Houle Chevrier Engineering

Geotechnical Investigation
Proposed Gymnasium Addition and Exterior Ice Rink
Boys and Girls Club of Ottawa
1463 Prince of Wales Drive

Ottawa, Ontario

a GEMTEC company

Submitted to:

Boys and Girls Club of Ottawa
c/o Hobin Architecture Incorporated
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Ottawa, Ontario
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Geotechnical Investigation
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Boys and Girls Club of Ottawa
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Ottawa, Ontario

March 23, 2017
Project: 61446.15

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1.0 INTRODUCTION

This report presents the results of a geotechnical investigation carried out for the proposed gymnasium addition and outdoor rink pad at the Boys and Girls Club building located at 1463 Prince of Wales Drive in Ottawa, Ontario (refer to Key Plan, Figure 1). The purpose of the investigation was to identify the general subsurface conditions at the site by means of a limited number of boreholes and, based on the factual information obtained, to provide engineering guidelines on the geotechnical design aspects of the project.

This investigation was performed in accordance with our proposal dated January 23, 2017.

2.0 PROJECT AND SITE DESCRIPTION

2.1 Project and Site Description

Plans are being prepared to construct a gymnasium addition to the south side of the existing building and an outdoor ice rink pad on the east side of the building located at 1463 Prince of Wales Drive, Ottawa. The new gymnasium is to be of slab on grade construction, and the outdoor rink pad will consist of an asphaltic concrete pavement structure.

The site for the proposed gymnasium currently consists of grass/tree covered landscaped and parking areas. The site of the proposed rink currently consists of an asphaltic concrete surfaced basketball court.

2.2 Review of Geology Maps and Previous Investigation

Overburden maps of the Ottawa area indicate that the subsurface conditions in the vicinity of the site consist of offshore and marine deposits of clay and silt. Drift thickness and bedrock geology maps indicate that the overburden deposits are underlain by interbedded limestone and dolostone bedrock of the Gull River formation at depths ranging from about 25 to 50 metres below ground surface.

3.0 SUBSURFACE INVESTIGATION

3.1 Geotechnical Investigation

On February 15, 2017, three (3) boreholes were advanced at the site using a track mounted drill rig supplied and operated by Marathon Drilling Inc. Details of the boreholes are provided below:

- Borehole 17-1 was advanced to a depth of about 3.1 metres below ground surface in the areas of the proposed rink.
- Boreholes 17-2 and 17-3 were advanced to depths of 6.7 and 9.8 metres below ground surface in the area of the proposed gymnasium addition.

Standard penetration tests were carried out in the boreholes and samples of the soils encountered were recovered using a 50 millimetre diameter split barrel sampler. The groundwater levels were estimated in the open boreholes prior to backfilling. One (1) sample of the soil recovered from borehole 17-3 was sent to Paracel Laboratories for basic chemical testing relating to corrosion.

The field work was supervised throughout by a member of our engineering staff who directed the drilling operations, logged the samples and carried out the in-situ testing. Following the field work, the soil samples were returned to our laboratory for examination by a geotechnical engineer. Selected samples of the soil were tested for water content, grain size distribution, and Atterberg limits.

The borehole locations were selected and determined relative to existing site features by Houle Chevrier Engineering Ltd. (HCEL) personnel. The boreholes were positioned and recorded using our Trimble R10 GPS survey instrument. The elevations in this report and on the Record of Borehole sheets are referenced to geodetic datum.

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 grain size distribution and moisture content testing are provided on the Record of Borehole sheets and on Figures A1 to A3 in Appendix A.

4.0 SUBSURFACE CONDITIONS

4.1 General

As previously indicated, the soil and groundwater conditions identified in the boreholes are given on the Record of Borehole sheets in Appendix A. The borehole 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. Subsurface conditions at other than the test locations may vary from the conditions encountered in the test holes. In addition to soil variability, fill of variable physical and chemical composition can be present over portions of the site.

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 judgment and HCEL 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 this investigation.

4.2 Pavement Structure

Pavement structure was encountered from surface at boreholes 17-1 and 17-3. At the location of borehole 17-1, the pavement structure consists of about 130 millimetres of asphaltic concrete overlying 300 millimetres of grey, crushed sand and gravel with trace silt (base/subbase material). At the location of borehole 17-3, the pavement structure consists of about 50 millimetres of asphaltic concrete overlying 400 millimetres of grey brown sand and gravel with trace silt (base/subbase material).

4.3 Topsoil Fill

A surficial layer of topsoil fill was encountered at borehole 17-2. The thickness of the topsoil fill is about 100 millimetres.

4.4 Fill Material

Fill material was encountered underlying the topsoil fill at borehole 17-2. The fill material extends to a depth of about 1.0 metre below ground surface.

The nature of the fill material can be generally described as brown silty clay with trace to some gravel, and trace debris (polyethylene sheet and wood).

The water content of a sample of the fill material is about 29 percent.

4.5 Weathered Crust

A native deposit of silty clay was encountered underlying the pavement structure at boreholes 17-1 and 17-3, as well as below the fill material at borehole 17-2. The silty clay deposit was encountered at depths ranging from about 0.4 to 1.0 metre below ground surface (elevations 81.0 to 81.8 metres, geodetic datum).

At all borehole locations, the upper portion of the silty clay has been desiccated to form a weathered crust. The weathered crust can be generally described as grey brown silty clay with trace amounts of sand. The thickness of the weathered crust was measured to be about 3.6 and 3.7 metres where fully penetrated at boreholes 17-2 and 17-3, respectively.

The SPT N values recorded within the weathered crust range between 6 and 24 blows per 0.3 metres of penetration. Based on our local experience and our review of the soil samples, N values within the silty clay deposit which are greater than about 2 blows per 0.3 metres would be indicative of a stiff to very stiff consistency.

A grain size distribution test was undertaken on a sample of the silty clay weathered crust collected from borehole 17-2. The test results show that the sample contains about 2 percent fine sand, 36 percent silt, and 62 percent clay. The results are provided on Figure A1 (Appendix A).

One (1) Atterberg limits test was undertaken on a sample of the weathered crust obtained from borehole 17-2. The results indicate that the silty clay sample is of high plasticity and has a liquid limit of about 56 percent, a plastic limit of about 25 percent and a plasticity index of about 31 percent. The results are provided on Figure A2 and the Record of Borehole sheets (Appendix A).

The moisture contents of the weathered crust samples tested are below the liquid limit value measured.

Borehole 17-1 was terminated within the weathered crust at a depth of about 3.1 metres below ground surface (elevation 79.2 metres, geodetic).

4.6 Clayey Silt

At the locations of boreholes 17-2 and 17-3, the silty clay weathered crust is underlain by a layer of grey brown clayey silt with varying sand content. The clayey silt was encountered at depths of 4.6 and 4.1 metres below ground surface at boreholes 17-2 and 17-3, respectively (elevations 77.4 and 77.6 metres, geodetic). The SPT N values recorded within the clayey silt range between 1 and 8 blows per 0.3 metres of penetration, which reflects a firm to stiff consistency.

One (1) Atterberg limits test was undertaken on a sample of the clayey silt obtained from borehole 17-3. The results indicate that the clayey silt sample is of low plasticity and has a liquid limit of about 20 percent, a plastic limit of about 19 percent and a plasticity index of about 1 percent. The results are provided on Figure A3 and the Record of Borehole sheets (Appendix A).

The moisture content of the tested clayey silt sample is above the liquid limit value measured.

4.7 Grey Silty Clay

Below the clayey silt layer at boreholes 17-2 and 17-3, grey silty clay with trace to some sand seams was encountered at depths of 6.1 and 5.3 metres below ground surface, respectively (elevations 75.9 and 76.4 metres, geodetic). The SPT N values recorded within the grey silty clay range between WH (static weight of hammer and drill rods) and 1 blow per 0.3 metres of penetration which reflects a firm consistency.

Boreholes 17-2 was terminated at a depth of about 6.7 metres below ground surface (elevation 75.3 metres, geodetic).

The moisture contents of the grey silty clay samples tested are below the liquid limit value measured.

4.8 Glacial Till

A deposit of glacial till was encountered below the silty clay in borehole 17-3 at a depth of about 7.6 metres below ground surface (elevation 74.1 metres, geodetic datum).

The glacial till can be generally described as a grey sandy silt with some clay and trace to some gravel. Cobbles and boulders should also be expected in the glacial till deposit.

Standard penetration tests carried out in the glacial till gave an N values 1 to 17 blows per 0.3 metres of penetration, which reflects a variable very loose to compact relative density.

Borehole 17-3 was terminated within the glacial till at a depth of about 9.8 metres below ground surface (elevation 72.0 metres, geodetic datum).

4.9 Groundwater Levels

Based on the conditions observed during drilling on February 15, 2017, the water levels were estimated at about 4.3 and 4.1 metres below ground surface at boreholes 17-2 and 17-3, respectively (elevations 77.7 and 77.6 metres, geodetic).

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

4.10 Soil Chemistry Relating to Corrosion

The results of chemical testing on a sample of soil recovered from borehole 17-3 at about 2.1 metres below ground surface are provided in Appendix B and summarized in Table 4.1.

Table 4.1 – Soil Chemistry Relating to Corrosion

Parameter	Units	Borehole 17-3 (SA 3 – 1.8m to 2.4m)
Sulphate	µg/g	111
Chloride	µg/g	296
pH	pH units	7.33
Conductivity	µS/cm	596

5.0 GEOTECHNICAL GUIDELINES AND RECOMMENDATIONS

5.1 General

The information in the following sections is provided for the guidance of the design engineers and is intended for the design of 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.

5.2 Gymnasium Addition

5.2.1 Excavation

The excavation for the proposed gymnasium addition will be carried out through pavement structure, fill material and native deposits of silty clay.

The sides of the excavation should be sloped in accordance with the requirements in Ontario Regulation 213/91 under the Occupational Health and Safety Act. According to the act, soils at this site can be classified as Type 3. That is, open cut excavations within overburden deposits should be carried out with side slopes of 1 horizontal to 1 vertical, or flatter.

No unusual constraints are expected for the excavation of the pavement structure, fill material and native silty clay deposits. The upper part of the silty clay (i.e., the weathered crust) has been impacted by past frost action. During removal of the fill material the upper part of the silty clay could unavoidably peel upwards and become disturbed. Where this occurs, it will likely be necessary to remove and replace the disturbed silty clay soil with imported granular material, such as material meeting Ontario Provincial Standards Specification (OPSS) requirements for Granular B Type II. Trimming to final grade elevation should be undertaken with a flat blade bucket in order to minimize disturbance of the native silty clay.

5.2.2 Excavation Next to Existing Building Foundations

To prevent undermining of the existing building foundations, it is recommended that no excavation be carried out in the zone extending down and out from the bottom edge of the existing and adjacent building foundations at 1 horizontal to 1 vertical, or flatter. If excavation is required within this zone, underpinning or temporary support of the existing and adjacent foundations may be required. Details for underpinning and/or support of foundations could be provided upon request.

The underside of footing level should match the existing underside of footing level where the new foundation walls abut the existing foundation walls.

5.2.3 Groundwater Management

The groundwater inflow from the overburden deposits, if any, should be controlled by pumping from sumps within the excavation where required.

The rate of groundwater inflow from the overburden deposits is not expected to exceed 50,000 litres per day, as such the water takings for this project will likely not be subject to an Environmental Activity and Sector Registry (EASR) in accordance with Environmental Protection Act Part II.2 Section 20.21.

5.2.4 Spread Footing Design

The existing fill material is not considered suitable for support of the loads for the proposed gymnasium addition and should be removed from the footprint of the proposed addition. In any areas where the proposed founding level is above the level of the native silty clay 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 OPSS requirements for Granular B Type II. The granular materials should be compacted in maximum 200 millimetre thick lifts to at least 98 percent of the standard Proctor maximum dry density. To allow spread of load beneath the footings, the engineered fill should extend horizontally at least 0.3 metres beyond the outside edges of the footings and then down and out from the edges of the footings at 1 horizontal to 1 vertical, or flatter. The excavations for the proposed addition foundation should be sized to accommodate this fill placement.

Based on the results of the geotechnical investigation, spread footings founded on or within native, undisturbed soil or on a pad of compacted granular fill above native, undisturbed soil at this site should be sized using a net geotechnical reaction at Serviceability Limit State (SLS) of 100 kilopascals and a factored net geotechnical resistance at Ultimate Limit State (ULS) of 200 kilopascals.

The post construction total and differential settlement of footings at SLS should be less than 25 and 20 millimetres, respectively, provided that all loose or disturbed soil is removed from the bearing surfaces. Since any settlement of the addition will be differential with respect to the existing structure, the foundations for the addition should be structurally separated from the existing structure by suitable control joints.

The bearing capacities and settlement estimates provided above assume that the subgrade surfaces are undisturbed, that any granular fill material is suitably compacted, and a maximum grade raise of 0.5 metres above the existing site grades in the vicinity of the gymnasium addition.

5.2.5 Frost Protection of Foundations

All exterior footings in heated portions of the structure should be provided with at least 1.5 metres of earth cover for frost protection purposes. All isolated, exterior footings located within unheated portions of the building 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.

5.2.6 Seismic Site Classification and Liquefaction Potential

In accordance with the 2012 National Building Code of Canada and the Ontario Building Code, Site Class D should be used for the design of the proposed gymnasium addition.

In our opinion, there is no potential for liquefaction of the overburden deposits at this site.

5.2.7 Foundation Wall Backfill

The fill material and native deposits at this site are frost susceptible and should not be used as backfill against the foundation walls. The backfill material should consist of imported sand or sand and gravel meeting OPSS requirements for Granular B Type I or II. Where the backfill will ultimately support areas of hard surfacing (pavement, sidewalks, parking areas or other similar surfaces), the backfill should be placed in maximum 200 millimetre thick lifts and should be compacted to at least 95 percent of the standard Proctor maximum dry density value using suitable vibratory compaction equipment.

Where future landscaped areas will exist next to the proposed structures and if some settlement of the backfill is acceptable, the backfill could be compacted to at least 90 percent of the standard Proctor maximum dry density value.

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 1.5 metres below finished grade to the underside of the granular base/subbase material for the hard surfaced areas. The frost tapers should be sloped at 2 horizontal to 1 vertical, or flatter.

5.2.8 Corrosion of Buried Concrete and Steel

The measured sulphate concentration in the sample of soil recovered from borehole 17-3 was 111 micrograms per grams. According to Canadian Standards Association (CSA) “Concrete Materials and Methods of Concrete Construction”, the concentration of sulphate can be classified as low. Therefore any concrete in contact with the native soil could be batched with General Use (GU) cement. The effects of freeze thaw in the presence of de-icing chemical (sodium chloride) use on the parking lot should be considered in selecting the air entrainment and the concrete mix proportions for any concrete.

Based on the conductivity, pH level, and chloride content of the sample, the native silty clay soil in this area can be classified as slightly aggressive towards unprotected steel. It should be noted that the corrosivity of the soil could vary throughout the year due to the application sodium chloride for de-icing.

5.2.9 Concrete Slab on Grade

To provide predictable settlement performance of the concrete slab on grade for the proposed addition, all topsoil and fill material should be removed from below the slab area to expose the native undisturbed silty clay deposit.

The grade below the proposed slab could then be raised, where necessary, with imported granular material conforming to OPSS requirements for Granular B Type I or II. A base layer composed of at least 150 millimetres of Granular A should be placed on the underside of the concrete slab on grade.

Granular A and Granular B Type I or II should be compacted in maximum 200 millimetre thick lifts to at least 98 percent of the standard Proctor dry density value using suitable vibratory equipment.

Underfloor drainage is not considered necessary provided that the floor slab level is above the finished exterior ground surface.

The floor slab should be wet cured to minimize shrinkage cracking and slab curling. The slab should be saw cut to about 1/3 the thickness of the slab as soon as curing of the concrete permits, in order to minimized shrinkage cracks.

Proper moisture protection with a vapour retarder should be used for any slab on grade where the floor will be covered by moisture sensitive flooring material or where moisture sensitive equipment, products or environments will exist. The “Guide for Concrete Floor and Slab Construction”, ACI 302.1R-04 should be considered for the design and construction of vapour retarders below the floor slab. The sulphate content of any imported granular material placed below the floor slab should be assessed to determine the appropriate exposure class for the concrete.

5.3 Rink Pad Construction

5.3.1 Renewal of Existing Pavement Structure

Following the removal of curbs and posts for the basketball nets, the existing asphaltic concrete could be pulverized and following inspection of the pulverized material, topped with a levelling layer of granular material meeting OPSS requirements for granular A. Compaction of the pulverized material and OPSS Granular A should be carried out using a large (10 tonne) vibratory steel drum roller under dry conditions. Any soft areas evident from the compaction should be subexcavated and replaced with suitable, compacted material.

Following this, a 50 millimetre thick layer of hot mix asphaltic concrete could be placed. The asphaltic concrete should consist of Superpave 12.5 (Traffic Level A or B) or HL3. Performance grade PG58-34 asphaltic concrete should be specified.

5.3.2 New Rink Pad Design

In the areas where the new rink pad will encroach on existing landscaped areas, or in areas where the thickness of the existing granular structure is less than 400 millimetres, it is suggested that the areas be excavated to design level and constructed using the following pavement structure:

- 50 millimetres of asphaltic concrete, over
- 400 millimetres of OPSS Granular A base/subbase material

The above pavement structure is recommended in order to match the adjacent pavement structure.

5.3.3 Compaction Requirements

The pulverized and granular base/subbase materials should be compacted in maximum 200 millimetre thick lifts to at least 98 percent of the standard Proctor maximum dry density value. The subgrade surface should be shaped and crowned to promote drainage of the granular base material.

6.0 ADDITIONAL CONSIDERATIONS

6.1 Winter Construction

In the event that construction is required during freezing temperatures, the soil below the footings should be protected immediately from freezing using straw, propane heaters and insulated tarpaulins, or other suitable means.

6.2 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. The magnitude of the vibrations should be much less than that required in order to cause damage to the nearby structures or services in good condition.

6.3 Design Review and Construction Observation

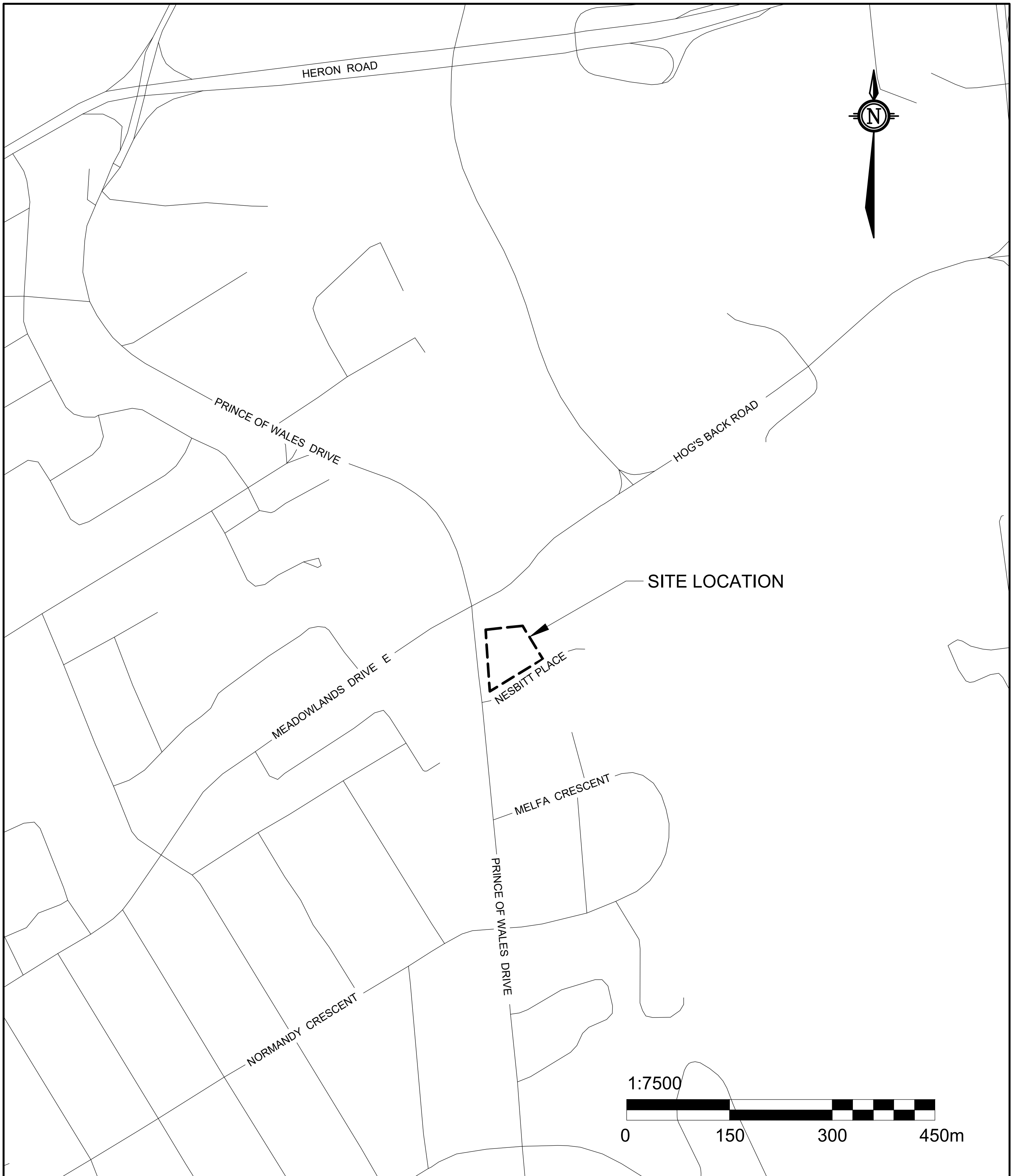
The details for the proposed construction were not available to us at the time of preparation of this report. It is recommended that the final design drawings be reviewed by the geotechnical engineer as the design progresses to ensure that the guidelines provided in this report have been interpreted 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 the report and that the construction activities do not adversely affect the intent of the design. The subgrade surfaces for the proposed addition and ice pad 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.

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.

Luc Bouchard, P.Eng. ing.

Brent Wiebe, P.Eng.
Senior Geotechnical Engineer



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Project			Drawing		
GEOTECHNICAL INVESTIGATION PROPOSED GYMNASIUM & ICE RINK 1463 PRINCE OF WALES OTTAWA, ONTARIO			KEY PLAN		
Drwn By	Chkd By	Date	Project No.	Revision No.	
P.C.	L.B.	MARCH 2017	61446.15	0	**FIGURE 1**

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LEGEND

BH 17-1 82.22 — BOREHOLE LOCATION IN PLAN
(current investigation by Houle Chevrier Engineering Ltd.)

Scale 1:400

0 8 16 24m

Houle Chevrier Engineering

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Client: HOBIN ARCHITECTURE INC.	Project: 61446.15
Location: 1463 PRINCE OF WALES DRIVE OTTAWA, ON	
Drwn by: P.C. / Chkd by: L.B.	BOREHOLE LOCATION PLAN
Date: MARCH 2017 / Rev.: 0	FIGURE 2

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APPENDIX A

Record of Borehole Sheets
Figures A1 to A3
List of Abbreviations and Terminology

RECORD OF BOREHOLE 17-1

PROJECT: 61446.15

LOCATION: See Borehole Location Plan, Figure 2

BORING DATE: February 15, 2017

SHEET 1 OF 1

DATUM: Geodetic

SPT HAMMER: 63.5 kg; drop 0.76 metres

BORING METHOD: Power Auger, 200 mm Diameter Hollow Stem

DEPTH SCALE METRES	SOIL PROFILE DESCRIPTION	ELEV. DEPTH (m)	SAMPLE NUMBER	TYPE	BLOWS/0.3m	PIEZOMETER OR STANDPIPE INSTALLATION
0	Ground Surface	82.22				
	Asphaltic Concrete	82.09 / 0.13				Asphaltic Cold Patch
	Grey, crushed sand and gravel, trace silt (BASE/SUBBASE MATERIAL)	81.79 / 0.43				
	Very stiff, brown SILTY CLAY, trace sand seams (WEATHERED CRUST)		1	50 D.O.	27	
1			2	50 D.O.	19	Borehole backfilled with auger cuttings
2			3	50 D.O.	21	
			4	50 D.O.	15	
3	End of borehole	79.17 / 3.05				No groundwater observed in the open borehole prior to backfilling.

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

DEPTH SCALE 1 to 50

Houle Chevrier Engineering

LOGGED: M.L.

CHECKED: L.B.

RECORD OF BOREHOLE 17-2

PROJECT: 61446.15
LOCATION: See Borehole Location Plan, Figure 2
BORING DATE: February 15, 2017

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

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	81.97					
	TOPSOIL FILL	81.87 / 0.10					
	Brown silty clay, trace to some gravel, trace debris (polyethylene sheet) and wood (FILL MATERIAL)	81.00 / 0.97					
1	Very stiff, grey brown SILTY CLAY, trace sand seams (WEATHERED CRUST)		1	50 D.O.	10		
2			2	50 D.O.	15	MH, See Fig. A2	Borehole backfilled with auger cuttings
			3	50 D.O.	14		
3			4	50 D.O.	10		
4		77.40 / 4.57	5	50 D.O.	9		
	Stiff to firm CLAYEY SILT, some sand		6	50 D.O.	5		Groundwater estimated from sample appearance at about 4.3 metres below ground surface (elevation 77.7 metres, geodetic).
5			7	50 D.O.	1		
6	Firm, grey SILTY CLAY	75.87 / 6.10	8	50 D.O.	WH		
	End of borehole	75.26 / 6.71					
7							
8							
9							
10							

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

GROUNDWATER OBSERVATIONS

DATE	DEPTH (m)	ELEV. (m)
17/02/15	4.27 ∇	77.70

DEPTH SCALE
1 to 50

Houle Chevrier Engineering

LOGGED: M.L.
CHECKED: L.B.

RECORD OF BOREHOLE 17-3

PROJECT: 61446.15

LOCATION: See Borehole Location Plan, Figure 2

BORING DATE: February 15, 2017

SHEET 1 OF 1

DATUM: Geodetic

SPT HAMMER: 63.5 kg; drop 0.76 metres

BORING METHOD: Power Auger, 200 mm Diameter Hollow Stem

SOIL PROFILE – DESCRIPTION	ELEV. / DEPTH (m)
Ground Surface	81.71
Asphaltic Concrete	0.05
Grey brown sand and gravel, trace silt (BASE/SUBBASE MATERIAL)	81.26 / 0.45
Very stiff, grey brown SILTY CLAY, trace sand (WEATHERED CRUST)	78.66 / 3.05
Very stiff, grey brown SILTY CLAY, trace to some sand seams (WEATHERED CRUST)	77.59 / 4.12
Stiff, grey brown CLAYEY SANDY SILT	76.37 / 5.34
Firm, grey SILTY CLAY, trace to some sand seams	74.08 / 7.63
Grey sandy silt, some clay, trace to some gravel, probable cobbles and boulders (GLACIAL TILL)	71.95 / 9.76
End of borehole	

SAMPLES – NUMBER	TYPE	BLOWS/0.3m
1	50 D.O.	26
2	50 D.O.	24
3	50 D.O.	20
4	50 D.O.	11
5	50 D.O.	6
6	50 D.O.	8
7	50 D.O.	8
8	50 D.O.	1
9	50 D.O.	WH
10	50 D.O.	1
11	50 D.O.	1
12	50 D.O.	17
13	50 D.O.	11

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

PIEZOMETER OR STANDPIPE INSTALLATION:

- Asphaltic Cold Patch
- Borehole backfilled with auger cuttings
- Groundwater estimated from sample appearance at about 4.1 metres below ground surface (elevation 77.6 metres, geodetic).

GROUNDWATER OBSERVATIONS

DATE	DEPTH (m)	ELEV. (m)
17/02/15	4.12	77.59

DEPTH SCALE 1 to 50

Houle Chevrier Engineering

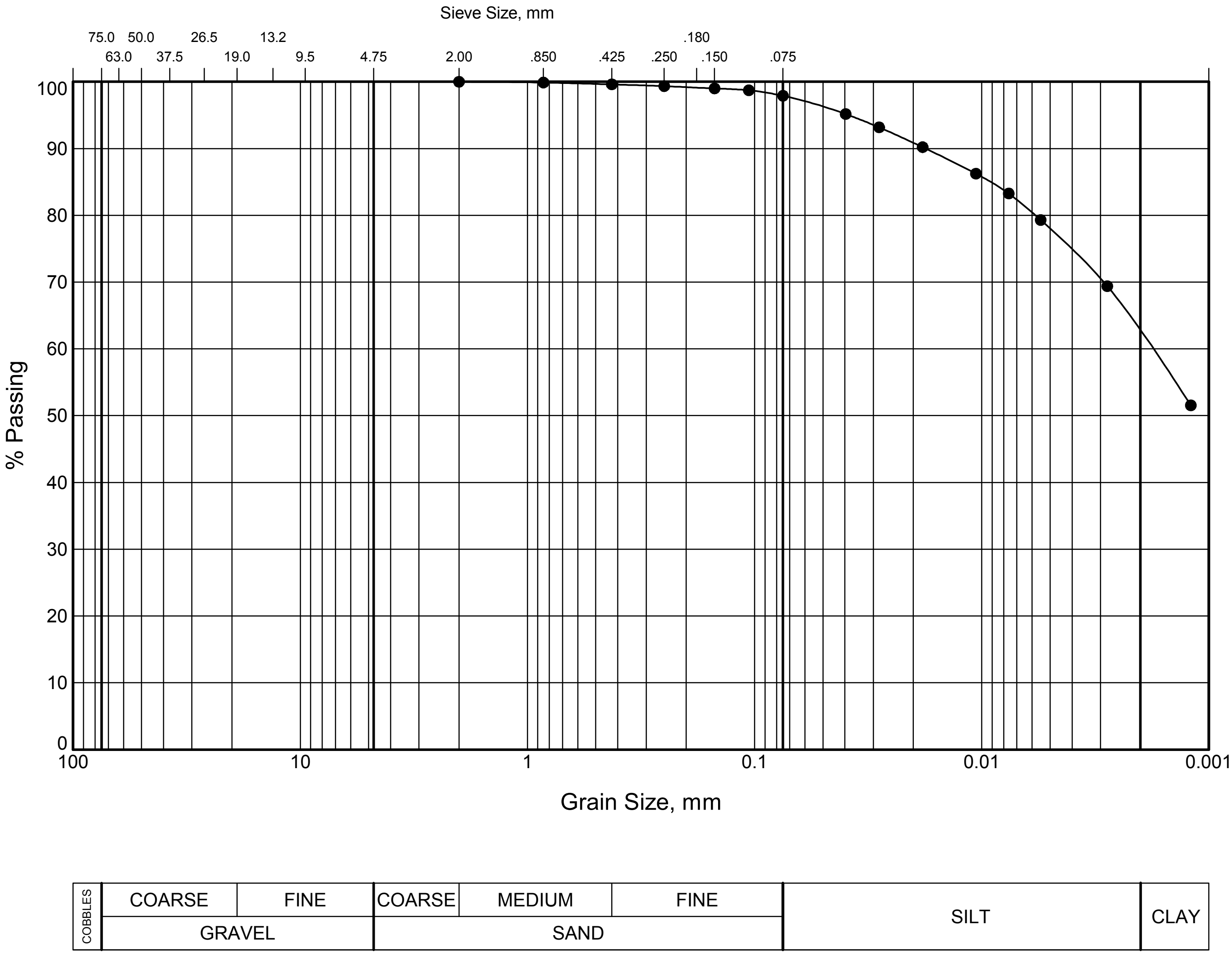
LOGGED: M.L.

CHECKED: L.B.

GRAIN SIZE DISTRIBUTION

SILTY CLAY

FIGURE A1



Legend	Borehole	Sample	Depth (m)	% Gravel	% Sand	% Silt	% Clay
●	17-2	2	1.5 - 2.1	0	2	36	62

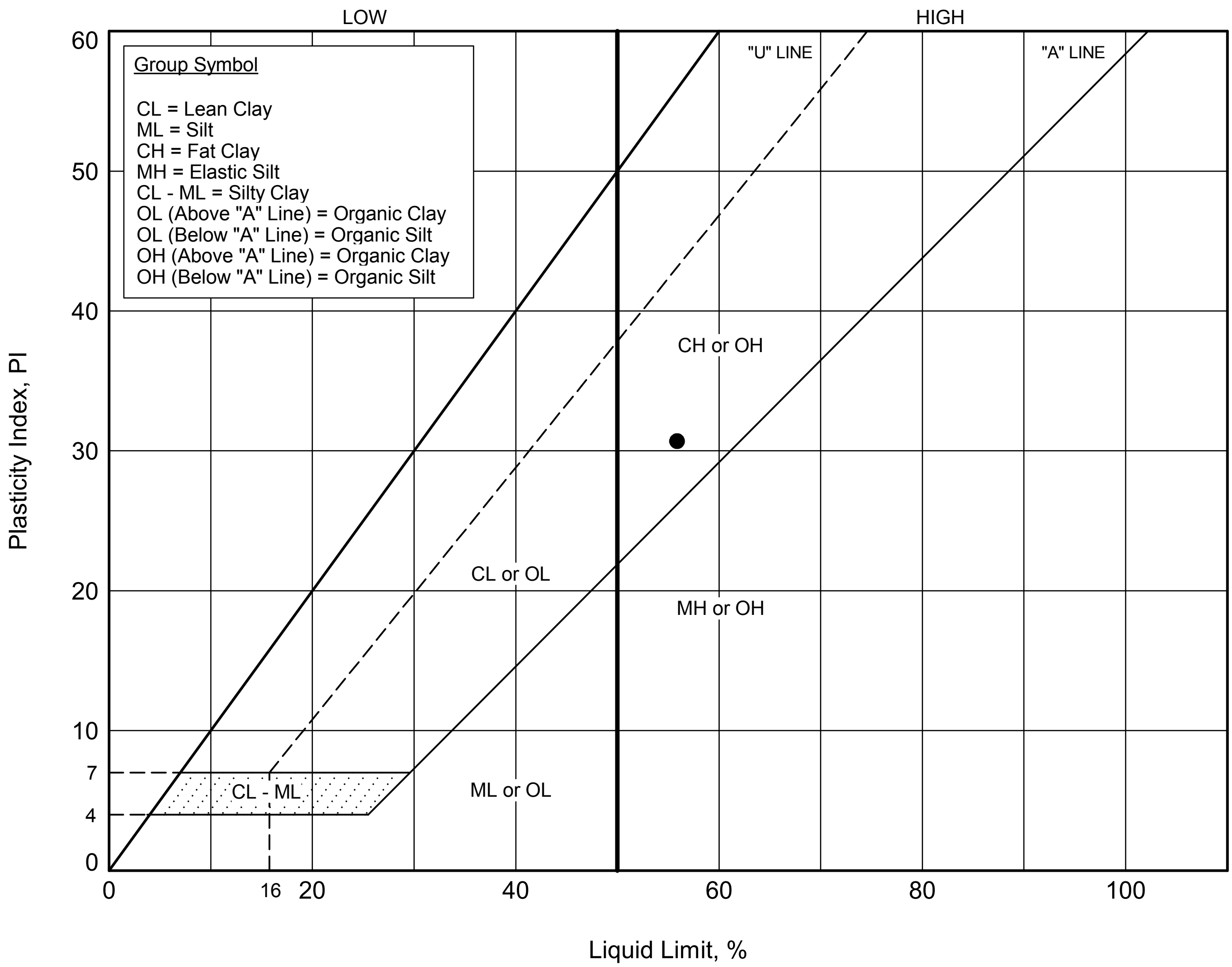
Houle Chevrier Engineering

Date: March 2017

Project: 61446.15

PLASTICITY CHART

FIGURE A2



Legend	Borehole	Sample	Depth (m)	Water Content %	LL %	PL %	PI %
●	17-2	2	1.5 - 2.1	41.8	55.9	25.2	30.7

HCE ATTERBERG LIMITS 61446.15_GINT LOGS_GNT_V01_2017-02-16.GPJ HOULE CHEVRIER FEB 9 2011.GDT 8/3/17

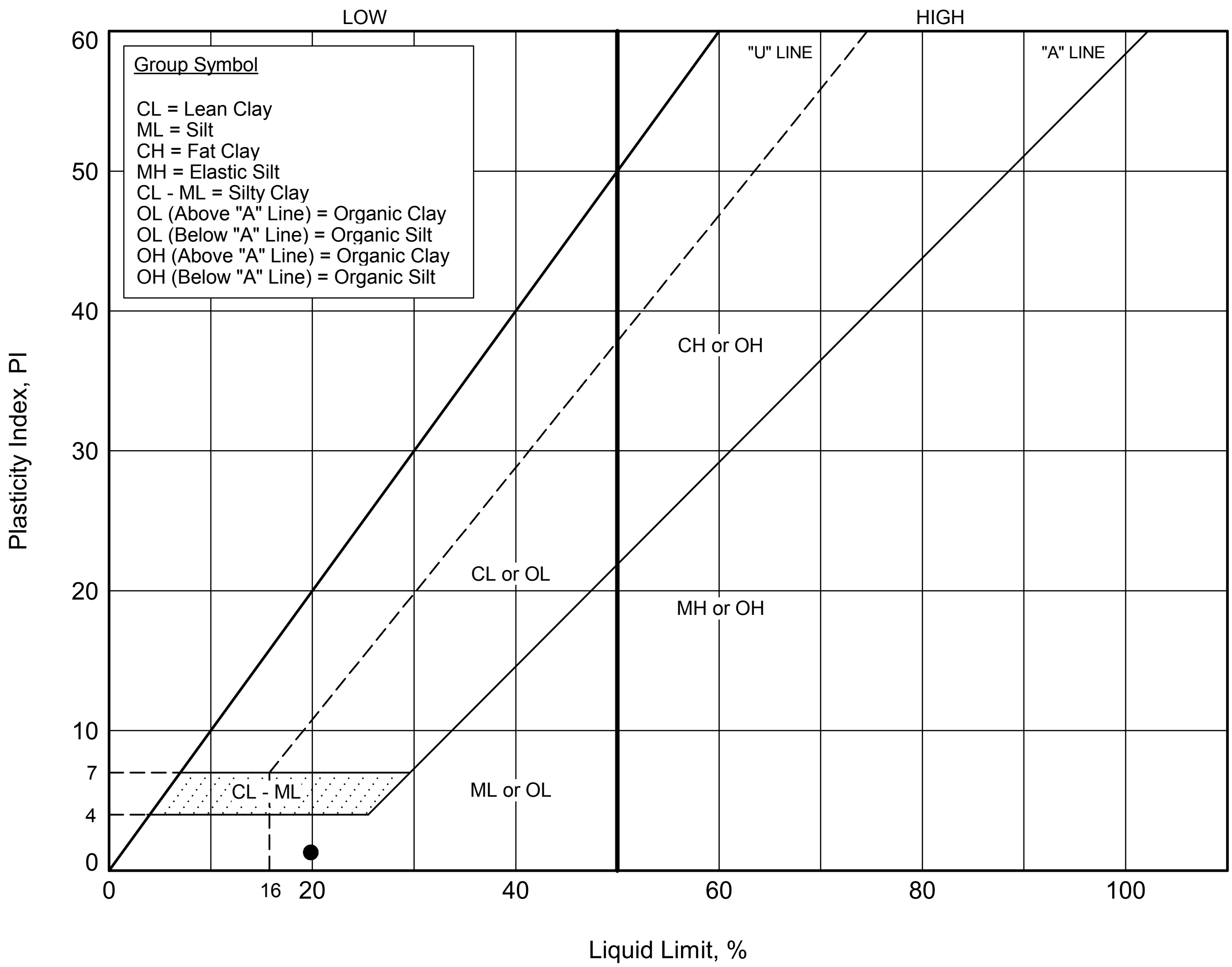
Houle Chevrier Engineering

Date: March 2017

Project: 61446.15

PLASTICITY CHART

FIGURE A3



Legend	Borehole	Sample	Depth (m)	Water Content %	LL %	PL %	PI %
●	17-3	7	4.6 - 5.2	25.4	19.8	18.5	1.3

Houle Chevrier Engineering

Date: March 2017

Project: 61446.15

LIST OF ABBREVIATIONS AND TERMINOLOGY

SAMPLE TYPES

AS	auger sample
CA	casing sample
CS	chunk sample
BS	Borros piston sample
DO	drive open
MS	manual sample
RC	rock core
ST	slotted tube
TO	thin-walled open Shelby tube
TP	thin-walled piston Shelby tube
WS	wash sample

PENETRATION RESISTANCE

Standard Penetration Resistance, N

The number of blows by a 63.5 kg hammer dropped 760 millimetre required to drive a 50 mm drive open sampler for a distance of 300 mm. For split spoon samples where less than 300 mm of penetration was achieved, the number of blows is reported over the sampler penetration in mm.

Dynamic Penetration Resistance

The number of blows by a 63.5 kg hammer dropped 760 mm to drive a 50 mm diameter, 60^{o} cone attached to 'A' size drill rods for a distance of 300 mm.

WH

Sampler advanced by static weight of hammer and drill rods.

WR

Sampler advanced by static weight of drill rods.

PH

Sampler advanced by hydraulic pressure from drill rig.

PM

Sampler advanced by manual pressure.

SOIL TESTS

C	consolidation test
H	hydrometer analysis
M	sieve analysis
MH	sieve and hydrometer analysis
U	unconfined compression test
Q	undrained triaxial test
V	field vane, undisturbed and remoulded shear strength

SOIL DESCRIPTIONS

Relative Density	'N' Value
Very Loose	0 to 4
Loose	4 to 10
Compact	10 to 30
Dense	30 to 50
Very Dense	over 50

Consistency	Undrained Shear Strength (kPa)
Very soft	0 to 12
Soft	12 to 25
Firm	25 to 50
Stiff	50 to 100
Very Stiff	over 100

LIST OF COMMON SYMBOLS

c_u	undrained shear strength
e	void ratio
C_c	compression index
c_v	coefficient of consolidation
k	coefficient of permeability
I_p	plasticity index
n	porosity
u	pore pressure
w	moisture content
w_L	liquid limit
w_P	plastic limit
ϕ^1	effective angle of friction
γ	unit weight of soil
γ^1	unit weight of submerged soil
σ	normal stress

APPENDIX B

Soil Chemistry Relating to Corrosion
Paracel Order No. 1709253

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Certificate of Analysis

Houle Chevrier

32 Steacie Drive
Kanata, ON K2K 2A9
Attn: Luc Bouchard

Client PO:
Project: 61446.15
Custody:

Report Date: 7-Mar-2017
Order Date: 1-Mar-2017

Order #: 1709253

This Certificate of Analysis contains analytical data applicable to the following samples as submitted:

Paracel ID	Client ID
1709253-01	BH17-3 SA3

Approved By: Mark Foto

Mark Foto, M.Sc.
Lab Supervisor

Analysis Summary Table

Analysis	Method Reference/Description	Extraction Date	Analysis Date
Anions	EPA 300.1 - IC, water extraction	6-Mar-17	6-Mar-17
Conductivity	MOE E3138 - probe @25 °C, water ext	4-Mar-17	4-Mar-17
pH, soil	EPA 150.1 - pH probe @ 25 °C, CaCl buffered ext.	1-Mar-17	2-Mar-17
Solids, %	Gravimetric, calculation	3-Mar-17	3-Mar-17

Certificate of Analysis
Client: Houle Chevrier
Client PO:

Report Date: 07-Mar-2017
Order Date: 1-Mar-2017
Project Description: 61446.15

	Client ID:	BH17-3 SA3	-	-	-
	Sample Date:	15-Feb-17	-	-	-
	Sample ID:	1709253-01	-	-	-
	MDL/Units	Soil	-	-	-
Physical Characteristics					
% Solids	0.1 % by Wt.	71.9	-	-	-
General Inorganics					
Conductivity	5 uS/cm	596	-	-	-
pH	0.05 pH Units	7.33	-	-	-
Anions					
Chloride	5 ug/g dry	296	-	-	-
Sulphate	5 ug/g dry	111	-	-	-

Certificate of Analysis
Client: Houle Chevrier
Client PO:

Report Date: 07-Mar-2017
Order Date: 1-Mar-2017
Project Description: 61446.15

Method Quality Control: Blank

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	ND	5	ug/g						
Sulphate	ND	5	ug/g						
General Inorganics									
Conductivity	ND	5	uS/cm						

Method Quality Control: Duplicate

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	304	5	ug/g dry	296			2.6	20	
Sulphate	115	5	ug/g dry	111			3.6	20	
General Inorganics									
Conductivity	398	5	uS/cm	393			1.3	6.2	
pH	7.70	0.05	pH Units	7.65			0.7	10	
Physical Characteristics									
% Solids	85.8	0.1	% by Wt.	83.9			2.2	25	

Method Quality Control: Spike

Analyte	Result	Reporting Limit	Units	Source Result	%REC	%REC Limit	RPD	RPD Limit	Notes
Anions									
Chloride	387	5	ug/g	296	90.6	78-113			
Sulphate	210	5	ug/g	111	98.3	78-111			

Qualifier Notes:

None

Sample Data Revisions

None

Work Order Revisions / Comments:

None

Other Report Notes:

n/a: not applicable
ND: Not Detected
MDL: Method Detection Limit
Source Result: Data used as source for matrix and duplicate samples
%REC: Percent recovery.
RPD: Relative percent difference.

Soil results are reported on a dry weight basis when the units are denoted with 'dry'.
Where %Solids is reported, moisture loss includes the loss of volatile hydrocarbons.

Paracel ID: 1709253

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Chain of Custody (Lab Use Only)

Page __ of __

Client Name: Houle Chevrier Engineering Ltd.	Project Reference: 61446.15
Contact Name: LUC BOUCHARD	Quote #
Address: 32 Steacie Drive, Ottawa, Ontario, K2K 2A9	PO #
Telephone: 613-836-1422	Email Address: lbouchard@hcgx.ca

Turnaround Time: ☐ 1 Day ☐ 3 Day ☐ 2 Day ☒ Regular

Date Required: ________

Criteria: ☐ O. Reg. 153/04 (As Amended) Table __ ☐ RSC Filing ☐ O. Reg. 558/00 ☐ PWQO ☐ CCME ☐ SUB (Storm) ☐ SUB (Sanitary) Municipality: ________ ☐ Other: ________

Matrix Type: **S** (Soil/Sed.) **GW** (Ground Water) **SW** (Surface Water) **SS** (Storm Sanitary Sewer) **P** (Paint) **A** (Air) **O** (Other)

Paracel Order Number: 1709253.

	Sample ID/Location Name	Matrix	Air Volume	# of Containers	Sample Taken Date	Sample Taken Time	CHLORIDE	pH/SO4	ELECTRICAL CONDUCTIVITY								
1	BH 17-3 SA3				Feb 15/17		☑	☑	☑	☐	☐	250mL.		☐	☐	☐	☐
2							☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
3							☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
4							☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
5							☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
6							☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
7							☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
8							☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
9							☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
10							☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Comments:

Method of Delivery: Walk-In

Relinquished By (Sign): [signature]	Received by Driver/Depot: [signature]	Received at Lab: Rachel Subject	Verified By: Rachel Subject
Relinquished By (Print): Allen Bolton	Date/Time: 03/01/17 12:15pm	Date/Time: Mar 1/17 3:09	Date/Time: Mar 1/17 4:09
Date/Time:	Temperature: 21.8 °C	Temperature: 7.5 °C	pH Verified ☒ By: N/A

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environmental

hydrogeology

materials testing & inspection

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