Geotechnical Investigation

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Proposed Addition to Larry Robinson Arena
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Introduction

EXP Services Inc. (EXP) is pleased to present the results of the geotechnical investigation completed for the proposed addition to Larry Robinson Arena (Metcalfe Community Centre) located at the municipal address of 2785 8th Line Road, in Ottawa (Metcalfe), Ontario (Figure 1). Terms and conditions of this assignment were outlined in EXP Services Inc. (EXP) proposal number: OTT-24000976-A0 dated January 24, 2024. This work was completed under EXP Standing Offer Agreement with the City of Ottawa RFSO- 24423-92500-S01 Category 5A and accepted by the City of Ottawa PO 0045107436 dated February 14, 2024.

The proposed addition will be located on the north side of the existing Larry Robinson Arena (Metcalfe Community Centre) and will measure approximately 9.5 m by 70.0 m for a total building footprint area of approximately 665 m^2. The proposed arena addition will be a slab-on-grade structure with no basement. It is our understanding that the design elevation of the ground floor will match that of the existing arena ground floor at Elevation 87.27 m.

As part of the proposed construction, the existing 2 m wide gravel pathway located along the east side of the existing parking lot will be paved. The area along the east side of the proposed addition will also be paved for use by service vehicles.

Fieldwork Program

The test hole fieldwork for this geotechnical investigation was undertaken on March 7 and 8, 2024 and includes six (6) boreholes (Borehole Nos. 1 to 6) and one (1) test pit (Test Pit No. 1). The six (6) boreholes were advanced to termination and auger refusal depths ranging from 1.6 m to 7.6 m below existing grade. The test pit was excavated to a bucket refusal depth of 1.5 m below existing grade. Standpipes were installed in selected boreholes to monitor the groundwater levels over time.

A seismic shear wave velocity survey consisting of one (1) survey line was conducted at the site on February 2,2024 by Geophysics GPR International Inc. (GPR). The purpose of the seismic shear wave survey is to determine the shear wave velocity of the site and based on the shear wave velocity provide the site classification for seismic site response.

Test Hole Findings

Beneath the surficial wood chip mulch and pavement structure, the subsurface conditions consist of fill that extends to depths of 1.0 m to 1.5 m (Elevation 86.0 m to Elevation 85.3 m). The fill in Borehole Nos. 1 and 3 is underlain by a 25 mm thick organic clayey silt layer. With the exception of Borehole No. 5, the fill and organic clayey silt are further underlain by compact to very dense/very stiff to hard glacial till. Inferred bedrock, cobbles and boulders exist in Borehole Nos. 2,4 and 6 at 1.6 m to 2.4 m depths (Elevation 85.3 m to Elevation 84.4 m). Shallow bedrock was contacted in Borehole Nos. 1,3 and 5 at 1.0 m to 3.2 m depths (Elevation 85.9 m to Elevation 83.6 m). The groundwater level in the boreholes is at 1.0 m to 1.4 m depths (Elevation 85.9 m to Elevation 85.6 m).

The exposed section of the existing footing in Test Pit No. 1 indicates the footing is founded at a 1.5 m depth (Elevation 85.6 m) on bedrock. The groundwater level in the test pit is at a 1.5 m depth (Elevation 85.6 m).

Geotechnical Comments and Recommendations

Based on a review of the borehole information, the subsurface conditions for the proposed addition to Larry Robinson Arena consist of fill underlain by compact to very dense/very stiff to hard glacial till followed by shallow bedrock at 1.0 m to 3.2 m depths (Elevation 85.9 m to Elevation 83.6 m). As discussed in Section 9 of this report, the proposed building addition may be supported by footings founded on the glacial till contacted at 1.0 m to 1.5 m depths (Elevation 86.0 m to Elevation 85.3 m) and/or on the competent sound bedrock that is free of weathered zones, loose material (soil and bedrock pieces) and soft seams.

The results of the seismic shear wave velocity survey and comparison of the results with the 2012 Ontario Building Code (as amended January 1, 2022), indicates that for footings founded less than 3.0 m from the bedrock surface, the site class is Class B. If the footings will be founded 1.6 m or less from the bedrock surface, the site class is Class A. The subsurface soils are not susceptible to liquefaction during a seismic event.

The boreholes indicate that the subsurface soils consist of fill underlain by compact to very dense/very stiff to hard glacial till followed by bedrock. Since the boreholes indicate that compressible clays do not exist at the site, there is no restriction for grade raise from a geotechnical perspective.

A review of the test hole information indicates that the proposed addition to the arena may be supported by strip and spread footings founded on the compact to very dense glacial till or on the sound bedrock that is free of weathered zones, loose material (soil and bedrock pieces) and soft seams. The existing fill is not considered suitable to support footings and the slab-on-grade ground floor of the proposed arena addition.

It is our understanding that the design elevation of the ground floor of the proposed arena addition will match that of the existing arena ground floor at Elevation 87.27 m. The information from Test Pit No. 1 indicates the underside of the existing footing will be at Elevation 85.6 m which is 1.5 m below existing grade and 1.7 m below the ground floor. Based on the assumption that the footings for the arena addition will be founded at a similar elevation as the existing exposed footing in Test Pit No. 1, the footings will be founded on the compact to very dense glacial till at Borehole Nos. 1, 2 and 4 and on the bedrock at Borehole No. 5. At Borehole No. 2, the footing will have to be stepped down to the glacial till contacted at Elevation 85.3 m. A Borehole No. 5, subexcavation of the very poor to poor quality of the bedrock may be required to reach the competent sound bedrock.

Spread and strip footings founded on the compact to very dense glacial till 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.

Alternatively, all footings may be designed to bear on the competent sound bedrock, that is free of weathered zones, loose material (soil and bedrock pieces) and soft seams and may be designed for a factored geotechnical resistance at ULS of 2000 kPa. The factored ULS value includes a geotechnical resistance factor of 0.5. The bearing pressure at SLS of the competent sound bedrock required to produce 25 mm settlement of the structure will be much larger than the recommended value for factored geotechnical resistance at ULS. Therefore, the factored geotechnical resistance at ULS will govern the design for footings founded on the competent sound bedrock.

Where a footing will be founded on the glacial till soil and partly on the competent sound bedrock, it is recommended that a gradual transition zone of 4H:1V be created for footings transitioning from bedrock to the glacial till and vice versa. The transition zone should be filled with Ontario Provincial Standard Specification (OPSS) Granular A or B Type II compacted to 100 percent standard Proctor maximum dry density (SPMDD). The SLS and factored ULS values for the glacial till soil should be used in the design of the footing.

Settlements of footing properly constructed and designed for the above recommended bearing pressure at SLS are expected to be within 19 mm differential settlement and 25 mm total settlement for footings founded on the glacial till and less than 10 mm of settlement for footings founded on the competent sound bedrock.

The ground floor of the proposed building addition may be designed and constructed as a slab-on-grade set on an engineered fill pad constructed on the native undisturbed compact to very dense glacial till or on the competent bedrock. The existing fill is not suitable to support the slab-on-grade and should be excavated and removed down to the compact to very dense glacial till or on the competent bedrock. The proposed addition to the arena should have a perimeter drainage system. While not present in Test Pit No. 1, should an existing perimeter drainage system of the existing arena building be encountered, it should be connected to the new perimeter drainage system of the proposed addition. Based on a review of the design elevation of Elevation 87.27 m for the ground floor of the arena addition and the groundwater level measurements, an underfloor drainage system is not required.

Excavations of the subsurface soils may be undertaken by conventional heavy equipment capable of removing debris within the fill and cobbles and boulders within the fill or glacial till.

The excavation for the proposed new building addition may be undertaken as open cut in accordance with the current Occupational Health and Safety Act (OHSA). Based on the definitions provided in OHSA, the subsurface soils are considered to be Type 3 soil and the excavation side slopes within Type 3 soil must be cut back at 1H:1 V from the bottom of the excavation.

It is anticipated that excavations will extend to the bedrock surface and may extend into the very poor to poor quality or weathered zones of the bedrock. The side walls of excavations that extend into the very poor to poor quality or weathered zone of the bedrock should be cut back at 1H:1V from the bottom of this zone. Excavation of the competent sound bedrock is anticipated to be at a minimum unless underground municipal services will be installed as part of the proposed arena addition. If excavations extend into the competent sound bedrock, considered to be very strong (R5), excavation side slopes may be cut back with near vertical sides subject to examination by a geotechnical engineer.

The upper level of the bedrock may be excavated using a hoe ram for removal of very small quantities of the bedrock; however, this process is expected to be extremely slow due to nature and strength of the bedrock. The excavation of the sound limestone bedrock to will likely require by line drilling and blasting method. Should blasting not be permitted, the excavation of the bedrock would have to be undertaken by line drilling and excavation. Specialized contractors bidding on this project should decide on their own the most preferred rock removal method; hoe ramming or line drilling and blasting.

It is anticipated that the majority of the material required for backfilling purposes in the interior and exterior of the proposed building addition would have to be imported and should preferably conform to the specifications provided in the attached geotechnical report.

Pavement structures for the existing 2 m wide gravel pathway located along the east side of the existing parking lot and the area along the east side of the proposed addition are provided in the attached geotechnical report.

The above and other related considerations are discussed in greater detail in the main body of the attached geotechnical report.

1. Introduction

EXP Services Inc. (EXP) is pleased to present the results of the geotechnical investigation completed for the proposed addition to Larry Robinson Arena (Metcalfe Community Centre) located at the municipal address of 2785 8th Line Road, in Ottawa (Metcalfe), Ontario (Figure 1). Terms and conditions of this assignment were outlined in EXP Services Inc. (EXP) proposal number: OTT-24000976-A0 dated January 24, 2024. This work was completed under EXP Standing Offer Agreement with the City of Ottawa RFSO- 24423-92500-S01 Category 5A and accepted by the City of Ottawa PO 0045107436 dated February 14, 2024.

The proposed addition will be located on the north side of the existing Larry Robinson Arena (Metcalfe Community Centre) and will measure approximately 9.5 m by 70.0 m for a total building footprint area of approximately 665 m^2. The proposed arena addition will be a slab-on-grade structure with no basement. It is our understanding that the design elevation of the ground floor will match that of the existing arena ground floor at Elevation 87.27 m.

As part of the proposed construction, the existing 2 m wide gravel pathway located along the east side of the existing parking lot will be paved. The area along the east side of the proposed addition will also be paved for use by service vehicles.

The geotechnical investigation was undertaken to:

a) Establish the subsurface soil and groundwater conditions at seven (7) test holes (six (6) boreholes and one (1) test pit) located at the site,

b) Classify the site for seismic site response in accordance with the requirements of the 2012 Ontario Building Code (as amended January 1,2022) and assess the potential for liquefaction of the subsurface soils during a seismic event,

c) Comment on grade-raise restrictions,

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

e) Provide comments regarding slab-on-grade construction and the requirement for perimeter and underfloor drainage systems,

f) Comment on excavation conditions and de-watering requirements during construction,

g) Discuss backfilling requirements and suitability of on-site soils for backfilling purposes,

h) Comment on the corrosion potential of subsurface soils buried concrete and steel structures/members,

i) Provide pavement structures for the gravel pathway and for the area along the east side of the proposed addition,

j) Comment on tree planting; and

k) Discuss the impact (if any) the proposed construction may have on neighboring properties.

The comments and recommendations given in this report are based on the assumption that the above-described design concepts 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 result 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.

2. Site Description

The proposed addition to the existing arena will be located on the north side of the existing arena building and will be located primarily in a paved area.

Based on the ground surface elevations of the boreholes and test pit located within the footprint of the proposed building addition, the existing ground surface is relatively flat with ground surface elevations of Elevation 87.09 m to Elevation 86.80 m.

3. Site Geology

3.1 Surficial Geology Map

The surficial geology was reviewed via the Google Earth applications published by the Ontario Ministry of Energy, Northern Development and Mines available le via www.mndm.gov.on.ca/en/mines-and-minerals/applications/ogsearth/surficial-geology and was last modified on May 23, 2017. The map indicates the Site is underlain by stone-poor, sandy silt to silty sand-textured glacial till on Paleozoic terrain. The surficial deposits are shown in Image 1 below.

🟩 Stone-poor, sandy silt to silty sand-textured glacial till on Paleozoic terrain

Image 1 – Surficial Geology

3.2 Bedrock Geology Map

The bedrock geology map (Ontario Geological Survey, Map MRD219 – Paleozoic geology of southern Ontario, published in 2007) indicates the site is underlain by dolostone, minor shale and sandstone of the Oxford formation. The bedrock geology is show in Image 2 below.

🟦 Oxford Formation: Lithology: Dolostone, minor shale and sandstone

Image 2 – Bedrock Geology

4. Procedure

4.1 Test Hole Fieldwork

The test hole fieldwork for this geotechnical investigation was undertaken on March 7 and 8, 2024 and includes six (6) boreholes and one (1) test pit. The six (6) boreholes were advanced to termination and auger refusal depths ranging from 1.6 m to 7.6 m below existing grade. The test pit was excavated to a bucket refusal depth of 1.5 m below existing grade. The test hole fieldwork was supervised on a full-time basis by a representative from EXP.

The locations and geodetic elevations of the boreholes and test pit were established on site by EXP and are shown in Figure 2. It is noted that the selection of the locations of the boreholes and test pit in some areas were restricted by the presence of overhead electrical (hydro) power lines and underground services.

Prior to the start of drilling the boreholes and the excavation of the test pit, the locations of the boreholes and test pit were cleared of any public and private underground services.

The boreholes were drilled using a CME-55 track-mounted drill rig equipped with continuous flight hollow-stem augers and rock coring equipment. The test pit was excavated using a rubber-tired backhoe.

Standard penetration tests (SPTs) were performed in all the boreholes on a continuous basis and soil samples were retrieved form the split spoon sampler. The presence of the bedrock was proven in three (3) boreholes by conventional rock coring techniques using the NQ size core barrel. A field record of wash water return, colour of wash water and any sudden drops of the core barrel were kept during rock coring operations.

A nineteen (19) mm diameter slotted standpipe was installed in three (3) boreholes for long-term monitoring of the groundwater levels. The slotted standpipe was installed in accordance with EXP standard practice, and the installation configuration is documented on the respective borehole log. The boreholes were backfilled upon completion of drilling and the installation of the standpipes.

The test pit was excavated to a bucket refusal depth of 1.5 m. Samples of the soils exposed in the test pit were collected at selected depth intervals. The test pit was backfilled upon completion of excavating operations and the backfill nominally packed in place using the backhoe bucket. Photographs of the test pits are shown in Appendix A.

All soil samples were logged and placed in labeled plastic bags. The recovered rock cores were logged and stored in core boxes and identified.

4.2 Laboratory Testing Program

On completion of the borehole and test pit fieldwork, the soil samples and rock cores were transported to the EXP laboratory in Ottawa where they were examined by a senior geotechnical engineer and logs of boreholes and test pit prepared. The main constituents of the soils are classified in accordance with the Unified Soil Classification System (USCS) using the soil group name and symbol and by the modified Burmister soil classification system for the classification of the minor constituents of the soil using adjectives and modifiers such as trace and some (2006 Fourth Edition of the Canadian Foundation Engineering Manual (CFEM)). The bedrock cores were logged in accordance with the Section 3.2 of the 2006 CFEM. Photographs of the bedrock cores were also taken.

A summary of the soil and bedrock laboratory testing program is shown in Table I.

Table I: Summary of Laboratory Testing Program

Type of Test	Number of Tests Completed
Soil Samples	
Moisture Content Determination	23
Grain Size Analysis	4
Atterberg Limits	1
Corrosion Analysis (pH, sulphate, chloride and resistivity)	1
Bedrock Core Sections	
Unconfined Compressive Strength Test	6
Unit Weight Determination	6
Corrosion Analysis (pH, sulphate, chloride and resistivity)	1

4.3 Seismic Shear Wave Velocity Survey

A seismic shear wave velocity survey consisting of one (1) survey line was conducted at the site on February 2,2024 by Geophysics GPR International Inc. (GPR). The purpose of the seismic shear wave survey was to determine the shear wave velocity of the site and based on the shear wave velocity provide the site classification for seismic site response. The seismic shear wave velocity survey report prepared by GPR is shown in Appendix B.

5. Subsurface Conditions and Groundwater Levels

A detailed description of the subsurface conditions and groundwater levels from the boreholes and test pit are given on the attached Borehole and Test Pit Logs, Figures 3 to 9 inclusive. The borehole and test pit 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 locations where sampling was conducted. The passage of time also may result in changes in the conditions interpreted to exist at the locations where sampling was conducted.

The boreholes were drilled and test pit excavated to provide representation of subsurface conditions as part of a geotechnical exploration program and are not intended to provide evidence of potential environmental conditions.

It should be noted that the soil boundaries indicated on the borehole and test pit logs are inferred from continuous and non-continuous sampling and observations during drilling and excavating operations. 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 and test pit logs form an integral part of this report and should be read in conjunction with this report.

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

5.1 Pavement Structure

Borehole Nos. 2 to 6 are located in a paved area where the pavement structure consists of 40 mm to 100 mm thick asphaltic concrete underlain by 225 mm to 300 mm thick granular fill base. In Borehole No. 2, the granular fill base is 1125 mm thick and extends to a 1.2 m depth (Elevation 85.6 m). The granular fill base consists of a silty sand and crushed gravel. Based on SPT N-values of 6 to 21, the granular fill base is in a loose to compact state. The moisture content of the granular fill base is 2 percent to 5 percent.

5.2 Wood Chip Mulch and Topsoil

The ground surface at Test Pit No. 1 is covered with a 100 mm thick wood chip mulch underlain by a 200 mm thick topsoil layer.

5.3 Fill

A granular fill extending to a 1.2 m depth (Elevation 85.9 m) was surficially encountered in Borehole No. 1. Beneath the pavement structure in Borehole Nos. 2 to 5, the asphaltic concrete in Borehole No. 6 and the wood chip mulch and topsoil in Test Pit No. 1, a fill was contacted extending to depths of 1.0 m to 1.5 m (Elevation 86.0 m to Elevation 85.3 m). The fill ranges from a silty sand and gravel to silty sand to clayey silt and silty clay. In Borehole No. 6, the silty sand fill contains organic black silty clay and possible cobbles and boulders. In Test Pit No. 1, the fill contains asphalt and concrete pieces. Based on SPT-N values of 4 to 24, the fill is in a loose to compact state. The moisture content of the fill ranges from 5 percent to 32 percent.

The results from the grain-size analysis conducted on two (2) samples of the fill are summarized in Table II and the grain size distribution curves are shown in Figures 10 and 11.

Table II: Summary of Results from Grain-Size Analysis – Fill Samples

Borehole No. (BH) – Sample No. (SS)	**Depth (m)**	**Grain-Size Analysis (%)**				
		GR	**SA**	**Silt**	**Clay**	**Soil Classification**
BH 1 – SS2	0.6-1.2	17	40	30	13	Silty Sand (SM): Some Clay and Gravel
BH 6 – SS2	0.6-1.2	9	50	35	6	Silty Sand (SM): Trace Gravel and Clay

GR= Gravel, SA= Sand

Based on a review of the results from the grain size analysis, the fill may be classified as a silty sand (SM) with trace to some gravel and clay.

5.4 Buried Organic Clayey Silt Layer

A 25 mm thick buried organic clayey silt layer was contacted beneath the fill in Borehole Nos. 1 and 3.

5.5 Glacial Till

With the exception of Borehole No. 5, the fill and buried organic clayey silt layer are underlain by glacial till. The glacial till extends to 2.0 m and 3.2 m depths (Elevation 85.1 m to Elevation 83.6 m) in Borehole Nos. 1 and 3. The glacial till consists of varying percentages of gravel, sand, silt and clay and contains possible cobbles and boulders. Based on the SPT N-values of 13 to 94, the cohesionless portion of the glacial till is in a compact to very dense state and the cohesive portion of the glacial till has a very stiff to hard consistency. The natural moisture content of the glacial till ranges from 7 percent to 12 percent and locally in Borehole No. 1 to 31 percent.

The results from the grain-size analysis and Atterberg limit determination conducted on two (2) samples of the glacial till are summarized in Table III. The grain-size distribution curves are shown in Figures 12 and 13.

Table III: Summary of Results from Grain-Size Analysis and Atterberg Limit Determination - Glacial Till Samples

Borehole No. (BH) - Sample No. (SS)	**Depth (m)**		**Grain-Size Analysis (%) and Moisture Content (%)**				**Atterberg Limits (%)**			
		GR	**SA**	**Silt**	**Clay**	**MC**	**LL**	**PL**	**PI**	**Soil Classification**
BH 3 – SS4	1.8-2.4	5	28	47	20	9	24	12	12	Sandy Silty Clay (CL) of Low Plasticity: Trace Gravel
BH 4 – SS3	1.2-1.8	26	38	32	4	8	-	-	-	Gravelly Silty Sand (SM): Trace Clay

GR= Gravel, SA= Sand, Fines = Silt and Clay, MC = Moisture Content, LL = Liquid Limit,
PL Plastic Limit, PI= Plasticity Index, LI = Liquidity Index

Based on a review of the results from the grain size analysis and Atterberg limit determination, the glacial till may be classified as a gravelly silty sand (SM) with trace clay to a sandy silty clay (CL) of low plasticity with trace gravel. The glacial till contains possible cobbles and boulders.

5.6 Inferred and Actual Bedrock

Auger refusal was met in Borehole Nos. 2,4 and 6 at 1.6 m to 2.4 m depths (Elevation 85.3 m to Elevation 84.4 m) on inferred cobbles, boulders or bedrock. Actual bedrock was encountered in Borehole Nos. 1, 3 and 5 and in Test Pit No. 1 at 1.0 m to 3.2 m depths (Elevation 85.9 m to Elevation 83.6 m). The bedrock consists of shale, sandstone and dolostone of the Oxford formation. A summary of the bedrock depth (elevation) is shown in Table IV.

Table IV: Summary of Bedrock Depths (Elevations)

Borehole (BH) and Test Pit (TP) No.	Ground Surface Elevation (m)	Bedrock Depth (Elevation), m
BH 1	87.09	2.0 (85.1)
BH 3	86.77	3.2 (83.6)
BH 5	86.91	1.0 (85.9)
TP 1	87.11	1.5 (85.6)

A review of the borehole logs indicates that the total core recovery (TCR) is 90 percent to 100 percent and the rock quality designation (RQD) is 0 percent to 76 percent. Based on the RQD values the bedrock has a very poor to quality. In Borehole No. 5, the upper 3.3 m of the bedrock is of a very poor to poor quality, becoming fair to good quality below a 4.3m depth. Photographs of the bedrock cores are shown in Figures 14 to 16.

Unit weight determination and unconfined compressive strength tests were conducted on six (6) rock core sections. The test results are summarized in Table V.

Table V: Summary of Unit Weight and Unconfined Compressive Strength Test Results – Bedrock Cores

Borehole #	Depth (m)	Unit Weight (kN/m^3)	Unconfined Compressive Strength (MPa)
BH 1 – Run 1	2.4 – 2.6	26.6	184.4
BH 1 – Run 2	4.2 – 4.3	27.3	145.9
BH 3 – Run 1	3.5 – 3.6	27.3	151.5
BH 3 – Run 3	7.2 – 7.4	29.1	235.7
BH 5 – Run 3	3.5 – 3.6	26.8	147.0
BH 5 – Run 5	5.4 – 5.5	28.7	198.4

A review of the test results in Table V indicates the strength of the bedrock may be classified as very strong (R5) in accordance with the 2006 CFEM.

5.7 Groundwater Level Measurements

A summary of the groundwater level measurements in the boreholes equipped with standpipes from April 5,2024 and from the test pit is shown in Table VI.

Table VI: Summary of Groundwater Level Measurements

Borehole No. (BH)	Ground Surface Elevation (m)	Elapsed Time in Days from Date of Installation	Depth Below Ground Surface (Elevation), m	
BH -2	86.80	29 days	1.0	85.8
BH- 4	86.96	29 days	1.4	85.6
BH-6	86.91	29 days	1.0	85.9
TP-1	87.11	March 7,2024 Upon Completion of Excavation	1.5	85.6

The groundwater level ranges from 1.0 m to 1.5 m depth below the existing ground surface (Elevation 85.9 m to Elevation 85.6 m).

The groundwater levels were determined in the boreholes and test pit at the time and under the condition stated in the report. Note that fluctuations in the level of groundwater may occur due to a 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.

6. Existing Footing Detail

Test Pit No. 1 located along the exterior west wall of the existing arena building and south of the northwest corner of the building indicates the following detail regarding the exposed section of the existing foundation wall and footing. A sketch showing the detail of the exposed footing is shown in Figure 17. Photographs of the test pit are shown in Appendix A. The foundation wall of the existing arena is of block wall construction. Details of the exposed section of the foundation wall and footing observed in the test pit are as follows:

- The block wall foundation is founded on a 600 mm thick concrete footing protruding 200 mm from exterior face of the foundation wall. The footing is set on the surface of the bedrock contacted at a depth of 1.5 m below existing grade (Elevation 85.6 m),
- A perimeter drainage system was not present in the test pit,
- Damp proofing and drainage board were not present along the exterior side of the foundation wall; and
- Water infiltration was noted in the test pit at a depth of 1.5 m (Elevation 85.6 m).

7. Site Classification for Seismic Site Response and Liquefaction Potential of Soils

7.1 Site Classification for Seismic Site Response

Based on a review of the borehole information, the subsurface conditions for the proposed addition to Larry Robinson Arena consist of fill underlain by compact to very dense/very stiff to hard glacial till followed by shallow bedrock at 1.0 m to 3.2 m depths (Elevation 85.9 m to Elevation 83.6 m). As discussed in Section 9 of this report, the proposed building addition may be supported by footings founded on the glacial till contacted at 1.0 m to 1.5 m depths (Elevation 86.0 m to Elevation 85.3 m) and/or on the competent sound bedrock that is free of weathered zones, loose material (soil and bedrock pieces) and soft seams.

The results of the seismic shear wave survey conducted by GPR is shown in Appendix B. The results of the survey and comparison of the results with the 2012 Ontario Building Code (as amended January 1, 2022), indicates that for footings founded less than 3.0 m from the bedrock surface, the site class is Class B. If the footings will be founded 1.6 m or less from the bedrock surface, the site class is Class A.

7.2 Liquefaction Potential of Soils

The subsurface soils are not susceptible to liquefaction during a seismic event.

8. Grade Raise Restrictions

The boreholes indicate that the subsurface soils consist of fill underlain by compact to very dense/very stiff to hard glacial till followed by bedrock. Since the boreholes indicate that compressible clays do not exist at the site, there is no restriction for grade raise from a geotechnical perspective.

9. Foundation Considerations

A review of the test hole information indicates that the proposed addition to the arena may be supported by strip and spread footings founded on the compact to very dense glacial till or on the sound bedrock that is free of weathered zones, loose material (soil and bedrock pieces) and soft seams. The existing fill is not considered suitable to support footings and the slab-on-grade ground floor of the proposed arena addition.

It is our understanding that the design elevation of the ground floor of the proposed arena addition will match that of the existing arena ground floor at Elevation 87.27 m. The information from Test Pit No. 1 indicates the underside of the existing footing is at Elevation 85.6 m which is 1.5 m below existing grade and 1.7 m below the ground floor. Based on the assumption that the footings for the arena addition will be founded at a similar elevation as the existing exposed footing in Test Pit No. 1, the footings will be founded on the compact to very dense glacial till at Borehole Nos. 1, 2 and 4 and on the bedrock at Borehole No. 5. At Borehole No. 2, the footing will have to be stepped down to the glacial till contacted at Elevation 85.3 m. A Borehole No. 5, subexcavation of the very poor to poor quality of the bedrock may be required to reach the competent sound bedrock.

Spread and strip footings founded on the compact to very dense glacial till 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.

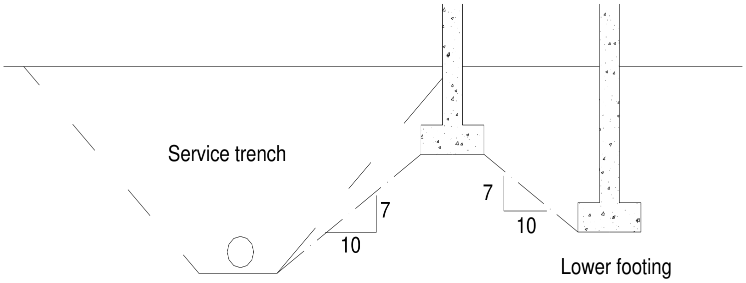
Alternatively, all footings may be designed to bear on the competent sound bedrock, that is free of weathered zones, loose material (soil and bedrock pieces) and soft seams and may be designed for a factored geotechnical resistance at ULS of 2000 kPa. The factored ULS value includes a geotechnical resistance factor of 0.5. The bearing pressure at SLS of the competent sound bedrock required to produce 25 mm settlement of the structure will be much larger than the recommended value for factored geotechnical resistance at ULS. Therefore, the factored geotechnical resistance at ULS will govern the design for footings founded on the competent sound bedrock.

Where a footing will be founded on the glacial till soil and partly on the competent sound bedrock, it is recommended that a gradual transition zone of 4H:1V be created for footings transitioning from bedrock to the glacial till and vice versa. The transition zone should be filled with Ontario Provincial Standard Specification (OPSS) Granular A or B Type II compacted to 100 percent standard Proctor maximum dry density (SPMDD). The SLS and factored ULS values for the glacial till soil should be used in the design of the footing.

The footings for the new arena addition located immediately adjacent to the footings of the existing arena building should be founded at the same level as the existing footings to eliminate the need for underpinning. This is subject to confirmation that the founding material at the same level as the existing footings is capable of supporting the design SLS and factored ULS values for the new footings provided above. The footings may be stepped up and founded in the glacial till or competent sound bedrock in areas away from the existing building.

Settlements of footing properly constructed and designed for the above recommended bearing pressure at SLS are expected to be within 19 mm differential settlement and 25 mm total settlement for footings founded on the glacial till and less than 10 mm of settlement for footings founded on the competent sound bedrock.

Footings founded in the glacial till at different elevations should be located such that the higher footings are set below a line drawn up at 10 horizontal to 7 vertical (10H:7V) from the near edge of the lower footing, as shown below. This concept should also be applied to service excavation, etc. to ensure that undermining is not a problem.



FOOTINGS NEAR SERVICE TRENCHES OR AT DIFFERENT ELEVATIONS

Footings at different elevations in competent sound bedrock should be located such that the higher footing is located 6V:1H from the limit of the footing excavation in the sound bedrock.

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

The bedrock subgrade for all footings should be thoroughly examined by a geotechnical engineer to ensure that the bedrock is competent and capable of supporting the factored ULS value. Where weathered zones, loose material (soil and bedrock pieces) and soft seams are encountered at the founding surface of the exposed bedrock, sub-excavation may be undertaken to the underlying more competent bedrock with the loose material and soft seams excavated and removed. The footing may be stepped down to the sound bedrock or any sub-excavated areas to sound bedrock may be backfilled with 25 MPa concrete to the proposed underside of footing.

It is noted that the exposed glacial till subgrade surface is susceptible to disturbance due to movement of workers and construction traffic and the prevailing weather conditions during construction. To prevent disturbance to the soil subgrade, the approved footing beds should be covered or protected with a 50 mm thick concrete mud slab within the same day of approval.

The proposed arena addition is assumed to be a heated structure. Therefore, for footings founded on the glacial till, a minimum of 1.5 m of earth cover should be provided to the exterior footings to protect the footings from frost action. Alternatively, a combination of earth cover and rigid insulation may also be used to protect the footings.

For footings founded on the competent sound bedrock that is free of weathered zones, loose material (soil or bedrock pieces) and soft seams, frost protection for the footings is not 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 and away from the test pit, when foundation construction is underway. The interpretation between boreholes and away from the test pit 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.

10. Floor Slab and Drainage Requirements

The ground floor of the proposed building addition may be designed and constructed as a slab-on-grade set on an engineered fill pad constructed on the native undisturbed compact to very dense glacial till or on the competent bedrock. The existing fill is not suitable to support the slab-on-grade and should be excavated and removed down to the compact to very dense glacial till or competent bedrock.

The exposed glacial till subgrade should be examined by a geotechnical engineer and any loose/soft areas should be excavated, removed and replaced with Ontario Provincial Standard Specification (OPSS) Granular B Type II material compacted to 95 percent standard Proctor maximum dry density (SPMDD).

The exposed bedrock subgrade surface should be examined by a geotechnical engineer and any weathered zones of the bedrock, loose material (soil and bedrock pieces) and soft seams should be removed from the exposed bedrock subgrade within the floor slab area.

The slab-on-grade for the proposed building may be set on a bed of well compacted 19 mm sized clear stone at least 200 mm thick placed on a minimum 300 mm thick engineered fill pad placed on the approved glacial till or bedrock subgrade. The engineered fill pad should consist of Ontario Provincial Standard Specification (OPSS) Granular B Type II material compacted to a minimum of 98 percent standard Proctor maximum dry density (SPMDD). The clear stone would minimize the capillary rise of moisture from the sub-soil to the floor slab. As an alternative for the clear stone layer only, the floor slab may be cast on a 200 mm thick bed of Ontario Provincial Standard Specification (OPSS) Granular A compacted to 98 percent SPMDD and placed on the engineered fill pad and overlain by a vapour barrier. Adequate saw cuts should be provided in the floor slabs to control cracking.

The proposed addition to the arena should have a perimeter drainage system. While not present in Test Pit No. 1, should an existing perimeter drainage system of the existing arena building be encountered, it should be connected to the new perimeter drainage system of the proposed addition.

Based on a review of the design elevation of Elevation 87.27 m for the ground floor of the arena addition and the groundwater level measurements, an underfloor drainage system is not required.

The finished floor slab should be set at least 150 mm higher than the finished exterior grade.

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

11. Excavations and De-Watering Requirements

11.1 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.

11.2 Excavations

Excavations for the footings of the proposed arena addition are expected to extend through the fill and into the glacial till and/or bedrock. Based on the groundwater level in the boreholes, the excavation is anticipated to be above or near the groundwater level.

11.2.1 Soil Excavation

Excavations of the subsurface soils may be undertaken by conventional heavy equipment capable of removing debris within the fill and cobbles and boulders within the fill and glacial till.

The excavation for the proposed new building addition may be undertaken as open cut in accordance with the current Occupational Health and Safety Act (OHSA). Based on the definitions provided in OHSA, the subsurface soils are considered to be Type 3 soil and the excavation side slopes within Type 3 soil must be cut back at 1H:1 V from the bottom of the excavation.

11.2.2 Rock Excavation

It is anticipated that excavations will extend to the bedrock surface and may extend into the very poor to poor quality or weathered zones of the bedrock. The side walls of excavations that extend into the very poor to poor quality or weathered zone of the bedrock should be cut back at 1H:1V from the bottom of this zone. Excavation of the competent sound bedrock is anticipated to be at a minimum unless underground municipal services will be installed as part of the proposed arena addition. If excavations extend into the competent sound bedrock, considered to be very strong (R5), excavation side slopes may be cut back with near vertical sides subject to examination by a geotechnical engineer.

The upper level of the bedrock may be excavated using a hoe ram for removal of very small quantities of the bedrock; however, this process is expected to be extremely slow due to nature and strength of the bedrock. The excavation of the sound limestone bedrock to will likely require by line drilling and blasting method. Should blasting not be permitted, the excavation of the bedrock would have to be undertaken by line drilling and excavation. Specialized contractors bidding on this project should decide on their own the most preferred rock removal method; hoe ramming or line drilling and blasting.

11.2.3 General Comments

The vibration limits for blasting should be monitored and in accordance with City of Ottawa Special Provisions (SP No. 1201).

It is recommended that a pre-construction condition survey of adjacent building(s) and infrastructure be undertaken prior to any earth (soil) and rock excavation work as well as vibration monitoring during excavation, blasting and construction operations. Prior to the commencement of blasting, a detailed blast methodology should be submitted by the Contractor.

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.

11.3 De-Watering Requirements

It should be possible to collect water entering the excavations at low points and to remove it by conventional pumping techniques. In areas of high infiltration such as in areas where more permeable soil layers may exist, a higher seepage rate should be anticipated. Therefore, high-capacity pumps may be required to keep the excavation dry.

For construction dewatering, an Environmental Activity and Sector Registry (EASR) approval may be obtained for water takings greater than 50 m^3 and less than 400 m^3. If more than 400 m^3 per day of groundwater are generated per day for dewatering purposes, then a Permit to Take Water (PTTW) must be obtained from the MECP. A hydrogeological investigation of the proposed excavation would be required to support a PTTW application.

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.

12. Backfilling Requirements and Suitability of On-Site Soils for Backfilling Purposes

The on-site soils to be excavated are mulch, topsoil, fill, glacial till and possible bedrock. From a geotechnical perspective, the on-site materials are not considered suitable for reuse as backfill material within the proposed new building addition or against foundation walls of the new addition. Select portions of the existing granular fill may be used as backfill along the exterior sides of the proposed arena addition, subject to additional examination and testing at time of construction.

It is anticipated that the majority of the material required for backfilling purposes in the interior and exterior of the proposed building addition would have to be imported and should preferably conform to the following specifications:

- Engineered fill under the floor slab of the proposed building addition - OPSS 1010 Granular B Type II placed in 300 mm thick lifts and each lift compacted to 98 percent SPMDD; and
- Backfill material for footing trenches and against foundation walls located outside the proposed building addition – OPSS 1010 Granular B Type II placed in 300 mm thick lifts and each lift compacted to 95 percent SPMDD.

13. Corrosion Potential

Chemical tests limited to pH, sulphate, chloride and resistivity were undertaken on one (1) soil sample and one (1) bedrock core section. A summary of the results is shown in Table VII. The laboratory certificate of analysis report prepared by AGAT is shown in Appendix C.

Table VII: Corrosion Test Results on Soil Sample and Section of Bedrock Core

Borehole (BH) – Sample No.	Depth (m)	Soil/Bedrock	pH	Sulphate (%)	Chloride (%)	Resistivity (ohm-cm)
BH 3- SS4	1.8- 2.4	Glacial Till	9.45	0.0046	0.0295	847
BH 5 – Run 1	1.2-1.3	Bedrock	8.81	0.0050	0.0055	3970

The results indicate the tested glacial till sample and the bedrock core section have a negligible sulphate attack on subsurface concrete. The concrete should be designed in accordance with CSA A.23.1-19.

The results of the resistivity tests indicate that glacial till is corrosive to moderately corrosive and the bedrock is mildly corrosive to bare steel as per the National Association of Corrosion Engineers (NACE). Appropriate measures should be taken to protect the buried bare steel from corrosion.

14. Pavement Structures

As part of the proposed construction, the existing 2 m wide gravel pathway located along the east side of the existing parking lot will be paved. The area along the east side of the proposed addition will also be paved for use by service vehicles. The proposed locations to be paved are shown on the Test Hole Location Plan, Figure 2.

The pavement structures for the gravel pathway to be paved and for the area along the east side of the proposed addition (for light and heavy-duty traffic) are presented in Table VIII.

Table VIII: Recommended Pavement Structure Thicknesses

Pavement Layer	Compaction Requirements	Computed Pavement Structures		
		Light Duty Traffic (Pedestrian Pathway)	Light Duty Traffic (Cars Only)	Heavy Duty Traffic (Service Vehicles, Fire and Garbage Trucks)
Asphaltic Concrete (PG 58-34)	92-97% MRD	50 mm HL3F	65 mm SP12.5 Cat. B	40 mm SP12.5 Cat. B 50 mm SP 19 Cat. B
OPSS 1010 Granular A Base (crushed limestone)	100% SPMDD	300 mm	150 mm	150 mm
OPSS 1010 Granular B Type II Sub-base	100% SPMDD	-	300 mm	450 mm

Notes:

1. SPMDD denotes standard Proctor maximum dry density, ASTM, D-698-12e2.
2. MRD denotes Maximum Relative Density, ASTM D2041.

The upper 300 mm of the subgrade fill must be compacted to 98 percent SPMDD.

Additional comments regarding the construction of the pavement for the pathway and area along the east side of the proposed addition are as follows:

- As part of the subgrade preparation, the proposed areas to be paved should be stripped of topsoil and other obviously unsuitable material. 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 finished pavement surface should be free of depressions and should be sloped (preferably at a minimum cross fall of 2 percent) to provide effective surface drainage towards catch basins. Surface water should not be allowed to pond adjacent to the outside edges of paved areas.
- The granular materials used for pavement construction should conform to Ontario Provincial Standard Specifications (OPSS 1010) for Granular A and Granular B Type II and should be compacted to 100 percent of the SPMDD.

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

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15. Tree Planting Restrictions

Since sensitive marine clays were not encountered at the site of the proposed building addition, there are no tree planting restrictions from a geotechnical perspective. However, a landscape architect should be consulted for the selection of suitable trees for this project.

16. Impact on Neighbouring Properties

Based on the proposed construction and subsurface conditions, it is anticipated that there will be no negative impact on neighbouring properties as a result of the construction of the proposed arena addition. However, a pre-construction condition survey and vibration monitoring of existing buildings and infrastructure located within the zone of construction are recommended as part of the proposed work.

17. General Comments

The comments given in this report are intended only for the guidance of design engineers. The number of boreholes and test pits 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 the 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 and test pit 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. Should specific information be required, including for example, the presence of pollutants, contaminants or other hazards in the soil, additional testing may be required.

We trust that the information contained in this report will be satisfactory for your purposes. Should you have any questions, please do not hesitate to contact this office.

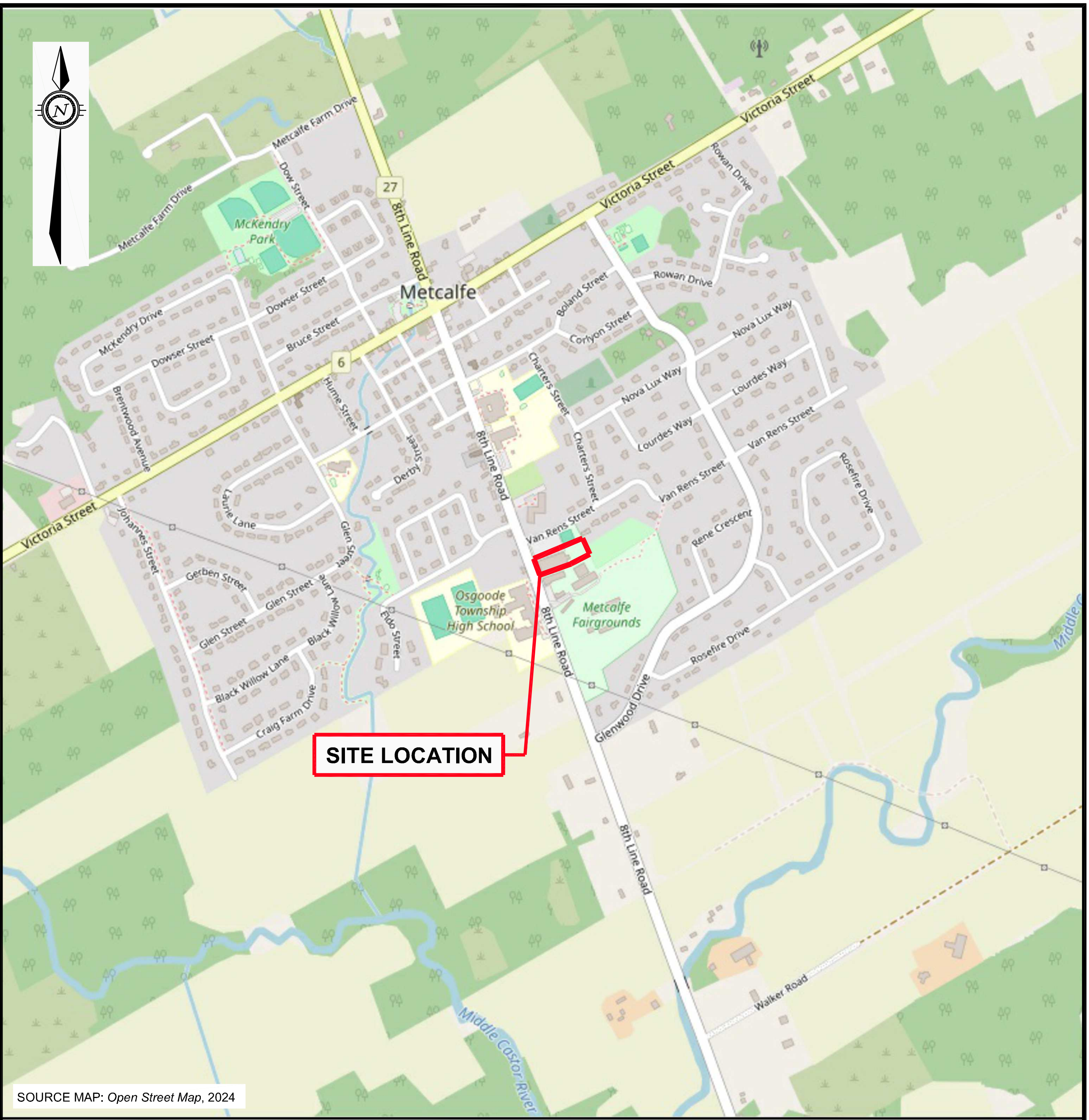
Sincerely

LICENSED PROFESSIONAL ENGINEER
ISMAIL TAKI
2023-05-31
PROVINCE OF ONTARIO

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

Susan Potyondy, P.Eng.
Senior Geotechnical Engineer
Earth and Environment

Figures



ORIGINAL SHEET SIZE = 8.5" x 11"

0 150m 300m 600m

HORIZONTAL 1:15,000

EXP Services Inc. www.exp.com
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2650 Queensview Drive, Suite 100
Ottawa, ON K2B 8H6, Canada

DATE APRIL 2024

DESIGN MZ / SP

CHECKED IT

DRAWN BY AS

CLIENT:

LARRY ROBINSON ARENA
GEOTECHNICAL INVESTIGATION

TITLE:

SITE LOCATION PLAN
2785 8TH LINE ROAD, OTTAWA (METCALFE), ONTARIO

project no. OTT-24000976-A0

scale 1:15,000

FIG 1

Filename: E:\OTT\OTT-24000976-A0\60 Execution\65 Drawings\OTT-24000976-A0_Geo.dwg
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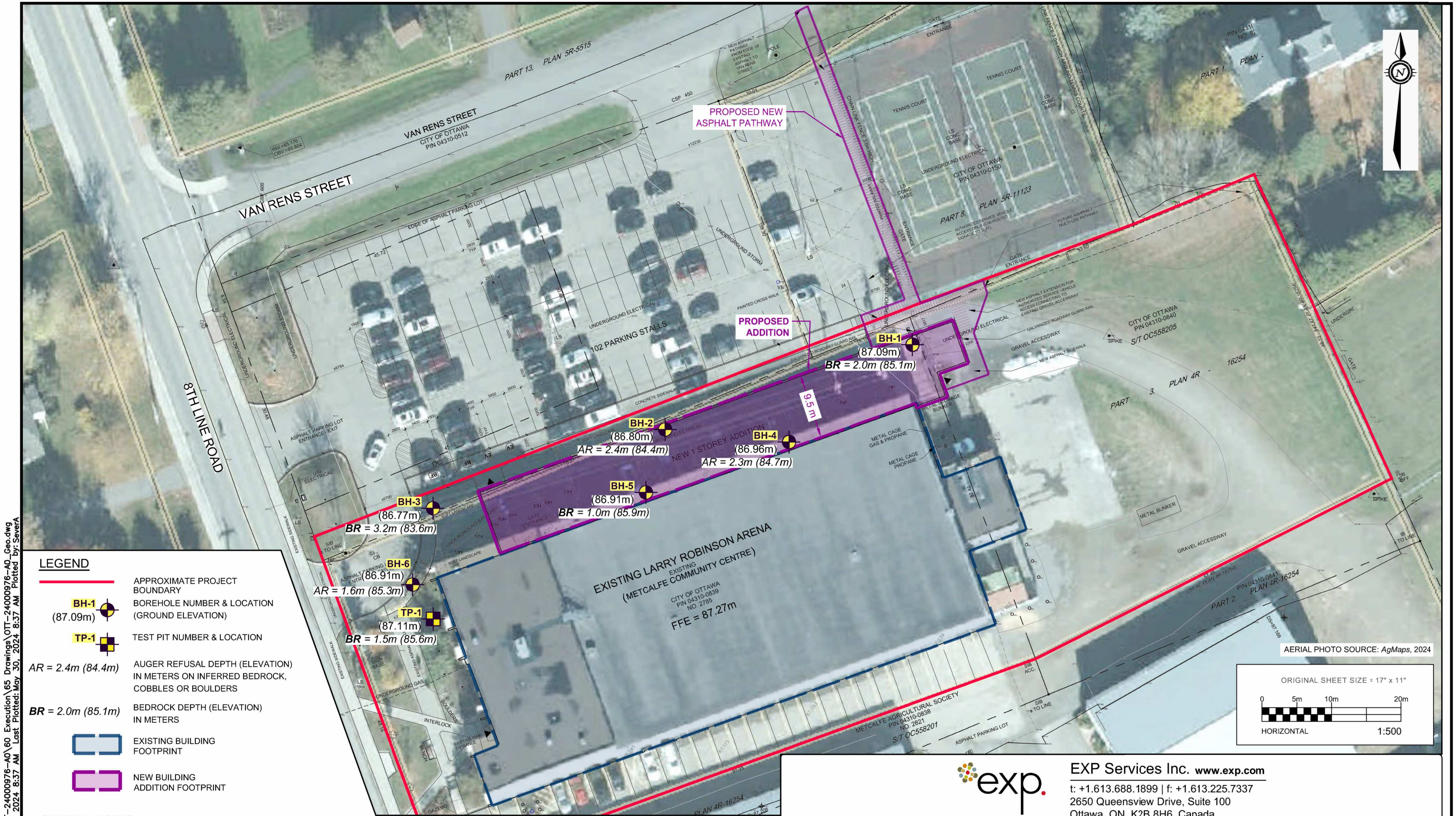

LEGEND

🟥	APPROXIMATE PROJECT BOUNDARY
BH-1 (87.09m)	BOREHOLE NUMBER & LOCATION (GROUND ELEVATION)
TP-1	TEST PIT NUMBER & LOCATION
AR = 2.4m (84.4m)	AUGER REFUSAL DEPTH (ELEVATION) IN METERS ON INFERRED BEDROCK, COBBLES OR BOULDERS
***BR** = 2.0m (85.1m)*	BEDROCK DEPTH (ELEVATION) IN METERS
▭	EXISTING BUILDING FOOTPRINT
▭	NEW BUILDING ADDITION FOOTPRINT

GENERAL NOTES:

1. THE BOUNDARIES, ROCK, AND SOIL TYPES HAVE BEEN ESTABLISHED ONLY AT TEST HOLE LOCATIONS. BETWEEN TEST HOLES THEY ARE ASSUMED AND MAY BE SUBJECT TO CONSIDERABLE ERROR.
2. ROCK AND SOIL SAMPLES WILL BE RETAINED IN STORAGE FOR THREE MONTHS AND THEN DESTROYED UNLESS THE CLIENT ADVISES THAT AN EXTENDED TIME PERIOD IS REQUIRED.
3. ASPHALT AND TOPSOIL QUANTITIES SHOULD NOT BE ESTABLISHED FROM THE INFORMATION PROVIDED AT THE TEST HOLE LOCATIONS.
4. TEST HOLE 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 SITE PLAN PRODUCED BY *CITY OF OTTAWA* AND *N45 ARCHITECTURE INC.*, PROJECT NO.: CR0xxx, SHEET NO.: A-001, ISSUE DATE: 2024-01-19

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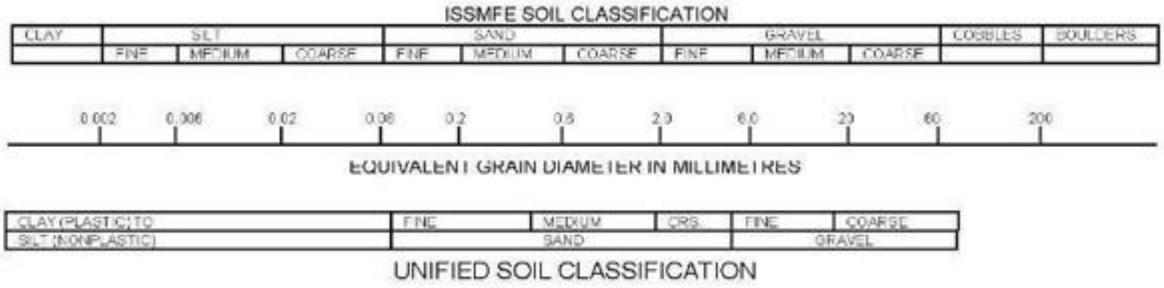
Ottawa, ON K2B 8H6, Canada

DATE MAY 2024	CLIENT:	LARRY ROBINSON ARENA GEOTECHNICAL INVESTIGATION	project no. OTT-24000976-A0
DESIGN MZ / SP	CHECKED IT	TEST HOLE LOCATION PLAN	scale 1:500
DRAWN BY AS	TITLE:	2785 8TH LINE ROAD, OTTAWA (METCALFE), ONTARIO	FIG 2

Filename: E:\OTT\OTT-24000976-A0\60 Execution\65 Drawings\OTT-24000976-A0_Geo.dwg
Last Saved: May 30, 2024 8:37 AM Last Plotted: May 30, 2024 8:37 AM Plotted by: SeverA

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-01

Project No: OTT-24000976-A0

Project: Proposed Addition to Larry Robinson Arena

Location: 2785 Eighth Line Road, Ottawa (Metcalfe), Ontario

Figure No. 3

Page. 1 of 1

Date Drilled: 'March 8, 2024

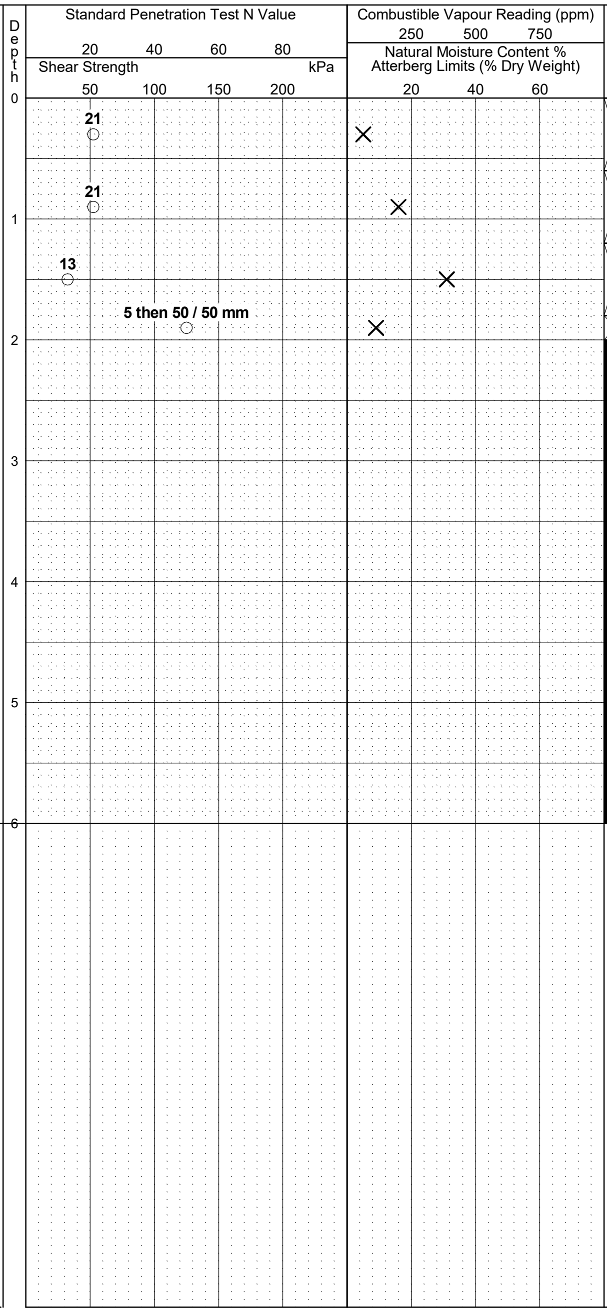
Drill Type: CME-55LC Rubber Track Mounted Drill Rig

Datum: Geodetic Elevation

Logged by: M.Z. Checked by: I.T.

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		

SOIL DESCRIPTION	Geodetic Elevation m	Depth
	87.09	0
GRANULAR FILL ~ 1200 mm thick Silty sand, some crushed gravel and clay, concrete piece, brown, moist, (compact)	85.9	
ORGANIC CLAYEY SILT ~ 25 mm thick	85.8	
GLACIAL TILL Clayey silt, some sand, trace gravel, possible cobbles and boulders, brown, damp to moist (compact)	85.1	
SANDSTONE BEDROCK	84.9	
DOLOSTONE BEDROCK With shale partings, grey, (fair quality)	82.7	
SANDSTONE BEDROCK	82.5	
DOLOSTONE BEDROCK With shale partings, grey, (poor quality)	81.1	6
Borehole Terminated at 6.0 m Depth		



SAMPLES	Natural Unit Wt. kN/m^3
SS1	
SS2	
SS3	
SS4	
Run 1	26.6
Run 2	27.3
Run 3	

NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. Borehole was backfilled upon completion.
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-24000976-A0

WATER LEVEL RECORDS

Date	Water Level (m)	Hole Open To (m)

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %
1	2 - 3.1	100	72
2	3.1 - 4.6	97	72
3	4.6 - 6	96	27

Log of Borehole BH-02

Project No: OTT-24000976-A0

Project: Proposed Addition to Larry Robinson Arena

Location: 2785 Eighth Line Road, Ottawa (Metcalfe), Ontario

Figure No. 4

Page. 1 of 1

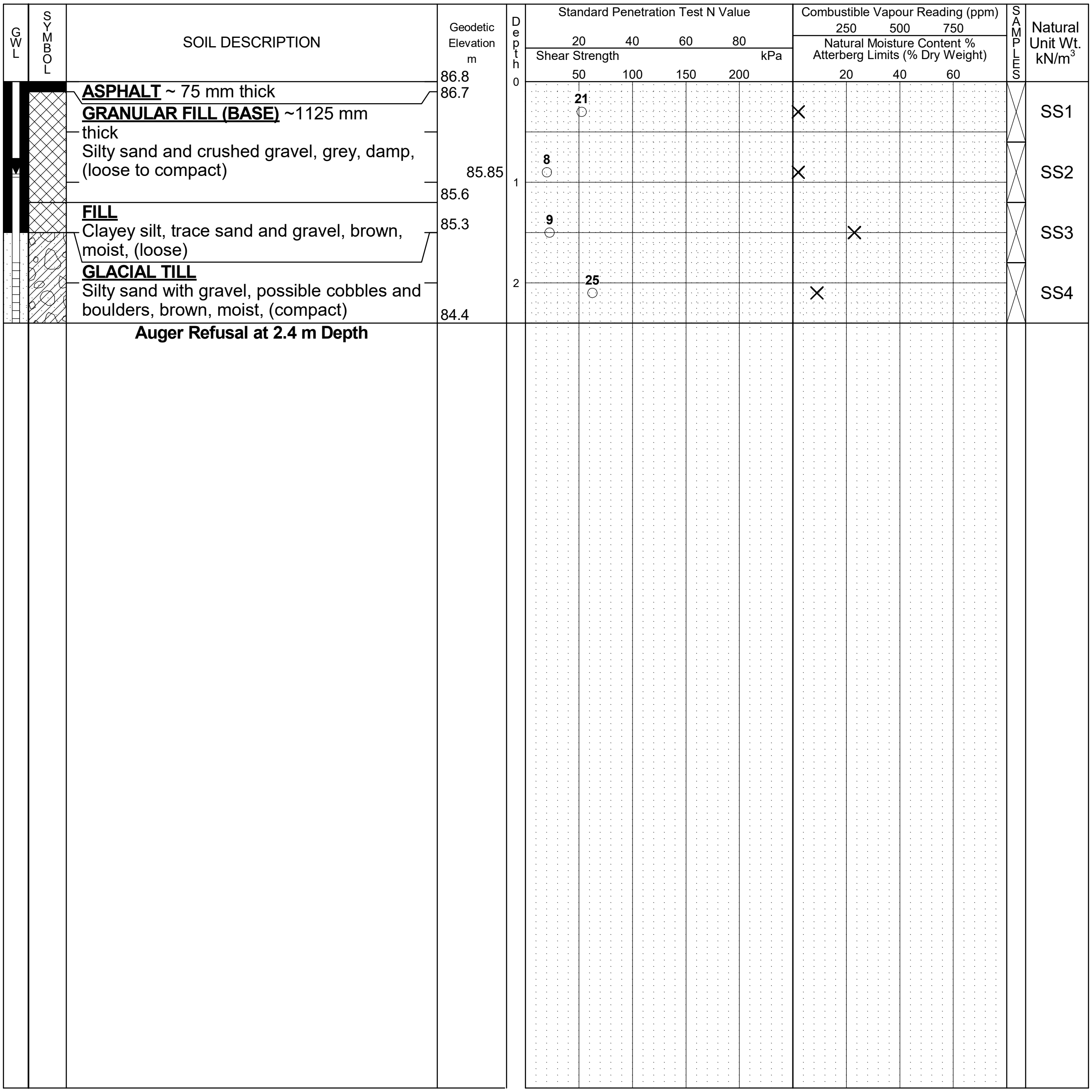
Date Drilled: 'March 7, 2024

Drill Type: CME-55LC Rubber Track Mounted Drill Rig

Datum: Geodetic Elevation

Logged by: M.Z. Checked by: I.T.

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		



Soil Description	Geodetic Elevation m	SPT N Value	Samples	Natural Unit Wt. kN/m³
	86.8			
ASPHALT ~ 75 mm thick	86.7	21	SS1	
GRANULAR FILL (BASE) ~1125 mm thick Silty sand and crushed gravel, grey, damp, (loose to compact)	85.85	8	SS2	
	85.6			
FILL Clayey silt, trace sand and gravel, brown, moist, (loose)	85.3	9	SS3	
GLACIAL TILL Silty sand with gravel, possible cobbles and boulders, brown, moist, (compact)	84.4	25	SS4	

Auger Refusal at 2.4 m Depth

NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. A 19 mm diameter standpipe installed as shown.
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-24000976-A0

WATER LEVEL RECORDS

Date	Water Level (m)	Hole Open To (m)
Upon Completion	Dry	2.4
April 5, 2024	1.0	

CORE DRILLING RECORD

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

Log of Borehole BH-03

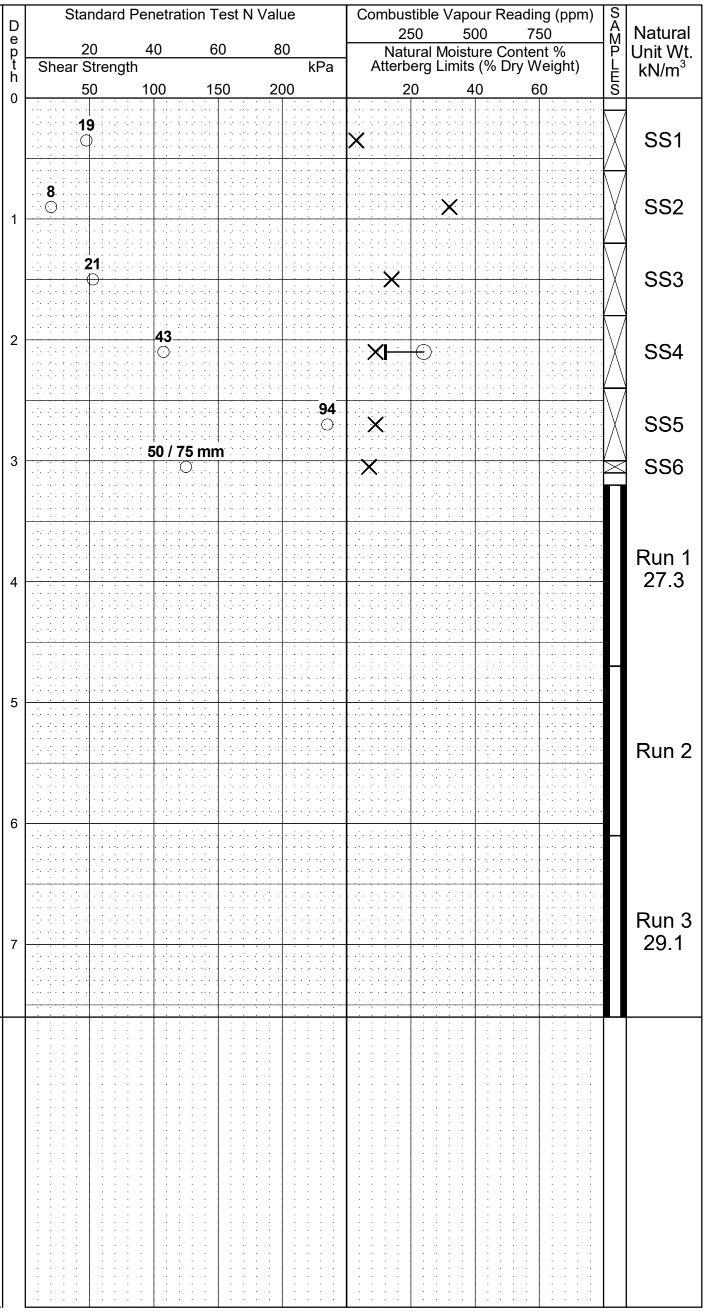
Project No: OTT-24000976-A0
Project: Proposed Addition to Larry Robinson Arena
Location: 2785 Eighth Line Road, Ottawa (Metcalfe), Ontario

Figure No. 5
Page. 1 of 1

Date Drilled: 'March 7, 2024
Drill Type: CME-55LC Rubber Track Mounted Drill Rig
Datum: Geodetic Elevation
Logged by: M.Z. Checked by: I.T.

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		

Geodetic Elevation m	SOIL DESCRIPTION
86.77	
86.7	**ASPHALT** ~ 40 mm thick
86.4	**GRANULAR FILL (BASE)** ~ 300 mm thick Silty sand and crushed gravel, grey, damp, (compact)
85.8	**FILL** Silty sand, some gravel, grey, moist, (loose)
85.7	**ORGANIC CLAYEY SILT** ~ 25 mm thick
	GLACIAL TILL Sandy silty clay of low plasticity, trace gravel, possible cobbles and boulders, brown, moist, (compact to very dense/very stiff to hard)
83.6	**SANDSTONE BEDROCK** Grey, (poor quality)
82.2	**SHALE BEDROCK** With limestone partings, dark grey to black, (fair quality)
79.2	**Borehole Terminated at 7.6 m Depth**



Sample	SPT N Value	Natural Unit Wt. kN/m³
SS1	19	
SS2	8	
SS3	21	
SS4	43	
SS5	94	
SS6	50 / 75 mm	
Run 1		27.3
Run 2		
Run 3		29.1

NOTES:
1. Borehole data requires interpretation by EXP before use by others
2. Borehole was backfilled upon completion.
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-24000976-A0

WATER LEVEL RECORDS

Date	Water Level (m)	Hole Open To (m)

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %
1	3.2 - 4.7	90	46
2	4.7 - 6.1	100	75
3	6.1 - 7.6	100	68

Log of Borehole BH-04

Project No: OTT-24000976-A0

Project: Proposed Addition to Larry Robinson Arena

Location: 2785 Eighth Line Road, Ottawa (Metcalfe), Ontario

Figure No. 6

Page. 1 of 1

Date Drilled: 'March 7, 2024

Drill Type: CME-55LC Rubber Track Mounted Drill Rig

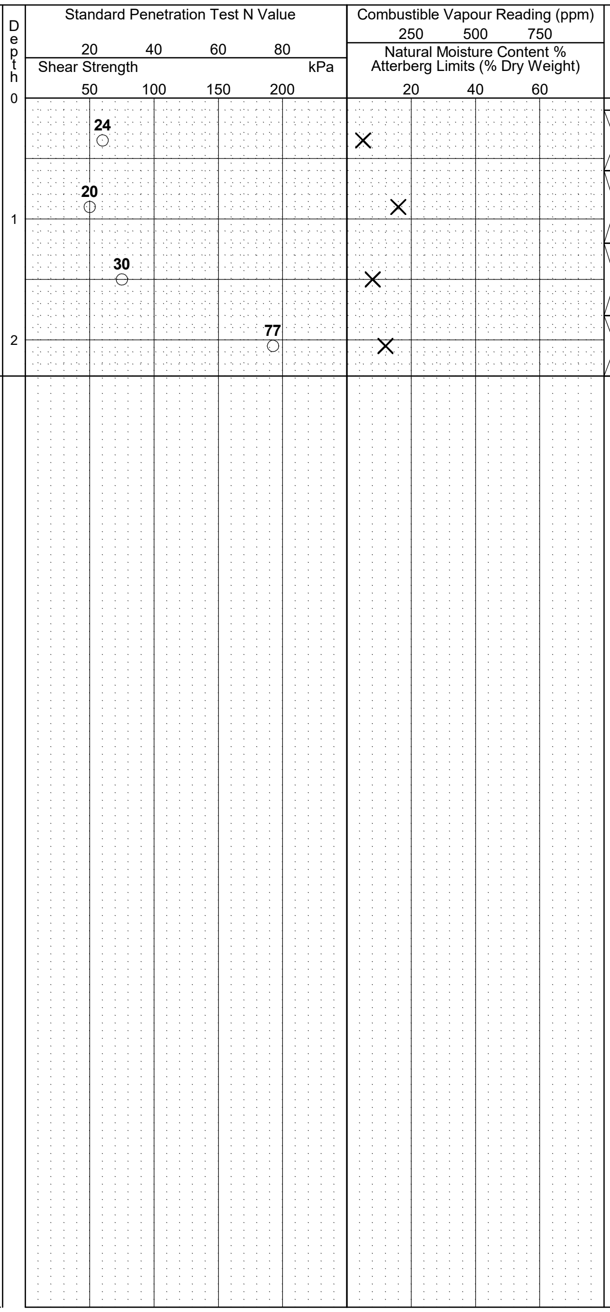
Datum: Geodetic Elevation

Logged by: M.Z. Checked by: I.T.

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		

SOIL DESCRIPTION	Geodetic Elevation m	Depth	SAMPLES
	86.96	0	
ASPHALT ~ 75 mm thick	86.9		
GRANULAR FILL (BASE) ~225 mm thick Silty sand and crushed gravel, grey, moist	86.7		SS1
FILL Silty sand and gravel, brown, moist (compact)	86.0	1	SS2
GLACIAL TILL Gravelly silty sand, trace clay, possible cobbles and boulders, brown, damp to moist, (dense to very dense)	85.53		SS3
		2	SS4
	84.7		

Auger Refusal at 2.3 m Depth



Natural Unit Wt. kN/m^3

NOTES:
1. Borehole data requires interpretation by EXP before use by others
2. A 19 mm diameter standpipe installed as shown.
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-24000976-A0

WATER LEVEL RECORDS

Date	Water Level (m)	Hole Open To (m)
Upon Completion	Dry	2.3
April 5, 2024	1.4	

CORE DRILLING RECORD

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

Log of Borehole BH-05

Project No: OTT-24000976-A0

Project: Proposed Addition to Larry Robinson Arena

Location: 2785 Eighth Line Road, Ottawa (Metcalfe), Ontario

Figure No. 7

Page. 1 of 1

Date Drilled: 'March 7, 2024

Drill Type: CME-55LC Rubber Track Mounted Drill Rig

Datum: Geodetic Elevation

Logged by: M.Z. Checked by: I.T.

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	Depth	Standard Penetration Test N Value (20, 40, 60, 80) Shear Strength kPa (50, 100, 150, 200)	Combustible Vapour Reading (ppm) (250, 500, 750) Natural Moisture Content % Atterberg Limits (% Dry Weight) (20, 40, 60)	SAMPLES	Natural Unit Wt. kN/m³
			86.91	0				
		ASPHALT ~ 75 mm thick	86.8					
		GRANULAR FILL (BASE) ~300 mm thick Silty sand and crushed gravel, grey, damp, (loose)	86.5		9	×	☒	SS1
		FILL Mixture of silty sand and silty clay, some gravel, grey, damp, (loose)	85.9	1	5 then 50 / 75 mm	×	☒	SS2
		SANDSTONE BEDROCK Grey, (very poor quality)		2				Run 1 Run 2
		DOLOSTONE BEDROCK With shale partings, grey, (very poor quality)	84.0	3 4				Run 3 26.8
		SHALE BEDROCK Dark grey to black, (fair to good quality)	82.6	5 6				Run 4 Run 5 28.7
		Borehole Terminated at 6.1 m Depth	80.8					

NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. Borehole was backfilled upon completion.
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-24000976-A0

WATER LEVEL RECORDS

Date	Water Level (m)	Hole Open To (m)

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %
1	1 - 1.6	100	0
2	1.6 - 3.1	92	0
3	3.1 - 4.3	100	18
4	4.3 - 4.6	100	69
5	4.6 - 6.1	100	76

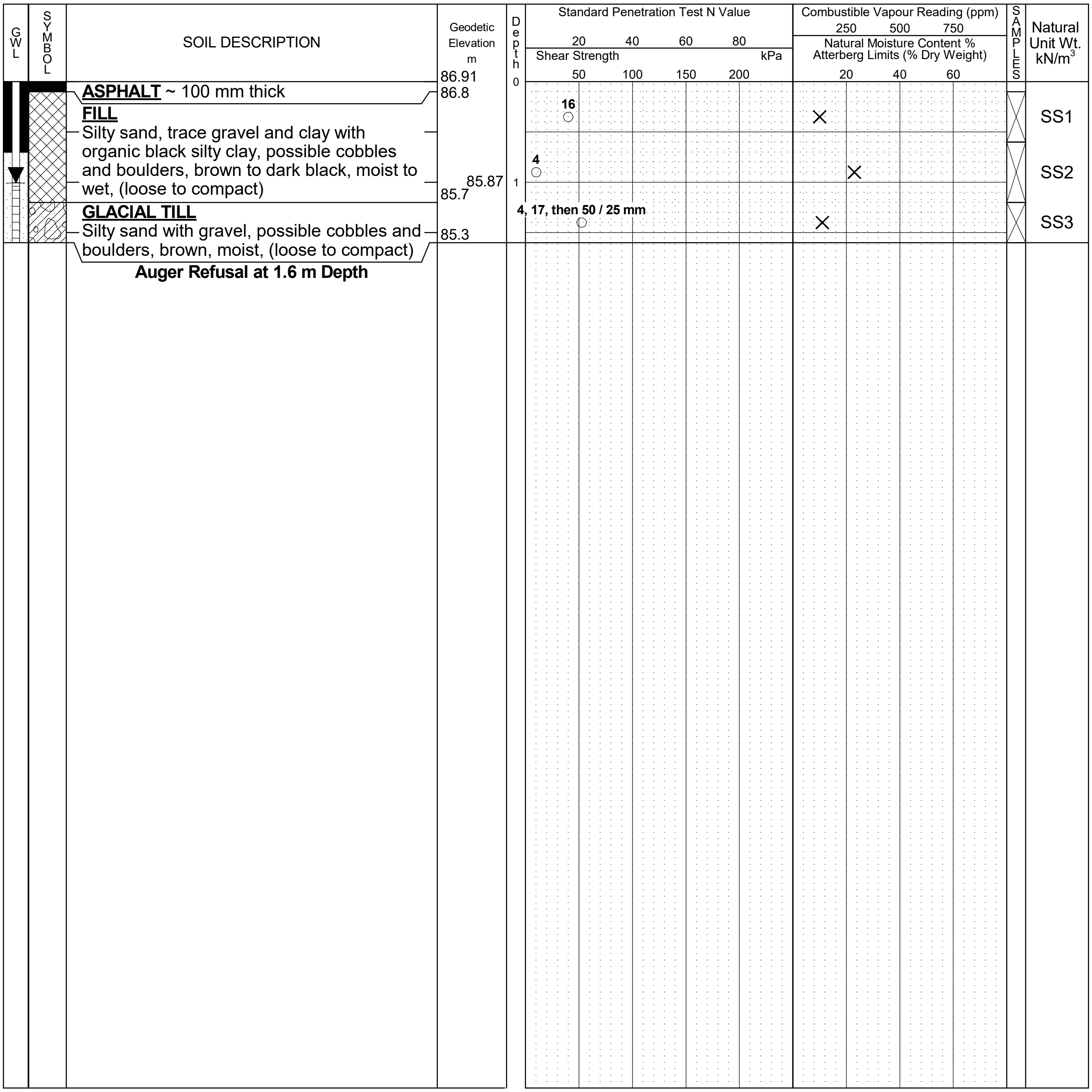
Log of Borehole BH-06

Project No: OTT-24000976-A0
Project: Proposed Addition to Larry Robinson Arena
Location: 2785 Eighth Line Road, Ottawa (Metcalfe), Ontario

Figure No. 8
Page. 1 of 1

Date Drilled: 'March 7, 2024
Drill Type: CME-55LC Rubber Track Mounted Drill Rig
Datum: Geodetic Elevation
Logged by: M.Z. Checked by: I.T.

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		



Geodetic Elevation m	Depth	SOIL DESCRIPTION	SPT N Value	Samples
86.91	0			
86.8		**ASPHALT** ~ 100 mm thick		
		FILL Silty sand, trace gravel and clay with organic black silty clay, possible cobbles and boulders, brown to dark black, moist to wet, (loose to compact)	16	SS1
85.87	1		4	SS2
85.7		**GLACIAL TILL** Silty sand with gravel, possible cobbles and boulders, brown, moist, (loose to compact)	4, 17, then 50 / 25 mm	SS3
85.3		**Auger Refusal at 1.6 m Depth**		

NOTES:
1. Borehole data requires interpretation by EXP before use by others
2. A 19 mm diameter standpipe installed as shown.
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-24000976-A0

WATER LEVEL RECORDS

Date	Water Level (m)	Hole Open To (m)
Upon Completion	Dry	1.6
April 5, 2024	1.0	

CORE DRILLING RECORD

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

Log of Borehole TP-01

Project No: OTT-24000976-A0

Project: Proposed Addition to Larry Robinson Arena

Location: 2785 Eighth Line Road, Ottawa (Metcalfe), Ontario

Figure No. 9

Page. 1 of 1

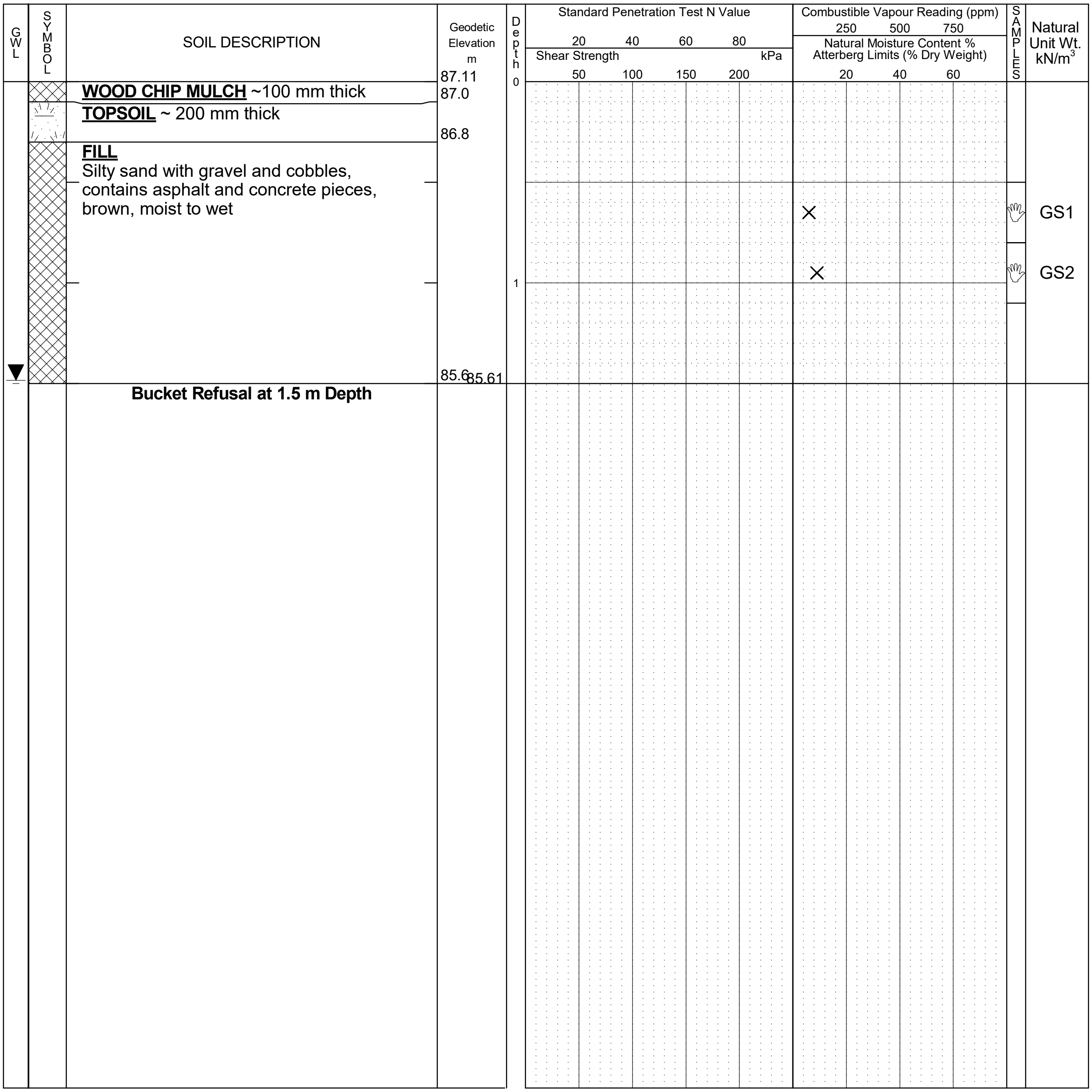
Date Drilled: 'March 7, 2024

Drill Type: Kubota KX080-4 Mini Excavator

Datum: Geodetic Elevation

Logged by: M.Z. Checked by: I.T.

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		



WOOD CHIP MULCH ~100 mm thick

TOPSOIL ~ 200 mm thick

FILL
Silty sand with gravel and cobbles, contains asphalt and concrete pieces, brown, moist to wet

Bucket Refusal at 1.5 m Depth

NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. Test pit backfilled upon completion of excavation
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-24000976-A0

WATER LEVEL RECORDS

Date	Water Level (m)	Hole Open To (m)
Upon Completion	1.5	1.5

CORE DRILLING RECORD

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

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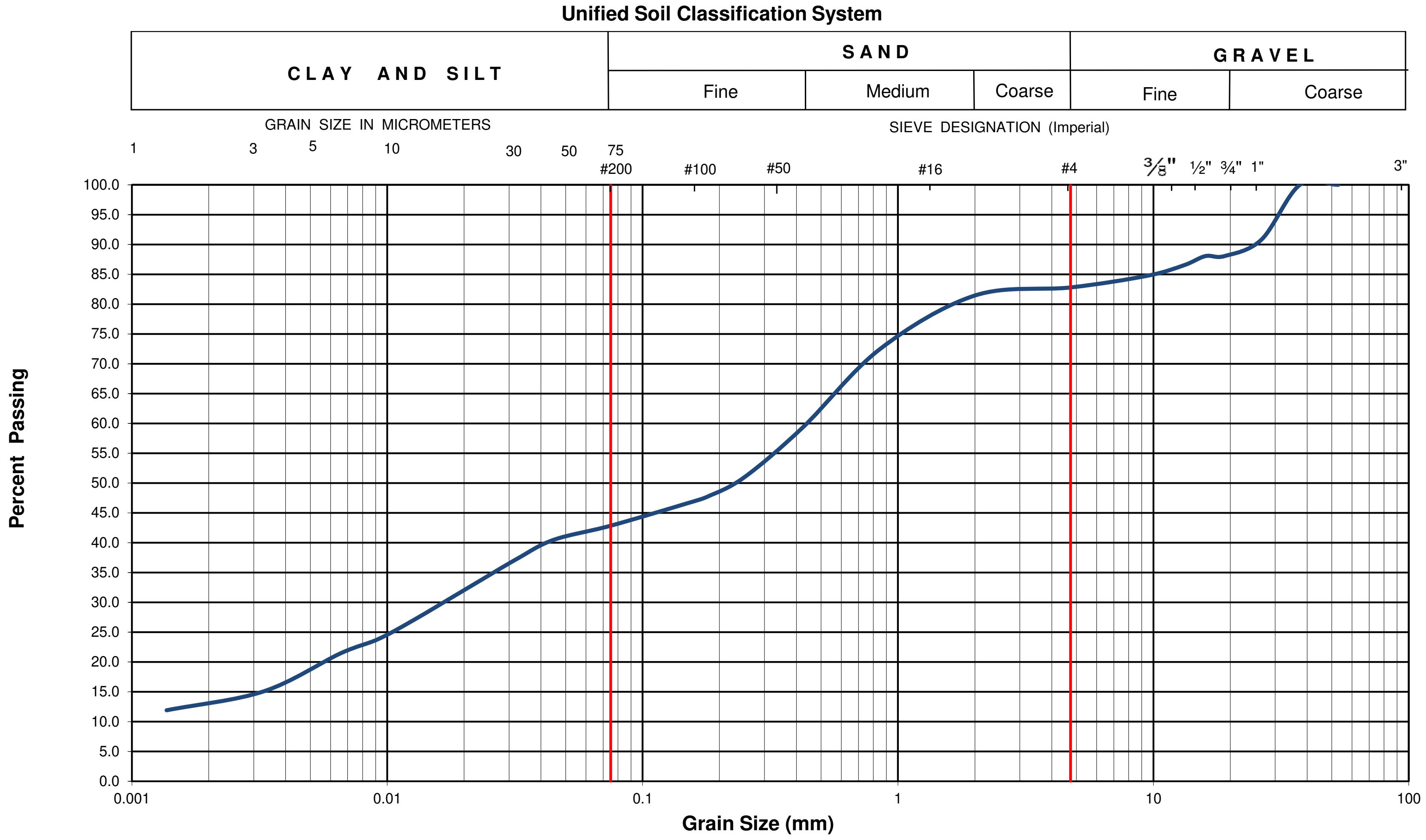
Ottawa, ON K2B 8H6

Grain-Size Distribution Curve
Method of Test For Particle Size Analysis of Soil
ASTM C-136/ASTM D422



EXP Project No.:	OTT-24000976-A0	**Project Name :**	Proposed Addition to Larry Robinson Arena. RFSO- 24423-92500-S01						
Client :	City of Ottawa	**Project Location :**	2785 8th Line Road, Ottawa (Metcalfe), Ontario						
Date Sampled :	March 8, 2024	**Borehole No:**	BH1		**Sample No.:**	SS2		**Depth (m) :**	0.6-1.2
Sample Description :		**% Silt and Clay**	43	**% Sand**	40	**% Gravel**	17	**Figure :**	10
Sample Description :	FILL: Silty Sand (SM) - Some Clay and Gravel								

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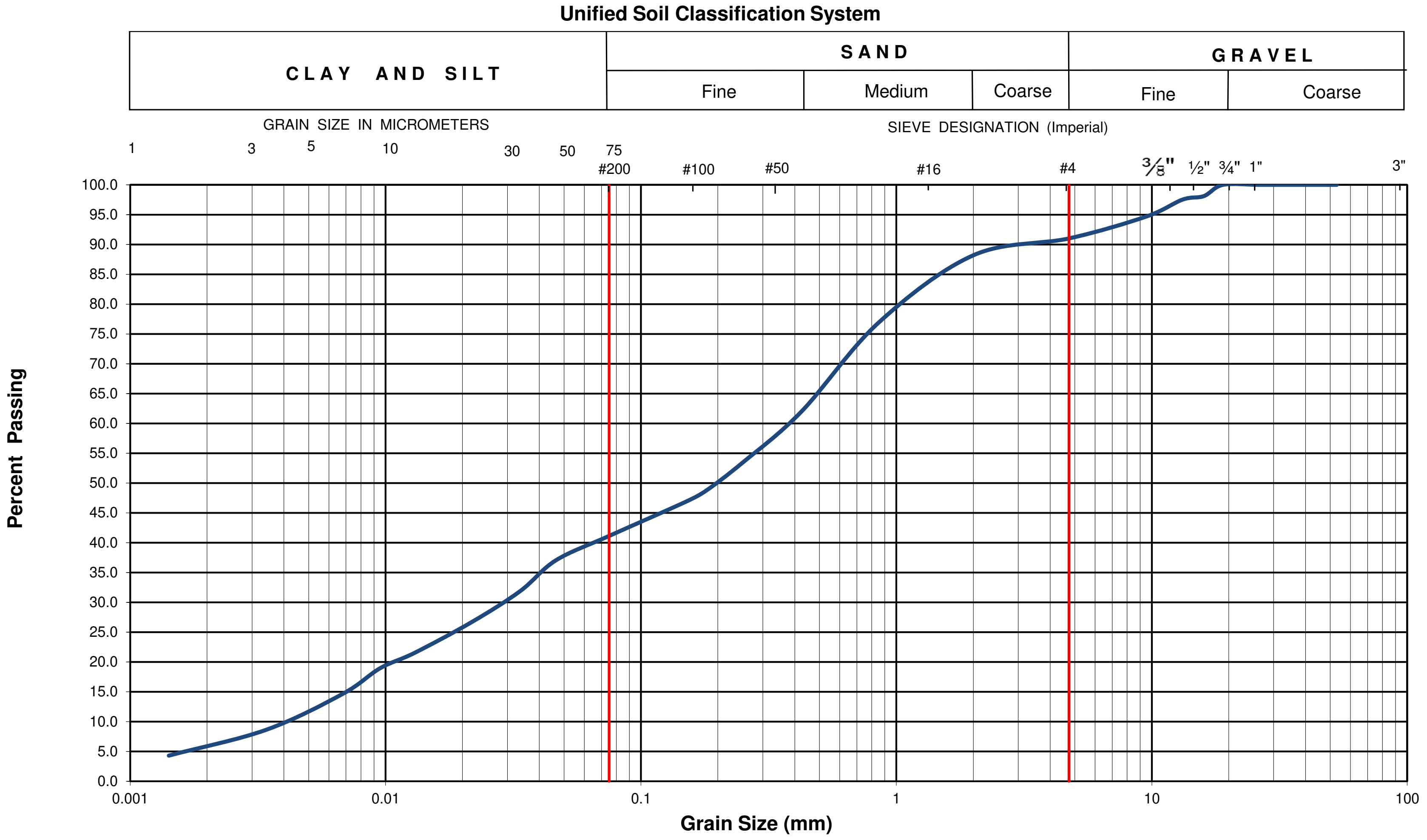
Grain-Size Distribution Curve
Method of Test For Particle Size Analysis of Soil
ASTM C-136/ASTM D422



EXP Project No.:	**OTT-24000976-A0**	**Project Name :**	**Propsod Addition to Larry Robinson Arena .RFSO- 24423-92500-S01**						
Client :	**City of Ottawa**	**Project Location :**	**2785 8th Line Road, Ottawa (Metcalfe), Ontario**						
Date Sampled :	**March 7, 2024**	**Borehole No:**	**BH6**	**Sample No.:**	**SS2**			**Depth (m) :**	**0.6-1.2**
Sample Description :		**% Silt and Clay**	**41**	**% Sand**	**50**	**% Gravel**	**9**	**Figure :**	**11**
Sample Description :	**FILL: Silty Sand (SM) - Trace Gravel and Clay**								

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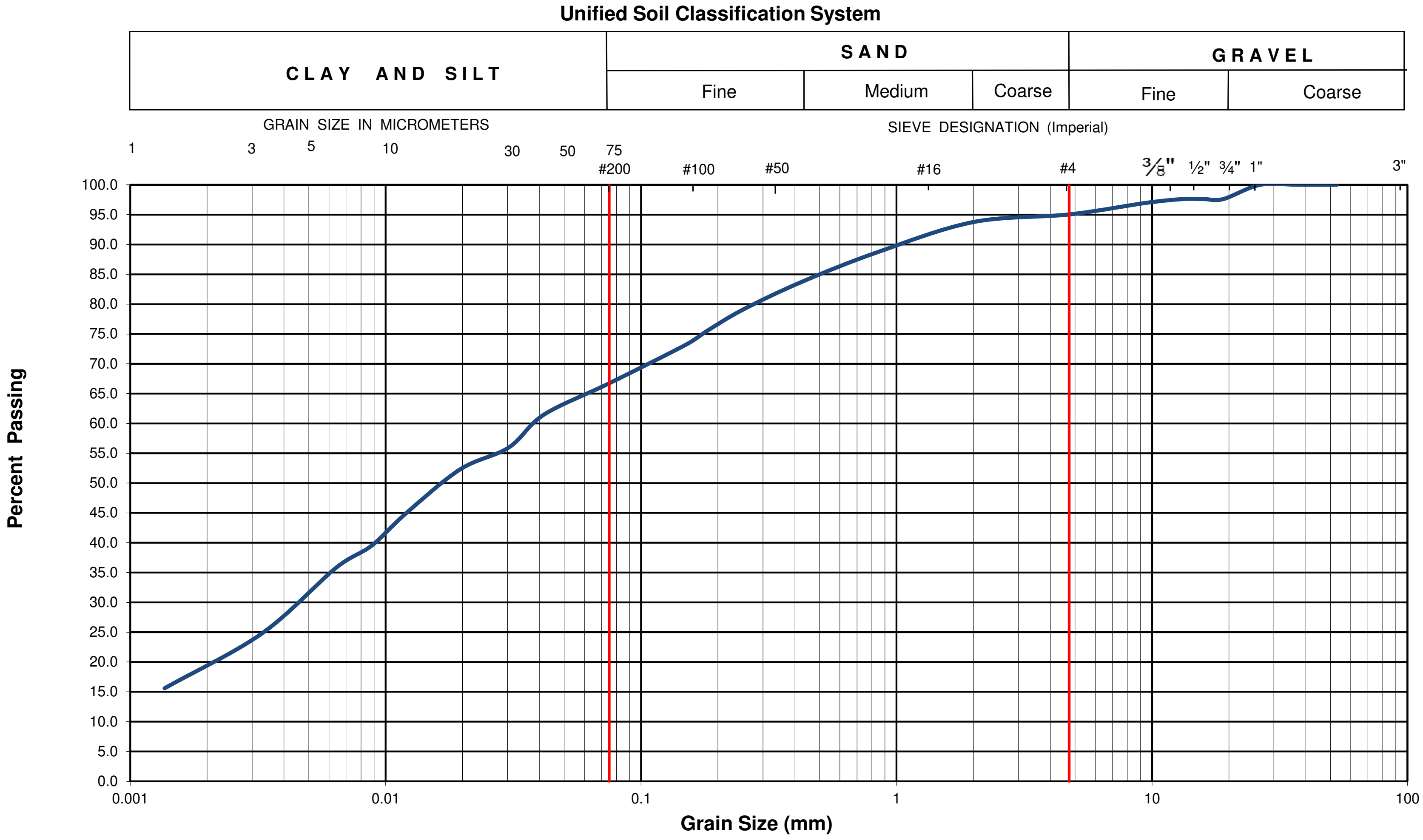
Grain-Size Distribution Curve
Method of Test For Particle Size Analysis of Soil
ASTM C-136/ASTM D422



EXP Project No.:	OTT-24000976-A0	Project Name :	Proposed Addition to Larry Robinson Arena. RFSO- 24423-92500-S01					
Client :	City of Ottawa	Project Location :	2785 8th Line Road, Ottawa (Metcalfe), Ontario					
Date Sampled :	March 7, 2024	Borehole No:	BH3	Sample No.:	SS4		Depth (m) :	1.8-2.4
Sample Description :		% Silt and Clay	67	% Sand	28	% Gravel 5	Figure :	12
Sample Description :	GLACIAL TILL: Sandy Silty Clay of Low Plasticity (CL) - Trace Gravel							

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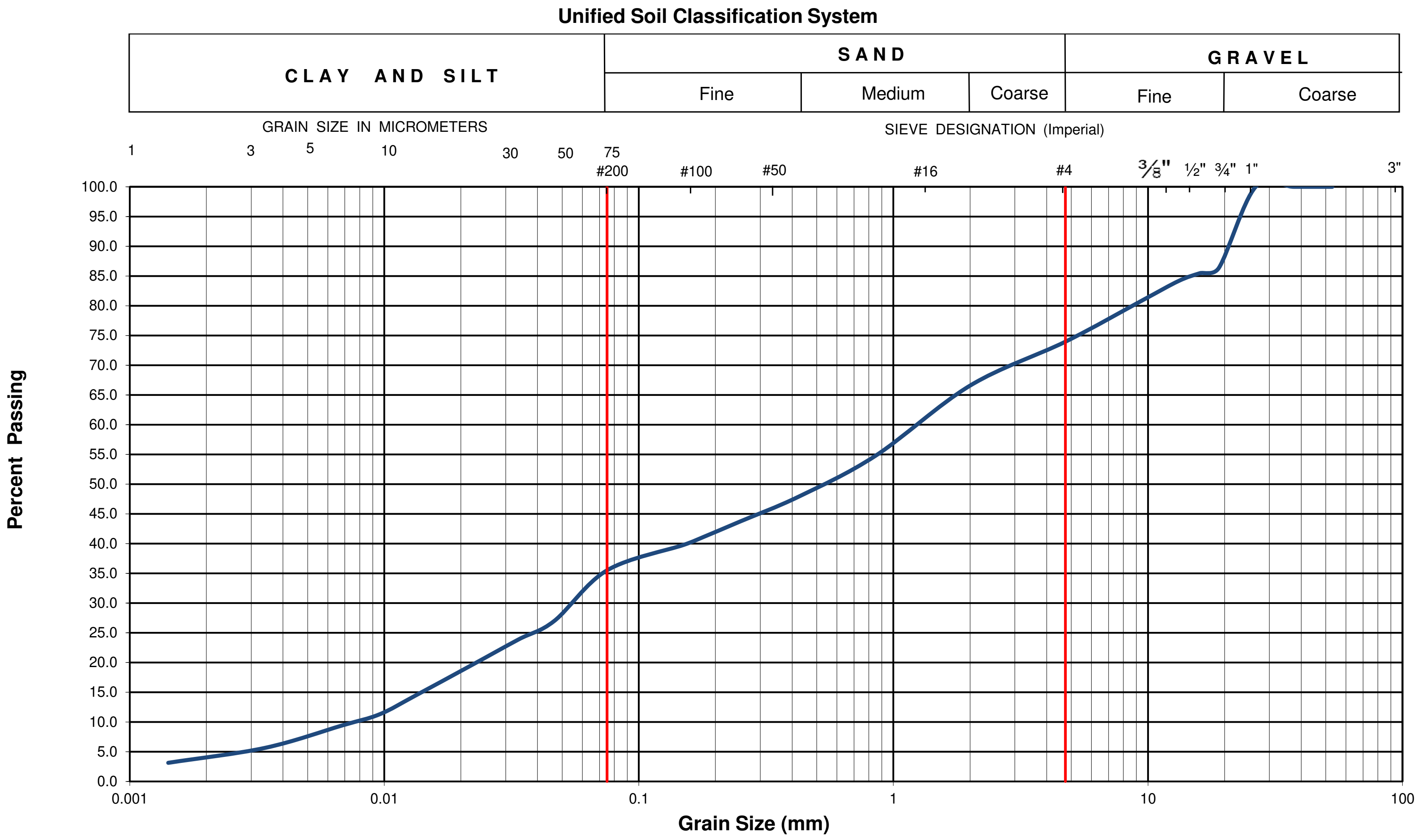
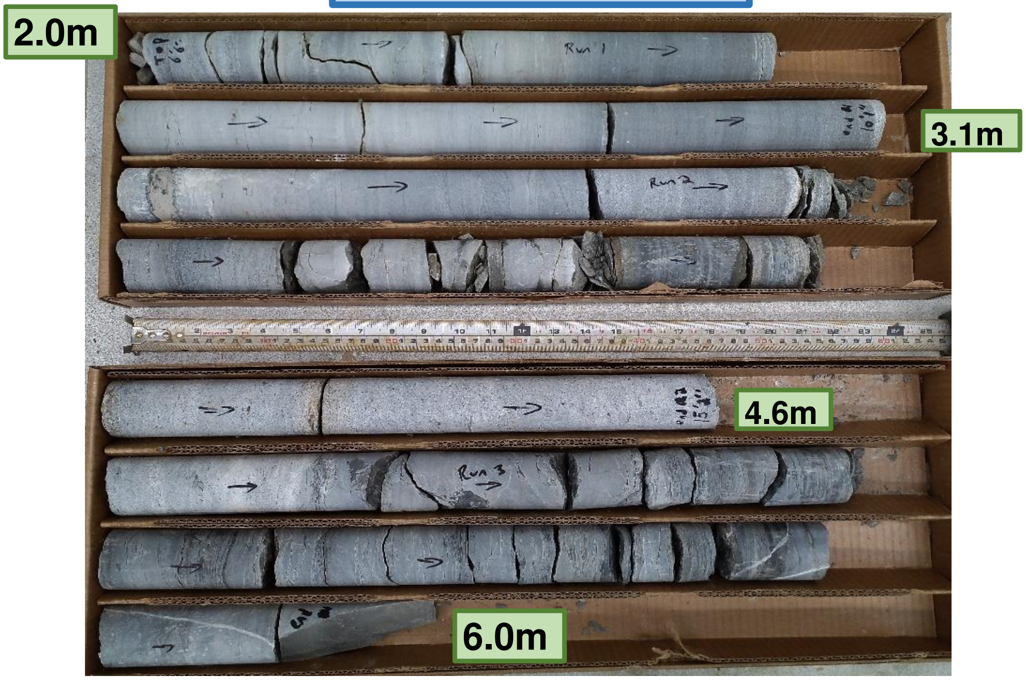
Grain-Size Distribution Curve
Method of Test For Particle Size Analysis of Soil
ASTM C-136/ASTM D422

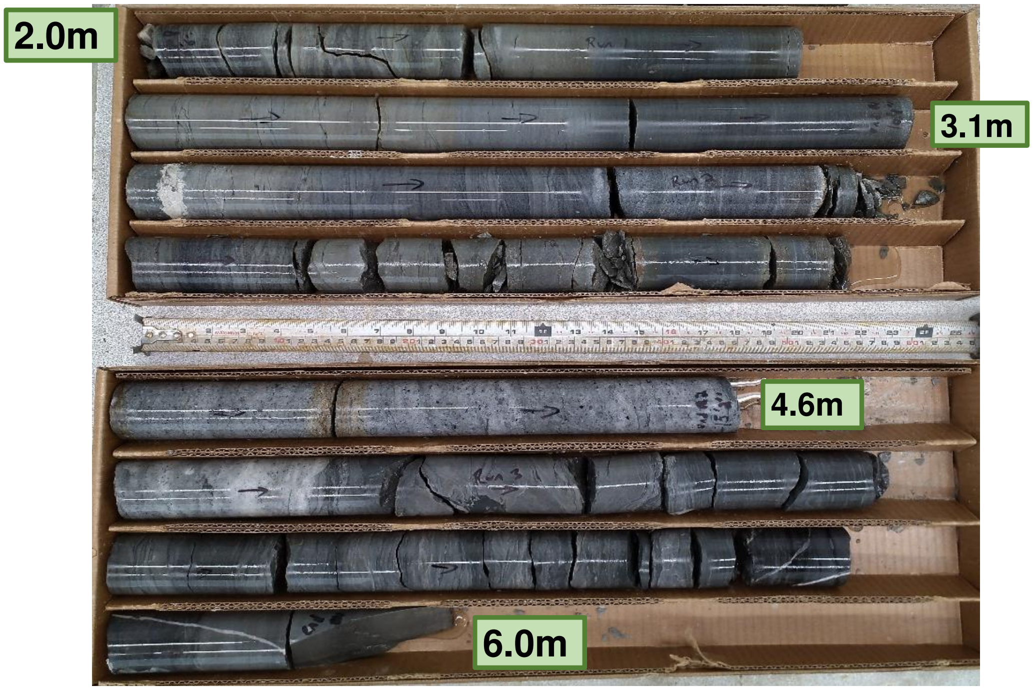


EXP Project No.:	OTT-24000976-A0	Project Name :	Proposed Addition to Larry Robinson Arena. RFSO- 24423-92500-S01						
Client :	City of Ottawa	Project Location :	2785 8th Line Road, Ottawa (Metcalfe), Ontario						
Date Sampled :	March 7, 2024	Borehole No:	BH4	Sample No.:	SS3			Depth (m) :	1.2-1.8
Sample Description :		% Silt and Clay	36	% Sand	38	% Gravel	26	Figure :	13
Sample Description :	GLACIAL TILL: Gravelly Silty Sand (SM) - Trace Clay								

DRY BEDROCK CORES



WET BEDROCK CORES



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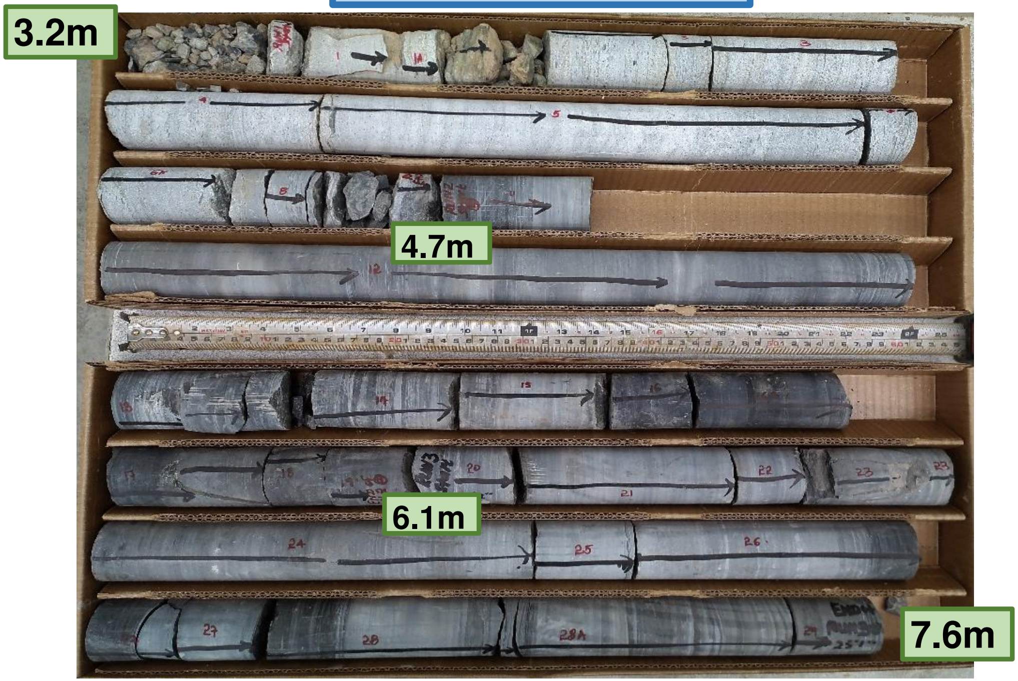
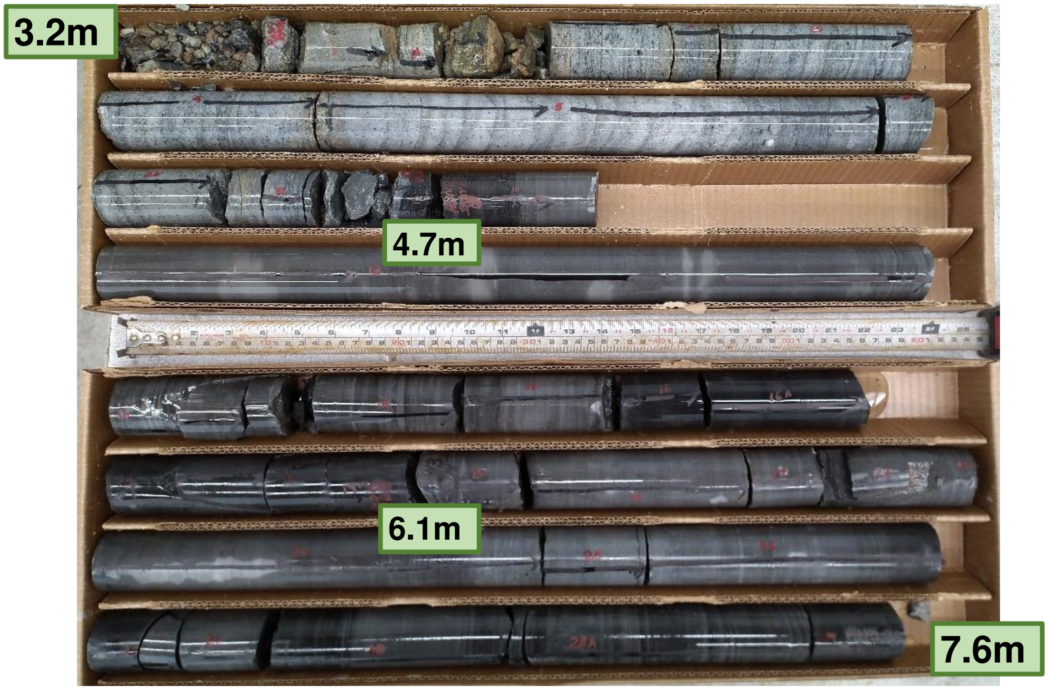
borehole no. **BH-01**	core runs Run 1: 2.0m - 3.1m Run 2: 3.1m - 4.6m Run 3: 4.6m - 6.0m End of Borehole	PROJECT ADDITION TO LARRY ROBINSON ARENA 2785 8th LINE ROAD, OTTAWA (METCALFE), ON	project no. OTT-24000976-A0
date cored Mar 08, 2024		ROCK CORE PHOTOGRAPHS	FIG 14

DRY BEDROCK CORES



WET BEDROCK CORES



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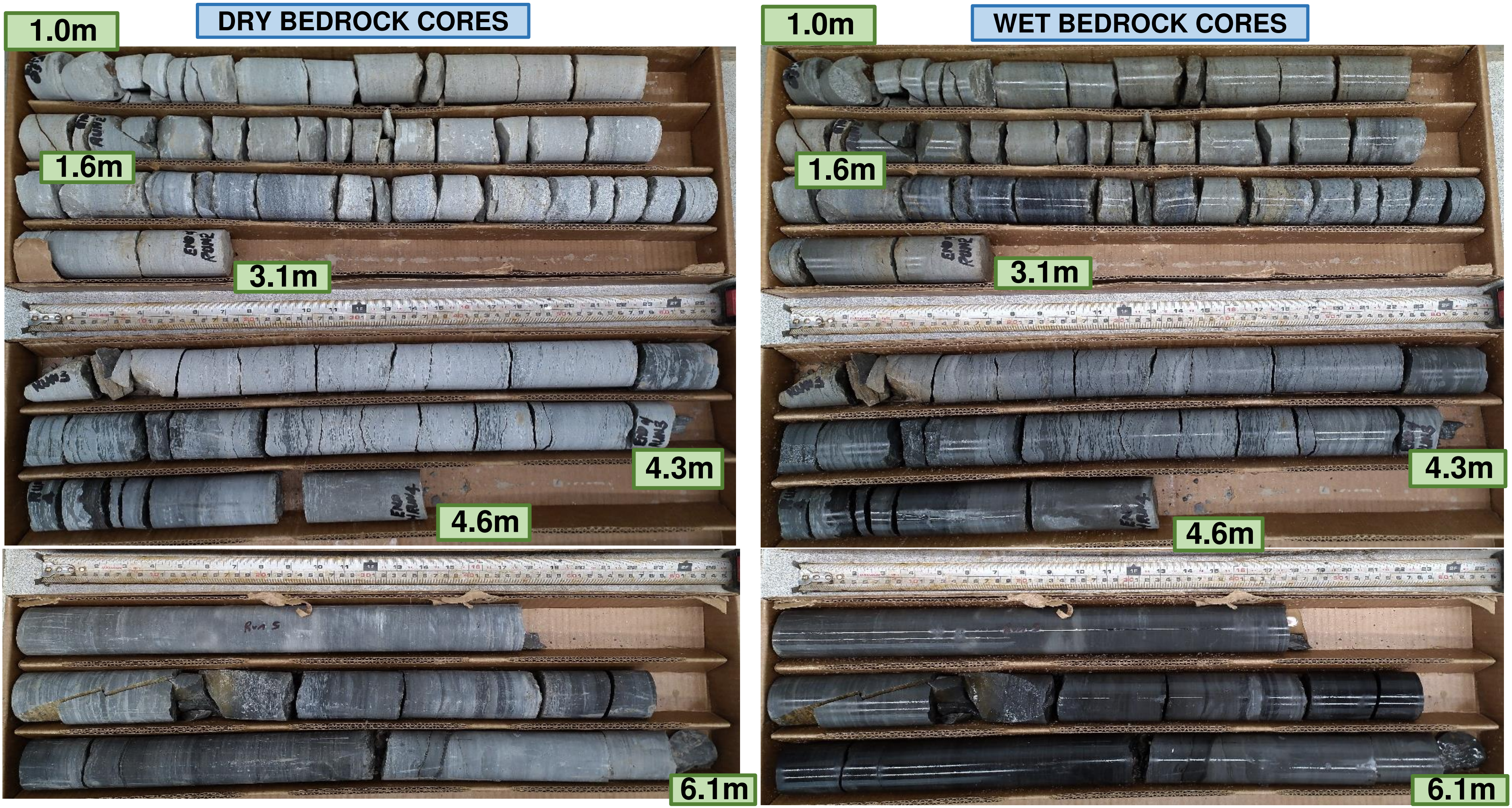
borehole no.	core runs	PROJECT	project no.
BH-03	Run 1: 3.2m - 4.7m Run 2: 4.7m - 6.1m Run 3: 6.1m - 7.6m End of Borehole	ADDITION TO LARRY ROBINSON ARENA 2785 8th LINE ROAD, OTTAWA (METCALFE), ON	OTT-24000976-A0
date cored Mar 07, 2024		ROCK CORE PHOTOGRAPHS	FIG 15



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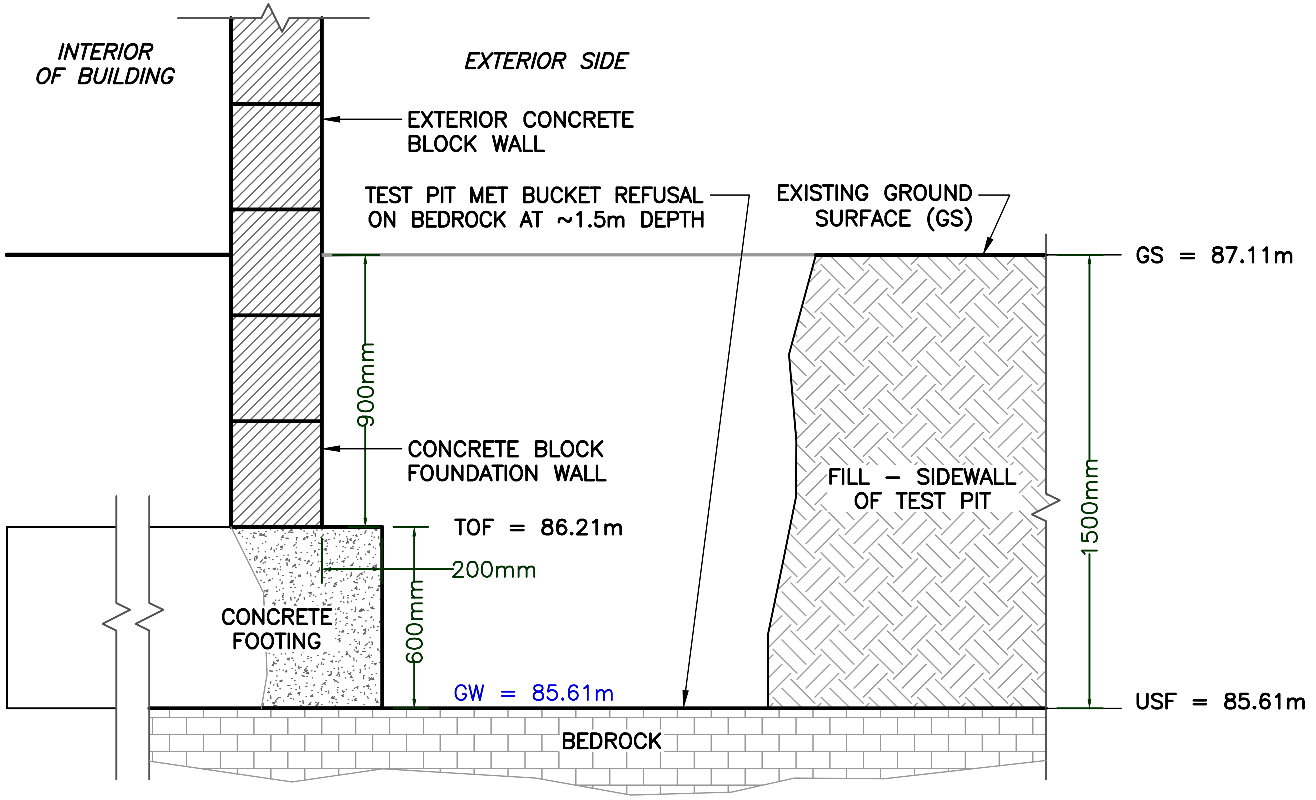
borehole no.	core runs	project	project no.
BH-05	Run 1: 1.0m - 1.6m Run 2: 1.6m - 3.1m Run 3: 3.1m - 4.3m Run 4: 4.3m - 4.6m Run 5: 4.6m - 6.1m End of Borehole	ADDITION TO LARRY ROBINSON ARENA 2785 8th LINE ROAD, OTTAWA (METCALFE), ON	OTT-24000976-A0
date cored Mar 07, 2024		ROCK CORE PHOTOGRAPHS	FIG 16

NOTES:

1) NO PERIMETER DRAINAGE SYSTEM (WEEPING TILE) PRESENT IN TEST PIT
2) NO DAMPPROOFING AND NO DRAINAGE BOARD ON VERTICAL FACE OF FOUNDATION WALL
3) GROUNDWATER WAS ENCOUNTERED AT 1.5m DEPTH BELOW GROUND SURFACE IN THE TEST PIT UPON COMPLETION OF EXCAVATION
4) TEST PIT BACKFILLED UPON COMPLETION WITH BACKFILL NOMINALLY PACKED IN PLACE WITH BACKHOE BUCKET



TEST PIT TP-1
PROFILE / CROSS-SECTION
(SCALE – 1:25)

LEGEND/DEFINITION:

TOF = Top of Footing
USF = Underside of Footing
GW = Groundwater Level

Filename: E:\OTT\OTT-24000976-A0\60 Execution\65 Drawings\OTT-24000976-A0_Geo.dwg Plotted by: SeverA
Last Saved: Apr 10, 2024 9:54 AM Last Plotted: Apr 10, 2024 9:54 AM

ORIGINAL SHEET SIZE = 11" x 8.5"

0 20cm 40cm 1m
HORIZONTAL 1:25

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2650 Queensview Drive, Suite 100
Ottawa, ON K2B 8H6, Canada

DATE APRIL 2024
DESIGN MZ / SP
CHECKED IT
DRAWN BY AS

CLIENT:
LARRY ROBINSON ARENA
GEOTECHNICAL INVESTIGATION

TITLE:
TEST PIT 1 – PROFILE OF EXISTING FOOTING
2785 8TH LINE ROAD, OTTAWA (METCALFE), ONTARIO

project no. OTT-24000976-A0
scale 1:25
FIG 17

Appendix A – Test Pit Photographs

Photograph No. 1: Location of Test Pit No. 1

Photograph No. 2: Test Pit No. 1 - Bedrock Depth

Photograph No. 3: Test Pit No. 1 - Footing Depth

Appendix B – Seismic Shear Wave Velocity Survey Report by GPR

GEOPHYSICS GPR
INTERNATIONAL INC.

March 28th, 2024

Transmitted by email : ismail.taki@exp.com
Our ref : GPR24-05204

Mr. Ismail Taki, M.Eng., P.Eng.
Senior Manager, Earth & Environment, Eastern Region
exp Services inc.
Suite 100 - 2650 Queensview Drive
Ottawa ON K2B 8H6

Subject: **Shear Wave Velocity Sounding for the Site Class Determination**
Larry Robinson Arena, 2785 8th Line Road, Metcalfe, Ottawa (ON)

[Project: OTT-24000976-A0]

Dear Mr. Taki,

Geophysics GPR International inc. has been mandated by **exp** Services inc. to carry out seismic surveys at the Larry Robinson Arena, located at 2785 8th Line Road, in Metcalfe, Ottawa (ON). The geophysical investigation used the Multi-channel Analysis of Surface Waves (MASW) and the Spatial AutoCorrelation (SPAC) methods. From the subsequent results, the seismic shear wave velocity values were calculated for the soils, to determine the Site Class.

The surveys were conducted on February 2nd, 2023, by Mrs. Karyne Faguy, B.Sc. geophysics and Mr. Timothy Ward, tech. Figure 1 shows the regional location of the site and Figure 2 illustrates the location of the seismic spreads. Both figures are presented in the Appendix.

The following paragraphs briefly describe the survey design, the principles of the testing methods, and the results presented in table and graph.

MASW Principle

The *Multi-channel Analysis of Surface Waves* (MASW) and the *SPatial AutoCorrelation* (SPAC or MAM for *Microtremors Array Method*) are seismic methods used to evaluate the shear wave velocities of subsurface materials through the analysis of the dispersion properties of the Rayleigh surface wave. The MASW is considered an "active" method, as the seismic signal is induced at known location and time in the geophones' spread axis. Conversely, the SPAC is considered a "passive" method, using the low frequency "signals" produced far away. The method can also be used with "active" seismic source records. The SPAC method generally allows deeper Vs soundings. Its dispersion curve can then be merged with the one of higher frequency from the MASW to calculate a more complete inversion. The dispersion properties are expressed as a change of velocities with respect to frequencies. Surface wave energy will decay exponentially with depth. Lower frequency surface waves will travel deeper and thus be more influenced by deeper velocity layering than the shallow higher frequency waves. The inversion of the Rayleigh wave dispersion curve yields a shear wave (V_S) velocity depth profile (sounding).

Figure 3 schematically outlines the basic operating procedure for the MASW method. Figure 4 illustrates an example of one of the MASW/SPAC records, the corresponding spectrogram analysis and resulting 1D V_S model.

INTERPRETATION

The main processing sequence involved data inspection and edition when required; spectral analysis (from MASW and SPAC); picking the fundamental mode; and 1D inversion of the MASW and SPAC shot records using the SeisImagerSW™ software. The data inversions used a nonlinear least squares algorithm.

In theory, all the shot records for a given seismic spread should produce a similar shear-wave velocity profile. In practice, however, differences can arise due to energy dissipation, local surface seismic velocities variations, and/or dipping of overburden layers or rock. In general, the precision of the calculated seismic shear wave velocities (V_S) is around 15% or better.

More detailed descriptions of these methods are presented in *Shear Wave Velocity Measurement Guidelines for Canadian Seismic Site Characterization in Soil and Rock*, Hunter, J.A., Crow, H.L., et al., Geological Surveys of Canada, General Information Product 110, 2015.

SURVEY DESIGN

The seismic spreads were laid out north of the actual building (Figure 2). The geophone spacing was 3.0 metres for the main spread, using 24 geophones. Two shorter seismic spreads, with geophone spacing of 0.5 and 1.0 metre, were dedicated to the near surface materials. The seismic records were produced with a seismograph Terraloc Pro2 (from ABEM Instrument), and the geophones were 4.5 Hz.

The seismic records counted 4096 data, sampled at 1000 µs for the MASW surveys, and at 40 µs for the seismic refraction. The records included a pre-trigged portion of 10 ms. An 8 kg sledgehammer was used as the energy source, with impacts being recorded off both ends of the seismic spreads. A stacking procedure was also used to improve the Signal / Noise ratio for the seismic records.

The shear wave depth sounding can be considered as the average of the bulk area within the geophone spread, especially for its central half-length.

RESULTS

The MASW calculated V_S results are illustrated at Figure 5.

The $\overline{V}_{S30}$ value results from the harmonic mean of the shear wave velocities, from the surface to 30 metres deep. It is calculated by dividing the total depth of interest (30 metres) by the sum of the time spent in each velocity layer from the surface down to 30 metres, as:

$$\overline{V}_{S30} = \frac{\sum_{i=1}^{N} H_i}{\sum_{i=1}^{N} H_i / V_i} \quad | \quad \sum_{i=1}^{N} H_i = 30\ \mathrm{m}$$

(N: number of layers; H_i: thickness of layer "*i*" ; V_i: V_S of layer "*i*")

Thus, the $\overline{V}_{S30}$ value represents the seismic shear wave velocity of an equivalent homogeneous single layer response, between the surface and 30 metres deep. The calculated $\overline{V}_{S30}$ value of the actual site is 1043.5m/s (Table 1), corresponding to the Site Class "B". However, the Site Classes A and B are not to be used if there is 3 metres or more between the rock surface and the bottom of the foundation. In the case the rock surface would be at 1.6 metres or less, the $\overline{V}_{S30}$* value would be greater than 1500 m/s, corresponding to the Site Class A (Table 2).

CONCLUSION

Geophysical surveys were carried out to identify the Site Class at the Larry Robinson Arena, in Metcalfe, Ottawa (ON). The seismic surveys used the MASW and the SPAC analysis to calculate the $\overline{V}_{S30}$ value. Its calculation is presented at Table 1.

The $\overline{V}_{S30}$ value of the actual site is 1044 m/s, corresponding to the Site Class "B" ($760 < \overline{V}_{S30} \leq 1500$ m/s), as determined through the MASW and SPAC results, Table 4.1.8.4.-A of the NBC (2015), and the Building Code, O. Reg. 332/12. It must be noted that the Site Classes A and B are not to be used if there is 3 metres or more of unconsolidated materials between the rock surface and the bottom of the spread footing or the mat foundation.

In the case there would be 1.6 metres or less of unconsolidated materials, the $\overline{V}_{S30}$* value would be greater than 1500 m/s, corresponding to the Site Class A.

It must also be noted that other geotechnical information gleaned on site; including the presence of liquefiable soils, very soft clays, high moisture content etc. (cf. Table 4.1.8.4.-A of the NBC 2015) can supersede the Site classification provided in this report based on the $\overline{V}_{S30}$ value.

The V_S values calculated are representative of the in situ materials and are not corrected for the total and effective stresses.

Hoping the whole to your satisfaction, we remain yours truly,

P. Eng.
Jean-Luc Arsenault, M.A.Sc., P.Eng.
Senior Project Manager

LICENSED PROFESSIONAL ENGINEER
J.-L. ARSENAULT
100148122
PROVINCE OF ONTARIO
2024-03-28

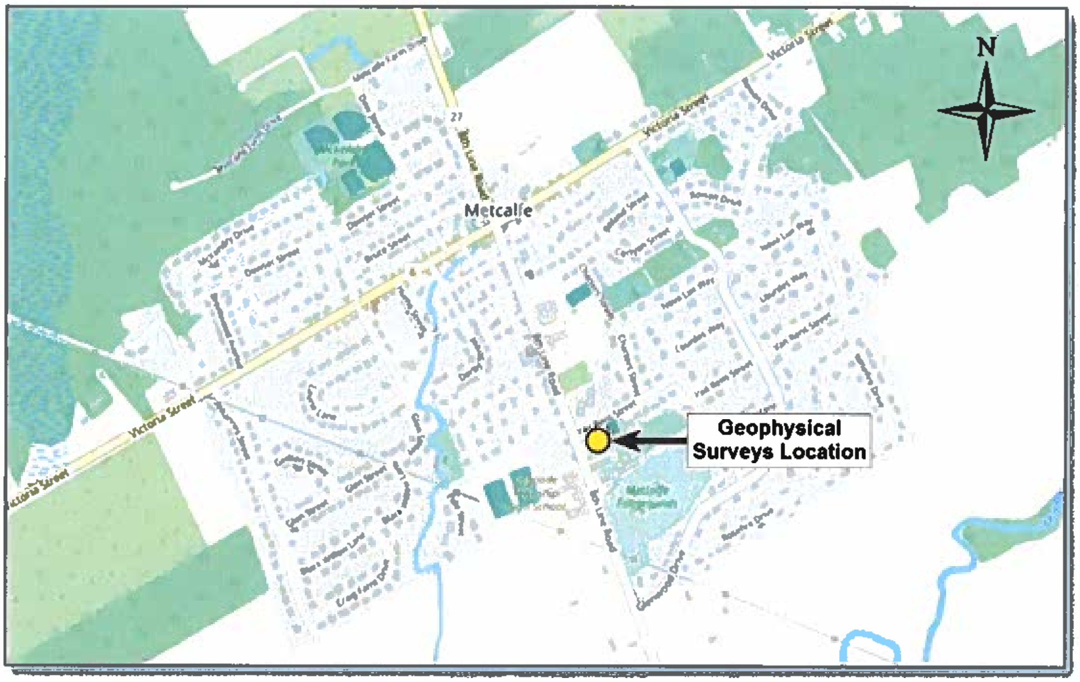


Figure 1: Regional location of the Site
(Source : OpenStreetMap©)

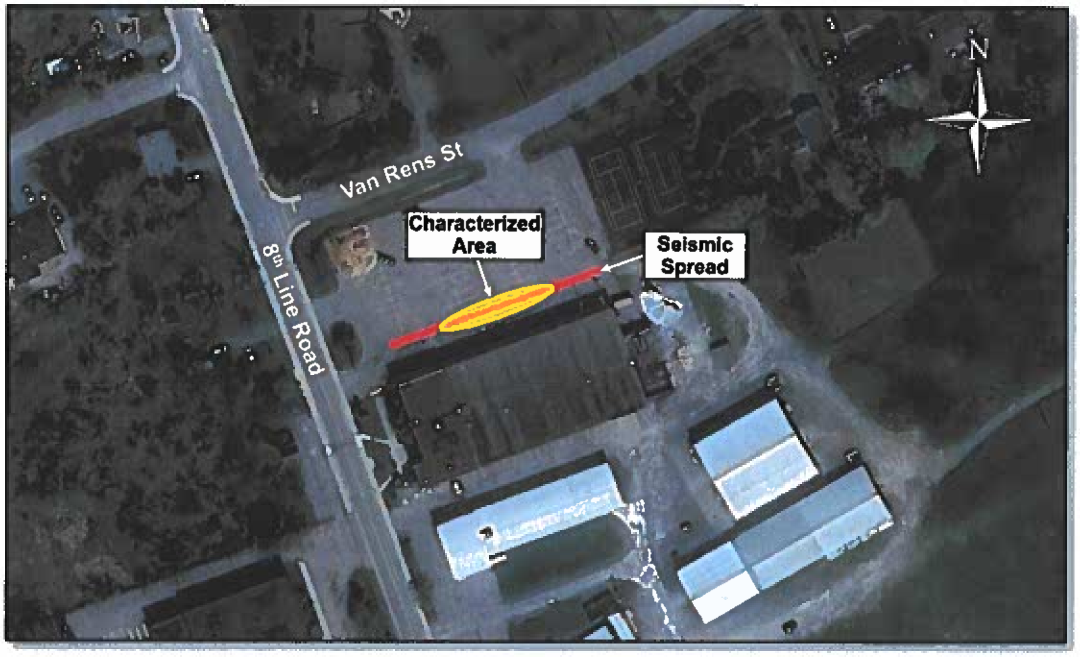


Figure 2: Location of the seismic spreads
(source: *Google Earth™*)

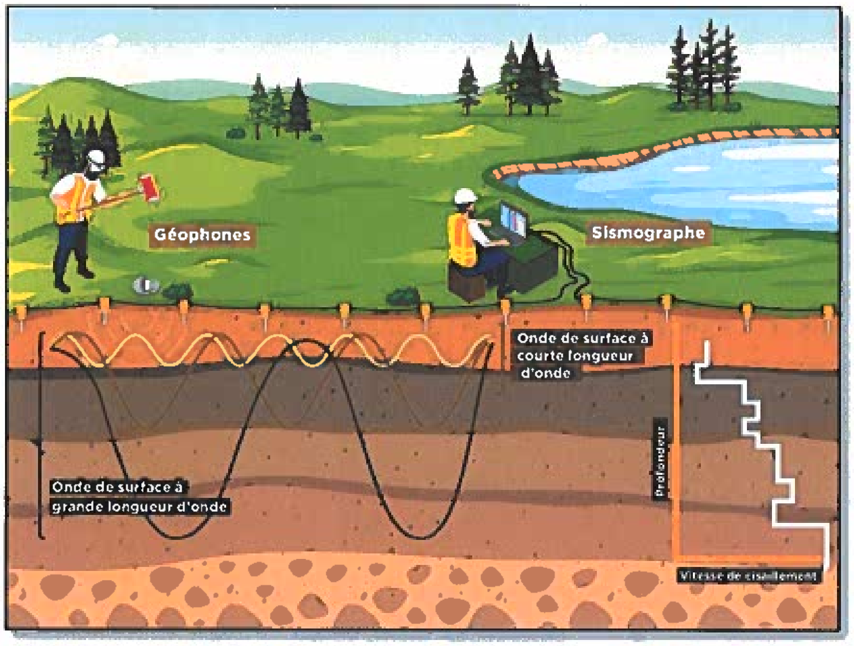
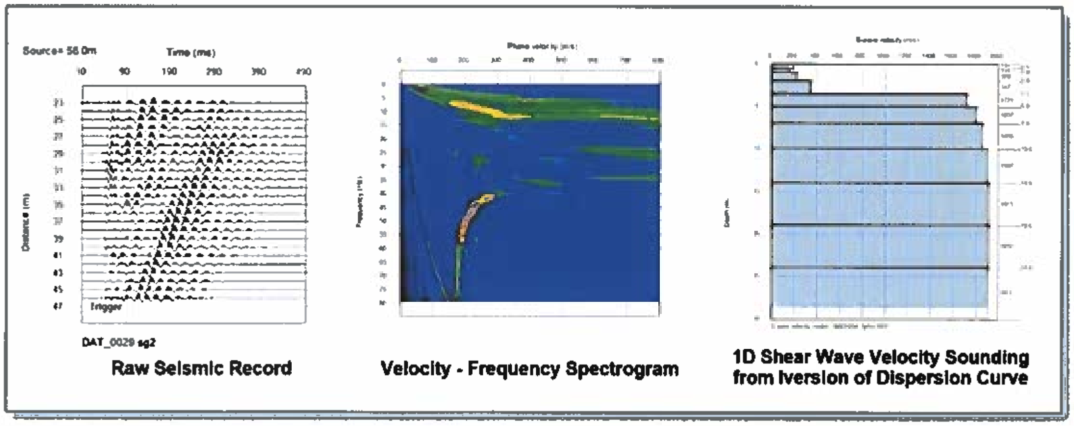


Figure 3: MASW Operating Principle



Raw Seismic Record

Velocity - Frequency Spectrogram

1D Shear Wave Velocity Sounding from Iversion of Dispersion Curve

Figure 4: Example of a MASW/SPAC record, Phase Velocity - Frequency curve of the Rayleigh wave and resulting 1D Shear Wave Velocity Model

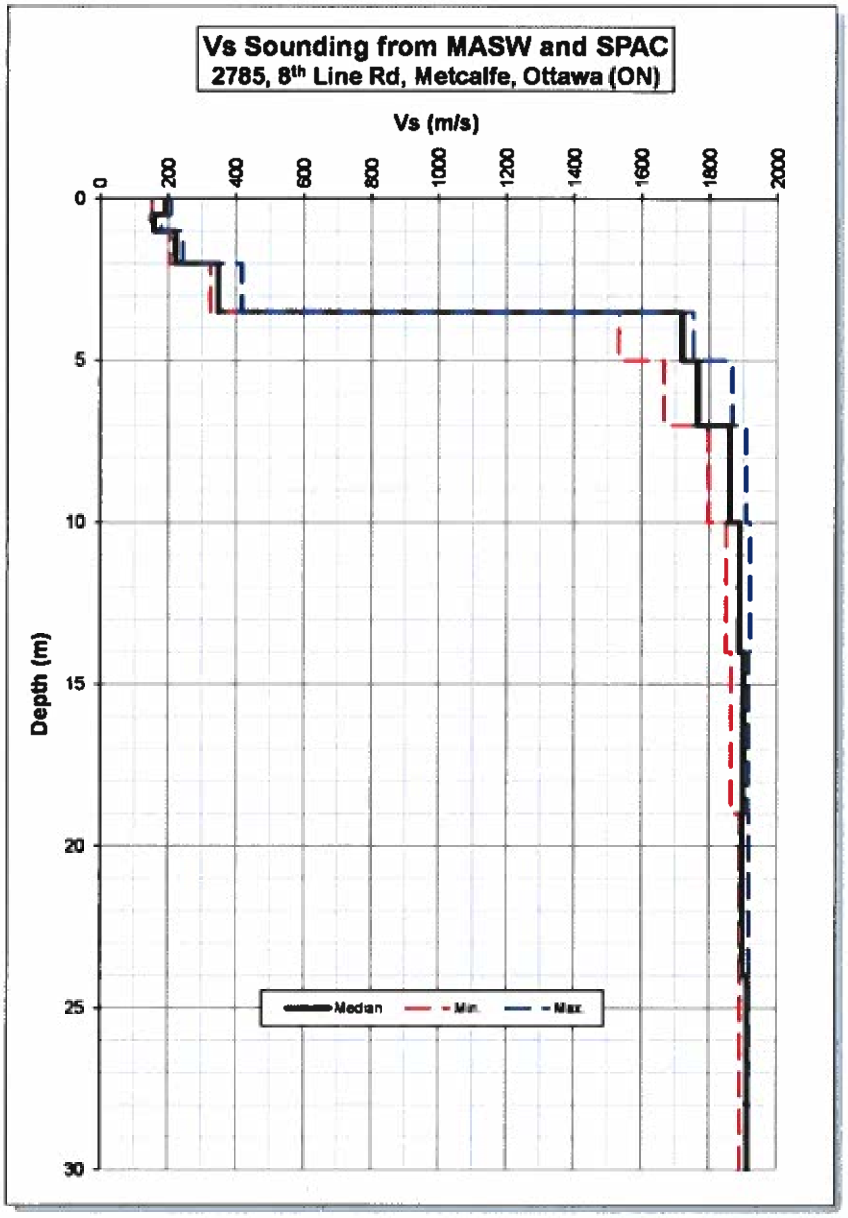


Figure 5: MASW Shear-Wave Velocity Sounding

TABLE 1

V_{S30} Calculation for the Site Class (actual site)

Depth	Vs			Thickness	Cumulative Thickness	Delay for med. Vs	Cumulative Delay	Vs at given Depth
	Min.	Median	Max.					
(m)	(m/s)	(m/s)	(m/s)	(m)	(m)	(s)	(s)	(m/s)
0	**151.2**	191.6	208.3	**Grade Level (February 2nd, 2024)**				
0.5	**147.2**	**158.0**	**178.7**	0.50	0.50	0.002610	0.002610	191.6
1.0	204.5	221.1	241.9	0.50	1.00	0.003165	0.005775	173.2
2.0	324.9	347.5	417.0	1.00	2.00	0.004524	0.010298	194.2
3.5	1534.2	1721.1	1753.3	1.50	3.50	0.004317	0.014615	239.5
5.0	1667.5	1765.1	1867.8	1.50	5.00	0.000872	0.015487	322.9
7.0	1798.5	1860.4	1909.1	2.00	7.00	0.001133	0.016620	421.2
10.0	1850.8	1889.3	1920.4	3.00	10.00	0.001613	0.018232	548.5
14.0	1865.6	1901.2	1915.3	4.00	14.00	0.002117	0.020350	688.0
19.0	1892.4	1897.4	1916.6	5.00	19.00	0.002630	0.022979	826.8
24.0	1892.1	1913.8	1917.3	5.00	24.00	0.002635	0.025615	937.0
30				6.00	30.00	0.003135	0.028750	1043.5

Vs30 (m/s)	**1043.5**
Class	**B (1)**

(1) The Site Classes A and B are not to be used if there is 3 metres or more of unconsolidated materials between the rock surface and the bottom of the spread footing or the mat foundation.

TABLE 2

V_{S30} * Calculation for the Site Class A

Depth	Vs			Thickness	Cumulative Thickness	Delay for med. Vs	Cumulative Delay	Vs at given Depth
	Min.	Median	Max.					
(m)	(m/s)	(m/s)	(m/s)	(m)	(m)	(s)	(s)	(m/s)
0	151.2	191.6	208.3	**Limit for the Site Class A (1.6 metres of soils)**				
0.5	147.2	158.0	178.7					
1.0	204.5	221.1	241.9					
1.9	204.5	221.1	241.9					
2.0	324.9	347.5	417.0	0.10	0.10	0.000452	0.000452	221.1
3.5	1534.2	1721.1	1753.3	1.50	1.60	0.004317	0.004769	335.5
5.0	1667.5	1765.1	1867.8	1.50	3.10	0.000872	0.005641	549.6
7.0	1798.5	1860.4	1909.1	2.00	5.10	0.001133	0.006774	752.9
10.0	1850.8	1889.3	1920.4	3.00	8.10	0.001613	0.008386	965.8
14.0	1865.6	1901.2	1915.3	4.00	12.10	0.002117	0.010504	1152.0
19.0	1892.4	1897.4	1916.6	5.00	17.10	0.002630	0.013133	1302.0
24.0	1892.1	1913.8	1917.3	5.00	22.10	0.002635	0.015769	1401.5
31.9				7.90	30.00	0.004128	0.019897	1507.8

Vs30 *	**1507.8**
Class	**A**

Appendix C –Laboratory Certificate of Analysis Report by AGAT

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: **Matthew Zammit**

PROJECT: **OTT-240000976-A0**

AGAT WORK ORDER: **24Z131429**

SOIL ANALYSIS REVIEWED BY: **Chuandi Zhang, Inorganic Supervisor**

DATE REPORTED: **Mar 27, 2024**

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

Disclaimer:

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Western Enviro-Agricultural Laboratory Association (WEALA)
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Certificate of Analysis

AGAT WORK ORDER: 24Z131429
PROJECT: OTT-240000976-A0

CLIENT NAME: EXP SERVICES INC
SAMPLING SITE:2785 8th Line Road, Ottawa

ATTENTION TO: Matthew Zammit
SAMPLED BY:EXP

(Soil) Inorganic Chemistry

DATE RECEIVED: 2024-03-19

DATE REPORTED: 2024-03-27

			SAMPLE DESCRIPTION:	BH3 SS4 6'-8'	BH5 Run 1 4'-4'3"
			SAMPLE TYPE:	Soil	Rock
			DATE SAMPLED:	2024-03-07	2024-03-07
Parameter	**Unit**	**G / S**	**RDL**	**5748601**	**5748602**
Chloride (2:1)	µg/g		2	295	55
Sulphate (2:1)	µg/g		2	46	50
pH (2:1)	pH Units		NA	9.45	8.81
Resistivity (2:1) (Calculated)	ohm.cm		1	847	3970

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

5748601-5748602 pH, Chloride and Sulphate were determined on the extract obtained from the 2:1 leaching procedure (2 parts DI water: 1 part soil). Resistivity is a calculated parameter.

Analysis performed at AGAT Toronto (unless marked by *)

Certified By:

Quality Assurance

CLIENT NAME: EXP SERVICES INC

PROJECT: OTT-240000976-A0

SAMPLING SITE:2785 8th Line Road, Ottawa

AGAT WORK ORDER: 24Z131429

ATTENTION TO: Matthew Zammit

SAMPLED BY:EXP

Soil Analysis

RPT Date: Mar 27, 2024			DUPLICATE			Method Blank	REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD		Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper
(Soil) Inorganic Chemistry															
Chloride (2:1)	5746129		10	10	NA	< 2	104%	70%	130%	97%	80%	120%	93%	70%	130%
Sulphate (2:1)	5746129		8	8	NA	< 2	96%	70%	130%	96%	80%	120%	94%	70%	130%
pH (2:1)	5753618		8.40	8.41	0.2%	NA	96%	80%	120%						

Comments: NA signifies Not Applicable.
pH duplicates QA acceptance criteria was met relative as stated in Table 5-15 of Analytical Protocol document.
Duplicate NA: results are under 5X the RDL and will not be calculated.

Certified By:

Method Summary

CLIENT NAME: EXP SERVICES INC **AGAT WORK ORDER: 24Z131429**

PROJECT: OTT-240000976-A0 **ATTENTION TO: Matthew Zammit**

SAMPLING SITE:2785 8th Line Road, Ottawa **SAMPLED BY:EXP**

PARAMETER	AGAT S.O.P	LITERATURE REFERENCE	ANALYTICAL TECHNIQUE
Soil Analysis			
Chloride (2:1)	INOR-93-6004	modified from SM 4110 B	ION CHROMATOGRAPH
Sulphate (2:1)	INOR-93-6004	modified from SM 4110 B	ION CHROMATOGRAPH
pH (2:1)	INOR 93-6031	modified from EPA 9045D and MCKEAGUE 3.11	PH METER
Resistivity (2:1) (Calculated)	INOR-93-6036	McKeague 4.12, SM 2510 B,SSA #5 Part 3	CALCULATION

AGAT Laboratories

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

Have feedback?
Scan here for a quick survey!

Laboratory Use Only

Work Order #: 24Z131429

Cooler Quantity: one-no ice/packs

Arrival Temperatures: 21.2 | 21.0 | 21.0
2.2 | 2.9 | 2.4

Custody Seal Intact: ☐Yes ☐No ☐N/A

Notes: bagged

Chain of Custody Record

If this is a Drinking Water sample, please use Drinking Water Chain of Custody Form (potable water consumed by humans)

Report Information:

Company: EXP Services Inc
Contact: Matthew Zammit
Address: 2650 Queensview Drive Unit 100, Ottawa, ON, K2B 8H6
Phone: 613-688-1891 Fax:
Reports to be sent to:
1. Email: matthew.zammit@exp.com
2. Email: jeff.macmillan@exp.com

Regulatory Requirements:

(Please check all applicable boxes)

☐ Regulation 153/04
Table ___ *Indicate One*
☐Ind/Com
☐Res/Park
☐Agriculture
Soil Texture *(Check One)*
☐Coarse
☐Fine

☐ Regulation 406
Table ___ *Indicate One*
☐ Regulation 558
☐ CCME

☐ Sewer Use
☐Sanitary ☐Storm
___ *Region*
☐ Prov. Water Quality Objectives (PWQO)
☐ Other
___ *Indicate One*

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-24000976-A0
Site Location: 2785 8th Line Road, Ottawa
Sampled By: EXP
AGAT Quote #: PO:
Please note: If quotation number is not provided, client will be billed full price for analysis.

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

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

Invoice Information:

Bill To Same: Yes ☑ No ☐

Company:
Contact:
Address:
Email:

Sample Matrix Legend

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

							O. Reg 153							O. Reg 558	O. Reg 406									
Sample Identification	Date Sampled	Time Sampled	# of Containers	Sample Matrix	Comments/ Special Instructions	Field Filtered - Metals, Hg, CrVI, DOC Y / N	Metals & Inorganics	Metals - ☐CrVI, ☐Hg, ☐HWSB	BTEX, F1-F4 PHCs	VOC	PAHs	PCBs	PCBs: Aroclors ☐	Landfill Disposal Characterization TCLP: TCLP: ☐M&I ☐VOCs ☐ABNs ☐B(a)P ☐PCBs	Regulation 406 SPLP Rainwater Leach SPLP: ☐Metals ☐VOCs ☐SVOCs	Regulation 406 Characterization Package pH, ICPMS Metals, BTEX, F1-F4	Corrosivity: ☐Moisture ☐ Sulphide	pH	Sulphate	Chloride	Resistivity			Potentially Hazardous or High Concentration (Y/N)
1. BH 3 SS4 6'-8'	March 7	AM PM	1	S														☑	☑	☑	☑			
2. BH 5 Run 1 4'-4'3"	March 7	AM PM	1	rock														☑	☑	☑	☑			
3.		AM PM																						
4.		AM PM																						
5.		AM PM																						
6.		AM PM																						
7.		AM PM																						
8.		AM PM																						
9.		AM PM																						
10.		AM PM																						
11.		AM PM																						

Samples Relinquished By (Print Name and Sign):	Date	Time	Samples Received By (Print Name and Sign):	Date	Time	
Jeff MacMillan	03/19/2024		C. Griffiths	03/19/24	15h20	
Ca to Duro	03/20/24	15h00		Mar 21	8:35 am	Page 1 of 1
						Nº:

Pink Copy - Client | Yellow Copy - AGAT | White Copy- AGAT

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