered fill pad consisting of OPSS Granular A compacted to 98 percent SPMDD. The engineered fill pad should be placed on an approved subgrade. The clear stone would prevent the capillary rise of moisture to the floor slab. Adequate saw cuts should be provided in the floor slab to control cracking.

Perimeter and underfloor drainage systems should be provided for both buildings.

The underfloor drainage system may consist of 100 mm diameter perforated pipe or equivalent placed in parallel rows at 5 m to 6 m centres and at least 300 mm below the underside of the floor slab. The drains should be set on 100 mm thick layer of 19 mm sized clear stone and covered on top and sides with 150 mm of clear stone that is completely wrapped with an approved porous non-woven geotextile membrane, such as Terrafix 270R or equivalent. The perimeter drains may also consist of 100 mm diameter perforated pipe set on the footings and surrounded with 150 mm of 19 mm clear stone completely wrapped with an approved porous non-woven geotextile. The perimeter and underfloor drains should be connected to separate sumps equipped with backup pumps and generators in case of mechanical failure and/or power outage, so that at least one system would be operational should the other fail.

For floor slabs founded on the shale bedrock, special procedures will be required during slab construction. The shale bedrock of the Billings formation is known to heave due to a complex mechanism caused in part by the bio-oxidation of sulphides in the rock which then react with the calcite seams to form expanding gypsum. This occurs when oxygen is permitted to enter the rock, usually by lowering the water table. Cracking of the floor slab due to heaving of the shale has occurred in some structures in Ottawa. It is therefore recommended that the water table at the site should be maintained above the shale surface. The invert of the drains should be set at least 150 mm above the shale bedrock surface. In addition, a 50 mm thick concrete mud slab should be placed on the surface of the shale as a seal prior to placement of the granular fill. Weep holes should be provided in the concrete mud slab to facilitate drainage. Any granular fill to be placed under the floor slab should be compacted to at least 98 percent of the SPMDD. Any elevator pits and sumps should be constructed as water-tight structures instead of trying to locally depress the groundwater table around them which may result in dewatering of the shale.

The finished exterior grade should be sloped away from the buildings to prevent ponding of surface water close to the exterior walls of the buildings.

Lateral Earth Pressure Against Subsurface Basement Walls

The subsurface basement walls of the proposed new buildings should be backfilled with free draining material, such as OPSS Granular B Type II and equipped with a perimeter drainage system to prevent the buildup of hydrostatic pressure behind the walls. The walls will be subjected to lateral static and dynamic (seismic) earth forces. The expressions below assume free draining backfill material, a perimeter drainage system, level backfill surface behind the wall and vertical face on the back side of the wall.

For design purposes, the lateral static earth thrust against the subsurface walls may be computed from the following equation:

$$P = K_0 h (½ \gamma h + q)$$

where P = lateral earth thrust acting on the subsurface wall; kN/m

K_0 = lateral earth pressure coefficient for 'at rest' condition for Granular B Type II backfill material

γ = unit weight of free draining granular backfill; Granular B Type II

h = depth of point of interest below top of backfill, m

q = surcharge load stress, kPa

The lateral dynamic (seismic) thrust may be computed from the equation given below:

$$\Delta_{Pe} = \gamma H^2 \frac{a_h}{g} F_b$$

where Δ_{Pe} = dynamic thrust in kN/m of wall

H = height of wall, m

γ = unit weight of backfill material =

$\frac{a_h}{g}$ = seismic coefficient = 0.32 (Ottawa area)

F_b = thrust factor = 1.0

The dynamic (seismic) thrust does not take into account the surcharge load. The resultant force acts approximately at 0.63H above the base of the wall.

All subsurface walls of the proposed new buildings should be properly waterproofed.

Lateral Earth Pressure Against Retaining Walls

The retaining walls will be subjected to lateral static earth as well as lateral dynamic (seismic) earth forces during a seismic event. Seismic loading will result in an increase in active lateral earth pressure on the wall.

The retaining walls should be backfilled with free draining material, such as OPSS Granular B Type II and equipped with a permanent drainage system to prevent the buildup of hydrostatic pressure behind the wall.

The seismic (dynamic) pressure distribution is an inverted triangle with maximum pressure at the top of the wall and a minimum at the bottom of the wall. Therefore, the resultant of earthquake pressure on the retaining wall is assumed to be applied at a height of 0.6 H above the base of the wall where H is the height the wall. The total active pressure distribution can be separated into static component and dynamic components and may be determined as follows (Mononobe and Matsuo, 1929):

$$\sigma_{AE}(z) = K_A\gamma z + (K_{AE} - K_A)\gamma(H - z) + q$$

Where $\sigma_{AE}(z)$ = the total combined active lateral earth pressure (dynamic and static) at depth z, (kPa).
z = depth below the top of the retaining wall
K_A = static lateral active earth pressure coefficient
K_{AE} = combined (static and dynamic) active earth pressure coefficient
γ = unit weight of the backfill soil (kN/m^3)
H = Total height of the wall (m)
q = surcharge such as traffic and compaction pressure, where applicable

As noted above, for the total active earth pressure, the seismic (dynamic) pressure distribution is an inverted triangle with maximum pressure at the top of the wall and a minimum at the bottom of the wall. Therefore, the resultant of the static and seismic (dynamic) pressures on the retaining wall is assumed to be applied at depths ranging between 0.67z from the top of the backfill behind the wall and 0.67 (H-z) from the bottom of the wall, respectively.

Soil Parameters for Subsurface Basement and Retaining Walls

The estimated lateral earth pressure parameters are summarized in Table III.

Table III: Soil Parameters

Soil Type:	OPSS Granular B Type II
Unit Weight of Soil (γ); kN/m^3	22
Angle of Internal Friction (ϕ'); degrees	30°
Coefficient of Static Active Lateral Earth Pressure Coefficient, K_A	0.33
Coefficient of Static At-Rest Lateral Earth Pressure Coefficient, K_0	0.50
Combined Lateral (static and seismic) Active Earth Pressure Coefficient, K_{AE} for a Yielding Wall (Retaining Wall)	0.44
Combined Lateral (static and seismic) Active Earth Pressure Coefficient, K_{AE} for a Non-Yielding Wall (Basement Wall)	0.60

For the calculation of the active dynamic (seismic) lateral earth pressure coefficients for retaining walls, the seismic coefficient in the horizontal direction, k_h, was taken as 0.5 times the peak ground acceleration (PGA) value of 0.32g. For basement walls the k_h was taken as 1.0 times the PGA value. The calculated active dynamic (seismic) lateral earth pressure coefficients assume the seismic coefficient in the vertical direction, k_v, is zero. If vertical acceleration is taken into consideration, the computed active and dynamic (seismic) lateral earth pressure coefficients values would be somewhat different.

The K_{AE} value calculations assume the back face of the wall is vertical, there is no friction between the concrete of the wall and the backfill soil (behind the wall) and the ground surface of the backfill (behind the wall) is level or flat and the ground surface of the backfill behind the wall is at the same level as the top of the retaining wall.

The static active condition for a retaining wall will be reached when the outward displacement of the wall is approximately 0.001 H to 0.004 H for granular soil backfill where 'H' is the height of the wall. For the seismic condition for a retaining wall the K_{AE} value is applicable for a wall designed to move by up to approximately 80 mm.

As per the City of Ottawa requirement, a global stability check must be performed on any retaining wall with a height of 1 m of greater. The final design of the retaining walls should be reviewed by this office.

Excavations and De-watering Requirements

Excess Soil Management

Ontario Regulation 406/19 specifies protocols that are required for the management and disposal of excess soils. As set forth in the regulation, specific analytical testing protocols need to be implemented and followed based on the volume of soil to be managed and the requirements of the receiving site. The testing protocols are specific as to whether the soils are stockpiled or in situ. In either scenario, the testing protocols are far more onerous than have been historically carried out as part of standard industry practices. These decisions should be factored in and accounted for prior to the initiation of the project-defined scope of work. EXP would be pleased to assist with the implementation of a soil management and testing program that would satisfy the requirements of Ontario Regulation 406/19.

Excavations

Excavations for the construction of new building foundations, retaining walls and the installation of new underground services at the site are expected to extend to approximately 3.5 m below the existing ground surface. The excavations will be undertaken predominantly through the fill, buried topsoil layer, sand and into the glacial till and shale bedrock. These excavations are expected to be below the groundwater table.

The soils at the site may be excavated with conventional mechanical equipment capable of removing construction debris (including possible reinforced concrete) within the fill as well as cobbles and boulders within the fill and glacial till. Shallow excavation into the shale bedrock may be undertaken with a large mechanical shovel and hoe ram in combination with line drilling; progress may be slow and time consuming. Deep excavations into the shale bedrock would require the use of line drilling and blasting techniques. The blasting should be carried out by an experienced contractor under the supervision of a blasting specialist to ensure that integrity of any existing structures and underground services is not adversely affected. A pre-construction condition survey of the existing structures and infrastructure within the construction zone of influence should be undertaken prior to commencement of construction. Vibrations generated by blasting operations should be monitored and should not exceed 50 mm per second at the property boundaries or City of Ottawa requirements. The most appropriate method of excavating the shale bedrock can be confirmed once building design details are available and an additional geotechnical investigation has been completed.

The excavations within the soils at the site may be undertaken as open cut provided they meet the requirements of the Ontario Occupational Health and Safety Act (OHSA). The soils are classified as Type 3 and must be cut back at 1H:1V from the bottom of the excavation. For excavations below the groundwater level, the side slopes should be flattened to a gradient ranging from 2H:1V to 3H:1V from the bottom of the excavation. If space restrictions prevent open-cut excavation, the excavations will have to be undertaken within the confines of an engineered support system designed and constructed in accordance with the above regulation and the 2006 CFEM. If shoring is required, this office should be contacted to provide the required soil/rock parameters and recommendations for the design and construction of the shoring system.

Underground services at the site may be installed as open cut as discussed above or within the confines of a pre-fabricated support system (such as a trench box), which is designed and installed in accordance with the above regulation.

Excavations at the site are not expected to experience a base-heave type of failure.

The shale bedrock may be excavated with near vertical sides, subject to examination by a geotechnical engineer. Some scaling back of the bedrock face, such as to a gradient of 1H:1V, may be required in the zone of the weathered bedrock. Exposed faces of the shale bedrock (weathered and sound) below the groundwater level should be protected from deterioration achieved by methods discussed in previous sections of this report.

Many geologic materials deteriorate rapidly upon exposure to meteorological elements. Unless otherwise specifically indicated in this report, walls and floors of excavations must be protected from moisture, desiccation, and frost action throughout the course of construction.

De-watering Requirements

Seepage of the surface and subsurface water into the excavations is anticipated. However, it should be possible to collect any water entering the excavations in perimeter ditches and to remove it by pumping from sumps. In areas of high infiltration, a higher seepage rate should be anticipated and high-capacity pumps may be required to keep the excavation dry.

It has been assumed that the maximum excavation depth at the site will be approximately 3.5 m and would necessitate groundwater removal from the site. It is noteworthy to mention that legislation came into force in Ontario on March 29, 2016 to regulate groundwater takings for construction dewatering purposes. Prior to March 29, 2016, a Category 2 Permit to Take Water (PTTW) was required from the Ontario Ministry of the Environment and Climate Change (MOECC) for groundwater takings related to construction dewatering, where taking volumes in excess of 50 m^3/day, but less than 400 m^3/day, and the taking duration was no more than 30 consecutive days. The new legislation replaces the Category 2 PTTW for construction dewatering with a new process under the Environmental Activity and Sector Registry (EASR). The EASR is an on-line registry, which allows persons engaged in prescribed activities, such as water takings, to register with the Ministry of Environment, Conservation and Parks (MECP) instead of applying for a PTTW.

To be eligible for the new EASR process, the construction dewatering taking must be less than 400 m^3/day under normal conditions. The water taking can be groundwater, storm water, or a combination of both. It should be noted that the 30-consecutive day limit on the water taking under the old Category 2 PTTW process has been removed in the new EASR process. Also, it should be noted that the EASR process requires two technical studies be prepared by a Qualified Person, prior to any water taking. These studies include a Water Taking Report, which provides assurance that the taking will not cause any unacceptable impacts, and a Discharge Plan, which provides assurance that the discharge will not result in any adverse impacts to the environment. A significant advantage of the new EASR process over the former Category 2 PTTW process, is that the groundwater taking may begin immediately after completing the on-line registration of the taking and paying the applicable fee, assuming the accompanying technical studies have been completed. The former PTTW process typically took more than 90 days, which had the potential to impact construction schedules.

Although this investigation has estimated the groundwater levels at the time of the fieldwork, and commented on dewatering and general construction problems, conditions may be present which are difficult to establish from standard boring and excavating techniques and which may affect the type and nature of dewatering procedures used by the contractor in practice. These conditions include local and seasonal fluctuations in the groundwater table, erratic changes in the soil profile, thin layers of soil with large or small permeabilities compared with the soil mass, etc. Only carefully controlled tests using pumped wells and observation wells will yield the quantitative data on groundwater volumes and pressures that are necessary to adequately engineer construction dewatering systems.

Pipe Bedding Requirements

It is recommended that the bedding for the underground services including material specifications, thickness of cover material and compaction requirements conform to City of Ottawa specifications and/or Ontario Provincial Standard Specifications and Drawings (OPSS and OPSD).

For guidance, the pipe bedding may consist of 300 mm thick well graded, crushed stone, such as OPSS Granular A. The bedding material may be placed along the sides and on top of the pipe to provide a minimum cover of 300 mm. The bedding should be compacted to at least 95 percent SPMDD.

The bedding thickness may be increased in areas where the subgrade is very loose/soft or becomes disturbed. Trench base stabilization techniques, such as removal of loose/soft material, placement of crushed stone sub-bedding (OPSS Granular B Type II material), completely wrapped in a non-woven geotextile, may also be used if trench base disturbance becomes a problem in wet or soft/very loose areas.

The invert of sections of the underground service pipes may be founded partly on the shale bedrock and partly on engineered fill or glacial till. In this case, transition zone treatment will be required to minimize bending stress in the service pipe. Transition zone treatment may be undertaken in the form of cutting back the surface of the bedrock from the soil/rock interface at 3H:1V and backfilling the transition zone area with extra bedding material compacted to 95 percent SPMDD.

The excavation, pipe installation and backfilling work should be co-ordinated such that the trenches are backfilled on the day that they are excavated.

Backfilling Requirements and Suitability of On-site Soils for Backfilling Purposes

The material to be excavated from the site is anticipated to comprise of topsoil, asphalt, fill, sand, glacial till and shale bedrock. Select portions of the glacial till above the groundwater level may be re-used in the backfilling of the service trenches situated outside the proposed building footprints, subject to further examination and testing prior to construction. The remaining materials are not suitable for backfilling purposes and should be discarded or used in the landscaped area for general grading purposes.

Based on the geotechnical investigation, all material required for backfilling against subsurface walls, retaining walls, footing and service trenches would have to be imported and should conform to the specifications given below:

(a) Engineered Fill under footings, underfloor fill and backfilling of footings and service trenches in the interior of the building – OPSS Granular B Type II placed in 300 mm thick lifts with each lift compacted to 100 percent under the footings and to 98 percent SMPDD under the floor slab.

(b) Backfill against the exterior subsurface walls of the proposed buildings and retaining walls - OPSS Granular B Type II placed in 300 mm thick lifts with each lift compacted to 95 percent SPMDD.

(c) Trench backfill to raise the grades outside the proposed building areas, retaining wall areas and for pavement subgrade – OPSS Select Subgrade Material (SSM), free of organics, debris and with a natural moisture content within 2 percent of the optimum moisture content. It should be placed in 300 mm thick lifts with each lift compacted to minimum 95 percent SPMDD.

The sides of the excavations for the utility trenches and subsurface basement walls that extend into the shale bedrock below the groundwater should be sprayed with gunnite to prevent deterioration and heave of the shale bedrock. For the underground services, an alternative to gunnite is to backfill the portion of the trenches in the bedrock below the groundwater level using clay or concrete.

Subsurface Concrete Requirements

A soil sample and a rock core section from the boreholes were submitted to AGAT Laboratories Ltd. for pH, sulphate, chloride and resistivity determination. The test results are summarized in Table IV and shown in Appendix A.

Table IV: Chemical Test Results

Borehole No.	Sample/Run No. (Depth)	Soil/Rock Type	Lab Test Results			
			pH	Sulphates (%)	Chlorides (%)	Resistivity (ohm-cm)
2	Run No. 1 (1.3 m)	Shale Bedrock	7.97	0.0210	0.0004	3140
3	SS 3 (1.5-2.1 m)	Glacial Till	7.78	0.0165	0.0103	2230

A review of Table IV indicates that the on-site native glacial till and shale bedrock contain less than 0.1 percent sulphates and less than 0.04 percent chlorides. The sulphate concentration in the soil would have a negligible potential of sulphate attack on subsurface concrete. The concrete should be designed in accordance with Table Nos. 3 and 6 of the CSA A.23-1-14. The concrete should be dense, well-compacted and cured.

The resistivity measurements indicate the soil and bedrock are mildly corrosive to steel members/structures. The degree of corrosion should be considered in the design and installation of underground/buried steel members/structures. A corrosion specialist should be consulted to provide comments and recommendations regarding corrosion protection.

Pavement Structure Design

Pavement structure thicknesses required for the proposed residential development were computed. The pavement subgrade is expected to consist of existing fill, glacial till and/or OPSS select subgrade material (SSM). The pavement structures are shown on Table No. V. The thicknesses are based upon an estimate of the subgrade soil properties determined from visual examination and textural classification of the soil samples and pavement functional design life of eight to ten years. The proposed functional design life represents the number of years to the first rehabilitation, assuming regular maintenance is carried out.

Table No. V: Recommended Pavement Structure Thicknesses

Pavement Layer	**Compaction Requirements**	**Pavement Structure Thickness**
		SSM/Glacial Till Subgrade
Asphaltic Concrete	92-97% MRD	65 mm HL-3
OPSS Granular A Base (crushed limestone)	100% SPMDD	150 mm
OPSS Granular B Type II Sub-Base	100% SPMDD	400 mm

SPMDD - Denotes standard Proctor maximum dry density; ASTM-D698.
MRD – Denotes Maximum Relative Density; ASTM-D2041.
Any subgrade fill must be compacted to 98% SPMDD for at least the upper 300 mm.

As part of the subgrade preparation, the proposed pavement areas should be stripped of topsoil and other obviously unsuitable material. Fill required to raise the grades to design subgrade elevations should conform to OPSS select subgrade material (SSM) and should be placed and compacted to 95 percent of the SPMDD. The subgrade should be properly shaped, crowned, then proofrolled with a heavy vibratory roller in the full-time presence of a representative of this office. Any soft or spongy subgrade areas detected should be sub excavated and properly replaced with suitable approved backfill compacted to 95% percent SPMDD (ASTM D698-12e2).

The granular materials used for pavement construction should conform to OPSS Granular A and Granular B Type II materials and should be compacted to 100 percent of the SPMDD.

The asphaltic concrete placement should meet OPSS 1150 or 1151 requirements. It should be compacted from 92 percent to 97 percent of the Maximum Relative Density (ASTM D2041). Asphalt placement should be in accordance with OPSS 310 and OPSS 313.

It is recommended that EXP be retained to review the final pavement structure design and drainage plans prior to construction to ensure they are consistent with the recommendations of this report.

Slope Stability

The existing ground surface of the site slopes down towards Beechwood Avenue. Review of the existing and final grades indicate that the gradient of the ground surface across the site is and will be approximately at 10H to 14H:1V. Therefore, based on the estimated gradient of 10H to 14H:1V of the existing and final grades across the site, slope stability is not a concern for this project.

Additional Geotechnical Investigation

It is recommended that in the early stages of the final design process, an additional geotechnical investigation consisting of boreholes and/or test pits should be conducted to further delineate the lateral and vertical (depths) extent throughout the site of the fill, buried topsoil layer, sand, glacial till and shale bedrock.

General Closure

The comments given in this letter are intended only for the guidance of design engineers. The number of boreholes or boreholes required to determine the localized underground conditions, between boreholes affecting construction costs, techniques, sequencing, equipment, scheduling, etc., would be much greater than has been carried out for design purposes. Contractors bidding on or undertaking the works should, in this light, decide on their own investigations, as well, as their own interpretations of the factual borehole results, so that they may draw their own conclusions as to how the subsurface conditions may affect them.

The information contained in this report is not intended to reflect on environmental aspects of the soils. Reference is made to the Phase One and Two Environmental Site Assessment reports prepared by EXP and presented under separate covers regarding the environmental aspects of the site.

We trust that the information contained in this letter-type report will be satisfactory for your purposes. Should you have any questions, please contact this office.

Sincerely,

EXP Services Inc.

LICENSED PROFESSIONAL ENGINEER
MARCH 25, 2022
S.M. POTYONDY
37232568
PROVINCE OF ONTARIO

Susan M. Potyondy, P.Eng.
Senior Project Manager
Earth and Environmental

Ismail M. Taki, M.Eng., P.Eng.
Senior Manager
Earth and Environment
Eastern Region

Cc:
Kayla Blakely <k.blakely@novatech-eng.com>
Jeremy Silburt <Jeremy@smartlivingproperties.ca>

Attachments:
FIGURES
Figure 1: Site Location Plan
Figure 2: Borehole Location Plan
Figures 3 to 7: Borehole Logs
Figure 8: Grain-size Distribution Curve
APPENDIX A: Certificate of Laboratory Analysis

FIGURES

0 200m 400m 800m

HORIZONTAL 1:20,000

exp Services Inc.

t: +1.613.688.1899 | f: +1.613.225.7337
2650 Queensview Drive, Suite 100
Ottawa, ON K2B 8H6
Canada

www.exp.com

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scale
1:20,000

date
MARCH 2022

drawn by
M.N. / A.S.

CLIENT: 229 AND 241 BEECHWOOD HOLDINGS INC.

TITLE:
SITE LOCATION PLAN
GEOTECHNICAL INVESTIGATION, PROPOSED RESIDENTIAL
DEVELOPMENT, 229 - 247 BEECHWOOD AVENUE, OTTAWA, ON

project no.
OTT-00238207-A0

FIG 1

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Last Saved: 3/24/2022 2:43:06 PM
Last Plotted: 3/24/2022 2:43:56 PM Plotted by: SeverA Pen Table:: exp-64.ctb

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NOTES :

1. THE BOUNDARIES AND SOIL/ ROCK TYPES HAVE BEEN ESTABLISHED ONLY AT BOREHOLE LOCATIONS. BETWEEN BOREHOLES THEY ARE ASSUMED AND MAY BE SUBJECT TO CONSIDERABLE ERROR.
2. SOIL AND ROCK SAMPLES WILL BE RETAINED IN STORAGE FOR THREE MONTHS AND THEN DESTROYED UNLESS THE CLIENT ADVISES THAT AN EXTENDED TIME PERIOD IS REQUIRED.
3. TOPSOIL AND ASPHALT QUANTITIES SHOULD NOT BE ESTABLISHED FROM THE INFORMATION PROVIDED AT THE BOREHOLE LOCATIONS.
4. BOREHOLE ELEVATIONS SHOULD NOT BE USED TO DESIGN BUILDING(S) OR FLOOR SLABS OR PARKING LOT(S) GRADES.
5. THIS DRAWING FORMS PART OF THE REPORT PROJECT NUMBER AS REFERENCED AND SHOULD BE USED ONLY IN CONJUNCTION WITH THIS REPORT.
6. BASE PLAN OBTAINED FROM ANNIS O'SULLIVAN VOLLEBEKK LTD., PART 1, PLAN OF LOTS 10, 11, 12, 24, 25, 26 PART OR REAR PASSAGE (AS CLOSED BYJUDGE'S ORDER LT476512 AND JUDGE'S ORDER LT113018) REGISTERED PLAN 4M-30, CITY OF OTTAWA. SURVEY COMPLETED ON JUNE 14, 2017.

LEGEND

BH1 58.70	BOREHOLE NUMBER, LOCATION AND ELEVATION
BM	GEODETIC BENCHMARK - CONCRETE SLAB LOCATED ON NORTH SIDE OF 231-235 BEECHWOOD AVENUE
▭	APPROXIMATE LOCATION OF PROPOSED BUILDING FOOTPRINT
▨	EXISTING STRUCTURES TO BE DEMOLISHED

exp Services Inc.
t: +1.613.688.1899 | f: +1.613.225.7337
2650 Queensview Drive, Suite 100
Ottawa, ON K2B 8H6
Canada
www.exp.com
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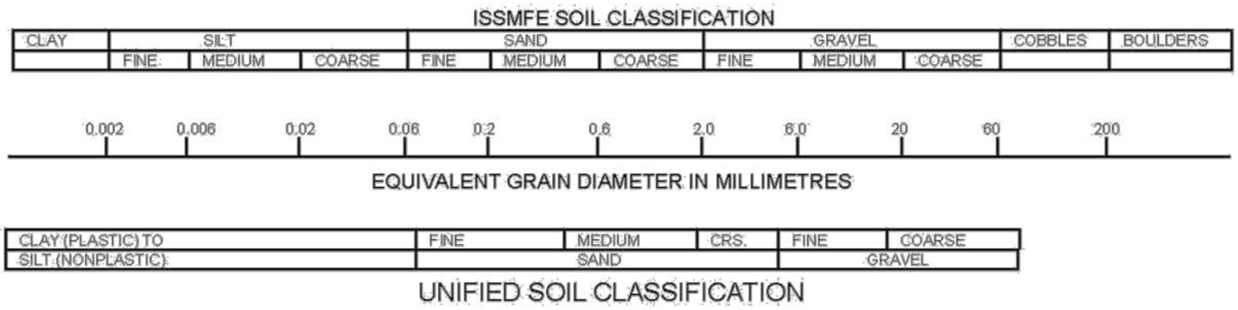
scale 1:250	CLIENT: 229 AND 241 BEECHWOOD HOLDINGS INC.	project no. OTT-00238207-A0
date MARCH 2022	TITLE: BOREHOLE LOCATION PLAN GEOTECHNICAL INVESTIGATION, PROPOSED RESIDENTIAL DEVELOPMENT, 229 - 247 BEECHWOOD AVENUE, OTTAWA, ON	FIG 2
drawn by M.N. / A.S.		

Notes On Sample Descriptions

1. All sample descriptions included in this report follow the Canadian Foundations Engineering Manual soil classification system. This system follows the standard proposed by the International Societv for Soil Mechanics and Foundation Engineering. Laboratory grain size analyses provided by **exp** Services Inc. also follow the same system. Different classification systems may be used by others; one such system is the Unified Soil Classification. Please note that, with the exception of those samples where a grain size analysis has been made, all samples are classified visually. Visual classification is not sufficiently accurate to provide exact grain sizing or precise differentiation between size classification systems.



2. Fill: Where fill is designated on the borehole log it is defined as indicated by the sample recovered during the boring process. The reader is cautioned that fills are heterogeneous in nature and variable in density or degree of compaction. The borehole description may therefore not be applicable as a general description of site fill materials. All fills should be expected to contain obstruction such as wood, large concrete pieces or subsurface basements, floors, tanks, etc., none of these may have been encountered in the boreholes. Since boreholes cannot accurately define the contents of the fill, test pits are recommended to provide supplementary information. Despite the use of test pits, the heterogeneous nature of fill will leave some ambiguity as to the exact composition of the fill. Most fills contain pockets, seams, or layers of organically contaminated soil. This organic material can result in the generation of methane gas and/or significant ongoing and future settlements. Fill at this site may have been monitored for the presence of methane gas and, if so, the results are given on the borehole logs. The monitoring process does not indicate the volume of gas that can be potentially generated nor does it pinpoint the source of the gas. These readings are to advise of the presence of gas only, and a detailed study is recommended for sites where any explosive gas/methane is detected. Some fill material may be contaminated by toxic/hazardous waste that renders it unacceptable for deposition in any but designated land fill sites; unless specifically stated the fill on this site has not been tested for contaminants that may be considered toxic or hazardous. This testing and a potential hazard study can be undertaken if requested. In most residential/commercial areas undergoing reconstruction, buried oil tanks are common and are generally not detected in a conventional geotechnical site investigation.

3. Till: The term till on the borehole logs indicates that the material originates from a geological process associated with glaciation. Because of this geological process the till must be considered heterogeneous in composition and as such may contain pockets and/or seams of material such as sand, gravel, silt or clay. Till often contains cobbles (60 to 200 mm) or boulders (over 200 mm). Contractors may therefore encounter cobbles and boulders during excavation, even if they are not indicated by the borings. It should be appreciated that normal sampling equipment cannot differentiate the size or type of any obstruction. Because of the horizontal and vertical variability of till, the sample description may be applicable to a very limited zone; caution is therefore essential when dealing with sensitive excavations or dewatering programs in till materials.

Log of Borehole BH 1

Project No: OTT-00238207-A0

Project: Proposed Residential Development

Location: 229-247 Beechwood Avenue, Ottawa, Ontario

Figure No. 3

Page. 1 of 1

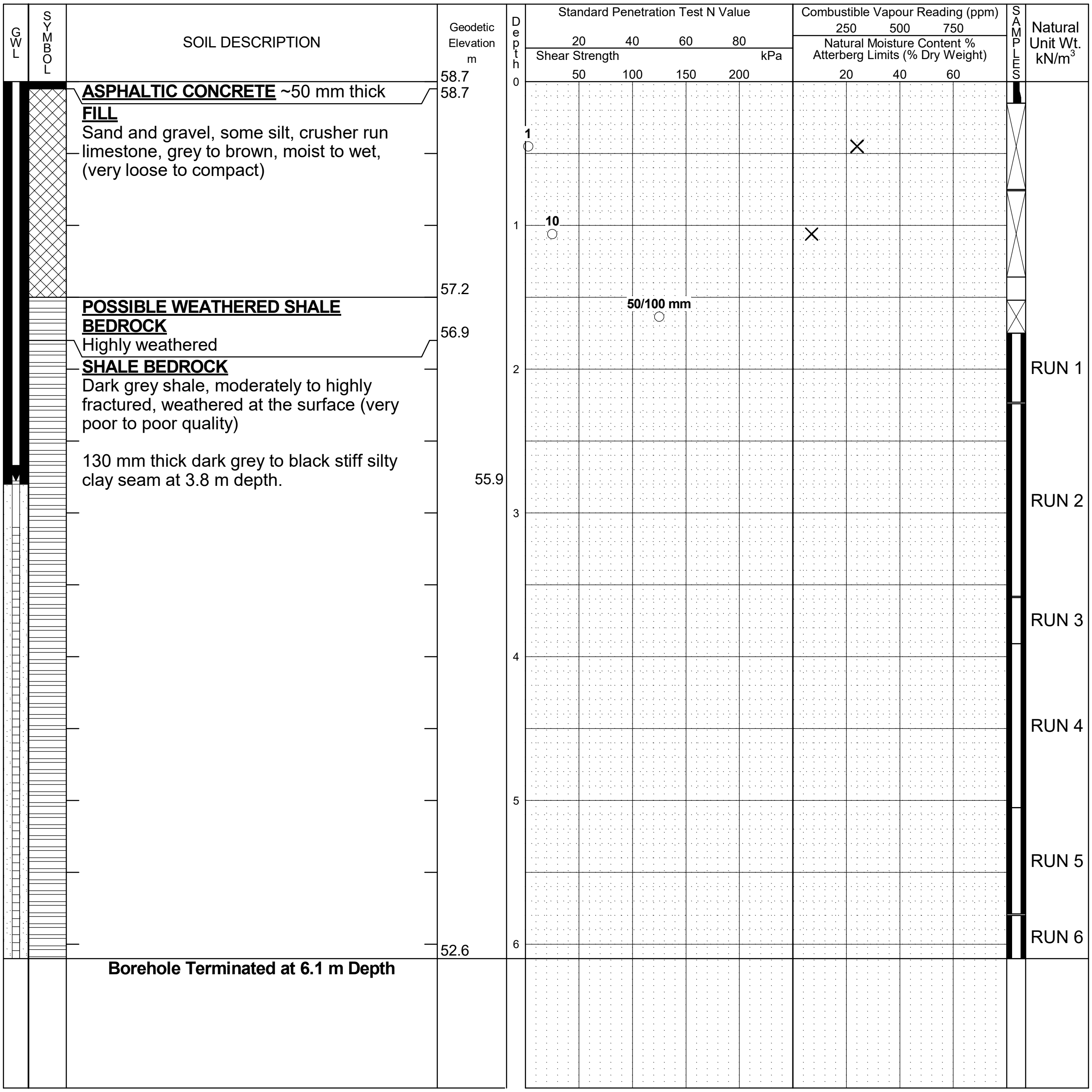
Date Drilled: 'June 26, 2017

Drill Type: CME-55 Truck Mounted Drill Rig

Datum: Geodetic Elevation

Logged by: MD Checked by: ZG

Split Spoon Sample	☒	Combustible Vapour Reading	☐
Auger Sample	◧	Natural Moisture Content	×
SPT (N) Value	○	Atterberg Limits	├─○
Dynamic Cone Test	—	Undrained Triaxial at % Strain at Failure	⊕
Shelby Tube	■		
Shear Strength by Vane Test	+ S	Shear Strength by Penetrometer Test	▲



ASPHALTIC CONCRETE ~50 mm thick

FILL
Sand and gravel, some silt, crusher run limestone, grey to brown, moist to wet, (very loose to compact)

POSSIBLE WEATHERED SHALE BEDROCK
Highly weathered

SHALE BEDROCK
Dark grey shale, moderately to highly fractured, weathered at the surface (very poor to poor quality)

130 mm thick dark grey to black stiff silty clay seam at 3.8 m depth.

Borehole Terminated at 6.1 m Depth

NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. A 31-mm diameter monitoring well was installed as shown upon completion of drilling.
3. Field work supervised by an **exp** representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-00238207-A0

WATER LEVEL RECORDS

Date	Water Level (m)	Hole Open To (m)
Upon Completion	1.4	
July 7, 2017	2.8	

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %
1	1.8 - 2.2	100	0
2	2.2 - 3.6	100	18
3	3.6 - 3.9	100	0
4	3.9 - 5.1	100	19
5	5.1 - 5.8	100	34
6	5.8 - 6.1	100	0

Log of Borehole BH 2

Project No: OTT-00238207-A0

Figure No. 4

Page. 1 of 1

Project: Proposed Residential Development

Location: 229-247 Beechwood Avenue, Ottawa, Ontario

Date Drilled: 'June 26, 2017

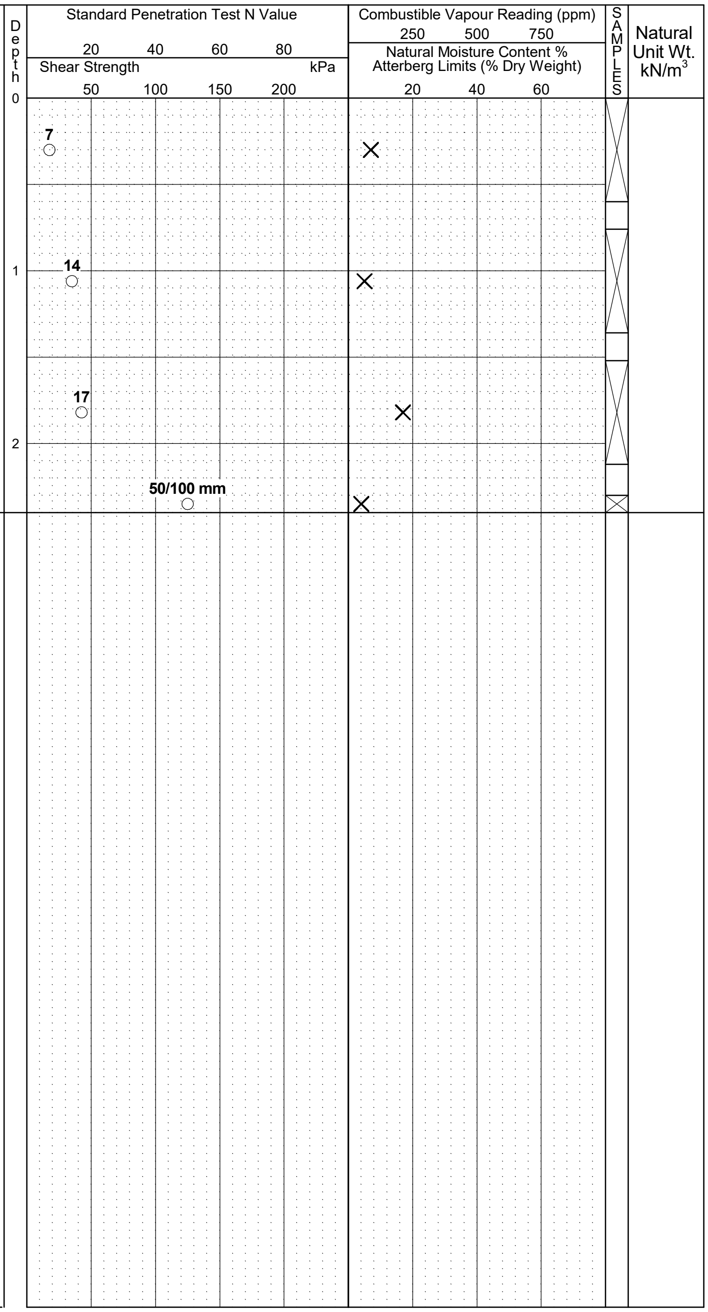
Drill Type: CME-55 Truck Mounted Drill Rig

Datum: Geodetic Elevation

Logged by: MD Checked by: ZG

Split Spoon Sample	☒	Combustible Vapour Reading	☐
Auger Sample	◨	Natural Moisture Content	×
SPT (N) Value	○	Atterberg Limits	├──○
Dynamic Cone Test	──	Undrained Triaxial at % Strain at Failure	⊕
Shelby Tube	■	Shear Strength by Penetrometer Test	▲
Shear Strength by Vane Test	+ S		

GWL	SYMBOL	SOIL DESCRIPTION	Geodetic Elevation m
			60.97
		TOPSOIL ~125 mm thick	60.9
		FILL Sand and gravel, some silt to silty, crusher run limestone, grey to brown, moist to wet, (loose to compact)	
		Shale fragments at 2.4 m Depth	58.6
		Sampler Refusal at 2.4 m Depth	



NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. Borehole backfilled with bentonite upon completion of drilling.
3. Field work supervised by an **exp** representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-00238207-A0

WATER LEVEL RECORDS

Date	Water Level (m)	Hole Open To (m)
Upon Completion	Dry	

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %

Log of Borehole BH 3

Project No: OTT-00238207-A0

Project: Proposed Residential Development

Location: 229-247 Beechwood Avenue, Ottawa, Ontario

Figure No. 5

Page. 1 of 1

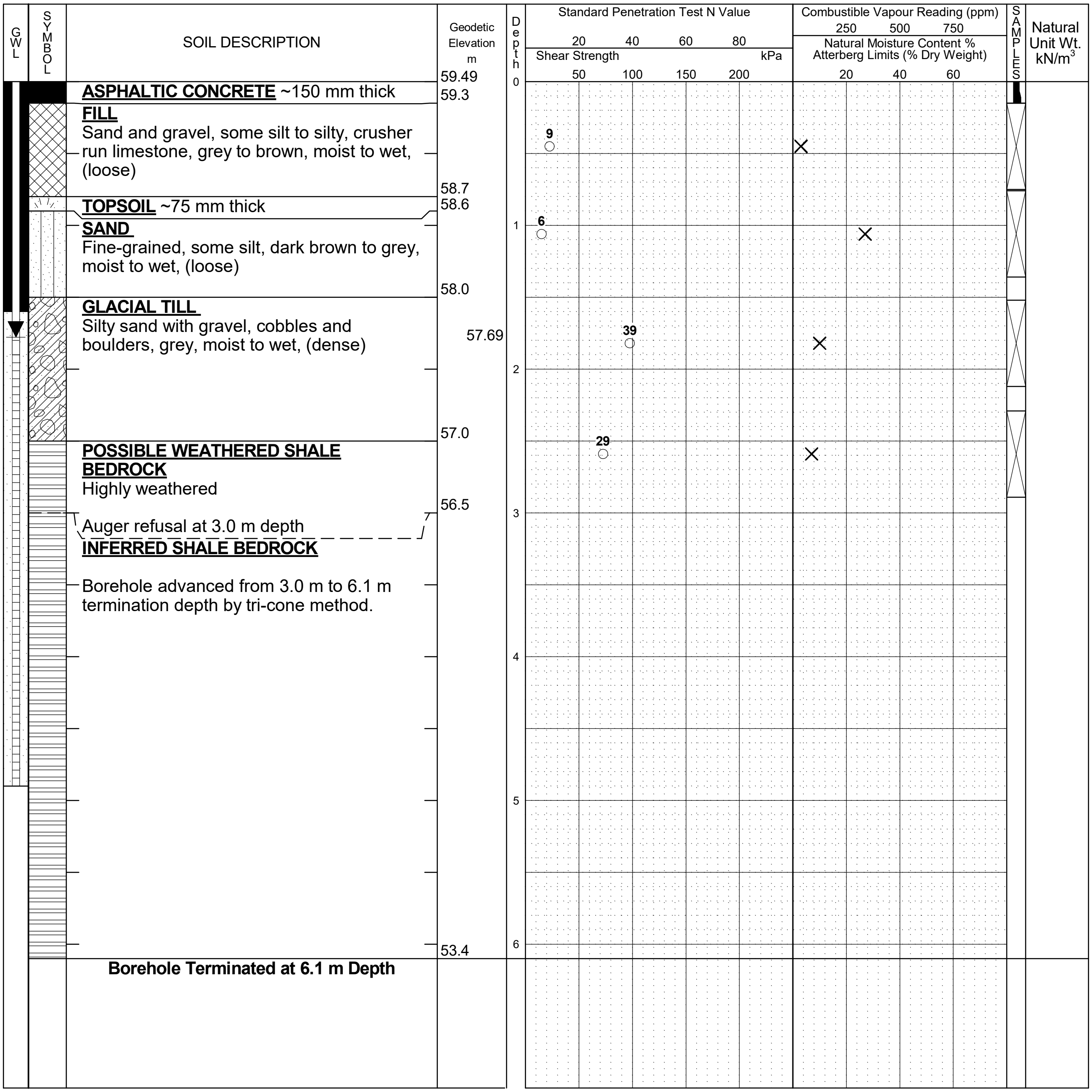
Date Drilled: 'June 27, 2017

Drill Type: CME-55 Truck Mounted Drill Rig

Datum: Geodetic Elevation

Logged by: MD Checked by: ZG

Split Spoon Sample	☒	Combustible Vapour Reading	☐
Auger Sample	◧	Natural Moisture Content	×
SPT (N) Value	○	Atterberg Limits	├──○
Dynamic Cone Test	──	Undrained Triaxial at % Strain at Failure	⊕
Shelby Tube	■		
Shear Strength by Vane Test	+ S	Shear Strength by Penetrometer Test	▲



Geodetic Elevation m	SOIL DESCRIPTION
59.49	
59.3	**ASPHALTIC CONCRETE** ~150 mm thick
58.7	**FILL** Sand and gravel, some silt to silty, crusher run limestone, grey to brown, moist to wet, (loose)
58.6	**TOPSOIL** ~75 mm thick
58.0	**SAND** Fine-grained, some silt, dark brown to grey, moist to wet, (loose)
57.69	
57.0	**GLACIAL TILL** Silty sand with gravel, cobbles and boulders, grey, moist to wet, (dense)
56.5	**POSSIBLE WEATHERED SHALE BEDROCK** Highly weathered
53.4	Auger refusal at 3.0 m depth **INFERRED SHALE BEDROCK** Borehole advanced from 3.0 m to 6.1 m termination depth by tri-cone method.

Borehole Terminated at 6.1 m Depth

NOTES:
1. Borehole data requires interpretation by EXP before use by others
2. A 31-mm diameter monitoring well was installed as shown upon completion of drilling.
3. Field work supervised by an **exp** representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-00238207-A0

WATER LEVEL RECORDS

Date	Water Level (m)	Hole Open To (m)
Upon Completion	3.1	
July 7, 2017	1.8	

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %

Log of Borehole BH 4

Project No: OTT-00238207-A0

Project: Proposed Residential Development

Location: 229-247 Beechwood Avenue, Ottawa, Ontario

Figure No. 6

Page. 1 of 1

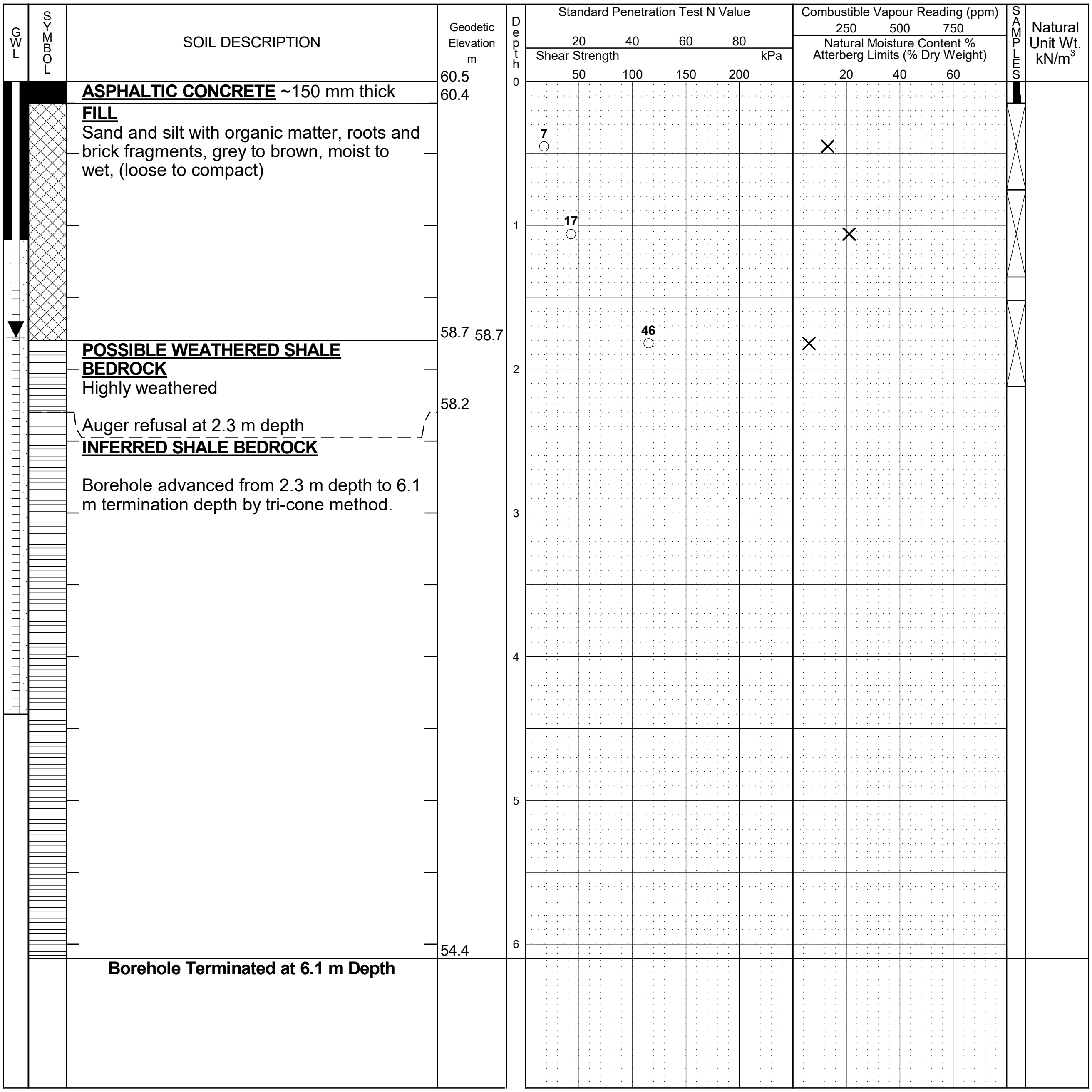
Date Drilled: 'June 27, 2017

Drill Type: CME-55 Truck Mounted Drill Rig

Datum: Geodetic Elevation

Logged by: MD Checked by: ZG

Split Spoon Sample	☒	Combustible Vapour Reading	☐
Auger Sample	◨	Natural Moisture Content	×
SPT (N) Value	○	Atterberg Limits	├─○
Dynamic Cone Test	───	Undrained Triaxial at % Strain at Failure	⊕
Shelby Tube	■		
Shear Strength by Vane Test	+ S	Shear Strength by Penetrometer Test	▲



Soil Description	Geodetic Elevation (m)
	60.5
ASPHALTIC CONCRETE ~150 mm thick	60.4
FILL Sand and silt with organic matter, roots and brick fragments, grey to brown, moist to wet, (loose to compact)	
POSSIBLE WEATHERED SHALE BEDROCK Highly weathered	58.7 58.7
Auger refusal at 2.3 m depth **INFERRED SHALE BEDROCK** Borehole advanced from 2.3 m depth to 6.1 m termination depth by tri-cone method.	58.2
	54.4

Borehole Terminated at 6.1 m Depth

NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. A 31-mm diameter monitoring well was installed as shown upon completion of drilling.
3. Field work supervised by an **exp** representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-00238207-A0

WATER LEVEL RECORDS

Date	Water Level (m)	Hole Open To (m)
July 7, 2017	1.8	

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %

Log of Borehole BH 5

Project No: OTT-00238207-A0

Project: Proposed Residential Development

Location: 229-247 Beechwood Avenue, Ottawa, Ontario

Figure No. 7

Page. 1 of 1

Date Drilled: 'June 27, 2017

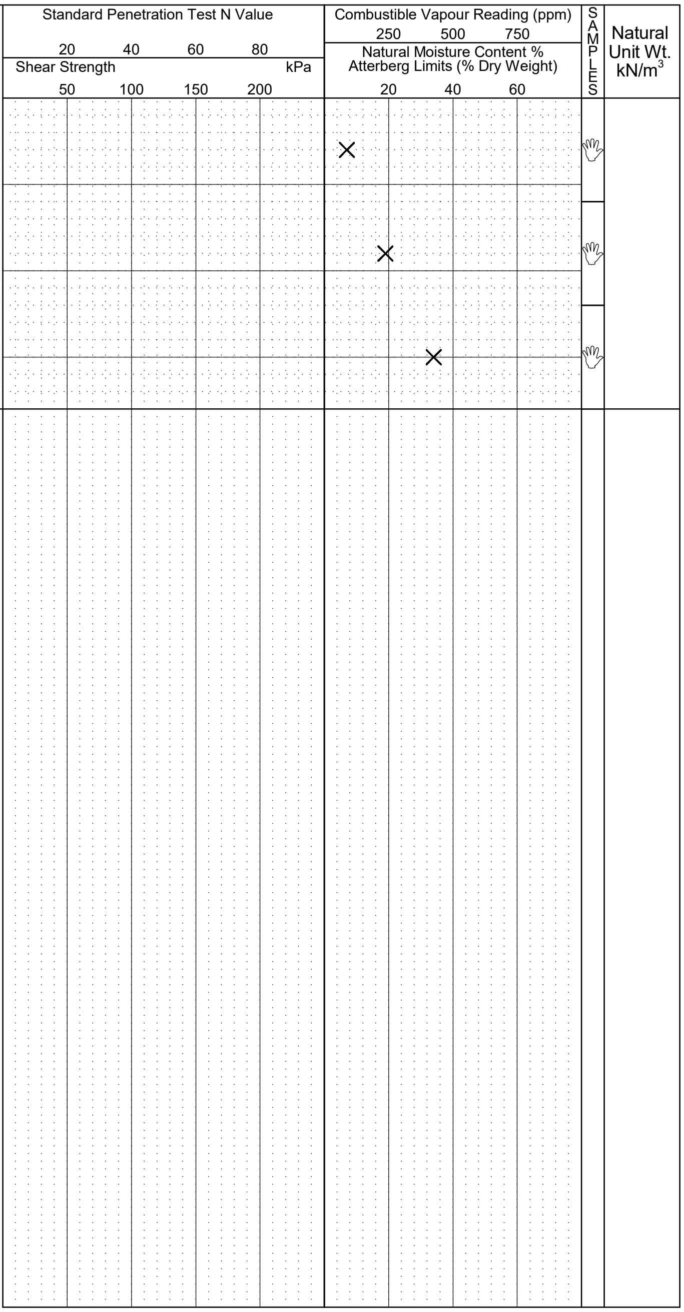
Drill Type: Portable Manual Equipment

Datum: Geodetic Elevation

Logged by: MD Checked by: ZG

Split Spoon Sample	☒	Combustible Vapour Reading	☐
Auger Sample	◧	Natural Moisture Content	×
SPT (N) Value	○	Atterberg Limits	⊢○
Dynamic Cone Test	—	Undrained Triaxial at % Strain at Failure	⊕
Shelby Tube	■		
Shear Strength by Vane Test	+ S	Shear Strength by Penetrometer Test	▲

SOIL DESCRIPTION	Geodetic Elevation m	Depth
	60.63	0
TOPSOIL ~180 mm thick	60.5	
FILL Sand, some gravel to gravelly, some silt, organic matter, roots, silty clay pockets, grey to brown, moist to wet	60.0	
FILL Silty clay, trace sand and gravel, roots, grey, moist to wet	59.63	1
	58.8	
Auger Refusal at 1.8 m Depth		



NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. A 31-mm diameter monitoring well was installed as shown upon completion of drilling.
3. Field work supervised by an **exp** representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-00238207-A0

WATER LEVEL RECORDS

Date	Water Level (m)	Hole Open To (m)
July 7, 2017	1.0	

CORE DRILLING RECORD

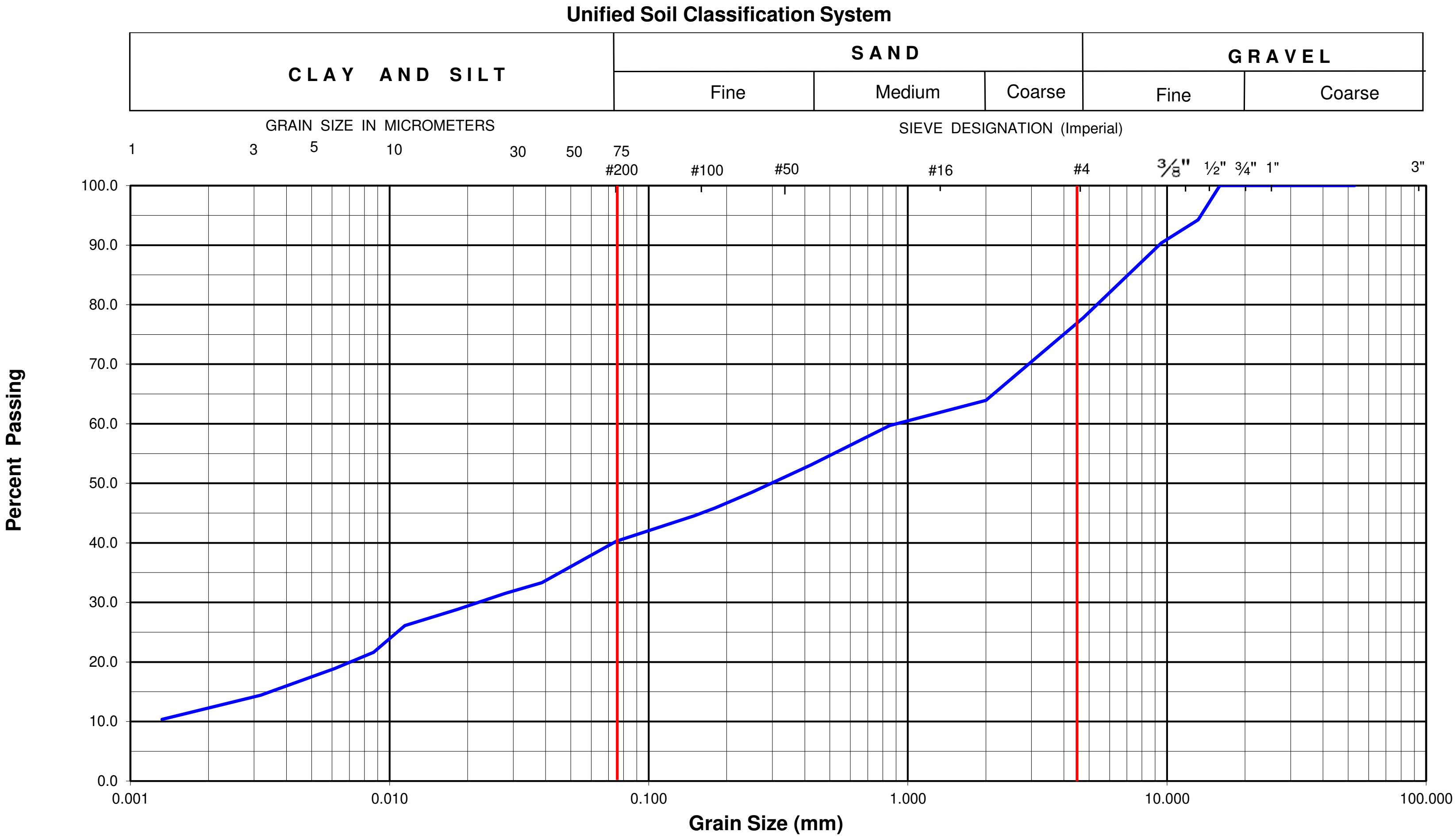
Run No.	Depth (m)	% Rec.	RQD %

exp Services Inc.
100-2650 Queensview Drive
Ottawa, ON   K2B 8H6

Grain-Size Distribution Curve

Method of Test for Particle Size Analysis of Soil

MTO Test Method LS - 702, Rev. No. 19



Exp Project No.:	**OTT-00238207-A0**	**Project Name :**	**Proposed Residential Development**		
Client :	**229 and 241 Beechwood Holdings Inc.**	**Project Location :**	**229-247 Beechwood Ave, Ottawa, Ontario**		
Date Sampled :	**June 27, 2017**	**Borehole No.:**	**3**	**Sample No.: SS4**	**Depth (m) : 1.5-2.1**
Sample Description :		**GLACIAL TILL: Silty Sand with Gravel (SM)**			**Figure : 8**

APPENDIX A: Certificate of Laboratory Analysis

AGAT Laboratories

5835 COOPERS AVENUE
MISSISSAUGA, ONTARIO
CANADA L4Z 1Y2
TEL (905)712-5100
FAX (905)712-5122
http://www.agatlabs.com

CLIENT NAME: EXP SERVICES INC
2650 QUEENSVIEW DRIVE, UNIT 100
OTTAWA, ON K2B8H6
(613) 688-1899

ATTENTION TO: Zohra Guetif; Ismail Taki

PROJECT: OTT-00238207-A0

AGAT WORK ORDER: 17Z233145

SOIL ANALYSIS REVIEWED BY: Amanjot Bhela, Inorganic Coordinator

DATE REPORTED: Jul 18, 2017

PAGES (INCLUDING COVER): 5

VERSION*: 1

Should you require any information regarding this analysis please contact your client services representative at (905) 712-5100

*NOTES

All samples will be disposed of within 30 days following analysis. Please contact the lab if you require additional sample storage time.

Certificate of Analysis

AGAT WORK ORDER: 17Z233145
PROJECT: OTT-00238207-A0

CLIENT NAME: EXP SERVICES INC
SAMPLING SITE:229 Beechwood Ave, Ottawa

ATTENTION TO: Zohra Guetif; Ismail Taki
SAMPLED BY:exp

Inorganic Chemistry (Soil)

DATE RECEIVED: 2017-07-04

DATE REPORTED: 2017-07-18

			SAMPLE DESCRIPTION:	BH#3 SS3 5'-7.5'	BH#2 Run #1 4'2"
			SAMPLE TYPE:	Soil	Rock
			DATE SAMPLED:	2017-06-27	2017-06-26
Parameter	**Unit**	**G / S**	**RDL**	**8525413**	**8525416**
pH, 2:1 CaCl2 Extraction	pH Units			7.78	7.97
Chloride (2:1)	µg/g		2	103	4
Sulphate (2:1)	µg/g		2	165	210
Resistivity (2:1)	ohm.cm		1	2230	3140

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

8525413-8525416 EC/Resistivity, Chloride and Sulphate were determined on the DI water extract obtained from the 2:1 leaching procedure (2 parts DI water:1 part soil). pH was determined on the 0.01M CaCl2 extract prepared at 2:1 ratio.

Certified By: Amanjot Bhela

Quality Assurance

CLIENT NAME: EXP SERVICES INC
PROJECT: OTT-00238207-A0
SAMPLING SITE:229 Beechwood Ave, Ottawa

AGAT WORK ORDER: 17Z233145
ATTENTION TO: Zohra Guetif; Ismail Taki
SAMPLED BY:exp

Soil Analysis

RPT Date: Jul 18, 2017			DUPLICATE				REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD	Method Blank	Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper
Inorganic Chemistry (Soil)															
pH, 2:1 CaCl2 Extraction	8551017		7.71	7.69	0.3%	<	101%	80%	120%	NA			NA		
Chloride (2:1)	8559695		3	4	NA	< 2	106%	70%	130%	102%	70%	130%	102%	70%	130%
Sulphate (2:1)	8559695		102	113	10.2%	< 2	95%	70%	130%	103%	70%	130%	106%	70%	130%

Comments: NA signifies Not Applicable.
Duplicate Qualifier: As the measured result approaches the RL, the uncertainty associated with the value increases dramatically, thus duplicate acceptance limits apply only where the average of the two duplicates is greater than five times the RL.

Certified By: Amanjot Bhela

Method Summary

CLIENT NAME: EXP SERVICES INC **AGAT WORK ORDER: 17Z233145**

PROJECT: OTT-00238207-A0 **ATTENTION TO: Zohra Guetif; Ismail Taki**

SAMPLING SITE:229 Beechwood Ave, Ottawa **SAMPLED BY:exp**

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Soil Analysis			
pH, 2:1 CaCl2 Extraction	INOR-93-6031	MSA part 3 & SM 4500-H+ B	PH METER
Chloride (2:1)	INOR-93-6004	McKeague 4.12 & SM 4110 B	ION CHROMATOGRAPH
Sulphate (2:1)	INOR-93-6004	McKeague 4.12 & SM 4110 B	ION CHROMATOGRAPH
Resistivity (2:1)	INOR-93-6036	McKeague 4.12, SM 2510 B,SSA #5 Part 3	EC METER

AGAT Laboratories

ISM

5835 Coopers Avenue
Mississauga, Ontario L4Z 1Y2
Ph: 905.712.5100 Fax: 905.712.5122
webearth.agatlabs.com

Chain of Custody Record

If this is a Drinking Water sample, please use Drinking Water Chain of Custody Form (potable water intended for human consumption)

Laboratory Use Only

Work Order #: 17T233145

Cooler Quantity: one

Arrival Temperatures: 23.0 | 23.1 | 23.0
8.6 | 7.9 | 8.4

Custody Seal Intact: ☐ Yes ☐ No ☐ N/A

Notes:

Report Information:

Company: exp Services Inc. Ottawa
Contact: Zohra. Guetif @exp.com
Address: 2650 Queensview dr. Unit 100
Ottawa ON K2B 8H6
Phone: 613-688-1899 Fax:
Reports to be sent to:
1. Email: zohra.guetif@exp.com
2. Email: ismail.taki@exp.com

Regulatory Requirements: ☐ No Regulatory Requirement

(Please check all applicable boxes)

☐ Regulation 153/04
Table ____ *Indicate One*
☐ Ind/Com
☐ Res/Park
☐ Agriculture

Soil Texture *(Check One)*
☐ Coarse
☐ Fine

☐ Sewer Use
☐ Sanitary
☐ Storm

Region ____ *Indicate One*

☐ Regulation 558
☐ CCME
☐ Prov. Water Quality Objectives (PWQO)
☐ Other
____ *Indicate One*

Is this submission for a Record of Site Condition? ☐ Yes ☐ No

Report Guideline on *Certificate of Analysis* ☐ Yes ☐ No

Turnaround Time (TAT) Required:

Regular TAT ☑ 5 to 7 Business Days

Rush TAT (Rush Surcharges Apply)

☐ 3 Business Days ☐ 2 Business Days ☐ Next Business Day

OR Date Required (Rush Surcharges May Apply):

Please provide prior notification for rush TAT
**TAT is exclusive of weekends and statutory holidays*

For 'Same Day' analysis, please contact your AGAT CPM

Project Information:

Project: OTT-00238207-A0
Site Location: 229 Beechwood ave. Ottawa
Sampled By: exp
AGAT Quote #: PO:
Please note: If quotation number is not provided, client will be billed full price for analysis.

Invoice Information:

Bill To Same: Yes ☑ No ☐

Company:
Contact:
Address:
Email:

Sample Matrix Legend

B	Biota
GW	Ground Water
O	Oil
P	Paint
S	Soil
SD	Sediment
SW	Surface Water

Sample Identification	Date Sampled	Time Sampled	# of Containers	Sample Matrix	Comments/ Special Instructions	Field Filtered - Metals, Hg, CrVI Y / N	Metals and Inorganics	☐ All Metals ☐ 153 Metals (excl. Hydrides) ☐ Hydride Metals	ORPs: ☐ B-HWS ☐ Cl ☐ CN ☐ Cr⁶⁺ ☐ EC ☐ FOC ☐ Hg ☐ pH ☐ SAR	Full Metals Scan	Regulation/Custom Metals	Nutrients: ☐ TP ☐ NH₃ ☐ TKN ☐ NO₃ ☐ NO₂ ☐ NO₃+NO₂	Volatiles: ☐ VOC ☐ BTEX ☐ THM	CCME Fractions 1 to 4	ABNs	PAHs	PCBs: ☐ Total ☐ Aroclors	Organochlorine Pesticides	TCLP: ☐ M&I ☐ VOCs ☐ ABNs ☐ B(a)P ☐ PCBs	Sewer Use	pH	Sulphate	Chlorides	Electrical Resistivity		
BH#3 SS3 5'-7.5'	June 27		1	~~Rock~~ Soil																	✓	✓	✓	✓		
BH#2 run#1 4'2"	June 26			rock																	✓	✓	✓	✓		

Samples Relinquished By (Print Name and Sign):	Date	Time	Samples Received By (Print Name and Sign):	Date	Time
Jeff MacMillan	June 30/17	4:45	Linda Berthelette	4-July-17	8h00
(B/O) Tofted Ey	4-July 17	16h00	Sima	17/7/5	905

Page 1 of 1

Nº: T 041765

Document ID: DIV-78-1511.013

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Date Issued: September 28, 2016