Houle Chevrier Engineering

Geotechnical Investigation
Proposed Development
18 McArthur Avenue
Ottawa, Ontario

a GEMTEC company

Houle Chevrier Engineering

Submitted to:

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1.0 INTRODUCTION

This report presents the results of a geotechnical investigation carried out for a proposed three (3) storey residential building located at 18 McArthur Avenue in Ottawa, Ontario. The purpose of the investigation was to identify the subsurface conditions at the site by means of a limited number of boreholes and, based on the results of the factual information obtained, to provide engineering guidelines and recommendations on the geotechnical design aspects of this project, along with construction considerations that could influence design decisions.

The subsurface investigation was carried out in general accordance with our proposal dated April 30, 2015.

2.0 PROJECT AND SITE DESCRIPTION

2.1 Project Description

Plans are being prepared to construct a three (3) storey residential building located at 18 McArthur Avenue in Ottawa, Ontario (see Key Plan, Figure 1). The building will consist of eight (8) residential units. It is our understanding that the proposed building will have a basement level. Surface parking may be included in the proposed development.

Based on a review of aerial photographs of the site, it is our understanding that a building previously existed at the site. The lot is currently a paved parking area.

2.2 Review of Geology Maps

Published geology maps of the area indicate that the subsurface conditions are expected to consist of offshore marine deposits of silt and clay. The underlying bedrock is mapped as shale bedrock of the Billings formation at depths ranging between about 2 and 5 metres. Fill material associated with the previous development should also be expected.

3.0 SUBSURFACE INVESTIGATION

The geotechnical investigation was carried out on May 19, 2015. At that time, two (2) boreholes, numbered 15-1 and 15-2, were advanced at the site. The boreholes were advanced to depths of about 5.4 and 5.8 metres below ground surface (elevation 50.7 and 50.9 metres, geodetic datum) using a truck mounted, hollow stem auger drill rig supplied and operated by Aardvark Drilling Inc.

Standard penetration tests were carried out in the boreholes and samples of the soils encountered were recovered using a 50 millimetre split barrel sampler. The groundwater conditions in the open boreholes were observed upon completion of drilling. The field work was observed by a member of our engineering staff who directed the drilling operations, observed the in situ testing and logged the samples and boreholes.

Following the field work, the soil samples were returned to our laboratory for examination by a geotechnical engineer. One (1) sample of the soil recovered from borehole 15-2 was submitted to Exova Canada Inc. for basic chemical testing relating to corrosion of buried concrete and steel. Selected samples of the soil were tested for water content and grain size distribution.

Descriptions of the subsurface conditions logged in the boreholes are provided on the Record of Borehole sheets in Appendix A. The approximate locations of the boreholes are shown on the Borehole Location Plan, Figure 2. The results of the laboratory classification tests on the soil samples are provided on Figure B1 in Appendix B and the Record of Borehole sheets. The results of the chemical analysis of a sample of soil relating to corrosion of buried concrete and steel are provided in Appendix C.

The borehole locations were determined relative to existing site features by Houle Chevrier Engineering Ltd. Personnel. The ground surface elevation at the location of boreholes was determined using a Trimble R8 global positional system. The elevation is referenced to geodetic datum and is considered to be accurate within the tolerance of the instrument.

4.0 SUBSURFACE CONDITIONS

4.1 General

The soil and groundwater conditions logged in the boreholes are given on the Record of Borehole sheets in Appendix A. The logs indicate the subsurface conditions at the specific test locations only. Boundaries between zones on the logs are often not distinct, but rather are transitional and have been interpreted. The precision with which subsurface conditions are indicated depends on the frequency and recovery of samples, the method of sampling and the uniformity of the subsurface conditions. Subsurface conditions at locations other than the test locations may vary from the conditions encountered in the test holes.

The soil descriptions in this report are based on commonly accepted methods of classification and identification employed in geotechnical practice. Classification and identification of soil involves judgement and Houle Chevrier Engineering Ltd. does not guarantee descriptions as exact, but infers accuracy to the extent that is common in current geotechnical practice.

The following presents an overview of the subsurface conditions encountered in the boreholes advanced during the geotechnical investigation.

4.2 Existing Pavement Structure

Asphaltic concrete with a thickness of about 40 and 100 millimetres was encountered from ground surface at both borehole locations. The asphaltic concrete is underlain by base material with a thickness of about 50 and 130 millimetres. The base material is composed of grey, crushed sand and gravel.

4.3 Fill Material

Fill material was encountered below the existing pavement structure at depths of about 0.1 and 0.2 metres below ground surface. The fill material is variable in nature and can generally be described as dark brown, brown and grey brown silty clay and sand with varying amounts of gravel. Foreign debris consisting of organic material and brick fragments were encountered within the fill material.

Possible fill material was encountered below the fill material in borehole 15-1 at a depth of about 1.1 metres below ground surface (elevation 55.1 metres, geodetic datum). The fill material is difficult to distinguish from native soils being of similar composition, and is often only identifiable by the presence of erroneous material (e.g. brick fragments, asphaltic concrete pieces, etc.). Since no erroneous material was observed in the recovered soil sample, and there is doubt regarding the depth to the undisturbed (native) material, the material was labelled as 'possible fill' material. The possible fill material can be described as grey brown sandy silt and has a thickness of about 0.4 metres.

The fill and possible fill material extend to depths of about 1.5 and 2.0 metres below ground surface in boreholes 15-1 and 15-2, respectively (elevation 54.8 and 54.5 metres, geodetic datum).

Standard penetration tests carried out on samples of the fill material gave N values of 7 to 9 blows per 0.3 metres of penetration, which reflects a loose relatively density.

Moisture content testing carried out samples of the fill and possible fill material indicates moisture contents ranging between about 16 and 26 percent.

4.4 Glacial Till

Native deposits of glacial till were encountered at depths of about 1.5 and 2.0 metres below ground surface in boreholes 15-1 and 15-2, respectively (elevation 54.8 and 54.5 metres, geodetic datum). The glacial till is heterogeneous mixture of all grain sizes but can generally be described as silty sand with varying amounts of clay and gravel. Cobbles and boulders should be expected within the glacial till.

Standard penetration tests carried out on samples of the glacial till gave N values of 5 to 50 blows per 0.3 metres of penetration, which reflects a loose to dense relatively density. The low N value of 5 recorded within the upper portion of the glacial till in borehole 15-1 may be indicative of soil disturbance from past construction activities at the site. One (1) Standard penetration test refusal was observed within the glacial till deposit at borehole 15-2, which may reflect the presence of cobbles or boulders within the glacial till.

Moisture content testing carried out on samples of the glacial till indicates moisture contents of 6 to 9 percent.

4.5 Inferred Bedrock

Inferred weathered bedrock was encountered in borehole 15-2 at a depth of about 5.2 metres below ground surface (elevation 51.3 metres, geodetic datum).

Auger refusal within the inferred weathered bedrock was encountered at depths of about 5.4 and 5.8 metres below ground surface in boreholes 15-1 and 15-2, respectively (elevation 50.7 and 50.9 metres, geodetic datum). It should be noted that the top of bedrock or bedrock conditions were not confirmed through bedrock coring.

4.6 Groundwater Conditions

No groundwater seepage was observed in the open boreholes upon completion of drilling. It should be noted that the groundwater conditions were only observed during the relatively short period of time that the boreholes were left open following drilling and does not represent stabilized groundwater conditions.

The groundwater levels may be higher during wet periods of the year such as the early spring or following periods of precipitation.

4.7 Groundwater Chemistry Relating to Corrosion

The results of chemical testing on a sample of soil recovered from borehole 15-2 are provided in Appendix C and summarized below.

- Resistivity 2940 Ohm - cm (Ohm centimetre)
- Conductivity 0.34 µS/cm (microSiemen per centimetre)
- pH 8.3
- Chloride 0.006 percent
- Sulphate 0.02 percent

5.0 GEOTECHNICAL GUIDELINES AND RECOMMENDATIONS

5.1 General

This section of the report provides engineering guidelines on the geotechnical design aspects of the project based on our interpretation of the boreholes advanced as part of this investigation and the project requirements. It is stressed that the information in the following sections is provided for the guidance of the designers and is intended for this project only. Contractors bidding on or undertaking the works should examine the factual results of the investigation, satisfy themselves as to the adequacy of the information for construction, and make their own interpretation of the factual data as it affects their construction techniques, schedule, safety and equipment capabilities.

The professional services retained for this project include only the geotechnical aspects of the subsurface conditions at this site. The presence or implications of possible surface and/or subsurface contamination resulting from previous uses or activities of this site or adjacent properties, and/or resulting from the introduction onto the site from materials from off site sources are outside the terms of reference for this report and have not been investigated or addressed.

5.2 Proposed Development

5.2.1 Excavation

The excavations for the proposed foundation will be through the existing pavement structure, fill material, possible fill material or otherwise deleterious material, and native deposits of glacial till. The sides of the excavations should be sloped in accordance with the requirements in Ontario Regulation 213/91 under the Occupational Health and Safety Act. According to the Act, the native overburden deposits can be classified as Type 3 and, accordingly, allowance should be made for excavation side slopes of 1 horizontal to 1 vertical extending upwards from the base of the excavation.

No groundwater seepage was observed in the open boreholes upon completing of drilling. It should be noted that groundwater inflow was only observed during the relatively short time that the boreholes were left open following drilling and do not represent stabilized groundwater conditions. Based on our previous experience, groundwater inflow from the glacial till deposits should be relatively small and controlled by pumping from filtered sumps within the excavations. Suitable detention and filtration will be required before discharging the water to a sewer or ditch. It is not expected that short term pumping during excavation will have a significant effect on nearby structures and services.

Any building rubble, foundation walls, footings, slabs, etc. from previous buildings at the site should be removed from within the area of the proposed building.

5.2.2 Placement of Engineered Fill

In areas where the proposed founding level is above the level of the native soil, or where subexcavation of disturbed material is required below proposed founding level, imported granular material (engineered fill) should be used. The engineered fill should consist of granular material meeting Ontario Provincial Standard Specifications (OPSS) requirements for Granular B Type II and should be compacted in maximum 200 millimetre thick lifts to at least 95 percent of the standard Proctor maximum dry density. In areas where groundwater inflow is encountered, pumping should be carried out from sumps in the excavation during placement of the engineered fill. To allow spread of load beneath the footings, the engineered fill should extend horizontally at least 0.3 metres beyond the footings and then down and out from the edges of the footings at 1 horizontal to 1 vertical, or flatter. The excavation for the building should be sized to accommodate this fill placement. Since the source of recycled material cannot be determined, it is suggested that for environmental reasons any granular materials used below founding level be composed of virgin material only. The engineered fill should be placed in accordance with the site grade raise restrictions, where applicable.

5.2.3 Foundation Bearing Capacity

The native undisturbed glacial till deposits are considered suitable to support the proposed building founded on conventional strip or pad footing foundations. All organic material, topsoil, existing pavement structure, fill material, possible fill material, former building foundations, and loose or water softened soils should be removed from within the proposed footing areas.

Based on information provided to us, it is our understanding that the underside of footings will be located at a depth of about 3 metres below existing grade which should be within the native glacial till layer. The proposed building could be founded on conventional spread footings bearing on or within the native, undisturbed deposits of glacial till or on a pad of compacted granular material (engineered fill) over native, undisturbed soil deposits. Spread footing foundations bearing on native, undisturbed deposits of glacial till or on a pad of engineered fill above native soil deposits should be sized using a net geotechnical reaction at Serviceability Limit States (SLS) of 150 kilopascals and a factored net geotechnical resistance at Ultimate Limit States (ULS) of 300 kilopascals.

The post construction total and differential settlement at SLS of footings bearing on the above noted deposits should be less than 25 and 20 millimetres, respectively, provided that fill material and loose or disturbed soil is removed from below the bearing surfaces.

5.2.4 Frost Protection of Foundations

All exterior footings for heated portions of the structure should be provided with at least 1.5 metres of earth cover for frost protection purposes. Footings located within unheated portions of the building or isolated footings outside the building footprint should be provided with at least 1.8 metres of earth cover for frost protection purposes. If the required depth of earth cover is not practicable, a combination of earth cover and polystyrene insulation could be considered. Further details regarding the insulation of foundations could be provided upon request.

5.2.5 Basement Foundation Wall Backfill and Drainage

To avoid frost adhesion and possible heaving, the foundations should be backfilled with imported, free-draining, non-frost susceptible granular material meeting OPSS Granular B Type I or II requirements. The backfill should be placed in maximum 200 millimetre thick lifts and compacted to at least 95 percent of the standard Proctor maximum dry density value using suitable vibratory compaction equipment.

Where areas of hard surfacing (concrete, sidewalk, pavement, etc.) abut the proposed building, a gradual transition should be provided between those areas of hard surfacing underlain by non-frost susceptible granular wall backfill and those areas underlain by existing frost susceptible native materials to reduce the effects of differential frost heaving. It is suggested that granular frost tapers be constructed from the bottom of the excavation or 1.5 metres below finished grade, whichever is less, to the underside of the granular base/subbase material for the hard surfaced areas. The frost tapers should be sloped at 1 horizontal to 1 vertical, or flatter.

In accordance with the Ontario Building Code, the following alternatives could be considered for drainage of the basement foundation walls:

- Damp proof the exterior of the foundation walls and backfill the walls with free draining, non-frost susceptible sand or sand and gravel such as that meeting Ontario Provincial Standard Specifications (OPSS) requirements for Granular B Type I or II. OR

- Damp proof the exterior of the foundation walls and install approved proprietary drainage material on the exterior of the foundation walls and backfill the walls with native material or imported soil.

A perforated drain should be installed around the perimeter of the basement area at the level of the bottom of the footings. The drain should outlet to a sump from which the water is pumped or should drain by gravity to a suitable drainage outlet.

To avoid ingress of fines into the voids in the clear stone (and possible post construction settlement of the ground around the building), a nonwoven geotextile should be placed between the clear stone and any sand backfill material.

Perimeter foundation drainage is not considered necessary for any slab on grade portions of the proposed structure (i.e., garages), provided that the floor slab level is above the finished exterior ground surface level.

Foundation walls that are backfilled with a granular material such as that meeting OPSS Granular B Type I or II requirements should be designed to resist “at rest” earth pressures calculated using the following formula:

$P_o = K_o (\gamma H + q)$

Where,

- P_o = At rest earth pressure at the bottom of the foundation wall (kilopascals)
- K_o = At rest earth pressure coefficient (0.44)
- γ = Unit weight of backfill material (22 kilonewtons per cubic metre)
- H = Height of foundation wall (metres)
- q = Uniform surcharge at ground surface behind the wall to take into account traffic, equipment, or stockpiled soil (typically 10 kilopascals)

Where conditions dictate, allowance should be made in the structural design of the foundation walls for loads due to ground supported vehicles/equipment. For example, the horizontal active load due to a uniform, vertical live load adjacent to the foundation wall could be determined using a horizontal earth pressure coefficient, K_o, of 0.44, times the vertical live load. The effects of other vertical loads (point loads, line loads, compaction loads, etc.) adjacent to or near the foundation walls could be provided, if required.

Heavy construction traffic should not be allowed to operate adjacent to foundation walls for the proposed building (say within about 2 metres horizontal) during construction, without the approval of the designers.

5.2.6 Seismic Site Class

Based on the results of the subsurface investigation, together with our experience in the area and published geology maps, the seismic site classification for seismic site response may be taken as Site Class C.

In our opinion, there is no potential for liquefaction of the soils below founding level.

5.2.7 Basement Slab Support (Heated Areas Only)

To provide predictable settlement performance of the basement slab, the existing pavement structure and fill material should be removed from the area of the proposed building. Any disturbed soil, organic material, possible fill material or deleterious material from the existing dwelling should also be removed.

The grade within the proposed building area could be raised, where necessary, with granular material meeting OPSS requirements for Granular B Type I or II. The use of Granular B Type II is preferred under wet conditions. The granular base for the proposed basement slab should consist of at least 150 millimetres of 19 millimetre clear crushed stone or OPSS Granular A.

City of Ottawa documents allow recycled asphaltic concrete and concrete to be used in Granular A and Granular B Type II materials. Since the source of recycled material cannot be determined, it is suggested that any granular materials used beneath the floor slab be composed of virgin material (100 percent crushed rock) only, for environmental reasons.

OPSS Granular A material placed below the proposed floor slab should be compacted in maximum 200 millimetre thick lifts to at least 95 percent of the standard Proctor maximum dry density value. Compaction of clear crushed stone is not considered essential.

If well graded granular material (such as OPSS Granular A) is used, rather than clear crushed stone below the basement floor slab, we suggest that drainage be provided by means of perforated plastic pipes spaced at about 6 metres horizontally or as required to link any hydraulically isolated areas to the perimeter drain or sump area. For clear crushed stone, perforated plastic pipes should be used to link any hydraulically isolated areas in the basement. The drains should outlet to a sump or gravity sewer.

If any areas of the building are to remain unheated during the winter period, thermal protection of the slab on grade may be required. Further details on the insulation requirements could be provided, if necessary.

5.3 Pipe Bedding

The bedding for service pipes should be in accordance with OPSD 802.010 and OPSD 802.031 for flexible and rigid pipes, respectively. The pipe bedding material should consist of at least 150 millimetres of granular material meeting OPSS for Granular A. OPSS documents allow recycled asphaltic concrete and concrete to be used in Granular A material. Since the source of recycled material cannot be determined, it is suggested that any granular materials used in the service trenches be composed of virgin (i.e., not recycled) material only for environmental reasons.

In areas where the subsoil is disturbed or where unsuitable material (such as fill material possible fill material, organic soil, or existing trench backfill material) exists below the pipe subgrade level, the disturbed/unsuitable material should be removed and replaced with a subbedding layer of compacted granular material, such as OPSS Granular A or Granular B Type II (50 or 100 millimetre minus crushed stone). To provide adequate support for the pipes in the long term in areas where subexcavation of material is required below design subgrade level, the excavations should be sized to allow a 1 horizontal to 1 vertical spread of granular material down and out from the bottom of the pipes. The use of clear crushed stone as bedding or subbedding material should not be permitted.

Cover material, from pipe spring line to at least 300 millimetres above the top of the pipe, should consist of granular material, such as OPSS Granular A.

The granular bedding and subbedding materials should be compacted in maximum 200 millimetre thick lifts to at least 95 percent of the standard Proctor dry density value.

5.4 Trench Backfill

In areas where the service trenches will be located below or in close proximity to existing or future areas of hard surfacing (pavement, sidewalk, etc.), acceptable native materials should be used as backfill between the pavement subgrade level and the depth of seasonal frost penetration in order to reduce the potential for differential frost heaving between the area over the trench and the adjacent hard surfaced area. The depth of frost penetration in exposed areas can normally be taken as 1.8 metres below finished grade. Where native backfill is used, it should match the native materials exposed on the trench walls. Backfill below the zone of seasonal frost penetration could consist of either acceptable native material or imported granular material conforming to OPSS Granular B Type I.

It is anticipated that most of the inorganic overburden materials encountered during the subsurface investigation will be acceptable for reuse as trench backfill. Any topsoil or organic soil should be wasted from the trench. Any cobbles and boulders within the glacial till should be wasted from the trench.

To minimize future settlement of the backfill and achieve an acceptable subgrade for the access roadways, parking areas, etc., the trench backfill should be compacted in maximum 300 millimetre thick lifts to at least 95 percent of the standard Proctor maximum dry density. The specified density may be reduced to 90 percent of the standard Proctor dry density in areas where the trench backfill is not located below or in close proximity to existing or future roadways, parking areas, sidewalks, etc. and provided that some settlement above the trench is acceptable.

Depending on the weather conditions at the time of construction, some wetting of the materials could occur. As such, the specified densities may not be possible to achieve and, as a consequence, some settlement of these backfill materials should be expected. Consideration could be given to implementing one or a combination of the following measures to reduce post construction settlement above the trenches, depending on the weather conditions encountered during the construction:

- Allow the overburden materials to dry to within 0 to 4 percent of optimum moisture content prior to compaction;
- Reuse any wet materials in the lower part of the trenches and make provision to defer final placement of the final lift of the asphaltic concrete for 3 months, or longer, to allow some of the trench backfill settlement to occur and thereby improve the final pavement appearance.

5.5 Seepage Barriers

In the event the underground services are located within the groundwater table seepage barriers should be installed along the service trenches just inside the property lines prevent groundwater lowering.

The seepage barriers should begin at subgrade level and extend vertically through the granular pipe bedding and granular surround to within the native backfill materials, and horizontally across the full width of the service trench excavation. The seepage barriers could consist of 1.5 metre wide dykes of compacted weathered silty clay. Alternatively, commercially available products such as polyethylene seepage collars (i.e. No-Seep, Antiseep Collar by Scheib Drainage Products) could be considered.

5.6 Corrosion of Buried Concrete and Steel

The measured sulphate concentration in a sample of soil recovered from the borehole 15-2 was 0.02 percent. According to Canadian Standards Association (CSA) "Concrete Materials and Methods of Concrete Construction", the concentration of sulphate can be classified as low. For low exposure conditions, any concrete that will be in contact with the native soil or groundwater should be batched with General Use (formerly Type 10) cement. The effects of freeze thaw in the presence of de-icing chemical (sodium chloride) near the proposed building should be considered in selecting the air entrainment and the concrete mix proportions for any concrete.

Based on the conductivity and pH of the soil sample, the groundwater can be classified as nonaggressive toward unprotected steel. It is noted that the corrosivity of the soil and groundwater could vary throughout the year due to the application of sodium chloride for de-icing.

5.7 Access Roadways and Parking Areas

5.7.1 Subgrade Preparation

In preparation for the construction of the access roadway and parking areas at this site, all surficial topsoil, and any loose/soft, wet, organic or deleterious materials should be removed from the proposed subgrade surface. This need not include removal of the existing fill material provided that some minor post construction settlement of the pavement structure can be tolerated. Prior to placing granular fill for the parking areas and access roadway, the exposed subgrade should be proof rolled with a large (minimum 10 tonne) vibratory steel drum roller under dry conditions and inspected and approved by geotechnical personnel. Any soft areas that are evident from the proof rolling should be subexcavated and replaced with suitable earth borrow.

Should it be necessary to raise the roadway/parking area grades, the grade raise fill for the roadway/parking areas could consist of material which meets OPSS specifications for Granular B Type I or II, Select Subgrade Material, or suitable earth borrow. The grade raise fill should be placed in maximum 300 millimetre thick lifts and compacted to at least 95 percent of the standard Proctor maximum dry density value using vibratory compaction equipment. It is noted, however, that clayey and silty earth borrow materials are sensitive to changes in moisture content, precipitation and frost heaving. As such, unless the earth material placement is planned during the dry period of the year (June to September), precipitation and freezing conditions may restrict or delay adequate compaction of these materials. Based on our experience, clayey earth borrow materials should be compacted within 0 to 4 percent above the optimum moisture content, as defined by a standard Proctor test, to reduce the post construction settlement of the fill material. Depending on the weather conditions, it may be necessary to allow the material to dry prior to compaction.

5.7.2 Flexible Pavement Structures for the Parking Lots and Access Roadways

It is suggested that parking areas to be used by light vehicles (cars, etc.) be constructed using the following minimum pavement structure:

- 50 millimetres of asphaltic concrete, over
- 150 millimetres of OPSS Granular A base, over
- 300 millimetres of OPSS Granular B Type II subbase

For parking areas and access roadways to be used by heavy truck traffic (including fire trucks) the suggested minimum pavement structure is:

- 100 millimetres of asphaltic concrete, over
- 150 millimetres of OPSS Granular A base over
- 400 millimetres of OPSS Granular B Type II subbase

The above pavement structures assume that the trench backfill is adequately compacted and that the subgrade surface is prepared as described in this report. If the subgrade surface is disturbed or wetted due to construction operations or precipitation, the granular thickness given above may not be adequate and it may be necessary to increase the thickness of the Granular B Type II subbase and/or to incorporate a woven geotextile separator between the roadway subgrade surface and the granular subbase material. The adequacy of the design pavement thickness should be assessed by geotechnical personnel at the time of construction.

If the granular pavement materials are to be used by construction traffic, it may be necessary to increase the thickness of the Granular B Type II, install a woven geotextile separator between the roadway subgrade surface and the granular subbbase material, or a combination of both, to prevent pumping and disturbance to the subbase material. The contractor should be made responsible for their construction access.

5.7.3 Asphaltic Concrete Type

The asphaltic concrete for the light vehicle areas should consist of 50 millimetres of Superpave 12.5. For heavy vehicle areas the asphaltic concrete surfacing thickness should be increased to 100 millimetres (40 millimetres of Superpave 12.5 over 60 millimetres of Superpave 19.0).

Performance grade PG 58-34 asphaltic cement should be specified for Superpave asphaltic concrete mixes (Traffic Level A or B).

5.7.4 Granular Material Compaction

The granular base and subbase materials for the parking areas and access roadways should be compacted in maximum 200 millimetre thick lifts to at least 98 percent of the standard Proctor maximum dry density value.

5.7.5 Pavement Drainage

Adequate drainage of the pavement granular materials and subgrade is important for the long term performance of the pavement at this site. The subgrade surfaces should be crowned and shaped to catch basins to promote drainage of the pavement granular materials.

The catch basins should be provided with minimum 3 metre long perforated stub drains which extend in at least two directions from each catch basin at pavement subgrade level.

6.0 ADDITIONAL CONSIDERATIONS

6.1 Effects of Construction Induced Vibration

Some of the construction operations (such as granular material compaction, excavation, etc.) will cause ground vibration on and off of the site. The vibrations will attenuate with distance from the source, but may be felt at nearby structures. However, the magnitude of the vibrations is expected to be much less than that required to cause damage to the nearby structures or services that are in good condition.

6.2 Winter Construction

The soils that exist at this site are highly frost susceptible and are prone to significant ice lensing. In the event that construction is required during freezing temperatures, the soil below the footings and floor slab should be protected immediately from freezing using straw, propane heaters and insulated tarpaulins, or other suitable means.

Any service trenches should be opened for as short a time as practicable and the excavations should be carried out only in lengths which allow all of the construction operations, including backfilling, to be fully completed in one working day. The materials on the sides of the trenches should not be allowed to freeze. In addition, the backfill should be excavated, stored and replaced without being disturbed by frost or contaminated by snow or ice.

6.3 Excess Soil Management Plan

It should be noted that the soil samples recovered during this investigation were not tested to assess the presence of contamination, either naturally occurring or due to human activity. This report does not constitute an excess soil management plan. The disposal requirements for excess soil from the site have not been assessed.

6.4 Design Review and Construction Observation

The final details of the proposed development were not available to us at the time of preparation of this report. It is recommended that the design drawings be reviewed by the geotechnical engineer as the design progresses to ensure that the guidelines provided in this report have been interpreted as intended.

The engagement of the services of the geotechnical consultant during construction is recommended to confirm that the subsurface conditions throughout the proposed excavations do not materially differ from those given in this report and that the construction activities do not adversely affect the intent of the design. The subgrade surfaces for the proposed building and access roadways should be inspected by experienced geotechnical personnel to ensure that suitable materials have been reached and properly prepared. The placing and compaction of earth fill and imported granular materials should be inspected to ensure that the materials used conform to the grading and compaction specifications. Full time field observation will be required during any engineered fill placement below foundations.

We trust this report provides sufficient information for your present purposes. If you have any questions concerning this report, please do not hesitate to contact our office.

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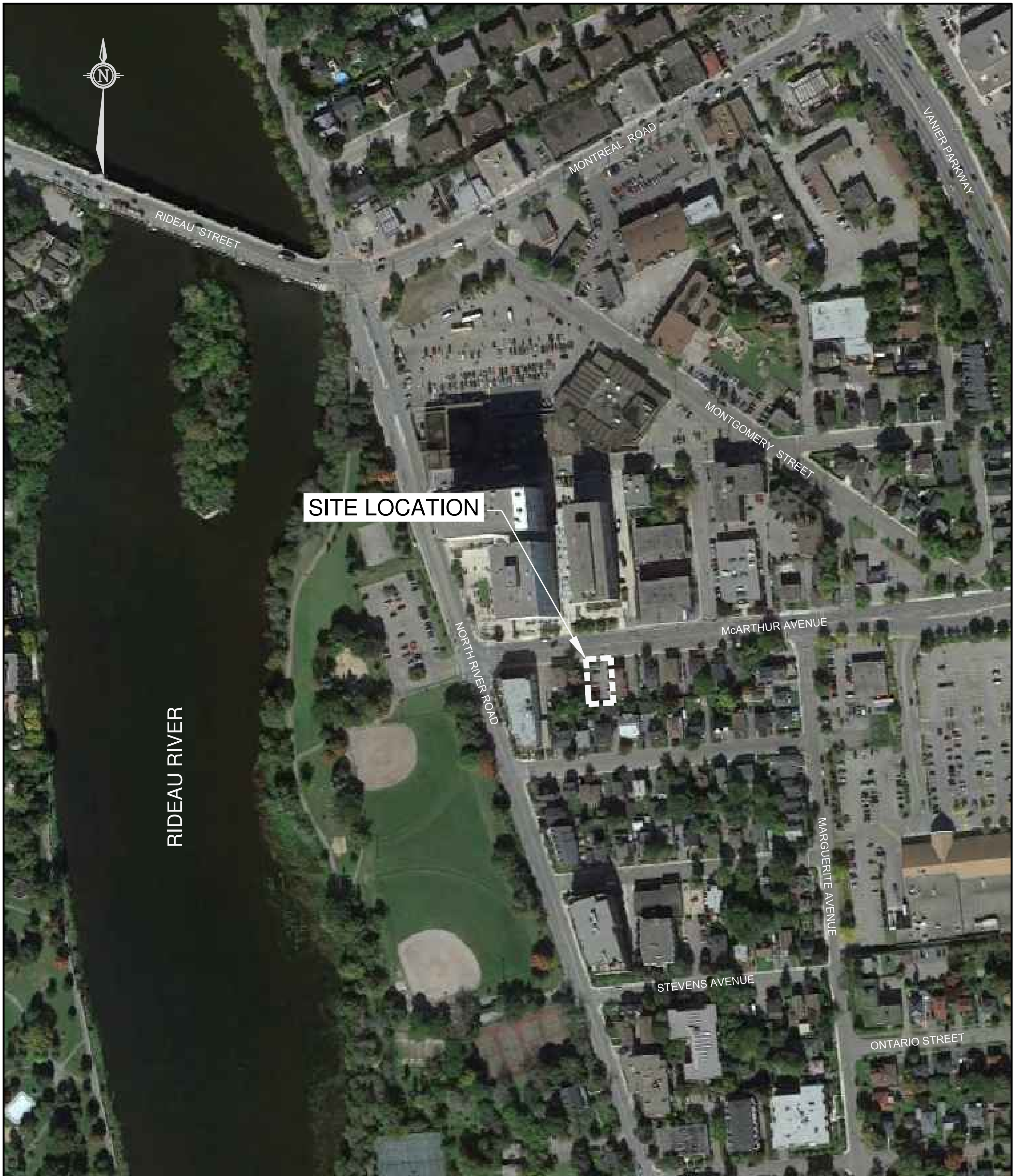

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32 Steacie Drive, Ottawa, ON
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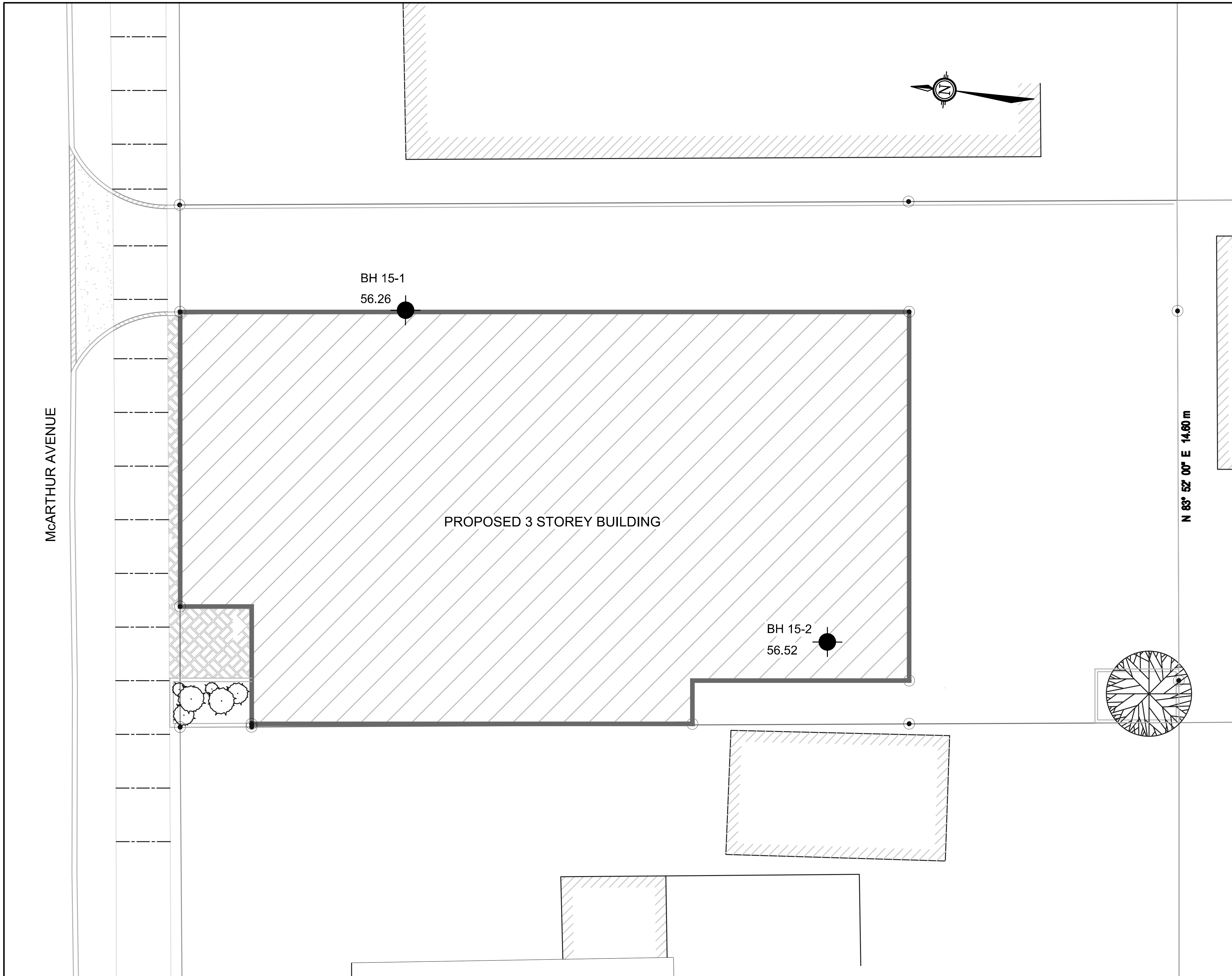
Project			Drawing		
GEOTECHNICAL INVESTIGATION PROPOSED DEVELOPMENT 18 McARTHUR AVENUE, OTTAWA, ONTARIO			KEY PLAN		
Drwn By	Chkd By	Date	Project No.	Revision No.	
D.J.R.	L.A.	MARCH 2016	64176.01	0	**FIGURE 1**



LEGEND

BH 15-1 — BOREHOLE LOCATION IN PLAN (current investigation by Houle Chevrier Engineering Ltd.)

56.26 — ELEVATION IN METRES GEODETIC DATUM

Scale 1:100

0 2 4 6m

Houle Chevrier Engineering

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Client	SOMA STUDIO
Project	64176.01
Location	18 McARTHUR AVENUE, OTTAWA, ON
Drwn by	D.J.R.
Chkd by	L.A.
Title	BOREHOLE LOCATION PLAN
Date	MARCH 2016
Rev.	0
	FIGURE 2

APPENDIX A

Record of Borehole Sheets

RECORD OF BOREHOLE 15-1

PROJECT: 15-128
LOCATION: See Site Plan, Figure 2
BORING DATE: May 19, 2015

SHEET 1 OF 1
DATUM: Geodetic
SPT HAMMER: 63.5 kg; drop 0.76 m

BORING METHOD: Power Auger, 200 mm Diameter Hollow Stem

SOIL PROFILE

DESCRIPTION	ELEV. / DEPTH (m)
Ground Surface	56.26
Asphaltic Concrete	56.16 / 0.10
Grey sand, gravel and boulders, trace silt (BASE MATERIAL)	56.03 / 0.23
Brown silty clay, some gravel with pockets of brown, fine to coarse grained sand, some silt, gravel, cobbles, boulders, brick debris(FILL MATERIAL)	55.42 / 0.84
Grey brown, silty clay, some sand, some gravel and organic material (FILL MATERIAL)	55.12 / 1.14
Grey brown sandy silt, trace clay (POSSIBLE FILL MATERIAL)	54.76 / 1.50
Grey brown to dark grey silty sand, some clay, some gravel, cobbles, possible boulders (GLACIAL TILL)	52.81 / 3.45
Dark grey to grey black silty sand, some gravel, cobbles, possible boulders (GLACIAL TILL)	50.87 / 5.39
Auger Refusal on Inferred Bedrock End of Borehole	

SAMPLES

NUMBER	TYPE	BLOWS/0.3m
1	C.S.	
2	50 D.O.	8
3	50 D.O.	5
4	50 D.O.	12
5	50 D.O.	16
6	50 D.O.	30
7	50 D.O.	34
8	50 D.O.	50 for 0.05m

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m: 20 40 60 80
SHEAR STRENGTH Cu, kPa: nat. V - + Q - ● rem. V - ⊕ U - ○ : 20 40 60 80

HYDRAULIC CONDUCTIVITY, k, cm/s: 10^{-5} 10^{-4} 10^{-3} 10^{-2}
WATER CONTENT, PERCENT: Wp ⊢—○W—⊣ Wl : 20 40 60 80

ADDITIONAL LAB. TESTING: Hydrometer (See Fig. B1)

PIEZOMETER OR STANDPIPE INSTALLATION:
- Cold Patch
- Borehole backfilled with auger cuttings
- No groundwater seepage observed in open borehole upon completion of drilling.

DEPTH SCALE METRES: 0 1 2 3 4 5 6 7

DEPTH SCALE
1 to 35

Houle Chevrier Engineering

LOGGED: A.N.
CHECKED:

RECORD OF BOREHOLE 15-2

PROJECT: 15-128
LOCATION: See Site Plan, Figure 2
BORING DATE: May 19, 2015

SHEET 1 OF 1
DATUM: Geodetic
SPT HAMMER: 63.5 kg; drop 0.76 m

BORING METHOD: Power Auger, 200 mm Diameter Hollow Stem

DEPTH SCALE METRES	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.3m	ADDITIONAL LAB. TESTING	PIEZOMETER OR STANDPIPE INSTALLATION
0	Ground Surface	56.52					
	Asphaltic Concrete	0.04					Cold Patch
	Grey, crushed sand and gravel, trace silt (BASE MATERIAL)	0.09					
	Brown, fine to medium grained sand, some silt (FILL MATERIAL)	0.14					
	Dark brown silty clay, some sand, some gravel, cobbles, brick debris (FILL MATERIAL)		1	C.S.			Bentonite
	Dark brown, silty clay, some sand, some gravel, possible cobbles, organic material (FILL MATERIAL)	55.76 / 0.76	2	50 D.O.	7		
			3	50 D.O.	9		
2	Grey brown to dark grey silty clay, some sand, gravel, cobbles, possible boulders (GLACIAL TILL)	54.52 / 2.00	4	50 D.O.	41	Corrosion	
			5	50 D.O.	35		Borehole backfilled with auger cuttings
	Dark grey to grey black silty sand, some gravel, possible cobbles and boulders (GLACIAL TILL)	52.71 / 3.81	6	50 D.O.	67 for 0.23m		
			7	50 D.O.	50		
	Possible weathered shale bedrock	51.34 / 5.18	8	50 D.O.	50 for 0.08m		
	Auger Refusal in Inferred Bedrock End of Borehole	50.73 / 5.79					No groundwater seepage observed in open borehole upon completion of drilling.

DYNAMIC PENETRATION RESISTANCE, BLOWS/0.3m: 20 40 60 80
SHEAR STRENGTH Cu, kPa: nat. V - + Q - ● rem. V - ⊕ U - ○ 20 40 60 80
HYDRAULIC CONDUCTIVITY, k, cm/s: 10^{-5} 10^{-4} 10^{-3} 10^{-2}
WATER CONTENT, PERCENT: Wp — W — Wl 20 40 60 80

DEPTH SCALE 1 to 35

Houle Chevrier Engineering

LOGGED: A.N.
CHECKED:

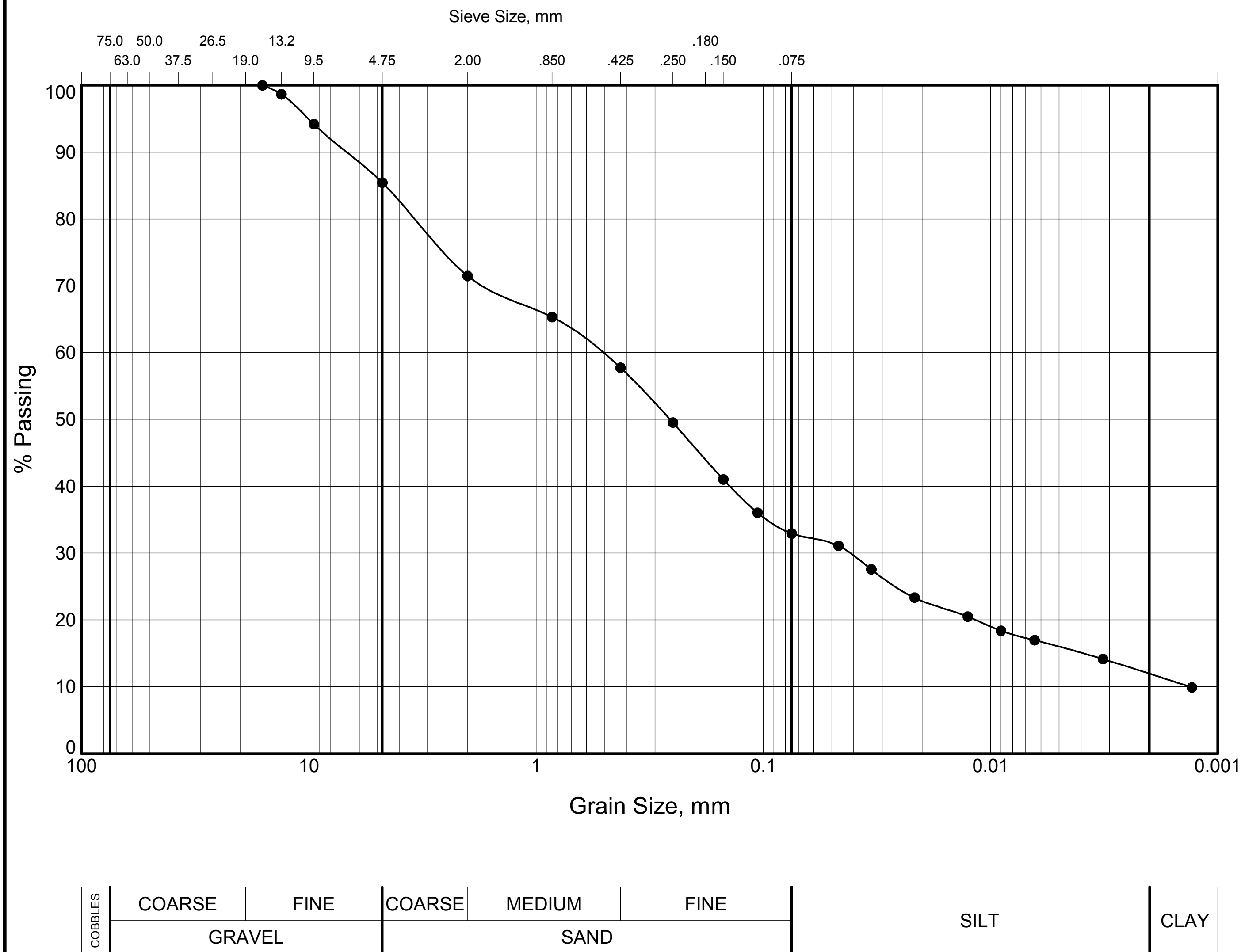
APPENDIX B

Laboratory Test Results
Figure B1

GRAIN SIZE DISTRIBUTION

Glacial Till

FIGURE B1



Legend	Borehole	Sample	Depth (m)	% Gravel	% Sand	% Silt	% Clay
●	15-1	4	2.3 - 2.9	15	53	21	12

SOILS GRAIN SIZE GRAPH UNIFIED % (HYDRO) 15128_BOREHOLE LOGS_GNT_V01_2015-05-20.GPJ HOULE CHEVRIER FEB 9 2011.GDT 5-29-15

Houle Chevrier Engineering

Date: June 2015

Project: 15-128

APPENDIX C

Chemical Testing of Soil Sample
Corrosion of Buried Concrete and Steel
EXOVA Laboratories Order No. 1508740

EXOVA ENVIRONMENTAL ONTARIO

Certificate of Analysis

Client: Houle Chevrier Engineering
32 Steacie Drive
Ottawa, ON
K2K 2A9
Attention: Ms. Lauren Ashe
PO#:
Invoice to: Houle Chevrier Engineering

Report Number: 1508740
Date Submitted: 2015-05-26
Date Reported: 2015-06-02
Project: 15-128
COC #: 797002

Dear Lauren Ashe:

Please find attached the analytical results for your samples. If you have any questions regarding this report, please do not hesitate to call (613-727-5692).

Report Comments:

APPROVAL: ______________________________
Lorna Wilson
Laboratory Supervisor, Inorganics

All analysis is completed in Ottawa, Ontario (unless otherwise indicated).

Exova Ottawa is accredited by CALA, Canadian Association for Laboratory Accreditation to ISO/IEC 17025 for tests which appear on our CALA scope of accreditation. It can be found at http://www.cala.ca/scopes/2602.pdf.

Exova (Ottawa) is certified and accredited for specific parameters by OMAFRA, Ontario Ministry of Agriculture, Food and Rural Affairs (for farm soils). Licensed by Ontario MOE for specific tests in drinking water.

Exova (Mississauga) is accredited for specific parameters by SCC, Standards Council of Canada (to ISO 17025)

Please note: Field data, where presented on the report, has been provided by the client and is presented for informational purposes only. Guideline values listed on this report are provided for ease of use (informational purposes) only. Exova recommends consulting the official provincial or federal guideline as required.

Certificate of Analysis

Client:	Houle Chevrier Engineering 32 Steacie Drive Ottawa, ON K2K 2A9
Attention:	Ms. Lauren Ashe
PO#:	
Invoice to:	Houle Chevrier Engineering

Report Number:	1508740
Date Submitted:	2015-05-26
Date Reported:	2015-06-02
Project:	15-128
COC #:	797002

Group	Analyte	MRL	Units	Guideline	Lab I.D. 1176214 Sample Matrix Soil Sample Type Sampling Date 2015-05-26 Sample I.D. BH15-2 SA4 7.5-9.5
Agri. - Soil	pH	2.0			8.3
General Chemistry	Cl	0.002	%		0.006
	Electrical Conductivity	0.05	mS/cm		0.34
	Resistivity	1	ohm-cm		2940
	SO4	0.01	%		0.02

Guideline = *** = Guideline Exceedence**

All analysis completed in Ottawa, Ontario (unless otherwise indicated by ** which indicates analysis was completed in Mississauga, Ontario).
Results relate only to the parameters tested on the samples submitted.
Methods references and/or additional QA/QC information available on request.

MRL = Method Reporting Limit, AO = Aesthetic Objective, OG = Operational Guideline, MAC = Maximum Acceptable Concentration, IMAC = Interim Maximum Acceptable Concentration, STD = Standard, PWQO = Provincial Water Quality Guideline, IPWQO = Interim Provincial Water Quality Objective, TDR = Typical Desired Range

Client: Houle Chevrier Engineering
32 Steacie Drive
Ottawa, ON
K2K 2A9
Attention: Ms. Lauren Ashe
PO#:
Invoice to: Houle Chevrier Engineering

Report Number: 1508740
Date Submitted: 2015-05-26
Date Reported: 2015-06-02
Project: 15-128
COC #: 797002

QC Summary

Analyte	Blank	QC % Rec	QC Limits
Run No: 287965 **Analysis Date:** 2015-05-27 **Method:** C CSA A23.2-4B			
Cl	<0.002 %	102	90-110
Run No: 288009 **Analysis Date:** 2015-05-27 **Method:** C SM4500-SO4--D			
SO4	<0.01 %	117	70-130
Run No: 288029 **Analysis Date:** 2015-05-27 **Method:** Ag Soil			
pH			90-110
Run No: 288236 **Analysis Date:** 2015-06-01 **Method:** Cond-Soil			
Electrical Conductivity			85-115
Resistivity			

geotechnical

environmental

hydrogeology

materials testing & inspection

experience • knowledge • reliability