• Ottawa-Carleton District School Board

Geotechnical Investigation

Type of Document
Final

Project Name
Geotechnical Investigation
Proposed Additions and Renovation
Elmdale Public School
49 Iona Drive, Ottawa, Ontario

Project Number
OTT-00245378-F0

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Date Submitted
December 13, 2018

Ottawa-Carleton District School Board

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Executive Summary

EXP Services Inc. (EXP) is pleased to present the results of the geotechnical investigation completed for the proposed additions and renovation at Elmdale Public School located at 49 Iona Drive, Ottawa, ON. This work was completed under EXP Standing Offer Agreement with the Ottawa District School Board No. 18-007 and was authorized by Mr. David Hendrycks on September 14, 2018.

It is understood that the proposed additions and renovation at Elmdale Public School will include the following:

a) Demolition of the existing single storey library located on the west side of the existing school;

b) Construction of a two-storey slab on grade building addition at the location of the demolished library. The building addition will have an approximate building footprint of 22 m by 37 m. It is understood the floor slab of the building addition will match that of the existing school at Elevation 72.4 m;

c) A new structure will be constructed along the west side of the north wing of the existing school and will house a new elevator. It is understood that the underside of the foundation for the elevator will be at Elevation 66.1 m;

d) Expansion of the outdoor surface parking lot situated in the northwest corner of the school property; and

e) Complete renovation of the existing school building.

The fieldwork for this investigation was undertaken on October 5 and 27, 2018 and included the drilling of nine (9) boreholes (Borehole Nos. 1 to 9) to depths ranging from 1.2 m to 8.7 m below existing grade. The borehole information indicates the subsurface conditions consist of a surficial pavement structure and topsoil layer underlain by fill overlying stiff to hard clay followed by very stiff silty clay, very loose to compact silty sand till and limestone bedrock contacted at 6.1 m depth, Elevation 65.5 m. The groundwater level ranges from 3.1m to 4.4 m depths (Elevation 68.2 m to 67.3 m).

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

Based on a review of the borehole information from this investigation and the results from the Multi-channel Analysis of Surface Waves (MASW) survey, the site may be classified as **Class C** for seismic site response in accordance with Section 4.1.8.4 of the 2012 Ontario Building Code (OBC).

Based on the subsurface conditions a site grade raise up to 0.80 m is considered feasible at the site.

The geotechnical investigation has revealed that the geotechnical conditions are well suited for founding the proposed building addition and elevator on spread and strip footings. For the building addition, strip footings having a maximum width of 1.0 m and square pad footings having a maximum size of 2.5 m by 2.5 m set at a maximum depth defined as the top of the native clay contacted at 0.2 m to 1.1 m depths, (Elevation 71.1 m to 70.6 m) may be designed for a bearing pressure at Serviceability Limit State (SLS) of

125 kPa and factored geotechnical resistance at Ultimate Limit State (ULS) of 200 kPa. The SLS/ULS values are valid provided the grades at the site are not raised more than 0.8 m and the underside of the footings are founded on the surface of the native clay. The factored geotechnical resistance at ULS includes a geotechnical resistance factor of 0.5.

It is understood that the underside of the elevator will be set at Elevation 66.1 m and likely founded on limestone bedrock. Footings founded on competent, sound bedrock free of soil filled seams may be designed for a factored geotechnical resistance at Ultimate Limit State (ULS) of 500 kPa. The factored geotechnical resistance at ULS includes a geotechnical resistance factor of 0.5. The bearing pressure at Serviceability Limit State (SLS) of the 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.

Settlements of footings designed for the above recommended bearing pressure at SLS and factored geotechnical resistance at ULS and properly constructed are expected to be within normally tolerable limits.

The footings of the new building addition and elevator located immediately adjacent to the existing footings of the school building should be founded at the same level as the existing footings to eliminate the need for underpinning. This is subject to the confirmation that the founding soil and bedrock are capable of supporting the design SLS and ULS values noted above. It is recommended that test pits be conducted adjacent to the existing footings of the school building, located close to the proposed elevator, to determine the depth and founding material of the existing footings and to assess underpinning requirements of the existing footings.

New footings placed on soil at different elevations should be located such that the higher footings are set below a line drawn up at 10H:7V from the near edge of the lower footing. The lower footings should be constructed before the upper footings to prevent the latter from being undermined during subsequent construction.

The floor of the proposed school addition and the base slab of the proposed elevator may be designed as a slabs-on-grade. A perimeter drainage system is recommended to be installed as part of the proposed construction of the proposed building addition and elevator. Underfloor drains are required for the proposed elevator.

Excavations must be undertaken in accordance with the current Ontario Occupational Health and Safety Act (OHSA 213/91) and may be undertaken as open cut or within the confines of an engineered support system (shoring system) as discussed in the excavation section in the main body of the report.

Excavations above the groundwater may be dewatered by conventional sump pumping techniques. Excavations below the groundwater level and in the water bearing very loose to compact silty sand with gravel to silty sand till such as for the proposed elevator, are expected to be subject to ‘base heave’ since the deposit has very loose zones. Therefore, de-watering of these excavations are expected to be more problematic and may result in greater water seepage, loss of ground and disturbance of the soils. The dewatering may also cause settlement of the adjacent existing footings, if they are founded on the clay, silty clay and glacial till. Under these conditions and the concern for settlement of the existing adjacent footings, it is recommended that these excavations be undertaken within the confines of a shoring system that is also designed to act as a cut-off barrier to minimize de-watering of the site and the infiltration of groundwater into the excavation. In this regard, seepage of groundwater into the shored excavation should still be anticipated but may be removed by collecting the water at low points within the excavation and pumping from sumps.

It is anticipated that the majority of the material required for backfilling purposes will need to be imported and should conform to the recommendations of this report.

Pavement structures for the proposed parking lot extension are provided in Table No. VIII of the attached report.

The above and other related considerations are discussed in greater detail in the attached report.

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1 Introduction

EXP Services Inc. (EXP) is pleased to present the results of the geotechnical investigation completed for the proposed additions and renovations at Elmdale Public School located at 49 Iona Drive, Ottawa, ON. This work was completed under EXP Standing Offer Agreement with the Ottawa Carleton District School Board (OCDSB) No. 18-007 and was authorized by Mr. David Hendrycks of the OCDSB on September 14, 2018.

It is understood that the proposed additions and renovations at Elmdale Public School will include the following:

a) Demolition of the existing single storey library located on the west side of the existing school;

b) Construction of a two-storey slab on grade building addition at the location of the demolished library. The building addition will have an approximate building footprint of 22 m by 37 m. It is understood the floor slab of the building addition will match that of the existing school at Elevation 72.4 m;

c) A new structure will be constructed along the west side of the north wing of the existing school and will house a new elevator. It is understood that the underside of the foundation for the elevator will be at Elevation 66.1 m;

d) Expansion of the outdoor surface parking lot situated in the northwest corner of the school property; and

e) Complete renovation of the existing school building.

The geotechnical investigation was undertaken to:

a) Establish the subsurface soil/bedrock and groundwater conditions at the nine (9) borehole locations;

b) Comment on the potential of the subsurface soils to liquefy during a seismic event and classify the site for seismic response in accordance with the requirements of the 2012 Ontario Building Code (OBC);

c) Comment on grade-raise restrictions;

d) Make recommendations regarding the most suitable type of foundations, founding depth, bearing pressure at Serviceability Limit State (SLS) and factored geotechnical resistance at Ultimate Limit State (ULS) of the founding strata for the proposed building addition and elevator;

e) Discuss slab-on-grade construction and permanent drainage requirements;

f) Provide lateral earth pressure parameters for subsurface basement wall design;

g) Pipe bedding requirements for underground services;

h) Discuss excavations and dewatering requirements;

i) Comment on backfilling requirements and suitability of on-site soils for backfilling purposes;

j) Recommend pavement structures for the proposed parking lot expansion; and

k) Comment on subsurface concrete requirements for buried concrete structures/members and corrosion potential of subsurface soils to buried metal structures/members.

The comments and recommendations given in this report are based on the assumption that the above-described design concept will proceed into construction. If changes are made either in the design phase or during construction, this office must be retained to review these modifications. The 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 existing Elmdale Public School is located in the northwest corner of the Clarendon Avenue and Iona Street intersection in Ottawa, ON. The site location plan is shown in Figure 1.

The ground surface in the general vicinity of the location of the proposed school addition, elevator and parking lot expansion is relatively flat, ranging from Elevation 71.3 m to 72.6 m, as indicated by the elevations of the ground surface at the borehole locations.

3 Procedure

The fieldwork for this investigation was undertaken on October 5 and 27, 2018 and included the drilling of nine (9) boreholes (Borehole Nos. 1 to 9). Borehole Nos. 1 to 4 are located within and near the proposed building addition footprint, Borehole Nos. 5 and 6 are located near the proposed elevator footprint and Borehole Nos. 7 to 9 are located near the proposed parking lot expansion. Borehole Nos.1 to 6 for the proposed building addition and elevator were advanced to auger refusal and termination depths of 5.0 m to 8.7 m below existing grade. Borehole Nos. 7 to 9 for the proposed parking lot expansion were advanced to depths of 1.2 m to 1.4 m below existing grade. The fieldwork was supervised on a full-time basis by a representative from EXP. The borehole locations are shown on the Borehole Location Plan in Figure 2.

The borehole locations were identified on site by EXP. The coordinates of the boreholes and geodetic elevations of the ground surface at the boreholes were determined by Farley, Smith and Denis Surveying Ltd. (Ontario Land Surveyors).

Prior to drilling and sampling operations, the borehole locations were cleared of any public and private underground services by a local underground service locating company. The boreholes were advanced using a CME-55 truck mounted drill rig equipped with hollow-stem augers and conventional rock coring capabilities. An auger sample was retrieved from Borehole No. 3 from ground surface to a 0.6 m depth. Standard penetration tests were performed in all boreholes on a continuous basis to 1.5 m depth intervals with soil samples retrieved by the split-barrel sampler. A 2.7 m length of the bedrock was cored in Borehole No. 2 using an NQ-size core barrel. A careful record of any sudden drops of the drill rods, colour of wash water and wash water return was kept during the rock coring operation.

Water levels were measured in the open boreholes on completion of drilling operations. Standpipes consisting of 19 mm diameter polyvinyl chloride pipe (PVC) with slotted section were installed in Borehole Nos. 2, 4 and 6. The installation configuration is documented on the respective borehole logs. All boreholes were backfilled upon completion of the fieldwork.

All the soil samples were visually examined in the field for textural classification, logged, preserved in plastic bags and identified. Similarly, all the rock cores were visually examined, placed in core boxes, identified and logged. On completion of the fieldwork, all the soil samples and rock cores were transported to the EXP laboratory in the City of Ottawa, Ontario where they were visually examined in the laboratory by a geotechnical engineer and borehole logs prepared. The engineer also assigned the laboratory testing which consisted of the following tests on selected soil samples and rock cores. The natural moisture content, unit weight, grain size analysis and Atterberg limit determination were conducted in accordance with the American Society for Testing and Materials (ASTM). The testing procedure for the corrosion analysis package is documented in the Laboratory Certificate of Analysis shown in Appendix B.

Natural Moisture Content	50 tests
Natural Unit Weight	15 tests
Grain-Size Analysis	6 tests

Atterberg Limits	6 tests
Corrosion Analysis Package (pH, sulphates, chlorides and resistivity)	2 tests

A Multi-channel Analysis of Surface Waves (MASW) survey was conducted on November 26, 2018 by Geophysics GPR International Inc. The purpose of the MASW survey was to determine the site classification for seismic site response and the shear wave velocity of the on-site soils.

4 Subsurface Conditions and Groundwater Levels

A detailed description of the geotechnical conditions encountered in the boreholes is given on the attached Borehole Logs, Figure Nos. 3 to 11 inclusive. The Borehole Logs and related information depict subsurface conditions only at the specific locations and times indicated. Subsurface conditions and water levels at other locations may differ from conditions at the 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.

Boreholes were drilled to provide representation of subsurface conditions as part of a geotechnical exploration program and are not intended to provide evidence of potential environmental conditions.

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

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

4.1 Pavement Structure/Topsoil

Borehole Nos. 1, 2 and 5 to 7 are located in paved areas. The pavement structure consists of 30 mm to 40 mm thick asphaltic concrete underlain by 125 mm and 175 mm thick crushed gravel. In Borehole No. 2, the pavement structure consists of 40 mm asphaltic concrete underlain by 75 mm thick crushed gravel followed by 25 mm thick asphaltic concrete layer. In Borehole No. 5, the 35 mm thick asphaltic concrete is underlain by 50 mm thick sand and gravel layer followed by a 100 mm thick crushed gravel layer underlain by a geotextile membrane. The pavement structure in Borehole No. 6 is underlain by a geotextile membrane.

Borehole No. 9 is located in a landscaped area and the surficial topsoil layer is 150 mm thick.

4.2 Fill

Fill was encountered at ground surface in Borehole Nos. 3, 4 and 8 and beneath the pavement structure and topsoil in Borehole Nos. 1, 2 and 9. The fill extends to depths of 0.6 m to 1.1 m (Elevation 71.9 m to 70.6 m). The fill consists of silty sand to silt sand with gravel. The fill in Borehole No. 7 contain asphalt debris and roots. Based on the standard penetration test (SPT) N-values of 4 and 7, the fill is in a loose state. The natural moisture content of the fill is 7 percent to 13 percent.

4.3 Clay

The pavement structure and fill in all nine (9) boreholes are underlain by native clay contacted at 0.2 m to 1.1 m depths (Elevation 71.9 m to 70.6 m). The native clay extends to depths ranging from 2.2 m to 3.6 m (Elevation 69.5 m to 67.5 m). Based on undrained shear strength measurements of 80 kPa to 240 kPa, the clay has a stiff to hard consistency. Based on sensitivity values of 5.0 to 6.3, the clay may be described as being sensitive. The natural moisture content of the clay is 32 percent to 55 percent. The natural unit weight of the clay is 16.3 kN/m^3 to 18.4 kN/m^3.

The results of the grain-size analysis and Atterberg limit determination are summarized in Tables I and II, respectively. The grain size distribution curves are shown in Figures 12 and 13.

Table I: Summary of Results from Grain-size Analysis – Clay Samples

Borehole No. - Sample No.	Depth (m)	Grain-size Analysis (%)		
		Gravel	Sand	Fines
BH1-SS2	1.5 - 2.1	0	1	99
BH4-SS3	1.5 - 2.1	0	1	99

Table II: Summary of Atterberg Limit Results – Clay Samples

Borehole No. - Sample No.	Depth (Elevation) (m)	Atterberg Limit Results (%)			
		W_n	LL	PL	PI
BH1-SS2	1.5 - 2.1	49	69	30	39
BH4-SS3	1.5 - 2.1	32	67	28	39

W$_n$: Natural Moisture Content; **LL**: Liquid Limit; **PL:** Plastic Limit; **PI**: Plasticity Index

(1): Refer to Casagrande Plasticity Chart (1932).

Based on the results of the grain-size analysis and Atterberg limit determination, the soil may be classified as a clay of high plasticity (CH) in accordance with the Unified Soil Classification System(USCS).

4.4 Silty Clay

A silty clay was contacted beneath the clay in Borehole Nos. 2 and 3 at 2.2 m and 3.2 m depths (Elevation 69.5 m and 68.5 m) and extends to depths of 3.7 m and 4.5 m (Elevation 68.0 m and 67.2 m). The undrained shear strength measurements from in-situ vane tests of greater than 120 kPa and 175 kPa indicate the silty clay has a very stiff consistency. The sensitivity value of the silty clay is 5.8 indicating the silty clay is sensitive. The natural moisture content of the silty clay is 44 percent to 58 percent.

The results of the grain-size analysis and Atterberg limit determination are summarized in Tables III and IV, respectively. The grain size distribution curve is shown in Figure 14.

Table III: Summary of Results from Grain-size Analysis – Clay Samples

Borehole No. - Sample No.	Depth (m)	Grain-size Analysis (%)		
		Gravel	Sand	Fines
BH2-SS6	3.8 – 4.4	0	12	88

Table IV: Summary of Atterberg Limit Results – Clay Samples

Borehole No. - Sample No.	Depth (Elevation) (m)	Atterberg Limit Results (%)			
		w_n	LL	PL	PI
BH2-SS6	3.8 – 4.4	53	40	18	22

W$_n$: Natural Moisture Content; **LL**: Liquid Limit; **PL:** Plastic Limit; **PI**: Plasticity Index

$^{(1)}$: Refer to Casagrande Plasticity Chart (1932).

Based on the results of the grain-size analysis and Atterberg limit determination, the soil may be classified as a silty clay of medium plasticity (CL) in accordance with the Unified Soil Classification System(USCS).

4.5 Glacial Till

The clay and silty clay in Borehole Nos. 1 to 6 are underlain by glacial till contacted at 2.7 m to 4.5 m depths (Elevation 69.2 m to 66.4 m). The glacial till extends to 6.1 m depth (Elevation 65.5 m) in Borehole No. 2. The glacial till may contain cobbles and boulders. Based on the N-values 2 to 17, the glacial till is in a very loose to compact state. Based on the dynamic cone penetration results in Borehole No. 1, glacial till is inferred from 5.2 m to cone refusal depth of 6.0 m (Elevation 66.4 m to 65.6 m). The natural moisture content of the glacial till ranges from 9 percent to 24 percent.

The results of the grain-size analysis conducted on three (3) samples of the glacial till are summarized in Table V. The grain-size distribution curves are shown in Figures 15 to 17.

Table V: Summary of Results from Grain-size Analysis – Glacial Till Samples

Borehole No. - Sample No.	Depth (m)	Grain-size Analysis (%)		
		Gravel	Sand	Fines
BH 1 – SS4	3.8 – 4.4	7	44	49
BH 2 – SS7	4.6 – 5.2	16	37	47
BH 3 – SS7	4.6 – 5.2	12	42	46

Based on the results of the grain-size analysis, the glacial till may be classified as silty sand with gravel (SM) to silty sand (SM) in accordance with the Unified Soil Classification System(USCS). As previously noted, the glacial till may contain cobbles and boulders.

4.6 Limestone Bedrock

Based on auger refusal criterion, boulders or bedrock are inferred in Borehole Nos. 1 and 3 to 6 at 5.0 m to 6.1 m depths (Elevation 66.1 m to 65.3 m). The presence of bedrock was proven in Borehole No. 2 by coring the bedrock from 6.1 m to 8.7 m depths (Elevation 65.5m to 63.0 m). A review of published geology map indicate the bedrock is limestone (with shaley partings) of the Ottawa formation.

A review of the rock cores indicates a Total Core Recovery (TCR) of 100 percent and Rock Quality Designation (RQD) of 67 percent and 87 percent. Based on the RQD values, the rock may be described as having a fair to good quality.

Photographs of the bedrock cores are shown in Figure 18.

4.7 Groundwater

Groundwater level observations were made in the boreholes during drilling and in the standpipes installed in boreholes subsequent to the completion of drilling operations. The recent groundwater level measurements made in the standpipes are summarized in Table VI.

Table VI: Summary of Groundwater Levels in Boreholes

Borehole No.	Ground Surface Elevation (m)	Drill Date	Date of Groundwater Level Measurement (Number of Days After Drilling)	Depth of Groundwater Level (m)	Elevation of Groundwater Level (m)
BH 2	71.72	October 5, 2018	November 5, 2018 (31 days)	4.4	67.3
BH 4	71.87	October 5, 2018	November 5, 2018 (31 days)	4.1	67.8
BH 6	71.28	October 27, 2018	November 5, 2018 (9 days)	3.1	68.2

The groundwater levels range from 3.1 m to 4.4 m depths (Elevation 68.2 m to 67.3 m). The groundwater level may not have stabilized and may not be representative of the actual groundwater level. Therefore, it is recommended that an additional set of groundwater level measurements be undertaken prior to tendering.

Water levels were determined in the boreholes at the times and under the conditions stated in the scope of services. 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.

5 Liquefaction Potential and Seismic Site Classification

5.1 Liquefaction Potential

The borehole information indicates the subsurface conditions consist of a surficial pavement structure and topsoil layer underlain by fill overlying stiff to hard clay followed by very stiff silty clay, very loose to compact silty sand till an limestone bedrock. The groundwater level ranges from 3.1m to 4.4 m depths (Elevation 68.2 m to 67.3 m).

The native soils consisting of clay, silty clay and glacial till were evaluated for their potential to liquefy during a seismic event. The plasticity index and the moisture content/liquid limit ratio of the fine-grained soils comprising of the clay and silty clay were plotted on the chart titled, Criteria for Liquefaction Assessment of Fine Grained Soils," Bray et al. 2004. The chart is shown in Figure 19. A review of the chart indicates the clay and silty clay are not susceptible to liquefaction during a seismic event.

The clay and silty clay in Borehole Nos. 1 to 6 are underlain by glacial till contacted at 2.7 m to 4.5 m depths (Elevation 69.2 m to 66.4 m). The glacial till extends to 6.1 m depth (Elevation 65.5 m) in Borehole No. 2. The glacial till may contain cobbles and boulders. Based on the N-values 2 to 17, the glacial till is in a very loose to compact state. The loose zone (N-values from SPT of 2 to 7) of the silty sand to silty sand with gravel till at 3.1 m to 5.9 m depths (Elevation 68.8 m to 65.8 m) may have a potential to liquefy during a seismic event. An MASW survey was conducted at the site to assess the liquefaction potential of the glacial till. The MASW survey report is shown in Appendix A. The findings from the MASW survey did not indicate the presence of any deep seated loose soils (shear velocity value (V_s) less than 200 m/s) within the 3.1 m to 5.9 m depth range. Therefore, the glacial till is not considered to be liquefiable during a seismic event. The low N-values may be attributed to possible disturbance of the soil during drilling and sampling operations.

In conclusion, the clay, silty clay and underlying glacial till are not considered to be liquefiable during a seismic event.

5.2 Seismic Site Classification

The MASW survey report indicates the average shear wave velocity to a 30 m depth is 846 m/s, which is within the range of average soil shear wave velocity for a seismic site classification of **Class B** in accordance with Table 4.1.8.4 A of the 2012 Ontario Building Code (OBC). However, Class B requires less than 3.0 m of overburden (soil) between the underside of the foundation and the bedrock. It is recommended that the building addition be supported by footings founded on top of the native clay surface. In this case, the clearance between the underside of the footing and the top of the bedrock will exceed the 3.0 m clearance and therefore, the seismic classification for the site is **Class C**.

6 Grade Raise Restrictions

The floor slab of the ground floor of the proposed school addition is anticipated to match that of the existing building at Elevation 72.4 m. Based on the ground surface elevations of the boreholes located in the vicinity of the proposed school addition, the anticipated maximum site grade raise is expected to be in the order of 0.8 m.

Based on a review of the findings from the boreholes, it is considered that a site grade raise up to 0.8 m is considered acceptable in combination with the foundation considerations presented in Section 8 of this report.

7 Site Grading

As part of the site preparation, the site grading within the footprint of the proposed building addition and parking lot expansion should consist of the excavation and removal of all topsoil, pavement structure, fill and any organic stained soils from the site; ie. to the surface of the native silty clay/clay. Any soft/loose areas identified in the interior of the building addition footprint should be excavated and replaced with Ontario Provincial Standard Specification (OPSS 1010 as amended by SSP110S13) Granular B Type II compacted to 98 percent standard Proctor maximum dry density in accordance with ASTM D-698-12e2 (SPMDD).

It may be possible to leave some of the existing fill in-place in the proposed parking lot expansion area only, pending further evaluation in the field during construction. For budgeting purposes, the contractor should assume that all the existing fill material will be required to be removed and replaced with imported granular material from the areas of the proposed building addition and parking lot expansion.

Following approval of the exposed subgrade within the proposed building addition area, the grades may be raised to the underside of the clear stone layer beneath the floor slab by the placement of engineered fill consisting of OPSS 1010 Granular B Type II (50 mm minus) placed in 300 mm thick lifts and each lift compacted to 98 percent of the SPMDD.

For the proposed parking lot expansion area, the site grades may be raised to the design subgrade level by the placement of OPSS 1010 select site material (SSM) compacted to 95 percent of the SPMDD.

In-place density tests should be performed on each lift of placed material to ensure that it has been compacted to the project specifications.

8 Foundation Considerations

It is our understanding that the ground floor of the school addition will match that of the existing school building at Elevation 72.4 m. It is further understood that the underside of the foundation of the proposed elevator will be set at Elevation 66.1 m.

The borehole information indicates the subsurface conditions consist of a surficial pavement structure and topsoil layer underlain by fill overlying stiff to hard clay followed by very stiff silty clay, very loose to compact silty sand till and limestone bedrock. The groundwater level ranges from 3.1m to 4.4 m depths (Elevation 68.2 m to 67.3 m).

Based on a review of the borehole information and the results from the MASW survey, the subsurface conditions are considered suitable for supporting the proposed building addition on footings designed to bear on the surface of the native clay and supporting the proposed elevator by footings set on the limestone bedrock.

8.1 Proposed Building Addition

Strip footings having a maximum width of 1.0 m and square pad footings having a maximum size of 2.5 m by 2.5 m, set at a maximum depth defined as the top of the native clay contacted at 0.2 m to 1.1 m depths, (Elevation 71.1 m to 70.6 m) may be designed for a bearing pressure at Serviceability Limit State (SLS) of 125 kPa and factored geotechnical resistance at Ultimate Limit State (ULS) of 200 kPa. The SLS/ULS values are valid provided the grades at the site are not raised more than 0.8 m and the underside of the footings are founded on the surface of the native clay. The SLS value assumes the sustained loads are equal to 1.0(Dead Load) + 0.5(Live Load) + 0.5(Snow Load). The factored geotechnical resistance at ULS includes a geotechnical resistance factor of 0.5. If the footing size and founding depth vary from those noted above, EXP should be contacted to provide SLS and ULS values.

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

A minimum of 1.5 m of earth cover should be provided to the footings of a heated structure to protect them from damage due to frost action. The frost cover should be increased to 2.1 m for unheated structures if snow will not be removed from their vicinity. If snow will be removed from the vicinity of the unheated structures, the frost cover should be increased to 2.4 m. In addition, it is recommended that 100 mm thick HI-40 insulation should be placed at entrances and doors of the proposed building addition and elevator (if applicable) extending a distance of 2.4 m from the edge of the structure to minimize differential frost heave during the freeze-thaw cycles.

8.2 Proposed Elevator

It is understood that the underside of the elevator will be set at Elevation 66.1 m. The auger refusal elevation occurred at Elevation 66.1 m and 66.0 m in Borehole Nos. 5 and 6 located near the proposed elevator. Limestone bedrock was found at Elevation 65.6 m in Borehole No. 2 located near the proposed building addition. Since the bedrock elevation in Borehole No. 2 is in close proximity to the auger refusal elevations in Borehole Nos. 5 and 6, it is considered that the elevator will likely be founded on limestone bedrock.

Footings founded on competent, sound bedrock free of soil filled seams may be designed for a factored geotechnical resistance at Ultimate Limit State (ULS) of 500 kPa. The factored geotechnical resistance at ULS includes a geotechnical resistance factor of 0.5. The bearing pressure at Serviceability Limit State (SLS) of the 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.

Settlements of footing designed for the above recommended factored geotechnical resistance at ULS and properly constructed are expected to be less than 10 mm.

8.3 Additional Foundation Comments

Review of available drawings indicate that the section of the existing school closest to the proposed addition does not have a basement, is supported by footings and the ground floor slab elevation is at Elevation 74.20 m. The footings of the new building addition located immediately adjacent to the existing footings of the school building should be founded at the same level as the existing footings to eliminate the need for underpinning. This is subject to the confirmation that the founding soil is capable of supporting the design SLS and ULS values noted above. If deeper excavation is required for new footings located adjacent to existing footings, underpinning of the existing footings may be required.

The west side of the north wing of the existing school, where the proposed elevator will be located, does have a basement with the basement floor slab at Elevation 68.16 m and as indicated on available drawings, is supported by footings set slightly below the slab. It is understood the foundation for the proposed elevator will be set at Elevation 66.1 m. Since the footings of the proposed elevator will be set deeper than the existing adjacent footings of the school building, it is anticipated that excavations for the proposed elevator will extend below the existing footings and underpinning of the existing footings will likely be required. It is recommended that test pits be conducted adjacent to the existing footings of the school building, located close to the proposed elevator, to determine the depth and founding material of the existing footings and to assess underpinning requirements of the existing footings.

New footings placed on soil at different elevations should be located such that the higher footings are set below a line drawn up at 10H:7V from the near edge of the lower footing. The lower footings should be constructed before the upper footings to prevent the latter from being undermined during subsequent construction.

All footing beds for the proposed building addition and elevator should be examined by a geotechnical engineer to ensure that the founding surfaces are capable of supporting the design bearing pressure and that the footing beds have been properly prepared.

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

9 Floor Slab Construction

Based on a review of the borehole information, the ground floor of the proposed building addition and the base slab of the elevator may be designed as a slabs-on-grade.

The slabs-on-grade may be set on a 200-mm thick bed of well compacted 19 mm clear stone placed on the engineered fill pad at least 300 mm thick constructed as recommended in Section 8 of the report; i.e. all fill and unsuitable material are removed and replaced with well compacted engineered fill. The clear stone would prevent the capillary rise of moisture from the sub-soil to the floor slab. Adequate saw cuts should be provided in the floor slab to control cracking.

It is recommended that a perimeter drainage system be provided for the proposed building addition and elevator. If a perimeter drainage system of the existing building is encountered during the construction of the building addition and elevator, it should be re-instated following construction. Underfloor drains should be provided for the base slab of the proposed elevator. Underfloor drains are not required for the floor slab of the building addition. The permanent drainage systems should be suitably outletted.

The finished floor of the proposed building addition should be set at least 150 mm higher than the surrounding finished exterior grade. The final grades should be sloped at an inclination of 2 percent to promote drainage of surface water away from the building addition.

10 Subsurface Walls

The subsurface walls of the proposed elevator should be backfilled with free draining material, such as OPSS 1010 Granular B Type II and equipped with a perimeter drainage system to prevent the buildup of hydrostatic pressure behind the walls. The walls will be subjected to lateral static and dynamic (seismic) earth forces. The expressions below assume free draining backfill material, a perimeter drainage system, level backfill surface behind the wall and vertical face on the back side of the wall.

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

$$P = K_0 \, h \, (½ \, \gamma h + q)$$

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

K_0 = lateral earth pressure coefficient for 'at rest' condition for Granular B Type II backfill material = 0.50

γ = unit weight of free draining granular backfill; Granular B Type II = 22 kN/m^3

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

q = surcharge load stress, kPa

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

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

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

H = height of wall, m

γ = unit weight of backfill material = 22 kN/m^3

$\frac{a_h}{g}$ = seismic coefficient = 0.32

F_b = thrust factor = 1.0

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

All subsurface walls should be properly waterproofed.

If the test pits along the existing footings of the school building, near the proposed elevator location, reveal that the existing footings are founded on the clay, silty clay or glacial till, there is a potential for these footings to settle due to dewatering from the permanent drainage systems of the adjacent proposed elevator. In this case, the elevator would have to be designed as a water-tight structure with the groundwater level assumed at the ground surface for design purposes. In this regard, EXP should be contacted to provide comments for the water tight structure.

11 Pipe Bedding Requirements

The maximum invert depth of the underground services are assumed to be at 2.4 m below existing grade. The borehole information indicates the subgrade at this invert depth is anticipated to consist of clay and silty clay.

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

Due to the presence of the clay, it is recommended the pipe bedding consist of 300 mm thick OPSS 1010 Granular B Type II sub-bedding material overlain by 150 mm thick OPSS 1010 Granular A bedding material. The bedding and surround materials should be compacted to at least 95 percent SPMDD.

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

12 Excavations and De-Watering Requirements

Excavations for the proposed building addition, parking lot expansion and underground service installation are expected to extend to an approximate 3.0 m depth below existing grade. The excavation for the elevator is anticipated to extend to an approximate 5.0 m depth below existing grade. The excavations are anticipated to be approximately 2.0 m below the groundwater level.

Excavation of the soil may be undertaken using conventional heavy equipment capable of removing debris within the fill and cobbles and boulders within the glacial till.

For the proposed elevator, excavations into the bedrock are anticipated to extend to shallow depths below the bedrock surface and will likely require hoe ramming for the removal of small quantities of bedrock; however, this process is expected to be very slow.

Excavations may be undertaken as open cut provided they meet the requirements of the current Ontario Occupational Health and Safety Act (OHSA 213/91). In accordance with the definitions provided in OHSA, the soils to be excavated are considered to be Type 3 and the excavation side slopes must be cut back at 1H:1V from the bottom of the excavation above the groundwater. Within zones of persistent seepage and below the groundwater level in the soils, the excavation side slopes are expected to slough and eventually stabilize at a slope of 2H:1V to 3H:1V. If the above side slopes cannot be achieved due to space restrictions on site, the excavation would have to be undertaken within the confines of an engineered support system and for underground service installation, within the confines of a prefabricated support system (such as trench box).

Excavations within the bedrock may be undertaken with near vertical sides subject to review by a geotechnical engineer.

Excavations above the groundwater may be dewatered by conventional sump pumping techniques. Excavations below the groundwater level and in the water bearing very loose to compact silty sand with gravel to silty sand till such as for the proposed elevator, are expected to be subject to ‘base heave’ since the deposit has very loose zones. Therefore, de-watering of these excavations are expected to be more problematic and may result in greater water seepage, loss of ground and disturbance of the soils. The dewatering may also cause settlement of the adjacent existing footings, if they are founded on the clay, silty clay and glacial till. Under these conditions and the concern for settlement of adjacent existing footings, it is recommended that these excavations should be undertaken within the confines of a shoring system that is also designed to act as a cut-off barrier to minimize de-watering of the site and the infiltration of groundwater into the excavation. In this regard, seepage of groundwater into the shored excavation should still be anticipated but may be removed by collecting the water at low points within the excavation and pumping from sumps.

Extra care should be exercised during excavation close to the existing building to prevent undermining any of the existing footings. Test pits conducted along the existing building at the location of the proposed building addition and elevator may assist in determining the depths and founding material of the existing footings as well as underpinning and shoring requirements.

It is recommended a preconstruction survey of the existing school building be undertaken prior to start of the construction of the proposed building addition and elevator.

It has been assumed that the maximum excavation depth at the site will be up to 5.0 m and would necessitate groundwater removal from the site. It is noteworthy to mention that new legislation came into force in Ontario on March 29, 2016 to regulate groundwater takings for construction dewatering purposes. Prior to March 29, 2016, a Category 2 Permit to Take Water (PTTW) was required from the Ontario Ministry of the Environment and Climate Change (MOECC) for groundwater takings related to construction dewatering, where taking volumes in excess of 50 m^3/day, but less than 400 m^3/day, and the taking duration was no more than 30 consecutive days. The new legislation replaces the Category 2 PTTW for construction dewatering with a new process under the Environmental Activity and Sector Registry (EASR). The EASR is an on-line registry, which allows persons engaged in prescribed activities, such as water takings, to register with the MOECC instead of applying for a PTTW.

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

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.

Although this investigation has estimated the groundwater levels at the time of the field work, and commented on de-watering and general construction problems, conditions may be present that are difficult to establish from standard boring techniques. These conditions may affect the type and nature of de-watering procedures used by the contractor. 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 de-watering systems.

13 Backfilling Requirements and Suitability of On-Site Soils for Backfilling Purposes

The soils to be excavated from the site will comprise topsoil, gravel and silty sand fill, clay, silty clay and silty sand with gravel to silty sand till. From a geotechnical perspective, these soils are not considered suitable for reuse as backfill material in the interior or exterior of the building. It may be possible to use the dry portion of the silty clay/clay soil from the upper 1.0 to 2.0 m as backfill of the service trenches outside the building. However, these soils are subject to moisture absorption due to precipitation and must be protected at all time from the elements. Some of the other soils excavated may be also used as fill in the landscaped areas of the site only.

Therefore, it is anticipated that the majority of the material required for backfilling purposes in the interior and exterior of the proposed building addition, elevator and in the service trenches will need to be imported and should preferably conform to the following specifications.

- Engineered fill, underfloor fill including backfilling in service trenches inside the building - OPSS 1010 (as amended by SSP110S13) for Granular B Type II (50 mm minus) placed in 300 mm thick lifts with each lift compacted to 98 percent SPMDD beneath the floor slab;
- Backfill against exterior subsurface walls - OPSS 1010 Granular B Type II placed in 300 mm thick lifts and compacted to 95 percent SPMDD;
- Trench backfill outside building area, and fill placement to subgrade level for pavement - OPSS 1010 Select Subgrade Material (SSM), free of organics, debris and with a natural moisture content within 2 percent of the optimum moisture content. It should be placed in 300 mm thick lifts compacted to minimum 95 percent SPMDD; and
- Landscaped areas - Clean fill that is free of organics and deleterious material and is placed in 300 mm thick lifts with each lift compacted to 92 percent of the SPMDD.

To minimize settlement of the pavement structure over services trenches, the trench backfill material within the frost zone, to 1.8 m depth below final grade, should match the existing material along the trench walls to minimize differential frost heaving of the subgrade soil, provided this material is compactible. Otherwise, frost tapers may be required.

14 Subsurface Concrete Requirements

Chemical tests limited to pH, sulphate, chloride and electrical conductivity (resistivity) were undertaken on two (2) selected soil samples and the results are shown in Table VII. The laboratory certificate of analysis showing the test results is provided in Appendix B.

Table VII: Results of pH, Chloride, Sulphate and Resistivity Tests on Selected Soil Samples

Borehole No. - Sample No.	Soil	Depth (m)	pH	Sulphate (%)	Chloride (%)	Resistivity (ohm.cm)
Threshold Values			**<5**	**>0.1**	**>0.04**	**<1500 ohm.cm Corrosive**
BH1 – SS1	Clay	0.8 – 1.4	7.40	0.0216	0.0146	2100
BH3 – SS3	Clay	1.5 – 2.1	7.62	0.0027	0.0055	6560

The results indicate a soil with a sulphate and chloride content of less than 0.1 percent and 0.04 percent respectively. These concentrations of sulphate and chloride in the soil would have a negligible potential of sulphate and chloride attack on subsurface concrete. The concrete should be in accordance with Table Nos. 3 and 6 of CSA A.23.1-14. However, the concrete should be dense, well compacted and cured.

The results of the resistivity tests indicate that the soil is mildly to moderately corrosive to bare steel. The test results should be taken into consideration for metal connections of the watermain. A corrosion expert should be contacted to provide corrosion protection recommendations.

15 Pavement Structure

Pavement structure thicknesses required for the parking lot expansion were computed and are shown on Table VIII. The thicknesses are based upon an estimate of the subgrade soil properties determined from visual examination and textural classification of the soil samples and pavement functional design life of 8 to 10 years. The proposed functional design life represents the number of years to the first rehabilitation, assuming regular maintenance is carried out. The subgrade in the proposed pavement parking lot expansion area is anticipated to consist of silty sand with gravel fill, native clay and select subgrade material (SSM).

Table VIII: Recommended Pavement Structure Thicknesses for Light and Heavy-Duty Traffic

Pavement Layer	**Compaction Requirements**	**Computed Pavement Structure**	
		Light Duty Traffic (Cars)	**Heavy Duty traffic (Trucks)**
Asphaltic Concrete (PG 58-34)	92-97% Maximum Relative Density (MRD)	65 mm SC	40 mm SC 50 mm BC
OPSS Granular A Base (crushed limestone)	100% SPMDD(1)	150 mm	150 mm
OPSS Granular B Type II Sub-base	100% SPMDD(1)	300 mm	450 mm

Notes:
1. SPMDD denotes standard Proctor maximum dry density, ASTM, D-698
2. Any subgrade fill must be compacted to 98% SPMDD for at least the upper 300 mm
3. SC Denotes Surface course asphalt and may comprise of Superpave OPSS 1151 SP 12.5 mm Mix (Category B)
4. BC Denotes Base course asphalt and may comprise of Superpave OPSS 1151 SP 19 mm Mix (Category B

The foregoing design assumes that construction is carried out during dry periods and that the subgrade is stable under the load of construction equipment. If construction is carried out during wet weather, and heaving or rolling of the subgrade is experienced, additional thickness of granular material and/or geotextile may be required.

Additional comments on the construction of the parking lot expansion areas are as follows:

1. As part of the subgrade preparation, the proposed pavement areas should be stripped of topsoil, pavement structure and other obviously unsuitable material. Fill required to raise the grades to design subgrade level should conform to requirement as per Section 8 and should be placed and compacted to 95 percent of the SPMDD. The subgrade should be properly shaped, crowned, then proofrolled with a heavy vibratory roller in the full-time presence of a representative of this office. Any soft or spongy subgrade areas detected should be sub excavated and properly replaced with suitable approved backfill compacted to 95 percent SPMDD (ASTM D698-12e2).

2. The long-term performance of the pavement structure is highly dependent upon the subgrade support conditions. Stringent construction control procedures should be maintained to ensure that uniform subgrade moisture and density conditions are achieved. The need for adequate drainage cannot be over-emphasized. Subdrains should be installed on both sides of the access road(s). Subdrains must be installed in the proposed parking area at low points and should be continuous between catchbasins to intercept excess surface and subsurface moisture and to prevent subgrade softening. This will ensure no water collects in the granular course, which could result in pavement failure during the spring thaw. The location and extent of subdrainage required within the paved areas should be reviewed by this office in conjunction with the proposed site grading.

3. To minimize the problems of differential movement between the pavement and catchbasins/manhole due to frost action, the backfill around the structures should consist of free-draining granular preferably conforming to OPSS Granular B Type II material. Weep holes should be provided in the catchbasins/manholes to facilitate drainage of any water that may accumulate in the granular fill.

4. 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.

5. 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 used, and its placement should meet OPSS 1150 or 1151 requirements. It should be compacted to between 92 and 97 percent of the Maximum Relative Density (ASTM D2041). Asphalt placement should be in accordance with OPSS 310 and OPSS 313. It is recommended that EXP be retained to review the final pavement structure design and drainage plans prior to construction to ensure they are consistent with the recommendations of this report.

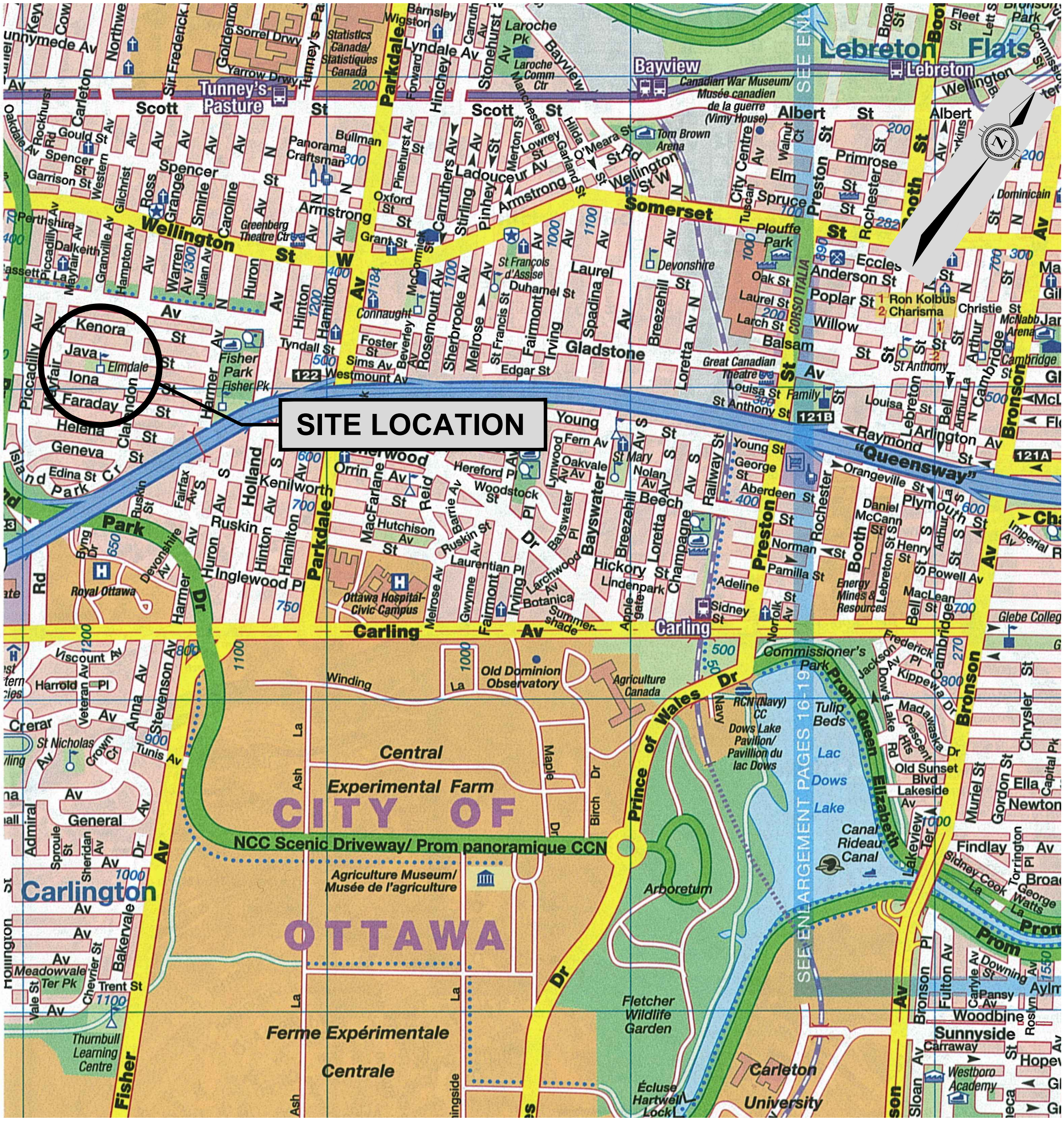
16 General Closure

The comments given in this report are intended only for the guidance of the design engineers. The number of boreholes required to determine the localized underground conditions between boreholes affecting construction costs, techniques, sequencing, equipment, scheduling, etc., would be much greater than has been carried out for design purposes. Contractors bidding on or undertaking the works should in this light, decide on their own investigations, as well as their own interpretation of the factual borehole results to 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 this report is satisfactory for your purposes. Should you have any questions, please do not hesitate to contact this office.

Figures



BACKGROUND MAP DATA © 2010,
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0 200m 400m 800m

HORIZONTAL 1:20,000

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scale
1:20,000

date
NOV. 2018

drawn by
M.N.

CLIENT:
OCDSB

TITLE:
SITE LOCATION PLAN
ELMDALE PUBLIC SCHOOL, PROPOSED ADDITIONS AND RENOVATION
49 IONA STREET, OTTAWA, ON

project no.
OTT-00245378-F0

FIG 1

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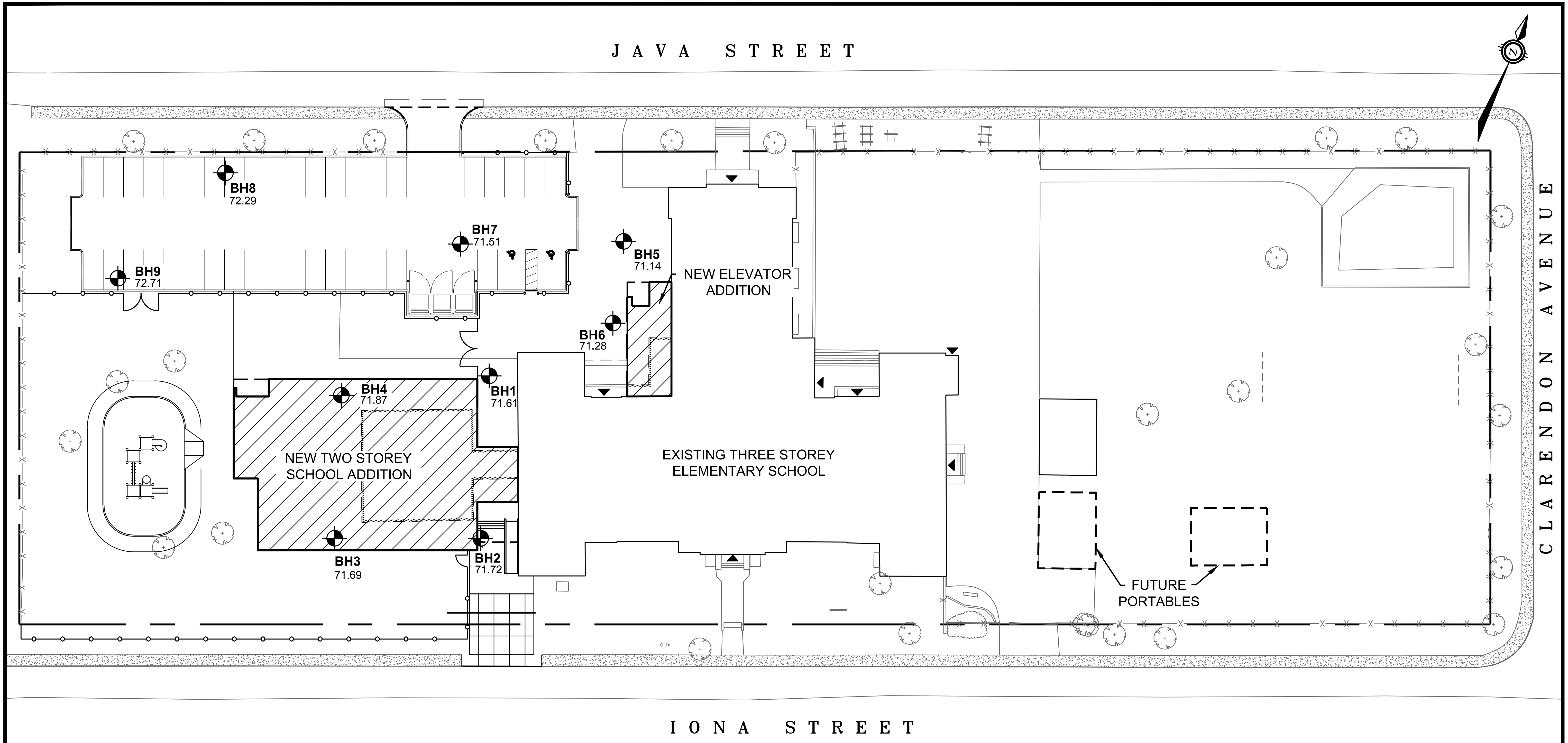
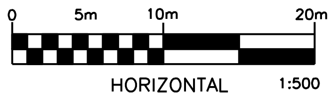


NOTES :

1. THE BOUNDARIES AND SOIL TYPES HAVE BEEN ESTABLISHED ONLY AT BOREHOLE LOCATIONS. BETWEEN BOREHOLES THEY ARE ASSUMED AND MAY BE SUBJECT TO CONSIDERABLE ERROR.
2. SOIL SAMPLES AND ROCK WILL BE RETAINED IN STORAGE FOR THREE MONTHS AND THEN DESTROYED UNLESS THE CLIENT ADVISES THAT AN EXTENDED TIME PERIOD IS REQUIRED.
3. TOPSOIL QUANTITIES SHOULD NOT BE ESTABLISHED FROM THE INFORMATION PROVIDED AT THE BOREHOLE LOCATIONS.
4. BOREHOLE ELEVATIONS SHOULD NOT BE USED TO DESIGN BUILDING(S) OR FLOOR SLABS OR PARKING LOT(S) GRADES.
5. THIS DRAWING FORMS PART OF THE REPORT PROJECT NUMBER AS REFERENCED AND SHOULD BE USED ONLY IN CONJUNCTION WITH THIS REPORT.
6. BASE PLAN OBTAINED FROM EDWARD J CUHACI & ASSOCIATES ARCHITECTS INC., SITE PLAN DRAWING NO. A001, ISSUE NO. 1, DATED 18-08-31

LEGEND

⊕ **BH1** 71.61	BOREHOLE NUMBER, LOCATION AND ELEVATION



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scale 1:500	CLIENT: OCDSB	project no. OTT-00245378-F0
date NOV. 2018	TITLE: BOREHOLE LOCATION PLAN ELMDALE PUBLIC SCHOOL, PROPOSED ADDITIONS AND RENOVATION 49 IONA STREET, OTTAWA, ON	FIG 2
drawn by M.N.		

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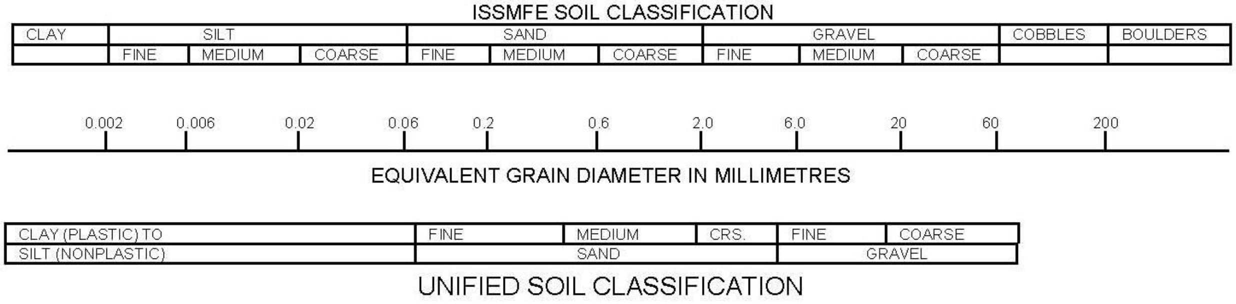
Notes On Sample Descriptions

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



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

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

Log of Borehole BH-1

Project No: OTT-00245378-F0

Project: Elmdale Public School - Additions and Renovation

Location: 49 Iona Street, Ottawa, ON.

Date Drilled: 'October 5, 2018

Drill Type: CME-55 Truck Mounted Drill Rig

Datum: Elevation

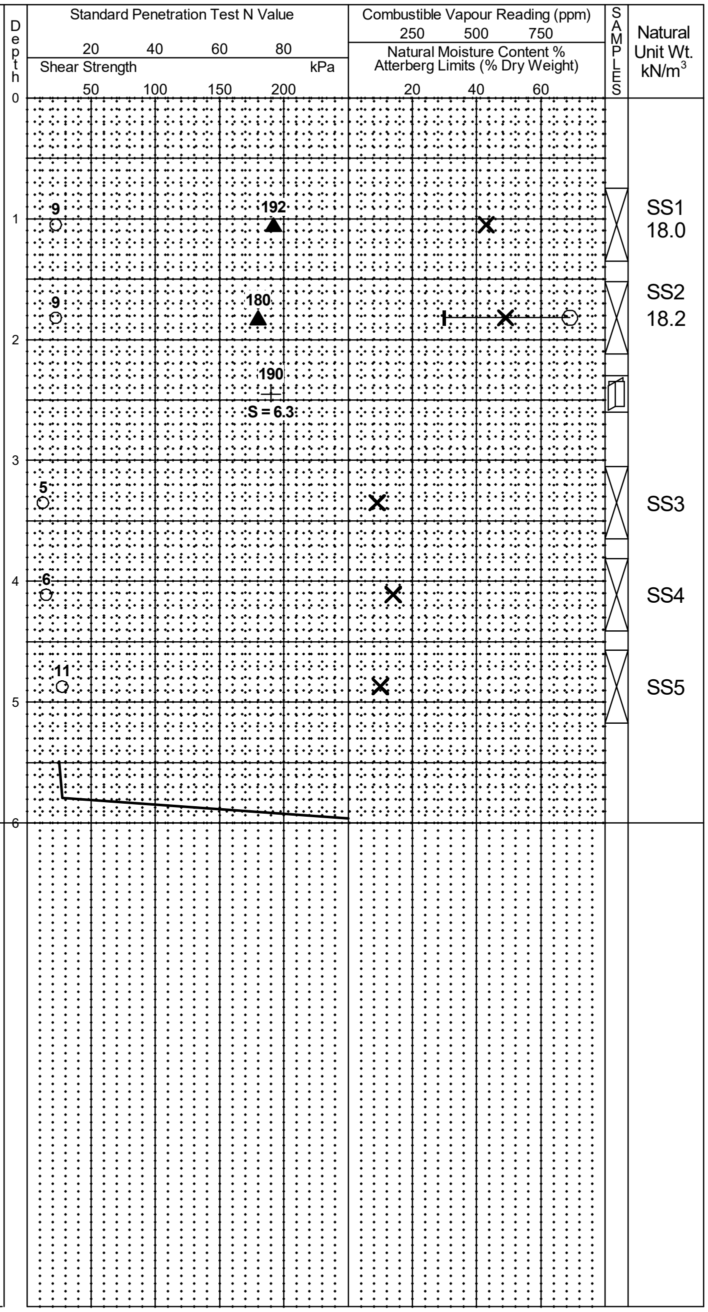
Logged by: M.L.
Checked by: I.T.

Figure No. 3

Page. 1 of 1

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

GWL	SOIL DESCRIPTION	Elevation m
		71.61
	ASPHALT ~40 mm	71.5
	GRANULAR FILL (BASE) ~ 200 mm of crushed gravel with sand and silt, grey, damp	71.4
	FILL Silty sand, brown, moist	71.0
	CLAY High plasticity, sensitive, brown, moist, (very stiff)	
	GLACIAL TILL Silty sand, grey, moist to wet, (loose to compact)	68.8
	INFERRED GLACIAL TILL Dynamic Cone Penetration Test (DCPT) conducted from 5.2 m depth to cone refusal at 6.0 m depth	66.4
	Auger and Cone Refusal at 6.0 m Depth	65.6



NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. Borehole backfilled upon completion of drilling.
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-00245378-F0

WATER LEVEL RECORDS

Elapsed Time	Water Level (m)	Hole Open To (m)
Completion	Dry	3.9

CORE DRILLING RECORD

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

Log of Borehole BH-2

Project No: OTT-00245378-F0

Project: Elmdale Public School - Additions and Renovation

Location: 49 Iona Street, Ottawa, ON.

Date Drilled: 'October 5, 2018

Drill Type: CME-55 Truck Mounted Drill Rig

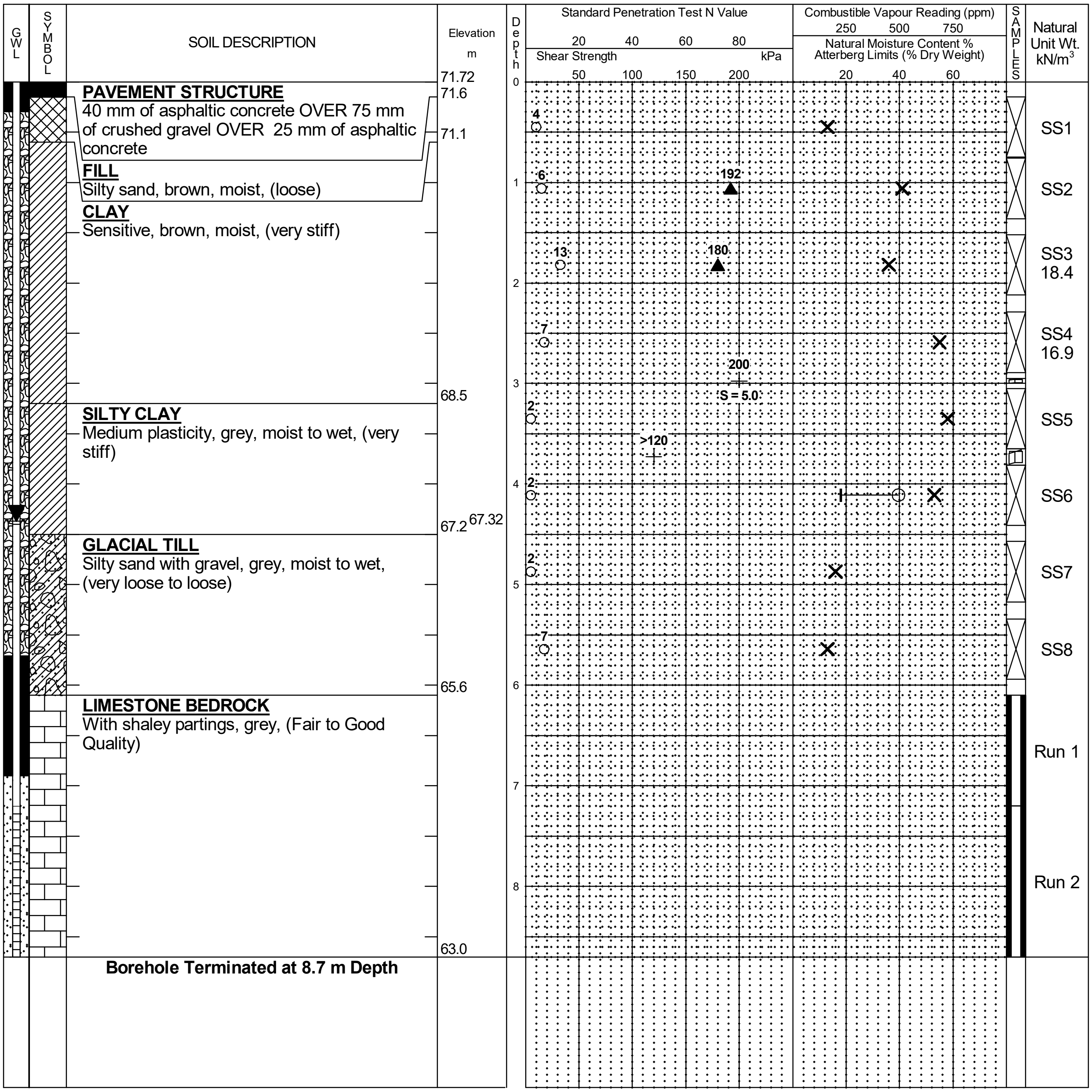
Datum: Elevation

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

Figure No. 4

Page. 1 of 1

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



PAVEMENT STRUCTURE
40 mm of asphaltic concrete OVER 75 mm of crushed gravel OVER 25 mm of asphaltic concrete

FILL
Silty sand, brown, moist, (loose)

CLAY
Sensitive, brown, moist, (very stiff)

SILTY CLAY
Medium plasticity, grey, moist to wet, (very stiff)

GLACIAL TILL
Silty sand with gravel, grey, moist to wet, (very loose to loose)

LIMESTONE BEDROCK
With shaley partings, grey, (Fair to Good Quality)

Borehole Terminated at 8.7 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-00245378-F0

WATER LEVEL RECORDS

Elapsed Time	Water Level (m)	Hole Open To (m)
Completion	N/A	N/A
31 days	4.4	

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %
1	6.1 - 7.2	100	87
2	7.2 - 8.7	100	67

Log of Borehole BH-3

Project No: OTT-00245378-F0

Project: Elmdale Public School - Additions and Renovation

Location: 49 Iona Street, Ottawa, ON.

Date Drilled: 'October 5, 2018

Drill Type: CME-55 Truck Mounted Drill Rig

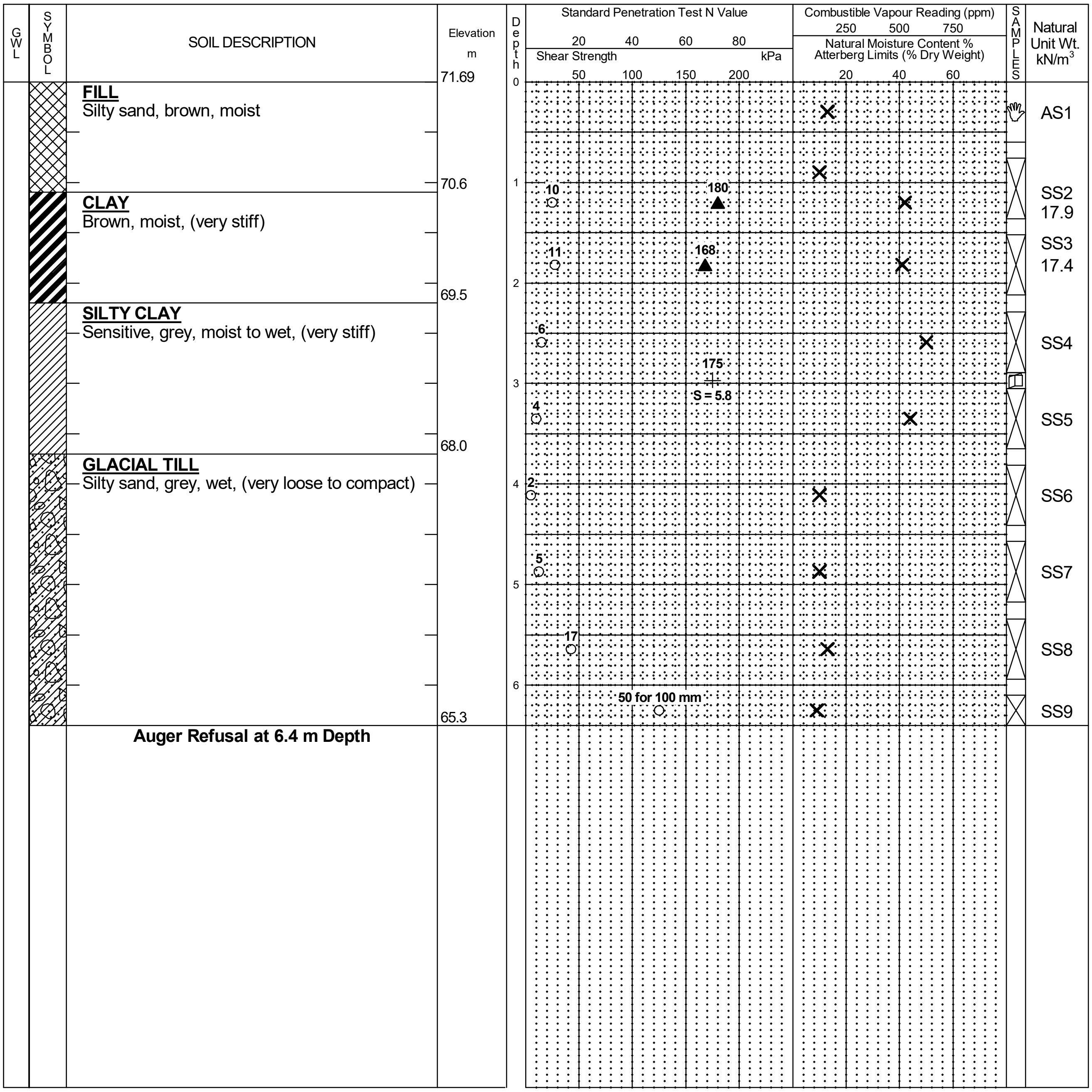
Datum: Elevation

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

Figure No. 5

Page. 1 of 1

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



Elevation (m)	Soil Description	Samples	Natural Unit Wt. kN/m³
71.69	**FILL** Silty sand, brown, moist	AS1	
70.6	**CLAY** Brown, moist, (very stiff)	SS2 SS3	17.9 17.4
69.5	**SILTY CLAY** Sensitive, grey, moist to wet, (very stiff)	SS4 SS5	
68.0	**GLACIAL TILL** Silty sand, grey, wet, (very loose to compact)	SS6 SS7 SS8 SS9	
65.3	**Auger Refusal at 6.4 m Depth**		

NOTES:
1. Borehole data requires interpretation by EXP before use by others
2. Borehole backfilled upon completion of drilling.
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-00245378-F0

WATER LEVEL RECORDS

Elapsed Time	Water Level (m)	Hole Open To (m)
Completion	Dry	3.9

CORE DRILLING RECORD

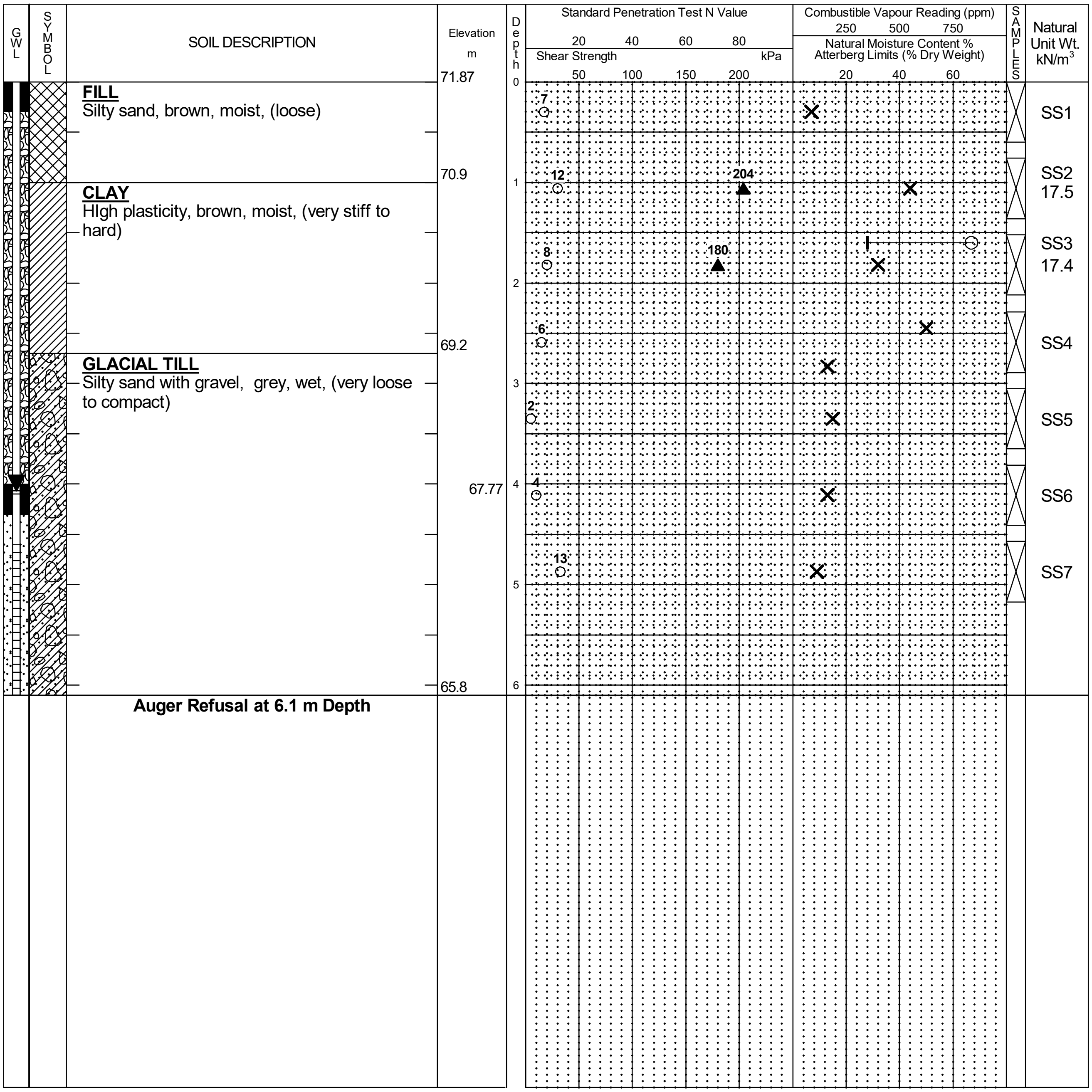
Run No.	Depth (m)	% Rec.	RQD %

Log of Borehole BH-4

Project No: OTT-00245378-F0
Project: Elmdale Public School - Additions and Renovation
Location: 49 Iona Street, Ottawa, ON.
Date Drilled: 'October 5, 2018
Drill Type: CME-55 Truck Mounted Drill Rig
Datum: Elevation
Logged by: M.L. Checked by: I.T.

Figure No. 6
Page. 1 of 1

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		



71.87

FILL
Silty sand, brown, moist, (loose)

70.9

CLAY
HIgh plasticity, brown, moist, (very stiff to hard)

69.2

GLACIAL TILL
Silty sand with gravel, grey, wet, (very loose to compact)

67.77

65.8

Auger Refusal at 6.1 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-00245378-F0

WATER LEVEL RECORDS

Elapsed Time	Water Level (m)	Hole Open To (m)
Completion	Dry	6.1
31 days	4.1	

CORE DRILLING RECORD

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

Log of Borehole BH-5

Project No: OTT-00245378-F0

Project: Elmdale Public School - Additions and Renovation

Location: 49 Iona Street, Ottawa, ON.

Date Drilled: 'October 27, 2018

Drill Type: CME-55 Truck Mounted Drill Rig

Datum: Elevation

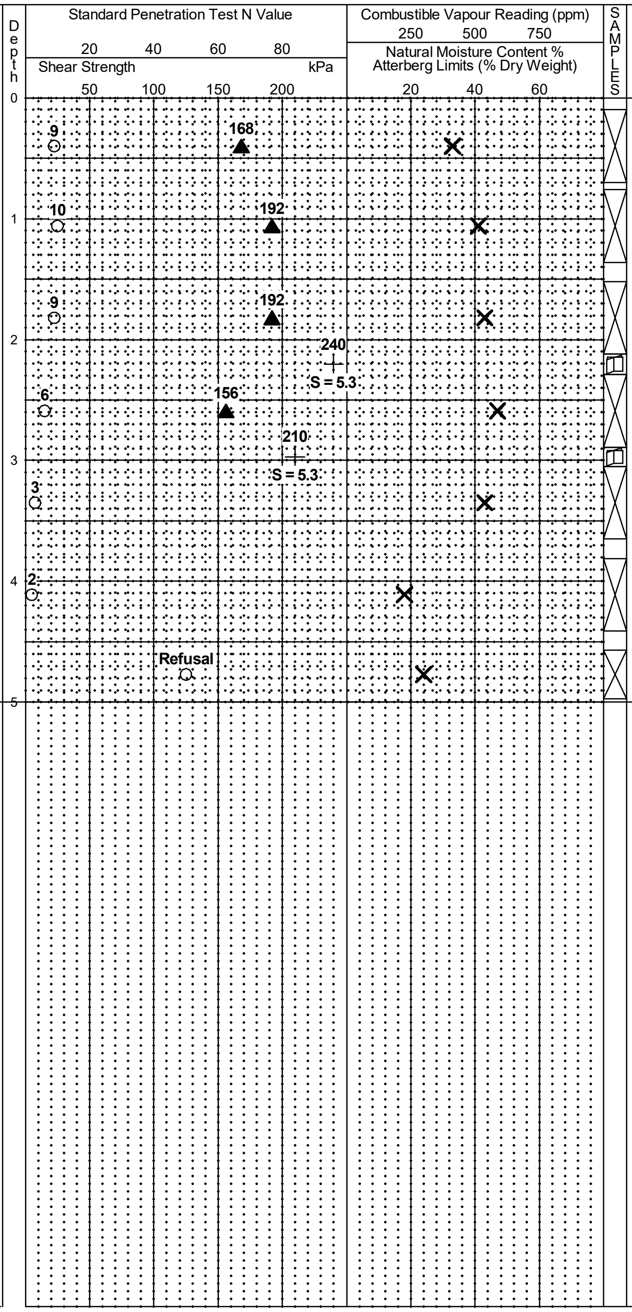
Logged by: M.L. Checked by: I.T.

Figure No. 7

Page. 1 of 1

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

GWL	SYMBOL	SOIL DESCRIPTION	Elevation m
			71.14
		ASPHALT ~35 mm	71.1
		FILL ~ 50 mm of sand and gravel, brown, moist	71.0
		GRANULAR FILL ~ 100 mm crushed gravel, grey, damp OVER Geotextile Membrane	70.9
		CLAY Sensitive, brown, moist, (very stiff to hard)	
			67.5
		GLACIAL TILL Silty sand with gravel, grey, moist to wet, (very loose)	
			66.1
		Auger Refusal at 5.0 m Depth	



SAMPLES	Natural Unit Wt. kN/m³
SS1	19.3
SS2	
SS3	18.4
SS4	
SS5	
SS6	
SS7	

NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. Borehole backfilled upon completion of drilling.
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-00245378-F0

WATER LEVEL RECORDS

Elapsed Time	Water Level (m)	Hole Open To (m)
Completion	Dry	5.0

CORE DRILLING RECORD

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

Log of Borehole BH-6

Project No: OTT-00245378-F0

Project: Elmdale Public School - Additions and Renovation

Location: 49 Iona Street, Ottawa, ON.

Date Drilled: 'October 27, 2018

Drill Type: CME-55 Truck Mounted Drill Rig

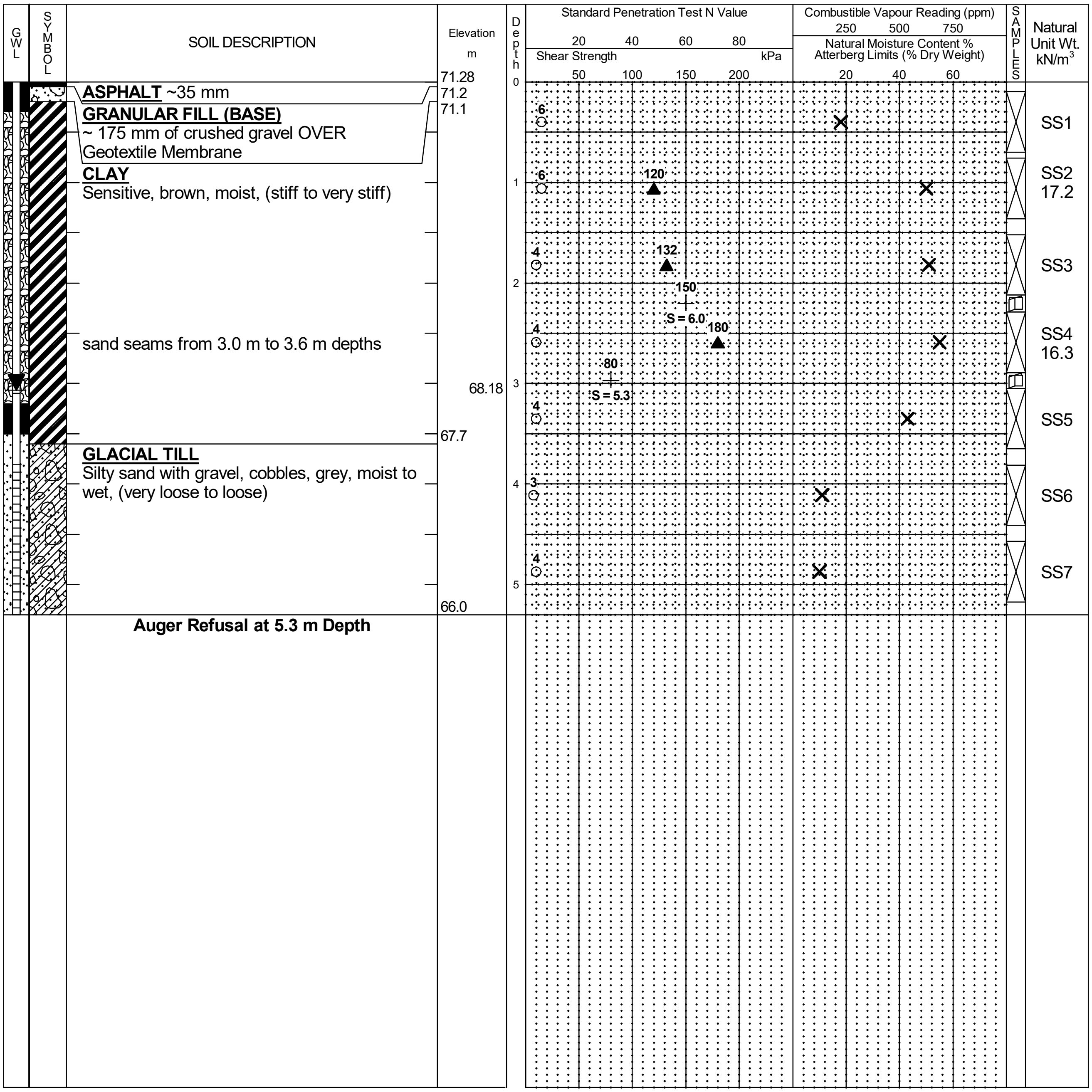
Datum: Elevation

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

Figure No. 8

Page. 1 of 1

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		



Elevation m	SOIL DESCRIPTION
71.28	
71.2	**ASPHALT** ~35 mm
71.1	**GRANULAR FILL (BASE)** ~ 175 mm of crushed gravel OVER Geotextile Membrane
	CLAY Sensitive, brown, moist, (stiff to very stiff) sand seams from 3.0 m to 3.6 m depths
68.18	
67.7	**GLACIAL TILL** Silty sand with gravel, cobbles, grey, moist to wet, (very loose to loose)
66.0	

Auger Refusal at 5.3 m Depth

SAMPLES	Natural Unit Wt. kN/m³
SS1	
SS2	17.2
SS3	
SS4	16.3
SS5	
SS6	
SS7	

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-00245378-F0

WATER LEVEL RECORDS

Elapsed Time	Water Level (m)	Hole Open To (m)
Completion	Dry	5.3
9 days	3.1	

CORE DRILLING RECORD

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

Log of Borehole BH-7

Project No: OTT-00245378-F0

Project: Elmdale Public School - Additions and Renovation

Location: 49 Iona Street, Ottawa, ON.

Date Drilled: 'October 27, 2018

Drill Type: CME-55 Truck Mounted Drill Rig

Datum: Elevation

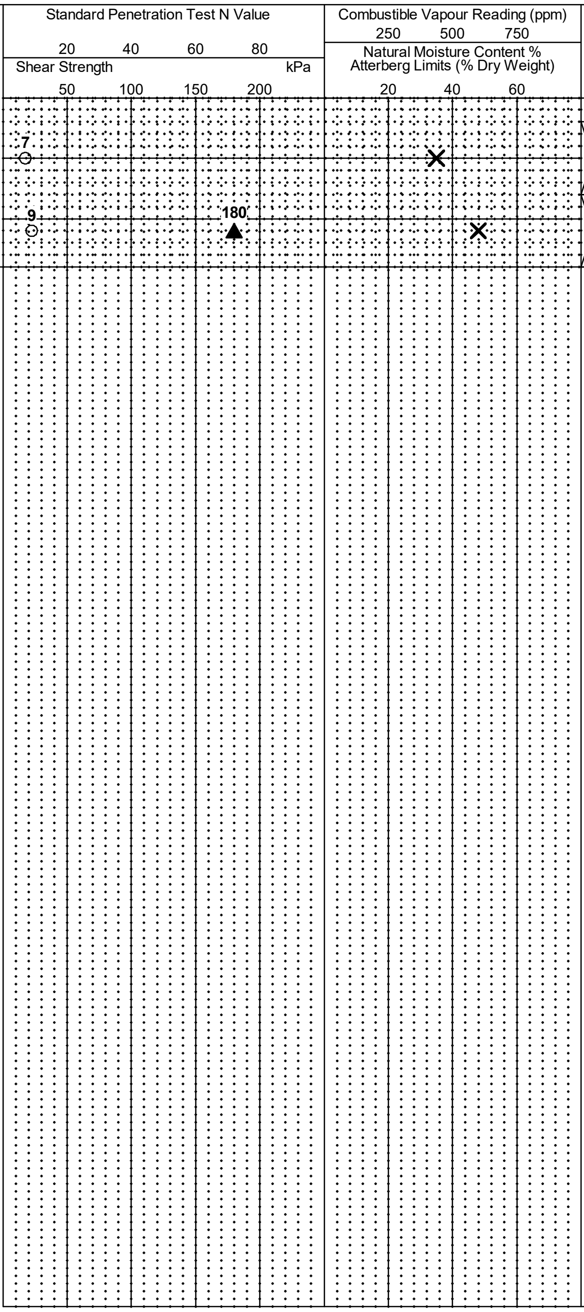
Logged by: M.L.　Checked by: I.T.

Figure No. 9

Page. 1 of 1

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

GWL	SYMBOL	SOIL DESCRIPTION	Elevation m	Depth
			71.51	0
		ASPHALT ~30 mm	71.5	
		GRANULAR FILL (BASE) ~ 125 mm of crushed gravel with sand and silt, grey, damp	71.4	
		FILL ~ 150 mm of silty sand with gravel, asphalt debris, roots, dark brown and dark grey, damp	71.2	1
		CLAY Brown, moist, (very stiff)	70.1	
		Borehole Terminated at 1.4 m Depth		



SAMPLES	Natural Unit Wt. kN/m^3
SS1	
SS2	17.4

NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. Borehole backfilled upon completion of drilling.
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-00245378-F0

WATER LEVEL RECORDS

Elapsed Time	Water Level (m)	Hole Open To (m)
Completion	Dry	1.4

CORE DRILLING RECORD

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

Log of Borehole BH-8

Project No: OTT-00245378-F0

Project: Elmdale Public School - Additions and Renovation

Location: 49 Iona Street, Ottawa, ON.

Figure No. 10

Page. 1 of 1

Date Drilled: 'October 27, 2018

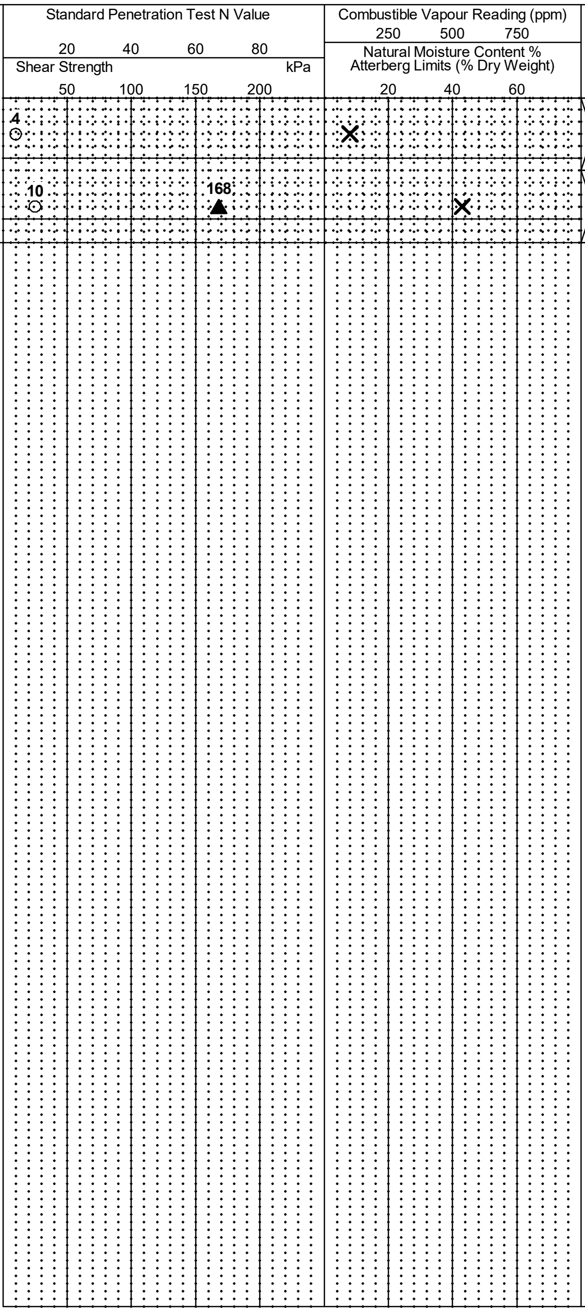
Drill Type: CME-55 Truck Mounted Drill Rig

Datum: Elevation

Logged by: M.L. 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 Vane Test	+ S	Shear Strength by Penetrometer Test	▲

GWL	SYMBOL	SOIL DESCRIPTION	Elevation m	Depth	SAMPLES	Natural Unit Wt. kN/m³
			72.29	0		
	▨	**FILL** Silty sand with gravel, brown, moist, (loose)			☒	SS1
			71.6			
	▨	**CLAY** Brown, moist, (very stiff)		1	☒	SS2 17.7
			71.1			
		Borehole Terminated at 1.2 m Depth				



NOTES:
1. Borehole data requires interpretation by EXP before use by others
2. Borehole backfilled upon completion of drilling.
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-00245378-F0

WATER LEVEL RECORDS

Elapsed Time	Water Level (m)	Hole Open To (m)
Completion	Dry	1.2

CORE DRILLING RECORD

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

Log of Borehole BH-9

Project No: OTT-00245378-F0

Project: Elmdale Public School - Additions and Renovation

Location: 49 Iona Street, Ottawa, ON.

Figure No. 11

Page. 1 of 1

Date Drilled: 'October 27, 2018

Drill Type: CME-55 Truck Mounted Drill Rig

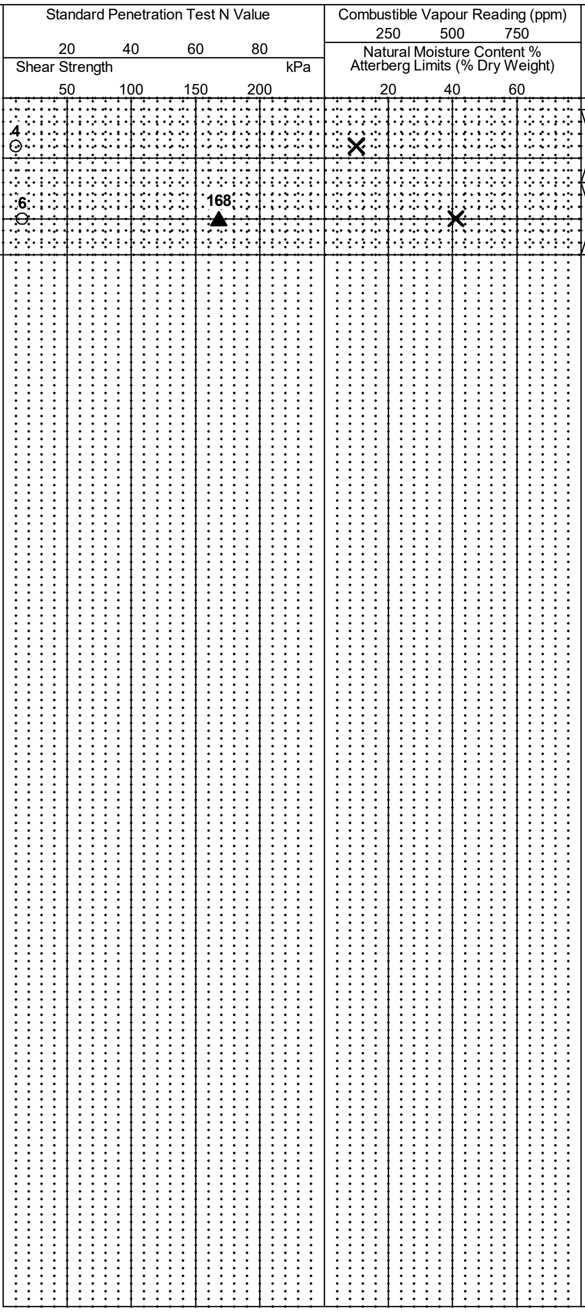
Datum: Elevation

Logged by: M.L.

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 Vane Test	+ S	Shear Strength by Penetrometer Test	▲

GWL	SYMBOL	SOIL DESCRIPTION	Elevation m	Depth	SAMPLES	Natural Unit Wt. kN/m³
			72.71	0		
		TOPSOIL ~ 150 mm	72.6			
		FILL Silty sand with gravel, brown, moist, (loose)			☒	SS1
		CLAY Brown, moist, (very stiff)	71.9	1	☒	SS2 18.2
			71.4			
		Borehole Terminated at 1.3 m Depth				



NOTES:

1. Borehole data requires interpretation by EXP before use by others
2. Borehole backfilled upon completion of drilling.
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. Log to be read with EXP Report OTT-00245378-F0

WATER LEVEL RECORDS

Elapsed Time	Water Level (m)	Hole Open To (m)
Completion	Dry	1.3

CORE DRILLING RECORD

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

EXP Services Inc.
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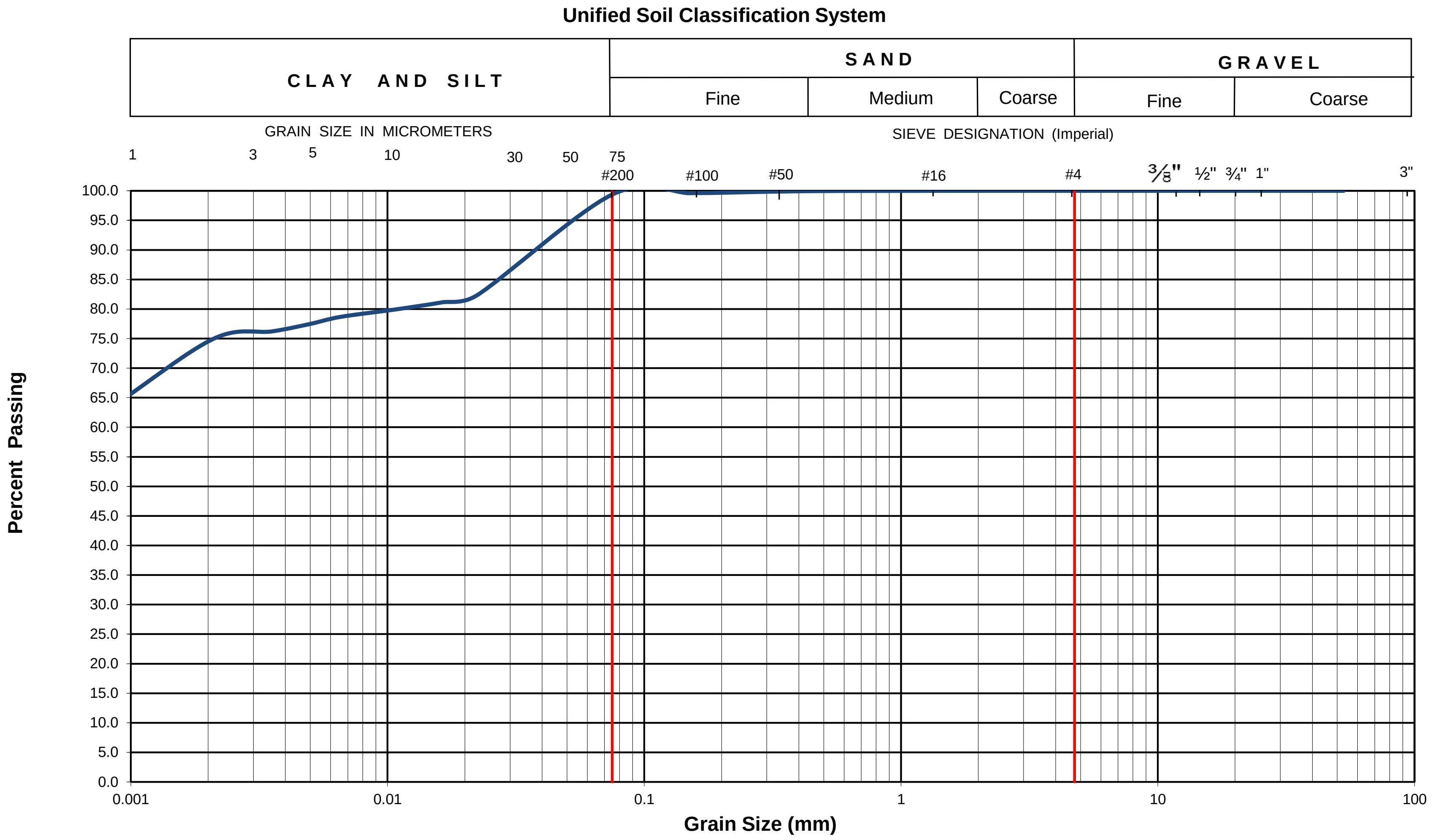
Ottawa, ON K2B 8H6

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



EXP Project No.: OTT-00245378-F0
Project Name : Elmdale Public School - Additions and Renovation
Client : Ottawa Carleton District School Board
Project Location : 49 Iona Street, Ottawa, ON.
Date Sampled : October 5, 2018
Borehole No: 1
Sample No.: SS2
Depth (m) : 1.5-2.1
Sample Description :
% Silt and Clay 99
% Sand 1
% Gravel 0
Figure : 12
Sample Description : Clay (CH)

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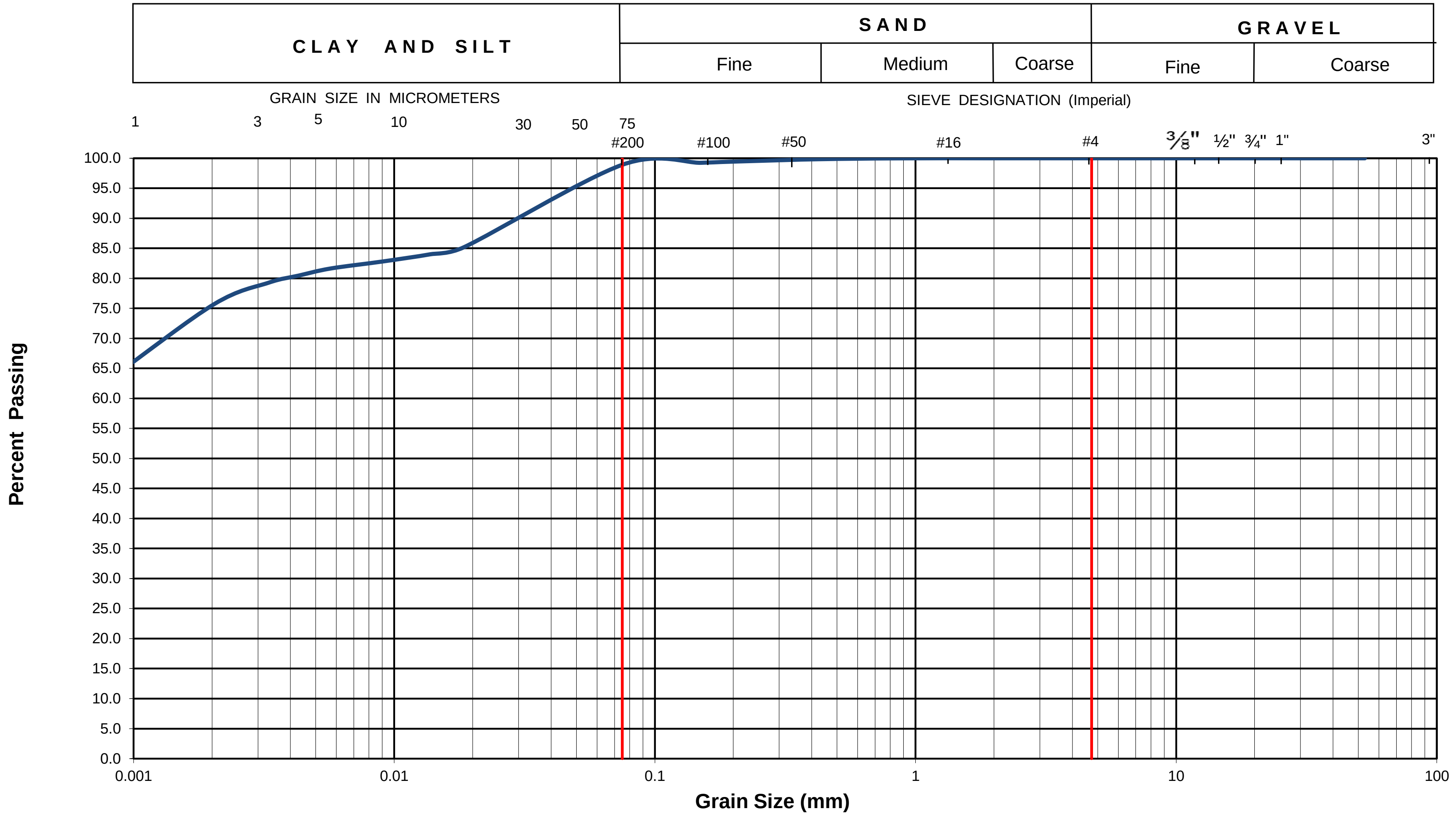
Ottawa, ON   K2B 8H6

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

Unified Soil Classification System



EXP Project No.:	**OTT-00245378-F0**	**Project Name :**	**Elmdale Public School - Additions and Renovation**						
Client :	**Ottawa Carleton District School Board**	**Project Location :**	**49 Iona Street, Ottawa, ON.**						
Date Sampled :	**October 5, 2018**	**Borehole No:**	**4**	**Sample No.:**	**SS3**			**Depth (m) :**	**1.5-2.1**
Sample Description :		**% Silt and Clay**	**99**	**% Sand**	**1**	**% Gravel**	**0**	**Figure :**	**13**
Sample Description :	**Clay (CH)**								

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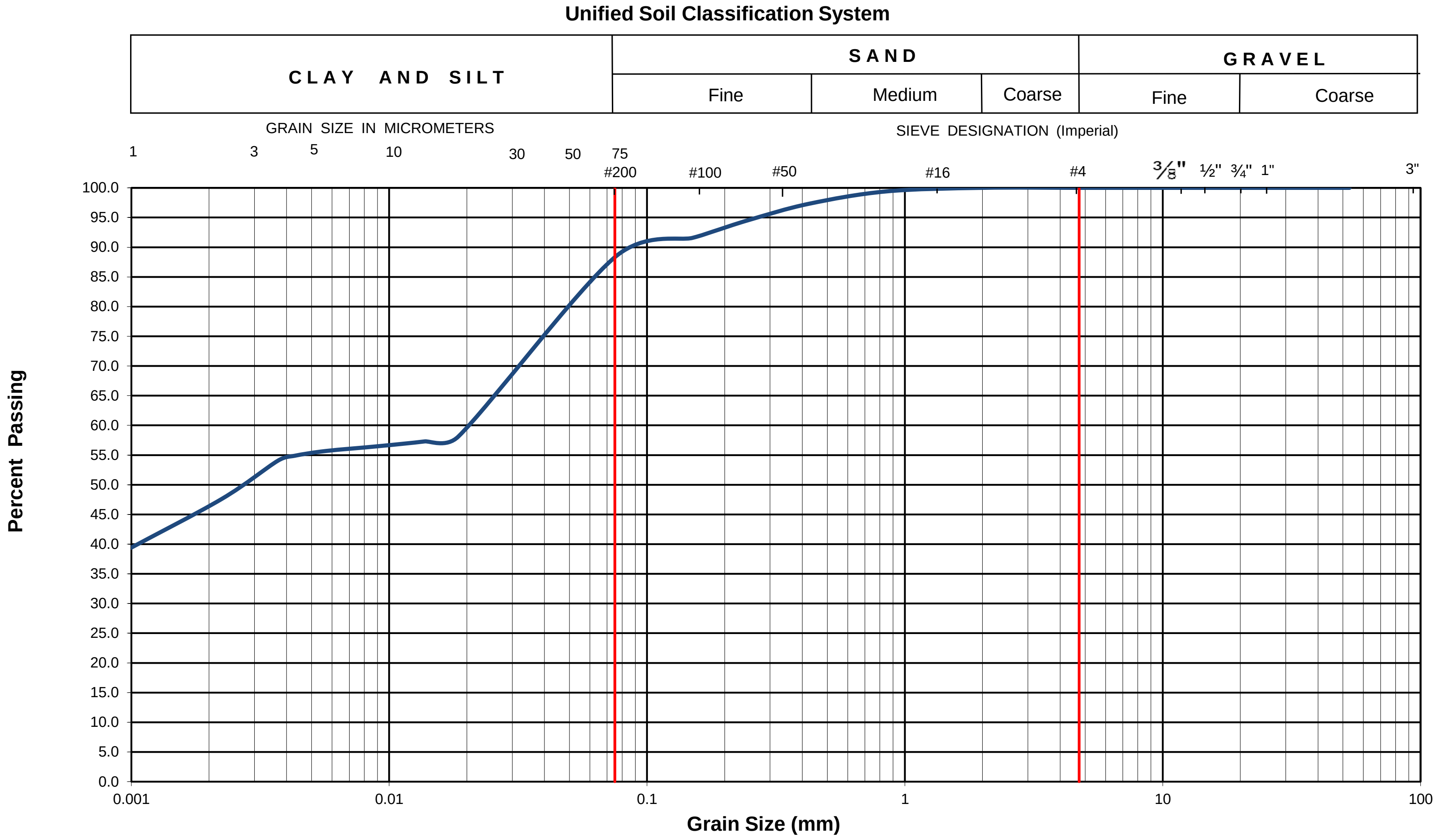
Grain-Size Distribution Curve
Method of Test For Particle Size Analysis of Soil
ASTM C-136/ASTM D422



EXP Project No.:	**OTT-00245378-F0**	**Project Name :**	**Elmdale Public School - Additions and Renovation**						
Client :	**Ottawa Carleton District School Board**	**Project Location :**	**49 Iona Street, Ottawa, ON.**						
Date Sampled :	**October 5, 2018**	**Borehole No:**		**2**	**Sample No.:**		**SS6**	**Depth (m) :**	**3.8-4.4**
Sample Description :		**% Silt and Clay**	**88**	**% Sand**	**12**	**% Gravel**	**0**	**Figure :**	**14**
Sample Description :	**Silty Clay (CL)**								

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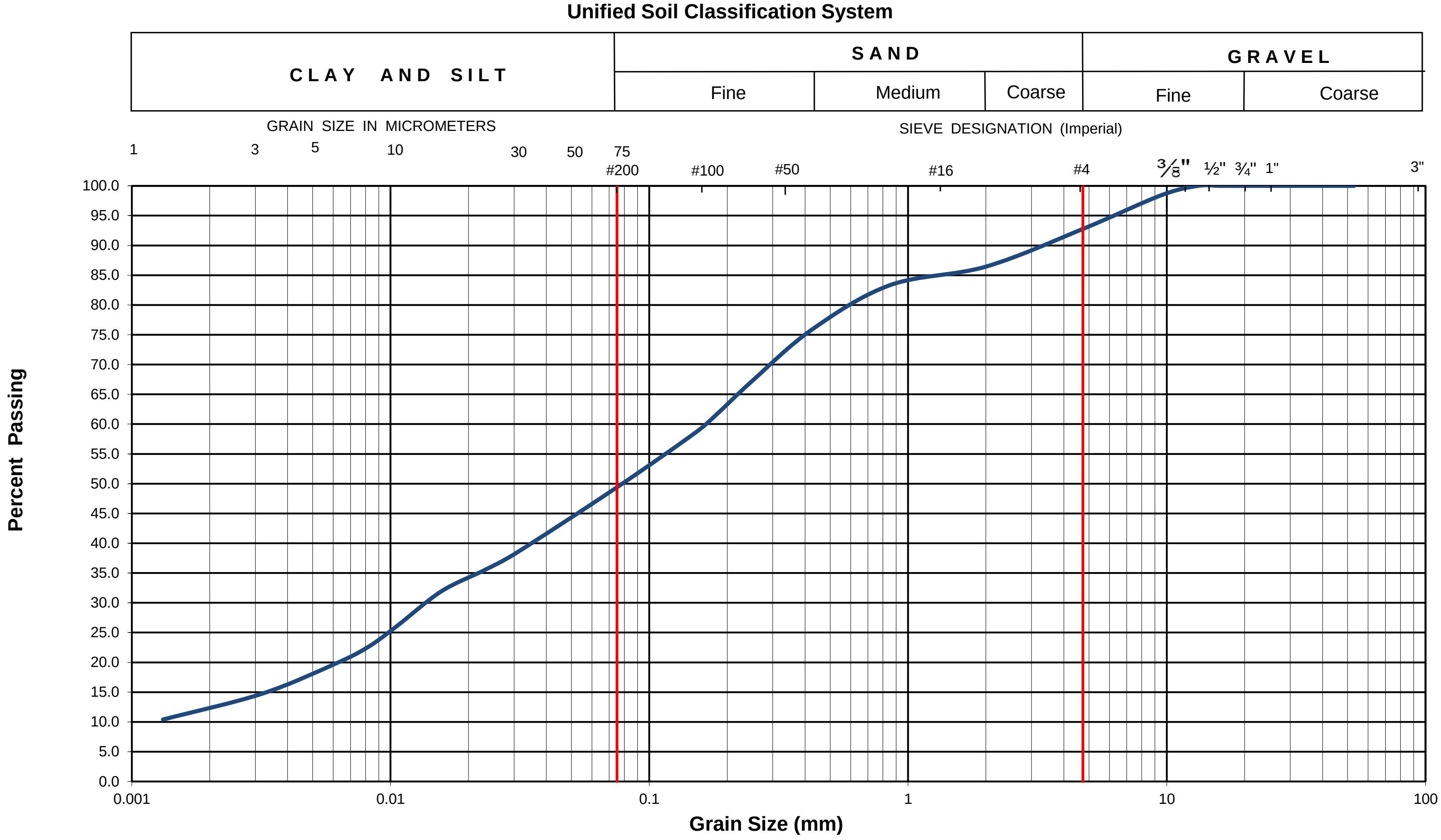
Grain-Size Distribution Curve
Method of Test For Particle Size Analysis of Soil
ASTM C-136/ASTM D422



EXP Project No.:	**OTT-00245378-F0**	**Project Name :**	**Elmdale Public School - Additions and Renovation**					
Client :	**Ottawa Carleton District School Board**	**Project Location :**	**49 Iona Street, Ottawa, ON.**					
Date Sampled :	**October 5, 2018**	**Borehole No:**	**1**	**Sample No.:**	**SS4**		**Depth (m) :**	**3.8-4.4**
Sample Description :		**% Silt and Clay**	**49**	**% Sand**	**44**	**% Gravel 7**	**Figure :**	**15**
Sample Description :		**Glacial Till: Silty Sand (SM)**						

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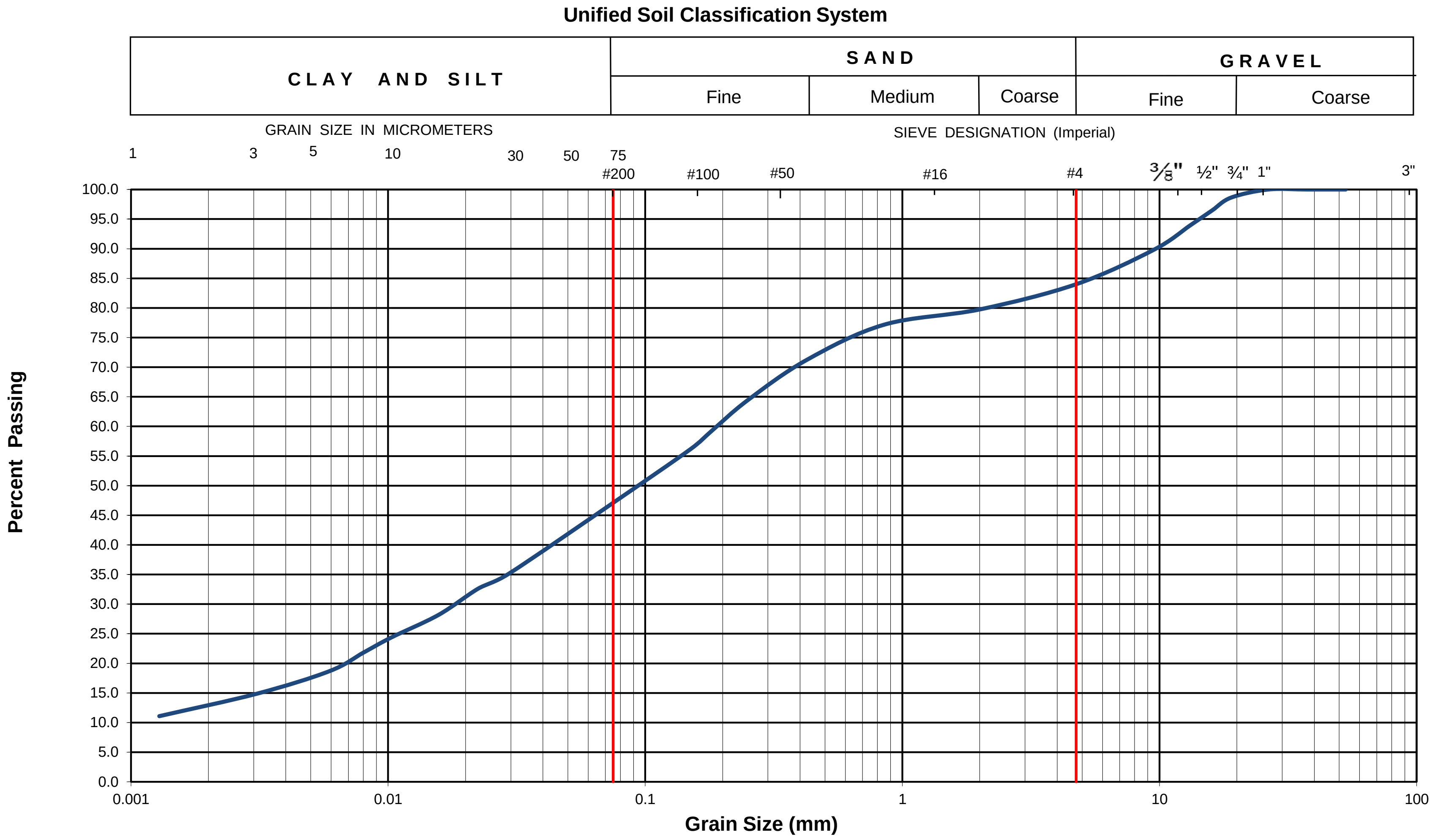
Grain-Size Distribution Curve
Method of Test For Particle Size Analysis of Soil
ASTM C-136/ASTM D422



EXP Project No.:	**OTT-00245378-F0**	**Project Name :**	**Elmdale Public School - Additions and Renovation**						
Client :	**Ottawa Carleton District School Board**	**Project Location :**	**49 Iona Street, Ottawa, ON.**						
Date Sampled :	**October 5, 2018**	**Borehole No:**	**2**	**Sample No.:**	**SS7**			**Depth (m) :**	**4.6-5.2**
Sample Description :		**% Silt and Clay**	**47**	**% Sand**	**37**	**% Gravel**	**16**	**Figure :**	**16**
Sample Description :	**Glacial Till: Silty Sand with Gravel (SM)**								

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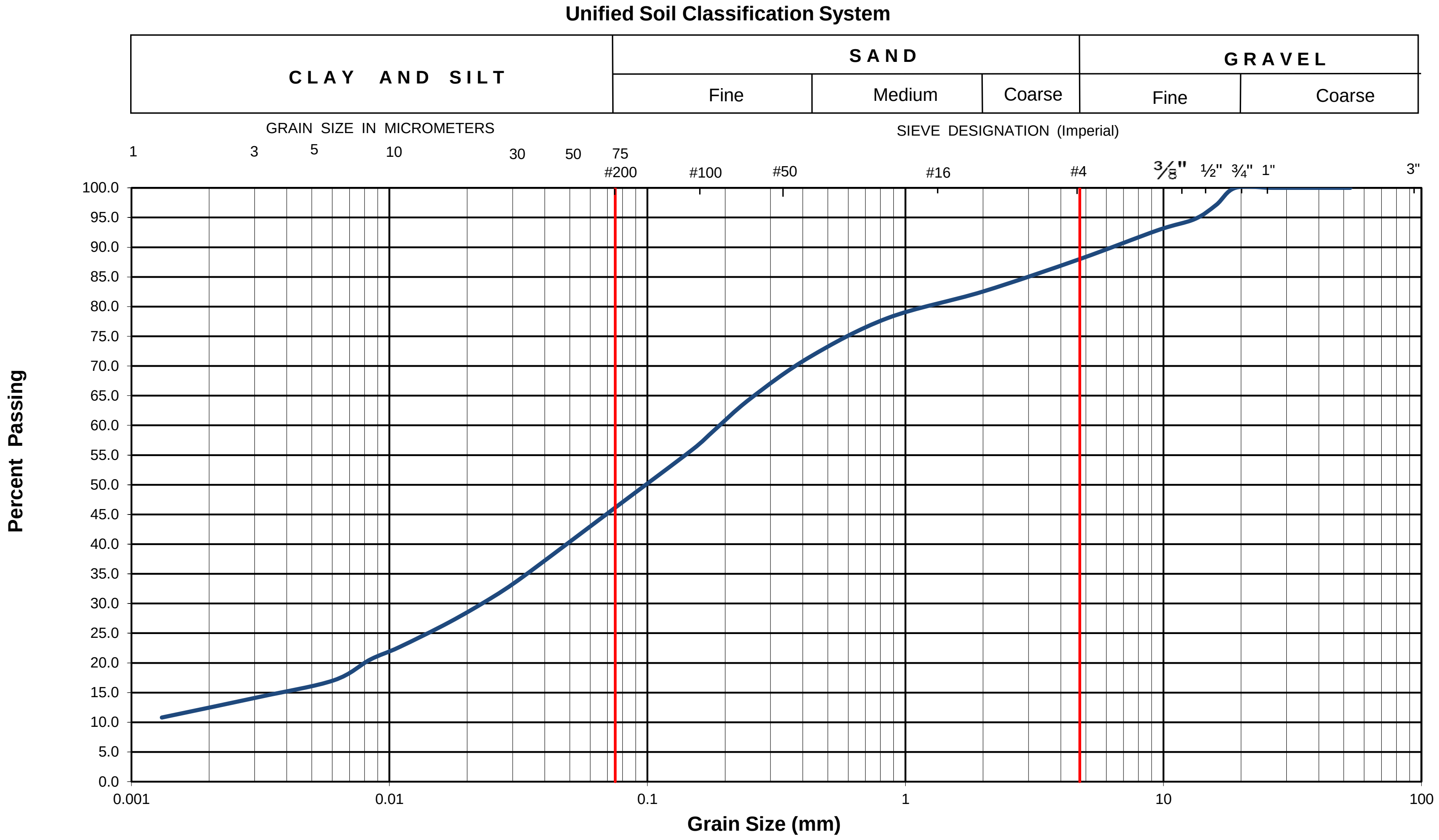
Grain-Size Distribution Curve
Method of Test For Particle Size Analysis of Soil
ASTM C-136/ASTM D422



EXP Project No.:	**OTT-00245378-F0**	**Project Name :**	**Elmdale Public School - Additions and Renovation**						
Client :	**Ottawa Carleton District School Board**	**Project Location :**	**49 Iona Street, Ottawa, ON.**						
Date Sampled :	**October 5, 2018**	**Borehole No:**	**3**	**Sample No.:**	**SS7**			**Depth (m) :**	**4.6-5.2**
Sample Description :		**% Silt and Clay**	**46**	**% Sand**	**42**	**% Gravel**	**12**	**Figure :**	**17**
Sample Description :	**Glacial Till: Silty Sand (SM)**								

DRY BEDROCK CORES

WET BEDROCK CORES

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2650 Queensview Drive, Suite 100
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Canada
www.exp.com

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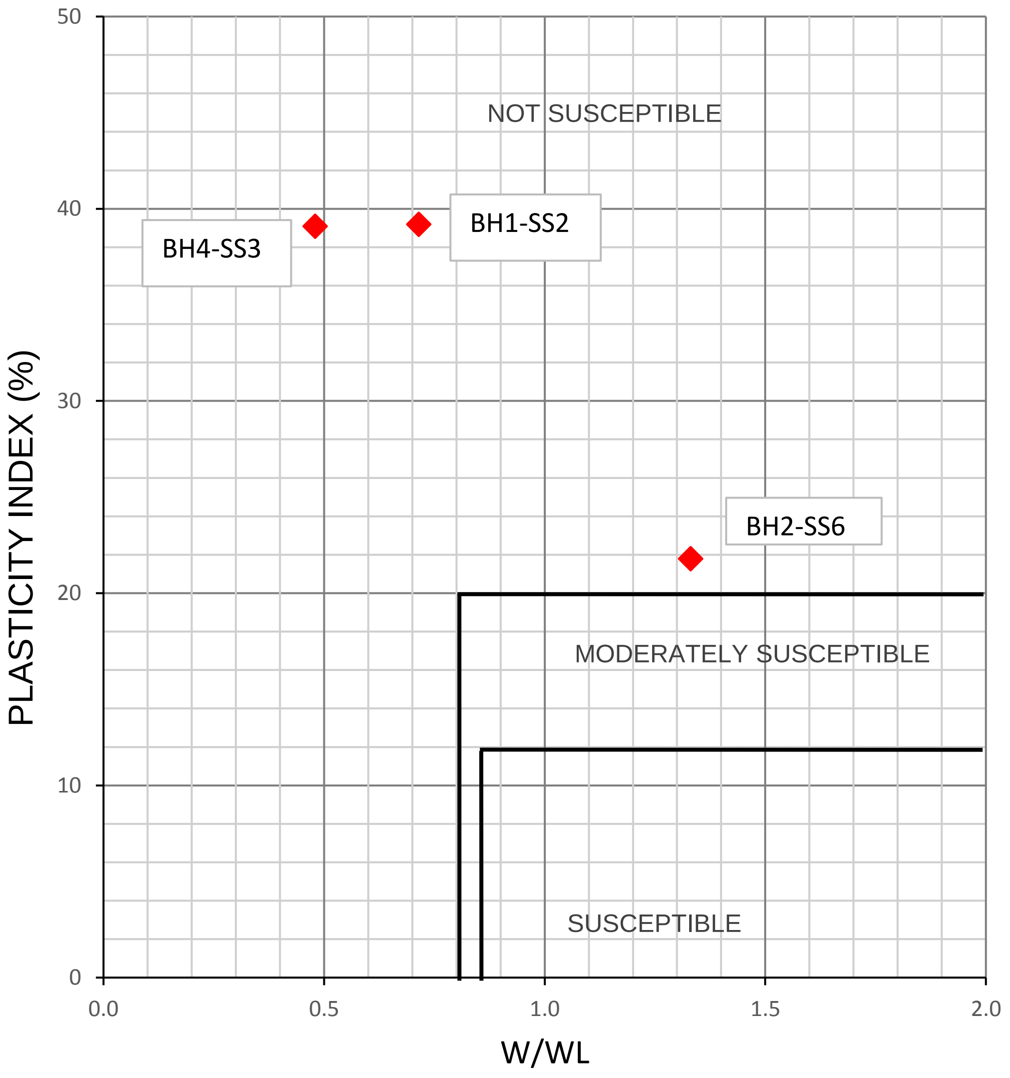
borehole no. BH-2	core runs Run 1: 6.1m-7.2m Run 2: 7.2m-8.7m	PROJECT PROPOSED ADDITIONS AND RENOVATION ELMDALE PUBLIC SCHOOL	project no. OTT-00245378-F0
date cored Oct 05, 2018		ROCK CORE PHOTOGRAPHS	FIG. 18



BRAY ET AL. (2004) CRITERIA FOR LIQUEFACTION ASSESSMENT OF FINE GRAINED SOILS

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scale: N.T.S.	CLIENT: Ottawa-Carleton District School Board	project no. OTT-00245378-F0
date: December 2018	TITLE: Additions and Renovation Elmdale School	FIG. 19
drawn by: SMP		

Appendix A: Multi-channel Analysis of Surface Waves (MASW) Seismic Survey

GEOPHYSICS GPR INTERNATIONAL INC.

6741 Columbus Road
Unit 14
Mississauga, Ontario
Canada,L5T 2G9

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November 28, 2018 GPR file: T181047

Ismail Taki, M.Eng. P.Eng.
EXP
2650 Queensview Drive
Suite 100
Ottawa, ON
K2B 8H6

RE: Shear-wave velocity sounding at Elmdale Public School, 49 Iona St., Ottawa, Ontario

Dear Mr. Taki:

Geophysics GPR International Inc. has been requested by EXP to carry out a shear-wave velocity sounding at the above site in Ottawa. Figure 1 shows the location of the seismic test.

The survey was performed on November 26, 2018.

The investigation included the multi-channel analysis of surface waves (MASW) and MAM methods to generate a shear-wave velocity model (Figure 4).

The following paragraphs describe the survey design, the principles of the test method, the methodology for interpreting the data, and provide a culmination of the results in table format.

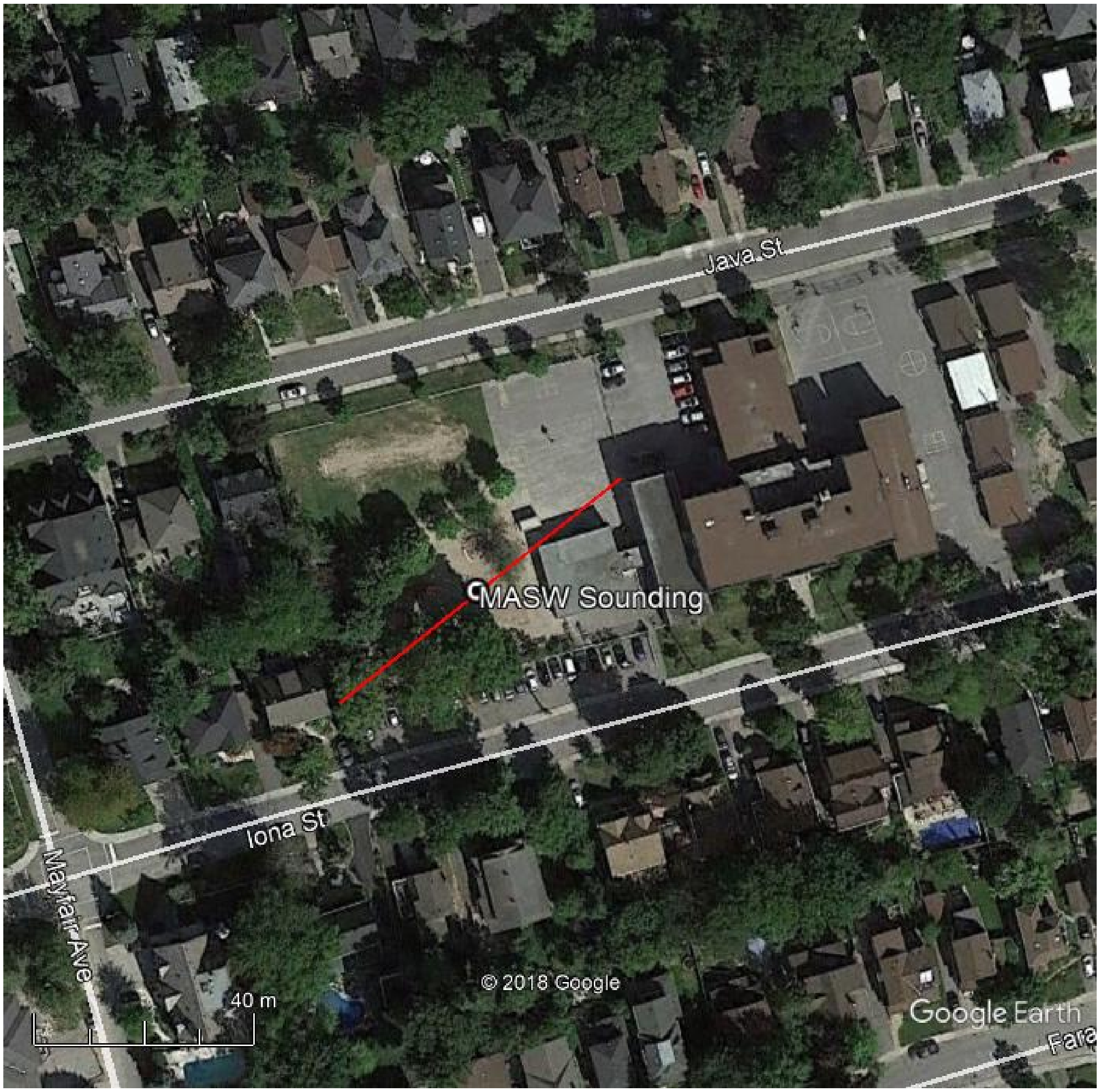


Figure 1: Approximate location of the shear-wave velocity sounding

MASW and MAM Surveys

Basic Theory

The Multi-channel Analysis of Surface Waves (MASW) and the Micro-tremor Array Measurements (MAM) are seismic methods used to evaluate the shear-wave velocities of subsurface materials through the analysis of the dispersion properties of Rayleigh surface waves ("ground roll"). The dispersion properties are measured as a change in phase velocity with frequency. 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. Inversion of the Rayleigh wave dispersion curve yields a shear-wave (V_s) velocity depth profile (sounding). Figure 2 outlines the basic operating procedure for the MASW method. Figure 3 is an example image of a typical MASW record and resulting 1D V_s model. A more detailed description of the method can be found in the paper *Multi-channel Analysis of Surface Waves,* Park, C.B., Miller, R.D. and Xia, J. Geophysics, Vol. 64, No. 3 (May-June 1999); P. 800–808.

Survey Design

The geometry of an MASW survey is similar to that of a seismic refraction investigation (i.e. 24 geophones in a linear array). The fundamental principle involves intentionally generating an acoustic wave at the surface and digitally recording the surface waves from the moment of source impact with a linear series of geophones on the surface. This is referred to as an "active source" method. Data were collected with geophones spacing of 3 m and 1 m. A sledgehammer was used as the primary energy source with traces being recorded at 4 locations for the 3 m spread and 5 locations for the 1 m spread.

Unlike the refraction method, which produces a data point beneath each geophone, the shear-wave depth profile is the average of the bulk area within the middle third of the geophone spread.

The theoretical maximum depth of penetration (34.5m) is half of the maximum seismic array length (69m), in practice the maximum depth of penetration is often influenced by the geology.

The MAM/passive survey used the same geophone array set up as for the MASW survey. Unlike the MASW survey, the MAM method is considered a "passive source" method in that there is no time break and the motions recorded are from ambient energy generated by cultural noise such as traffic, wind, wave motion, etc. Data collection for the passive method involves recording approximately 10 minutes of background "noise." The records generated by the MAM method contain lower frequency data, thus increasing the data resolution at greater depths of investigation. Typically the MAM results aid in clarifying the MASW results for depths greater than 20 m; however, the direction of noise propagation relative to the spread orientation can influence the results.

Interpretation Method and Accuracy of Results

The main processing sequence involved plotting, picking, and 1-D inversion of the MASW shot records using the SeisimagerSW™ software package. In theory, all MASW shot records should produce a similar shear-wave velocity profile. In practice, however, differences can arise due to energy dissipation and localized surface variations. The results of the inversion process are inherently non-unique and the final model must be judged to be geologically realistic. The inversion modelling also assumes that all layering is flat/horizontal and laterally uniform.

The results of the MASW test are presented in chart format as Figure 4. The chart presents the 1-D shear wave velocity values from the inversion models of the seismic records.

The V_s30 values for the sounding are presented in Table 1. The V_s30 values are based on the harmonic mean of the shear wave velocities over the upper 30 m. The V_s30 value is calculated by dividing the total depth of interest (e.g. 30 m) by the sum of the time spent in each velocity layer up to that depth. This harmonic mean value reflects the equivalent single layer response.

The estimated error in the average V_s30 value determined through MASW tests is typically +/-10 to 15% for overburden sites. The shear-wave velocities modelled through the MASW method within bedrock have a higher estimated error.

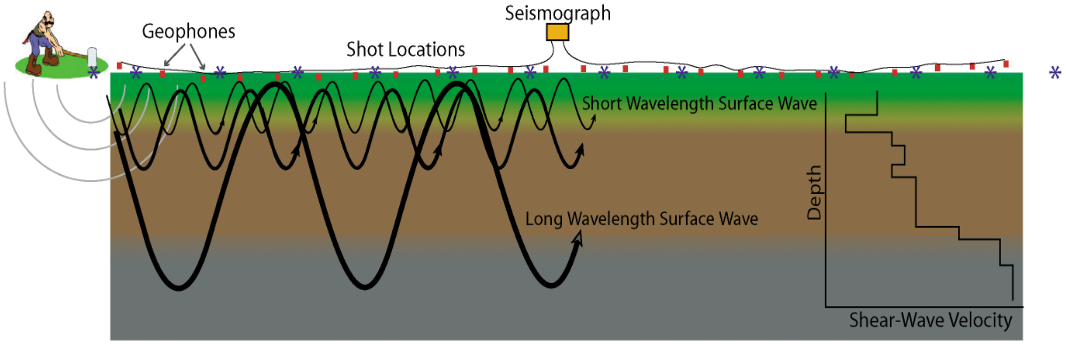
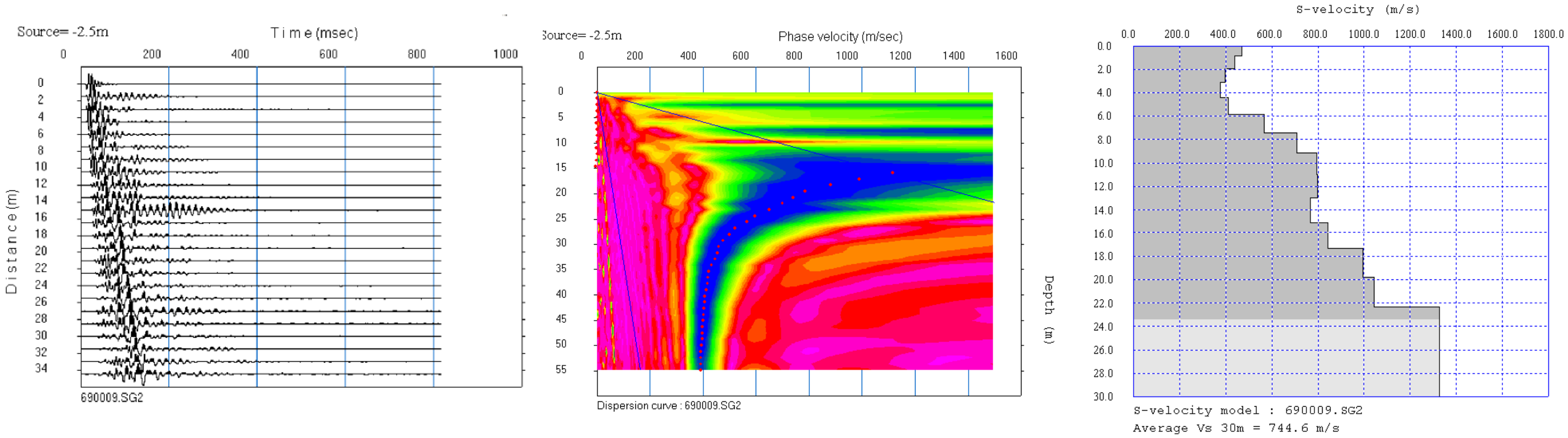


Figure 2: MASW Operating Principle



Raw Seismic Shot Record

Phase Velocity-Frequency Transformation indicating Dispersion Curve

1D Shear-Wave Velocity Profile from Inversion of Dispersion Curve

Figure 3: Example of a typical MASW shot record, phase velocity/frequency curve and resulting 1D shear-wave velocity model.

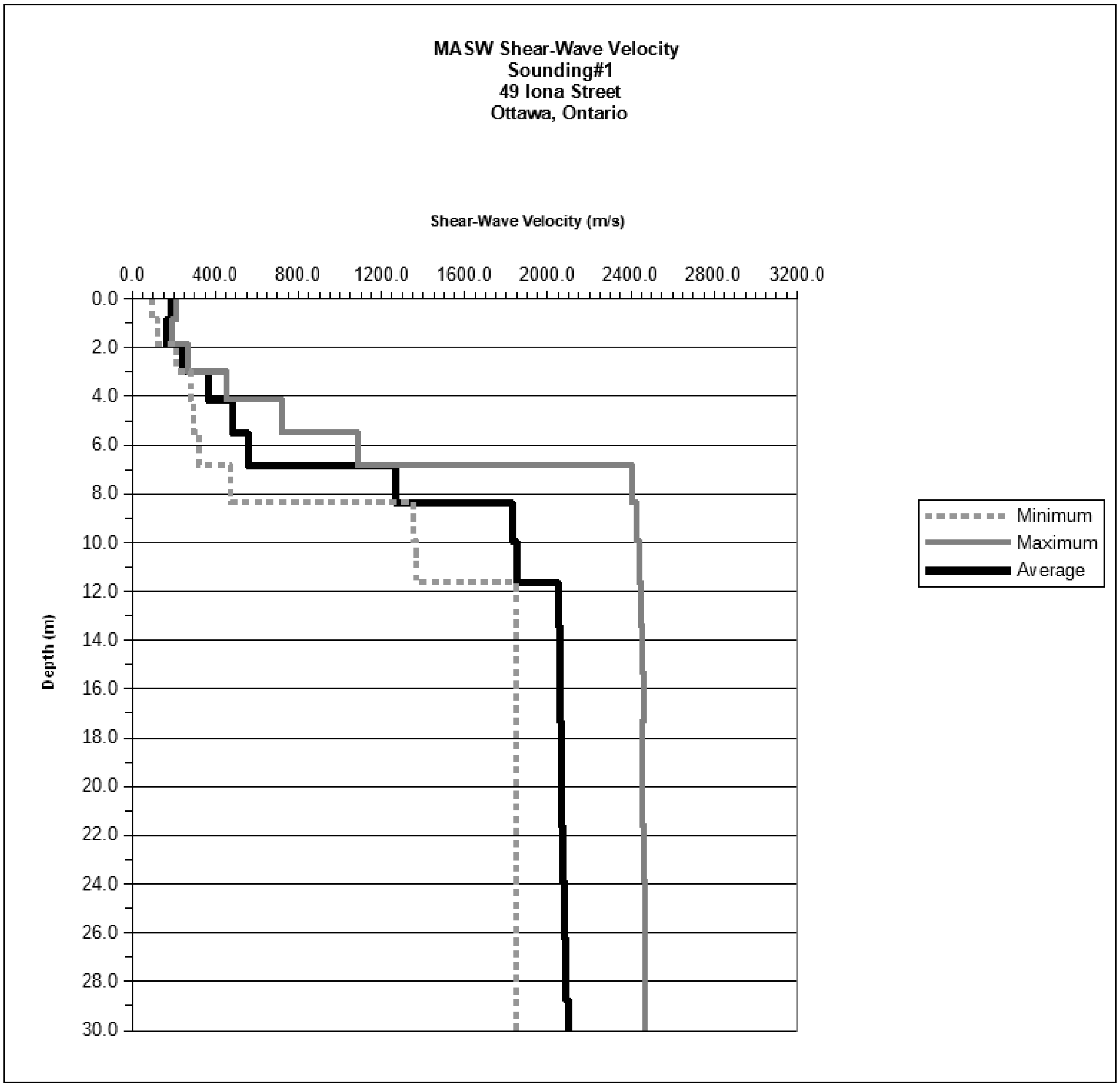


Figure 4: Shear-wave velocity Profile

Depth		Vs values (m/s)		Thickness	Cumulative Thickness	Seismic delay Time (for average)	Total seismic delay until depth (for average)	Vs at given Depth
(m)	Avg	Min	Max	(m)	(m)	(seconds)	(seconds)	(m)
0.0	187	98	212					
0.9	169	129	194	0.9	0.9	0.004783	0.00478	187
1.9	240	215	271	1.0	1.9	0.005872	0.01065	177
3.0	365	285	459	1.1	3.0	0.004562	0.01522	196
4.2	484	299	722	1.2	4.2	0.003266	0.01848	226
5.5	559	325	1087	1.3	5.5	0.002669	0.02115	259
6.9	1270	476	2411	1.4	6.9	0.002490	0.02364	290
8.4	1831	1357	2427	1.5	8.4	0.001174	0.02482	337
9.9	1850	1369	2441	1.6	9.9	0.000869	0.02568	387
11.6	2049	1850	2453	1.7	11.6	0.000914	0.02660	437
13.4	2056	1850	2460	1.8	13.4	0.000873	0.02747	489
15.3	2058	1850	2462	1.9	15.3	0.000919	0.02839	539
17.3	2063	1850	2459	2.0	17.3	0.000966	0.02936	589
19.4	2068	1850	2460	2.1	19.4	0.001012	0.03037	638
21.6	2074	1850	2466	2.2	21.6	0.001058	0.03143	686
23.9	2079	1850	2471	2.3	23.9	0.001103	0.03253	734
26.2	2086	1850	2469	2.4	26.2	0.001148	0.03368	779
28.7	2100	1850	2475	2.5	28.7	0.001191	0.03487	824
30				1.3	30.0		0.035471	846

Vs30(m/s) **846**

CONCLUSIONS

The approximate location of the shear-wave sounding is presented in Figure 1.

The MASW shear-wave models are presented in Figure 4. The results are presented in Table 1 and summarized in Table 2. The background seismic noise levels at this site were moderate. The quality of the seismic records and resulting dispersion curves was good.

Borehole data was provided by the client. The borehole data indicated limestone bedrock at 6.1 m below grade in one borehole and refusal depths of 5.0 m to 6.4 m in five additional boreholes. The borehole data also noted the presence of "sensitive" clays.

Seismic refraction measurements and simple critical distance calculations indicate a bedrock depth on the order of 6 m +/- 1 m. The compressional (P) wave velocity of the rock was measured to be approximately 4400 m/s to 4600 m/s. The seismic refraction data was used to constrain the shear-wave velocity models.

Table 2: Calculated V_s30 values (m/s) from the MASW data (0 to 30m)

Sounding	Minimum	Average	Maximum	Site Class
1	597	**846**	1054	**C***

The calculated average V_s30 values from the 1D MASW soundings collected was 846 m/s +/- 10% to 15%.

The V_s30 values calculated for the minimum and the maximum envelopes ranged from 597 to 1054 m/s.

Low shear-wave velocities (< 200 m/s) are noted in the upper 2 m. Low shear-wave velocities can be indicative of soft or liquefiable soils that may require additional geotechnical analysis.

Based on the average V_s30 values (as determined through the MASW method) and table 4.1.8.4.A of the National Building Code of Canada, 2015 Edition, the investigated area is site class "C" ($360< V_S30 \leq 760$ m/s).

*Site class "B" ($760< V_S30 \leq 1500$ m/s) requires less than 3 m of overburden material between the foundation and rock. (Commentary "J" sentence 100 *"Site Classes A and B, are not to be used if there is more than 3 m of soil between the rock surface and the bottom of the spread footing or mat foundation, even if the computed average shear wave velocity is greater than 760m/s*").

It must be noted that the site classification provided in this report is based solely on the V_s30 value as derived from the MASW method and that it can be superseded by other geotechnical information. This geotechnical information includes, but is not limited to, the presence of **sensitive** and/or liquefiable soils, more than 3m of soft clays, high moisture content, etc. The reader is referred to section 4.1.8.4 of the National Building Code of Canada, 2015 Edition for more information on the requirements for site classification.

This report has been written by Ben McClement, P.Eng.

Ben McClement, P.Eng.

LICENSED PROFESSIONAL ENGINEER
R.B. McCLEMENT
PROVINCE OF ONTARIO

Appendix B: Laboratory Certificate of Analysis

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: Maxime Leroux

PROJECT: OTT-00245378-F0

AGAT WORK ORDER: 18Z397193

SOIL ANALYSIS REVIEWED BY: Amanjot Bhela, Inorganic Supervisor

DATE REPORTED: Oct 19, 2018

PAGES (INCLUDING COVER): 5

VERSION*: 1

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

NOTES

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

Certificate of Analysis

AGAT WORK ORDER: 18Z397193

PROJECT: OTT-00245378-F0

CLIENT NAME: EXP SERVICES INC

ATTENTION TO: Maxime Leroux

SAMPLING SITE:Elmdale PS

SAMPLED BY:exp

Inorganic Chemistry (Soil)

DATE RECEIVED: 2018-10-15

DATE REPORTED: 2018-10-19

			SAMPLE DESCRIPTION:	BH#1 SS1 2'6"-4'6"	BH#3 SS3 5'-7'
			SAMPLE TYPE:	Soil	Soil
			DATE SAMPLED:	2018-10-05	2018-10-05
Parameter	**Unit**	**G / S**	**RDL**	**9624727**	**9624728**
pH (2:1)	pH Units		N/A	7.40	7.62
Resistivity (2:1)	ohm.cm		1	2100	6580
Chloride (2:1)	µg/g		2	146	55
Sulphate (2:1)	µg/g		2	216	27

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

9624727-9624728 EC/Resistivity, pH, Chloride and Sulphate were determined on the DI water extract obtained from the 2:1 leaching procedure (2 parts DI water:1 part soil).

Amanjot Bhela

AMANJOT BHELA

Certified By:

Quality Assurance

CLIENT NAME: EXP SERVICES INC
PROJECT: OTT-00245378-F0
SAMPLING SITE:Elmdale PS

AGAT WORK ORDER: 18Z397193
ATTENTION TO: Maxime Leroux
SAMPLED BY:exp

Soil Analysis

RPT Date:			DUPLICATE				REFERENCE MATERIAL			METHOD BLANK SPIKE			MATRIX SPIKE		
PARAMETER	Batch	Sample Id	Dup #1	Dup #2	RPD	Method Blank	Measured Value	Acceptable Limits		Recovery	Acceptable Limits		Recovery	Acceptable Limits	
								Lower	Upper		Lower	Upper		Lower	Upper
Inorganic Chemistry (Soil)															
pH (2:1)	9624727	9624727	7.40	7.43	0.4%	N/A	101%	90%	110%	NA			NA		
Chloride (2:1)	9624727	9624727	146	144	1.4%	< 2	100%	70%	130%	108%	70%	130%	97%	70%	130%
Sulphate (2:1)	9624727	9624727	216	214	0.9%	< 2	95%	70%	130%	107%	70%	130%	98%	70%	130%

Comments: NA signifies Not Applicable.

Certified By: Amanjot Bhela

ASSOCIATION OF THE CHEMICAL PROFESSION OF ONTARIO
CHARTERED
AMANJOT BHELA
CHEMIST

Method Summary

CLIENT NAME: EXP SERVICES INC

PROJECT: OTT-00245378-F0

SAMPLING SITE:Elmdale PS

AGAT WORK ORDER: 18Z397193

ATTENTION TO: Maxime Leroux

SAMPLED BY:exp

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

AGAT Laboratories

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

Chain of Custody Record

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

Laboratory Use Only

Work Order #: 18Z397193
Cooler Quantity: One
Arrival Temperatures: 20.8|20.9|20.8
Custody Seal Intact: ☐Yes ☐No ☐N/A
Notes: no ice

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

Report Information:

Company: Exp Services Inc. Ottawa
Contact: Maxime Leroux
Address: 2650 Queensview Dr. Unit 100
Ottawa ON K2B 8H6
Phone: 613-688-1899 Fax:
Reports to be sent to:
1. Email: maxime.leroux@exp.com
2. Email:

Regulatory Requirements: ☐ No Regulatory Requirement

(Please check all applicable boxes)

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

☐ Sewer Use
☐ Sanitary
☐ Storm
Region ___ *Indicate One*
☐ MISA

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

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

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

Project Information:

Project: OTT-00245378-FO
Site Location: Elmdale PS
Sampled By: exp
AGAT Quote #: PO:
Please note: If quotation number is not provided, client will be billed full price for analysis.

Sample Matrix Legend

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

Invoice Information:

Bill To Same: Yes ☑ No ☐

Company:
Contact:
Address:
Email:

Sample Identification	Date Sampled	Time Sampled	# of Containers	Sample Matrix	Comments/ Special Instructions	Field Filtered - Metals, Hg, CrVI Y / N	Metals and Inorganics	O. Reg 153: ☐ All Metals ☐ 153 Metals (excl. Hydrides) ☐ Hydride Metals ☐ 153 Metals (incl. Hydrides)	ORPs: ☐ B-HWS ☐ Cl ☐ CN ☐ Cr^{6+} ☐ EC ☐ FOC ☐ Hg ☐ pH ☐ SAR	Full Metals Scan	Regulation/Custom Metals	Nutrients: ☐ TP ☐ NH_3 ☐ TKN ☐ NO_3 ☐ NO_2 ☐ NO_3+NO_2	Volatiles: ☐ VOC ☐ BTEX ☐ THM	PHCs F1 - F4	ABNs	PAHs	PCBs: ☐ Total ☐ Aroclors	Organochlorine Pesticides	TCLP: ☐ M&I ☐ VOCs ☐ ABNs ☐ B(a)P ☐ PCBs	Sewer Use	pH	sulphate	chlorides	Electrical Resistivity
BH#1 SS1 2'6"-4'6"	Oct.5		1	S																	/	/	/	/
BH#3 SS3 5'-7'	Oct.5		1	S																	/	/	/	/

Samples Relinquished By (Print Name and Sign):	Date	Time	Samples Received By (Print Name and Sign):	Date	Time
Jeff MacMillan	Oct. 13/18	2:20	Linda Berthelette	18/10/15	8h30
LB to FedEx	18/10/15	16h00			

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