City of Iqaluit

Preliminary Geotechnical Investigation Report
Revision 1

Type of Document:
FINAL

Project Name:
Proposed New Landfill Facility
Iqaluit, NU

Project Number:
OTT-00248813-A0

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Date Submitted:
January 28, 2020

City of Iqaluit

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Attention: Mr. Matthew Van Strien, Procurement Officer

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Legal Notification

This report was prepared by EXP Services Inc. for the account of the **City of Iqaluit.**

Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. EXP Services Inc. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this project.

Executive Summary

EXP Services Inc. (EXP) carried out a geotechnical investigation at the site of the proposed landfill to be located on a 22 hectare site approximately 8 km northwest of the City of Iqaluit. This work was authorized by the City of Iqaluit via Service Contract SC000818 dated August 16, 2018. The results of this investigation were reported to the City of Iqaluit under our Project No. OTT-00248813-A0 dated July 26, 2019 2019 titled Preliminary Geotechnical Investigation, New Landfill Site, Iqaluit, NU. Since the preparation of that report, we were notified that the elevations provided previously were incorrect. New elevations of the boreholes were provided and we were requested to revise the report accordingly. The revised elevations are higher than the previously supplied borehole elevations by 10.2 m to 10.9 m. Since revised topographical map and revised design elevations are not available for the preparation of this report, it has been assumed that the revised topographical and design elevations will also be higher by an average of the difference in the borehole elevations, i.e. 10.6 m.

In December 2019, EXP was provided with new sections for the cells as well as additional groundwater monitoring results complete by Dillon Consultant and requested to revise the July 26, 2019 to discuss the feasibility of lowering the bottom of the cell by 2 and 4 m. This report supersedes the draft report issued in July 26, 2019.

The purpose of the investigation was to establish the geotechnical and groundwater conditions at the site and to make recommendations regarding the design and construction of the facility from a geotechnical perspective.

The proposed landfill will comprise of a landfill cell, leachate collection sump and leachate holding ponds. A potential equipment building, and site trailers are also proposed to be installed at the site as per the preliminary site plan layout provided by Dillon Consulting on May 7, 2019.

Initial plan and scope of work called for the drilling of five (5) sampled boreholes throughout the site. However, additional drilling and installation was requested prior to the execution of the fieldwork by the designers. Therefore, the preliminary geotechnical investigation comprised of drilling six (6) sampled boreholes (Boreholes BH-101 to BH-106) to 3 m to 6 m depth and five additional boreholes (TH-107/W-107 to TH-111/W-101) to 5.5 m to 7.0m depth for installation of PVC piping and thermistors and standpipes for long-term groundwater and ground temperature monitoring at the site.

The investigation revealed that the site predominantly contains sand and gravel, which extends to the bedrock contacted at a depth of 1.0 m to 5.0 m. This stratum has a low moisture content and is free of ice lensing. Geological information indicates that the bedrock at the site is likely to be Monzogranite. At the time of the fieldwork, soil at the site was frozen to the ground surface and therefore, the groundwater table and the active layer thickness could not be established.

The salinity of the on-site soils is low. General Use (GU) Portland cement may be used in subsurface concrete requirements at the site. The concrete mix design should conform to CSA A23.1.

The site has been classified as **Class C** for seismic site classification in accordance with the requirements of Section 4.1.8.4 of the National Building Code of Canada, 2015.

The investigation has revealed that the on-site soils are suitable for construction of the proposed landfill. Since the natural soils are permeable, the landfill cell, leachate collection sump and leachate holding ponds will have to be fully lined. The guidelines recommend the following:

1.) The base of the cells and the leachate holding ponds should be set at a depth of 1 m below existing grade or 1.5 m above the seasonal high groundwater table or at the permafrost level. Information regarding the seasonal high groundwater table and the permafrost level was not available at the time of writing this report. It is likely that the seasonal high groundwater table may govern the design. Therefore, additional monitoring of groundwater and temperature are recommended on the spring prior to finalizing of the design.

2.) Since the on-site soils are very permeable and clayey impermeable soils are not available in the Iqaluit area, the landfill cell and inside slopes of the berms, leachate collection sump and leachate holding ponds will all have to be lined with two liners, i.e. a 60 mil geosynthetic clay liner and a 60 mil High Density Poly Ethylene (HPDE) liner. A leachate collection system should be installed in a 600 mm granular layer above the HDPE liner leading to the leachate sump. Leachate from the sump should be directed to the leachate holding ponds.

3.) The berms of the proposed landfill cell and the leachate holding ponds are expected to be stable when sloped back on an inclination of 3H:1V. This would require conformation based on slope stability analysis once the design of the facility has been finalized. The inside faces of the berms of the landfill, leachate holding ponds and the sides of the leachate collection sump should also be lined with a 60 mil geosynthetic clay liner overlain by 60 mil thick HDPE liner. The outside slopes of the berms and the leachate holding pond should be protected with coarse gravel to minimize erosion.

4.) Any permanent buildings proposed to be constructed would have to be supported on rock socketed piles. Additional recommendation on foundation alternatives and design will be provided once the design is finalized.

Excavation for construction of the landfill storage cell will extend to 0.5 m to 4.0 m below the existing ground surface. The excavation base in the granular soils below the groundwater table would be susceptible to “base heave” type of failure and should be undertaken only after the groundwater table has been lowered to below the final excavation base.

The on-site soils underneath the landfill are expected to thaw due to the heat generated by decomposition of the waste. Similarly, the soils under the leachate holding ponds are expected to thaw due to absorption of heat from the sun rays by the leachate. The settlements of the cell and the leachate holding ponds were estimated to vary from 20 mm to 150 mm. It is therefore recommended that liners should be installed with enough folds to accommodate the anticipated settlements. The manufacturer of the liners should be consulted for this purpose.

Groundwater and temperature monitoring should be undertaken throughout the year at the site to establish seasonal high groundwater table and to establish the active layer thickness.

It is also recommended that groundwater and gas monitoring networks should be installed to ensure that the leachate is not impacting the groundwater and that explosive gases are not migrating from the property during operation of the landfill.

Methane monitoring devices should be installed in any of the structures located on the site to ensure that methane is not accumulating in the building(s).

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

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1 Introduction

EXP Services Inc. (EXP) carried out a geotechnical investigation at the site of the proposed landfill to be located on a 22 hectare site approximately 8 km northwest of the City of Iqaluit. This work was authorized by the City of Iqaluit via Service Contract SC000818 dated August 16, 2018. The results of this investigation were reported to the City of Iqaluit under our Project No. OTT-00248813-A0 dated May 13, 2019 titled Preliminary Geotechnical Investigation, New Landfill Site, Iqaluit, NU. Since the preparation of that report, we were notified that the elevations provided previously were incorrect. New elevations of the boreholes were provided and we were requested to revise the report accordingly. The revised elevations are higher than the previously supplied borehole elevations by 10.2 m to 10.9 m. Since revised topographical map and revised design elevations are not available for the preparation of this report, it has been assumed that the revised topographical and design elevations will also be higher by an average of the difference in the borehole elevations, i.e. 10.6 m. therefore, boreholes elevations noted should not be used for design of any of the proposed installation. The report was revised in July 26, 2019.

In December 2019, EXP was provided with new sections for the cells as well as additional groundwater monitoring results complete by Dillon Consultant and requested to revise the July 26, 2019 to discuss the feasibility of lowering the bottom of the cell by 2 and 4 m. This report supersedes the draft report issued in July 26, 2019.

The proposed facility would comprise of a solid waste storage cell, leachate collection sump and two leachate holding ponds. A potential equipment building, and site trailers are also proposed to be installed at the site as per the preliminary site plan layout provided by Dillon Consulting on December, 2019.

Current preliminary layout plan of the facilities and cross-sections of the landfill cell and the leachate collection sump were provided for preparation of this report. These latest plans and sections indicate that the bottom of the landfill cell will vary from Elev. 168.0 m to Elev. 173.0 m. The height of the berms of the landfill cell will vary from approximately 3.0 m to approximately 8 m. The proposed crest width of the berms is approximately 4 m. The invert of the leachate holding ponds and the heights of the berms were not provided.

The investigation was undertaken to provide preliminary comments related to:

1.) Geotechnical and groundwater profile at the site;
2.) Define key properties of the on-site soils;
3.) Ground temperature and active layer thickness;
4.) Groundwater table;
5.) Seismic site classification in accordance with the requirements of National Building Code of Canada 2015 Edition and comment on liquefaction potential of on-site soils;
6.) Recommend base preparation for construction of the landfill cell and the leachate holding ponds;
7.) Assess the need to line the proposed cell and ponds and recommend suitable type of liners;
8.) Settlements of the landfill cell and leaching holding ponds due to the ice thawing in soil pores;

9.) Steepest berm slopes that will be stable under static and seismic loading conditions;

10.) Suitability of on-site soils for construction of the berms and as cover material.

It is noted that seepage and contaminant transport assessment and thermal regime assessment (spatially and temporally) was not part of the terms of reference.

The comments and recommendations given in this report are preliminary since they are based on preliminary design concept and subject to change. This office must be given an opportunity to revise the report once the design of the facilities is finalized.

2 Site Description

The proposed landfill site would be located on a 64.12-hectare parcel of land located approximately 8 km northwest of the City of Iqaluit (Figure 1). The proposed landfill would comprise of a solid waste storage cell, leachate collection sump and two leachate holding ponds.

Figure 2 also shows the existing site conditions and proposed installation. A review of this plan indicates that a hummock is located in the south part of the site. The elevation of the top of the hummock is Elev. 189.6 m approximately on east, north and south sides. Along the west property boundary, the elevations of the hummock at the property boundary vary from Elev. 180.6 m at the center to Elev. 160.6 m approximately at the southwest corner, and at Elev. 155.6 m at the northwest corner of the site. In addition, three hummocks are located along the north property boundary with their peak elevations at Elev. 182.6 m to 183.6 m approximately. A valley is located in the central portion of the site and extends from northwest corner of the site in a southeasterly direction. The bottom of the valley is at Elev. 168.6 m to 166.6 m approximately. Therefore, it is evident that the terrain at the site is hummocky and undulating.

Two drainage ditches are located along the east boundary of the landfill site and run in a north-south direction. The ditches converge into one ditch close to the southeast corner of the landfill site. Another drainage ditch is located close to the west boundary of the landfill site and runs in a southeast direction to ponds located at the east boundary of the site.

3 Procedure

Access to the site was only available by ATV and through rough and undulating site topography and entailed crossing numerous water-logged areas; as such, it was not possible to mobilize the drilling equipment to the site in the summer without potential damage to the terrain/tundra and crossing water bodies. As a result, it was agreed to complete a desktop study for the site as presented in our letter dated October 19, 2018 and delay the fieldwork until the winter of 2019. For the purpose of the fieldwork, Canadrill Ltd. (Canadrill), a local drilling company, completed modifications and mounted the air-track drill on a mechanical shovel which in turns was used to drag the compressor and associated equipment throughout the tundra and snow covered area to allow the completion of the investigation in March-April of 2019 (refer to Photos in Appendix A).

The fieldwork for this project was undertaken between March 26 and April 4, 2019 using an air-track drill mounted on a mechanical shovel rented from Canadrill. The fieldwork was supervised on a full-time basis by a senior geotechnician from EXP experienced with permafrost soils and northern construction techniques.

Initial plan and scope of work called for the drilling of five (5) sampled boreholes throughout the site. However, additional drilling and installation was requested prior to the execution of the fieldwork by Dillon Consulting, i.e. the designers retained for this project.. Therefore, the preliminary geotechnical investigation comprised of drilling six sampled boreholes (Boreholes BH-101 to BH-106) to 3 m to 6 m depth and five additional boreholes (TH-107/W-107 to TH-111/W-101) to 5.5m to 7.0m depth for installation of PVC piping and standpipes for long-term groundwater and ground temperature monitoring at the site.

The locations of the boreholes were established in the field by EXP's representative using a GPS and are shown on the appended Site Plan, Figure 2. Their elevations were established using contour plans provided on a topographical survey prepared by Arctic UAV acting as a sub-contractor to EXP in the summer of 2018, and therefore are considered approximate. Therefore, it is recommended that the final locations and elevations of the boreholes be established in the summer prior to final issuance of the report. Also the elevation noted shouldn't be used for design of any of the proposed installations.

The coordinates of the boreholes and their revised elevations have been tabulated on Table 1.

Table 1: Locations and Estimated Elevations of Boreholes

Borehole No.	Eastings	Northings	Estimated Elevations (m**)
BH-101	520917	7075935	172.5
BH-102	520843	7076288	172.5
BH-103	520543	7076508	161.9
BH-104	520978	7076619	173.5
BH-105	521235	7076674	178.8
BH-106	521094	7076291	166.1
TW-107	521117	7076090	164.8

Table 1: Locations and Estimated Elevations of Boreholes			
Borehole No.	**Eastings**	**Northings**	**Estimated Elevations (m**)**
TW-108	520966	7075812	164.0
TW-109	520669	7076316	169.6
TW-110	520755	7076668	174.2
TW-111	521441	7076739	190.0

During drilling, bulk soil samples were obtained from different depths from Boreholes BH-101 to BH-106. All the soil samples retrieved were visually examined and logged. Samples were preserved in watertight plastic bags. A portion of each sample was placed in a smaller plastic bag and weighted on-site to assure accurate moisture content determination. Boreholes TH/W 107 to TH-111/W-111 were not sampled but were logged based on examination of the drill cuttings. The soil samples were transported to the EXP laboratory in the City of Ottawa, Ontario, where they were visually examined in the laboratory by a senior geotechnical engineer and borehole logs prepared. The engineer also assigned the laboratory testing, which consisted of performing natural moisture content on all the samples and grain-size analyses, pH, sulphate, chloride and electrical conductivity tests on selected soil samples.

Installation of solid PVC piping with a capped bottom was completed at each of the borehole locations TH-107 to TH-111. In addition, another shallow slotted pipe was also installed at each of these locations to a depth of 2.4 m. The solid and slotted PVC pipes were installed at the request of Dillon Consulting for long-term temperature and groundwater monitoring at the site. Photographs of the installation are included in Appendix A.

4 Site Geology

A review of the surficial geology map of Iqaluit was undertaken and the surficial geology at the landfill site has been plotted on Figure 3. It indicates that the majority of the site comprises of a till veneer (T_v) except close to the northeast corner of the site where it is expected to be till blanket (T_b).

The geological map indicates that the till veneer (T_v) is approximately 0.5 m to 2 m thick. According to the geological information, greater than 40 percent of this area is expected to be composed of the till and less than 60 percent is expected to comprise of rock layers, knobs and rubble.

The till blanket (T_b) is expected to be 1 m to 10 m thick with undulating plain with minor fluted, hummocky, ridged or channeled areas. The hummocky till consists of a sediment resulting from dry land erosion that is unsorted to poorly sorted and contains particles ranging in size from clay to boulders, suspended in a matrix of mud or sand.

The bedrock at the site underlying the till is expected to be Monzogranite.

The site visit revealed the presence of bedrock outcrops at the northeast and southeast corners of the site. A field of boulders was also noted at the north side of the site (Figure 3).

5 Soil Description

A detailed description of the subsurface soil and groundwater conditions determined from the boreholes are given on the attached Borehole Logs, Figures 4 to 14 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 the purpose of geotechnical design and should not be interpreted as exact planes of geological change. The “Note on Sample Descriptions” preceding the borehole logs form 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 in descending order:

5.1 Tundra

In Borehole Nos. BH-101 and BH-106, a surficial layer of tundra 50 mm thick was encountered.

5.2 Weathered Bedrock

In Borehole BH-103, the surficial layer is weathered bedrock, which extends to 0.6 m depth (Elev. 161.3 m).

5.3 Sand and Gravel

The predominant overburden soil in Boreholes BH-101 to BH-106 - except Borehole in BH-103 - is sand and gravel with cobbles and boulders, which extends to 1.0 m to 5.0 m depth (Elev. 161.2 m to 188.6 m). This stratum is moist. Its natural moisture content varied from 1.7 to 21.5 percent.

The results of the ten (10) grain-size analyses performed on the overburden samples have been summarized on Table 2 and the individual test results have been plotted on Figures 15 to 24 inclusive. This table indicates that the soil composition consists of 5 to 25 percent clay and silt, 49 to 82 percent sand and 8 to 46 percent gravel. It is noted that cobbles and boulders in the overburden were not sampled. Therefore, the gradations presented on Table 2 do not represent whole samples and some of the sand may have been pulverized to finer particles as a result of the drilling operation.

Table 2: Summary of Grain-Size Analyses on Overburden Samples					
Borehole No.	Depth. (m)	Soil Composition (%)			Figure No.
		Silt and Clay	Sand	Gravel	
BH-101	0 – 1	9	72	19	15
BH-101	1 – 2	10	73	17	16
BH-102	0 – 1	25	71	4	17
BH-102	1 – 2	16	78	6	18
BH-104	0 – 1	5	50	45	19
BH-104	2 – 3	15	77	8	20
BH-104	3 – 4	5	84	11	21
BH-105	0 – 1	6	74	20	22
BH-106	0 – 1	17	75	8	23
BH-106	1 – 2	21	71	8	24

5.4 Bedrock

The boreholes were drilled using an air-track drill rig, which breaks down the soil and bedrock to fine cuttings. The cuttings area spewed to the surface. As a result, the cuttings were mixed and it is not possible to accurately establish the bedrock depth, type or its condition. Therefore, the depth to bedrock indicated is approximate.

A review of the geological maps of Iqaluit indicates that the bedrock is likely to be Monzogranite.

6 Ground Temperature Readings/Groundwater Monitoring

Solid PVC pipe with capped bottom and top was installed at each of the borehole locations TH-107 to TH-111. In addition, another shallow slotted pipe was also installed at each of these locations to a depth of 2.4 m. The solid and slotted PVC pipes were installed at the request of Dillon Consulting for long-term temperature and groundwater monitoring at the site. Photographs of the installation are included in Appendix A.

6.1 Ground Temperature Readings

Subsequent to completion of drilling the boreholes and installation of PVC pipes in Boreholes TH-107 to TH-111, permanent thermistors were installed in early June 2019 and the first set of readings in the new thermistors were taken on June 3, 2019. The readings have been listed on Table 3. Additional readings will eb collected next time EXP is in Iqaluit for another project or task. Also, additional reading can be taken by the consultant.

Table 3: Summary of Temperature Measurements collected on June 3, 2019

TH-107		TH-108		TH-109	
Depth of Bulb (m)	June 3, 2019 Temp. (Celsius)	Depth of Bulb (m)	June 3, 2019 Temp. (Celsius)	Depth of Bulb (m)	June 3, 2019 Temp. (Celsius)
-0.0	12.3	-0.0	5.7	-0.0	8.5
-0.5	9.9	-0.5	8.5	-0.5	8.9
-1.0	-0.8	-1.0	10.5	-1.0	14.6
-1.5	-3.2	-1.5	5.2	-1.5	8.9
-2.0	-4.6	-2.0	-0.3	-2.0	-0.8
-2.5	-5.9	-2.5	-2.0	-2.5	-3.1
-3.0	-7.0	-3.0	-3.7	-3.0	-4.9
-3.5	-7.8	-3.5	- 5.5	-3.5	-6.3
-4.0	-8.3	-4.0	- 7.0	-4.0	-7.6
-4.5	-8.6	-4.5	- 8.1	-4.5	-8.3
-5.0	-8.7	-5.0	- 8.6	-5.0	-10.2
-6.0	-8.5	-6.0	-8.8	-6.0	-9.4
-7.0	-8.2	-7.0	- 8.6	-7.0	-9.3

= Bead above GS

Depth of Bulb from top of beads as manufactured except for TH-111. to be confirmed during subsequent visits

Table 3 (cont.): Summary of Temperature Measurements collected on April 18, 2019				
TH-110		TH-111		
Depth (m)	June 3, 2019 Temp. (Celsius)	Depth (m)	June 3, 2019 Temp. (Celsius)	
-0.0	6.7	2.0	6.3	
-0.5	12.6	2.5	8.9	
-1.0	14.9	2.0	8.7	
-1.5	7.0	1.5	8.1	
-2.0	-1.0	1.0	9.1	
-2.5	-2.5	0.5	12.6	
-3.0	-2.5	0.0	13.6	
-3.5	-5.5	-0.5	-0.5	
-4.0	-6.3	-1.0	-3.0	
-4.5	-7.0	-1.5	-5.0	
-5.0	-8.0	-2.5	-6.1	
-6.0	-8.0	-3.0	-7.0	
-7.0	-7.9	-3.5	-7.5	
		-4.0	-7.9	
		-4.5	-8.2	
		-5.5	-8.2	= Bead above GS

6.2 Groundwater Monitoring

Water level readings were taken in the standpipes installed in Boreholes TH-107 to TH-111 by EXP on June 3, 2019 and Dillon Consultant on September 6, 2019 as summarised in Table 4 below.

Table 4: Groundwater Monitoring Results						
Date	Borehole No.	Water Level Reading (m)	Water Level Elev. (m)	Date	Water Level Reading	Water Level Elev.(m)
June 13, 2019 (EXP)	TW-107	Dry	--	Sept 6, 2019 (Dillon)	0.29	164.5
	TW 108	0.2	163.8		0.94	163.1
	TW-109	0.2	169.4		0.42	169.2
	TW-110	Dry	--		0.71	173.5
	TW-111	Dry	188.8		0.83	189.2

It is recommended that periodic groundwater readings should be taken in the boreholes during late spring and summer months to establish the active layer thickness. The active layer thickness is expected to be maximum at the end of summer or early fall.

7 Soil Salinity

The salinity of the on-site soils was measured by conducting electrical conductivity tests on selected samples. The test results have been listed on Table 5.

Table 5: Salinity of On-Site Soils

Borehole No.	Sample Depth (m)	Salinity in Parts Per Thousand (ppt)
BH-101	3.0 – 4.0	0.042
BH-102	1.0 – 2.0	0.052
BH-104	2.0 – 3.0	0.059
BH-104	3.0 – 4.0	0.040
BH-105	0 – 1.0	0.060
BH-106	1.0 – 2.0	0.061

The above readings indicate that the on-site soils are low in salinity.

8 Chemical Tests on Soil Samples and Subsurface Concrete Requirements

Chemical tests limited to pH, sulphates, chlorides and electrical conductivity were performed on six selected soil samples. The test results are given on Table 6. The testing was performed by AGAT Laboratories, Mississauga, Ontario.

Table 6: Results of Chemical Tests on Soil Samples

Parameter	Borehole No. and Depth						Threshold Values
	BH 101 3 m – 4 m	BH 102 1 m – 2 m	BH 104 2 m -3 m	BH 104 3 m - 4 m	BH 105 0 m – 1 m	BH 106 1 m – 2 m	
pH	7.93	8.04	8.17	8.03	7.68	7.71	< 5
Sulphates (%)	0.0007	0.0004	0.0017	0.0003	0.0021	0.0016	0.1
Chlorides (%)	0.0005	0.0004	0.0007	0.0006	0.0003	0.0009	0.04
Electrical Resistivity (ohm/cm)	15150	12345	10870	16130	10750	10525	< 700 ohm.cm High corrosion potential

The test results indicate the soil contains a sulphate content of less than 0.1 percent, and a chloride content of less than 0.04 percent. This concentration of sulphates and chlorides in the soil would have a negligible potential of attach on subsurface concrete. Therefore, General Use (GU) Portland cement may be used in the subsurface concrete at this site. The concrete for the site should be designed in accordance with the requirements of CSA- A23.1-17.

The resistivity results indicate that the subsurface soil is not corrosive to buried steel.

9 Site Classification and Seismic Site Response

The investigation has revealed that the geotechnical conditions at the site consist of 0.6 m to 4.0 m of sand and gravel overburden underlain by bedrock. Geological maps indicate that the bedrock is likely to be Monzogranite. Therefore, the site has been classified as **Class C** for seismic site response in accordance with the requirements of Section 4.1.8.4 of the National Building Code of Canada, 2015.

The overburden soils are also considered to be non-liquefiable.

10 Discussion and Recommendations

The proposed solid waste disposal facility will comprise of solid waste storage cell, a leachate collection sump, and two leachate holding ponds. The cell and the leachate holding pond will be made by construction of berms around them. Preliminary site plan and sections of the solid waste storage cell were provided for preparation of the report.

It is considered that from a geotechnical perspective, there are three important considerations for construction of the cell and the leachate holding ponds. These are:

1.) Prevention of leakage of leachate from the cell and the holding ponds to the environment, which would necessitate lining of the cells with geosynthetic liners since the on-site soils are permeable.

2.) Stability of the berm slopes including selection of suitable material for construction of the berms, its placement and proper compaction.

3.) Degradation of the permafrost beneath the cell and the leachate holding ponds and resulting settlements of the berms and the bases. These three aspects are discussed in detail below.

10.1 Excavation for Construction of Cell and Leachate Holding Ponds

10.1.1 Excavation for Solid Waste Storage Cell #1

It is understood that current plans (December 2019) indicates that the elevation of the bottom of the solid waste storage cell will vary from Elev. 168 to 173 m. This would result in an excavation which would vary for 0.5 m to 4 m in depth. This excavation will be undertaken in the silty sand and gravel stratum and will terminate either in the overburden or in the bedrock. In areas where the excavation will terminate in the overburden and is located below the groundwater table, the excavation base will be susceptible to a “base heave” type of failure. Therefore, the site would need dewatering by pumping from large capacity sumps prior to undertaking the excavation below the groundwater table. The excavation in the granular soils above the groundwater table may be cut back at 1H:1V. Below the groundwater table, the sides of excavation are susceptible to sloughing and may eventually stabilize at a slope of 3H:IV. The bedrock may be excavated with near vertical sides.

10.1.2 Excavation for Leachate Holding Ponds

It is recommended that the proposed footprint of the leachate holding ponds should extend at least 2 m beyond the toe of the outside berm slopes. The extended footprint should be stripped of any existing tundra, organic/peat layers and/or any other soft natural materials encountered to expose a structurally stable subgrade of either unfrozen or frozen natural inorganic soils. The subgrade should be reviewed and approved by qualified geotechnical personnel.

It is recommended that any over-excavation required should be carried out in stages such that an over-excavated area can be backfilled to pre-existing grades within one day. This is intended to limit the time of exposure for underlying permafrost soils and minimize short-term permafrost thaw and global instability of the berms. If over-excavated areas are not backfilled to at least the current grade the same day, then additional thawing of the frozen soils is anticipated, potentially resulting in soft soil conditions throughout the base and requiring over-excavation to remove the soft soils. It is also noted the site contains deposit of silt and sandy silt, which are dilatant and will become wet and saturated when thawed. Therefore, an allowance should be made in the contract for the removal and replacement of such material, if encountered during construction with granular stable material.

10.2 Base Preparation of Cell and Leachate Holding Ponds

Guidelines indicate that for construction of the base of the landfill cell and the leachate holding ponds, unconsolidated soils should be preferably excavated to a depth of 1 m, to the permafrost line or to 1.5 m above the seasonal high groundwater table, whichever is encountered first. It appears that the seasonal high groundwater table may govern the design. However, the guidelines also indicate that alternatively the hydraulic gradient could be lowered by installation of an appropriate drainage and pumping system. Groundwater drainage system should provide for positive drainage of the groundwater away from the landfill site.

Although the groundwater at the site was established at a depth of 0.3 m to 0.9 m below the existing ground surface, these readings likely do not represent the high groundwater table at the site. The high groundwater table at the site is expected in the summer or early fall.

Excavation should be undertaken to the proposed subgrade level. The exposed subgrade should be proof rolled with a heavy roller. Five hundred millimeters of granular fill should then be placed in 300 mm lift thicknesses on the subgrade and each lift compacted to at least 95 percent of Standard Proctor Maximum Dry Density in accordance with ASTM D-698-12e2 (SPMDD). It is anticipated that the on-site soils will be suitable for this purpose provided that particles greater in size than 150 mm are discarded.

Depending on the exposed soils, the placement of the initial lift(s) of material may be inhibited by the build-up of excess porewater pressures within the native subgrade. It is recommended that emphasis be placed on covering the permafrost the same day as excavation and returning the area to current grade. Compaction should be monitored by qualified geotechnical personnel, and if the lift begins to exhibit signs that excess porewater pressure exists within the underlying materials (spongy or rolling appearance under traffic), then compaction should be stopped immediately and the next lift placed. Lifts above current grade should be placed and compacted to at least 95% of the SMPDD as outlined above and this may require that the initial lifts be allowed to drain over the course of several days.

10.3 Solid Waste Storage Cell and Leachate Holding Pond Lining

There is a scarcity of silty clay in Iqaluit and it is unlikely that silty clay would be available for lining of the solid waste storage cell and the leachate holding pond. It is therefore considered that two flexible membrane liners would be required. The construction of the bases of the cell and the leachate holding ponds may consist of the following:

- 500 mm of compacted granular base material;
- Non-woven geotextile;
- Geosynthetic clay liner, minimum thickness 60 mil.
- 60 mil. thick High Density Poly Ethylene (HPDE) liner;
- 300 m of protective layer consisting of compacted free-draining granular material;
- 300 mm leachate collection layer containing drains;
- Protective geotextile.

Solid waste may be stored above the protective geotextile. The leachate holding pond will not require installation of the drainage system.

10.4 Berm Construction

It is considered that the on-site sand and gravel overburden would be suitable for constructing the berms provided cobbles and boulders greater than 150 mm are removed. Proper compaction of the fill will be necessary to ensure stability of the berm slopes.

Based on the laboratory testing undertaken and previous experience in the area, the engineering properties of the soils listed on Table 7 may be assumed for slope stability analysis.

Table 7: Engineering Properties of Soils Selected for Slope Stability Analysis

Soil Type	Unit Weight (kN/m^3)	Effective Cohesion, C' (kPa)	Effective Angle of Internal Friction Ø' (degrees)
Sand and Gravel Fill compacted to minimum 95% SPMDD	22.0	0	34º
In-situ Sand and Gravel	22.0	0	35º
Compacted Waste	10.0	0	18º

The inclination at which the berm slopes would be stable is a function of a number of factors including:

1.) Height and width of the berms;

2.) Height of solid waste in the cells;

3.) Material used to construct the berms and its degree of compaction;

4.) Height of leachate in the holding ponds.

For preliminary design purposes, it may be assumed that berm slopes at an inclination of 3H:1V would be stable. A detailed slope stability analysis would be required once the design has been finalized to determine the stable slope inclination of the berms. The slope stability analysis would take into consideration slope loading (static and seismic).

The inside slopes of the berms of the cell and leachate holding ponds should also be lined with synthetic liners as discussed previously. The upper end of the liners (at the crest of the berms) should be buried in approximately 0.6 m deep key trench and backfilled with well compacted fill.

The outside slopes of the berms should be provided with suitable erosion protection.

Test pits are recommended prior to tendering and in the summer to evaluate the characteristics of the on-site granular material and their potential re-use in the construction of the berms and for general grading purpose at the site.

10.5 Groundwater Control

A number of streams cross the site and carry the runoff in a south to southeasterly direction. In order to facilitate construction of the landfill, it would be necessary to have a 1.5 m separation between the seasonal high groundwater table and the leachate. Therefore, construction of drainage ditch around the landfill will be required to direct the flow away from the landfill. This may be achieved by construction of drainage ditch around the perimeter of the landfill to divert the surface water from the site. The drainage ditch should be deep enough to capture all the run off during the period when the active layer is fully thawed.

The drainage ditch should be constructed prior to commencement of the excavation work on the site to minimize water control difficulties during construction and to allow the soil to dry. The construction of the drainage ditch will also minimize groundwater flow under the proposed cells during summer months thereby minimizing the potential of settlement of the berms due to washing out of the fines as a result of the groundwater flow under the cells.

Seepage of water into the excavations during construction should be anticipated. Any water entering the excavation may be collected in a shallow ditch located along the perimeter of the excavation and pumped from sump located at the low point. Care should be exercised when discharging the water to ensure that it does not result in erosion or transportation of sediment in accordance with the applicable government regulations.

10.6 Settlement of Cell and Berms

The on-site soils are expected to be thaw stable since they are predominantly free draining and contain low ice content. However, the on-site soils under the cell and the ponds will thaw due to the heat generated by decomposition of the waste and under the leachate holding pond due to absorption of heat from the sun rays by the leachate. Therefore, settlement of the bases of the cells and the berms were estimated. For this purpose, it was assumed that the on-site soils may thaw up to the underlying bedrock. The thaw strain of the soils was estimated based on soil type and estimated density. The settlements computed varied from 20 mm to 150 mm at the locations of Boreholes BH-101 to BH-106 inclusive.

It is recommended that the liners should be installed with several folds to prevent large strain development in the liners due to settlement of the ground. The manufactured of the liners should be consulted for this purpose.

10.7 Permanent Buildings Foundation

Any permanent building required to be constructed as part of the proposed facility will have to be supported on rock socketed piles. Other Types of foundation may be available depending on type of structures proposed as well as intended use. EXP can provide additional foundation recommendation once the plans and designs of the facility and all its component are finalized.

10.8 Monitoring Requirements

It is recommended that groundwater and gas monitoring networks should be installed to ensure that the leachate is not impacting the groundwater and that explosive gases are not migrating from the property during operation of the landfill.

Methane monitoring devices should be installed in any of the structures located on the site to ensure that methane is not accumulating in the building(s).

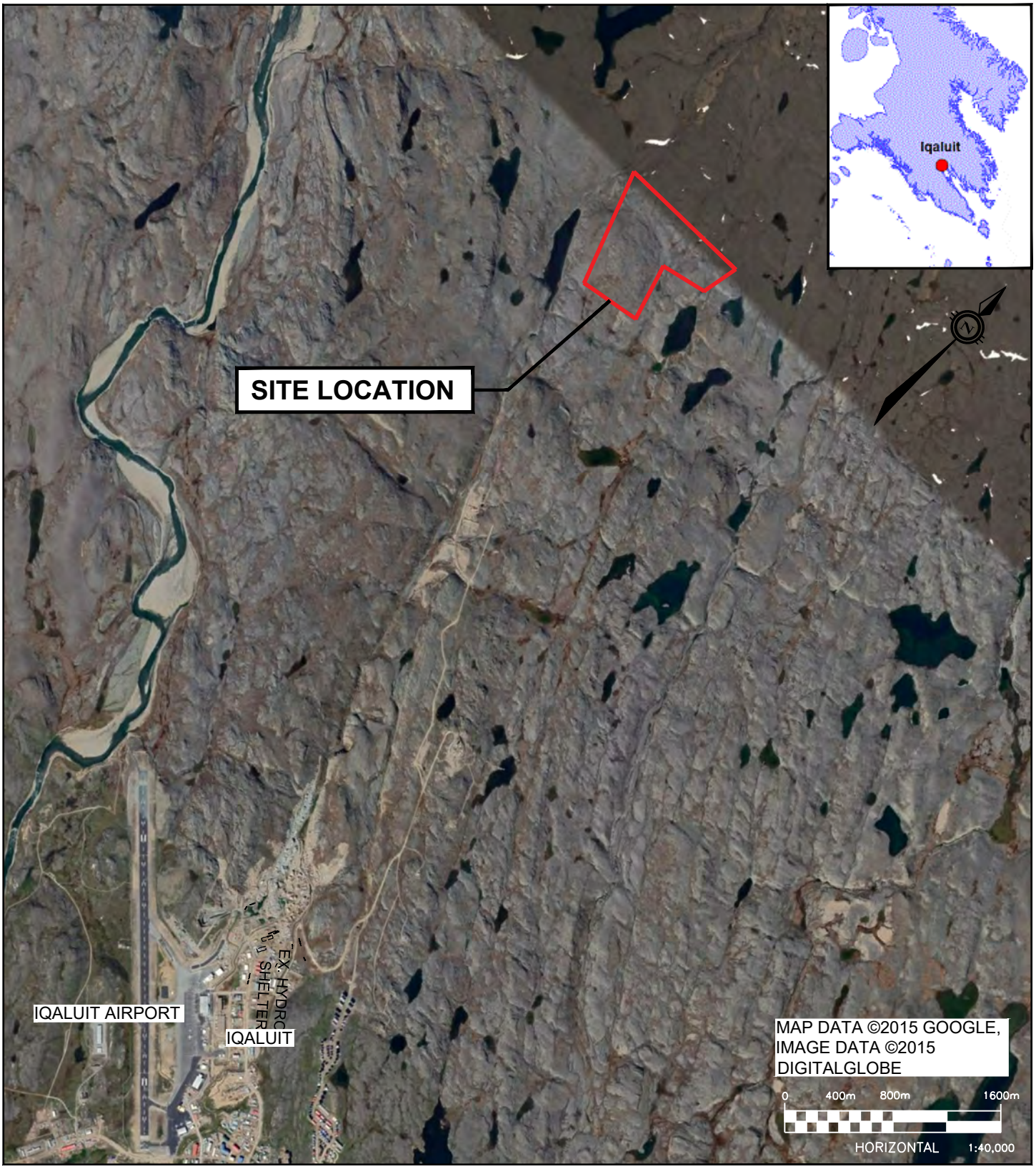
11 General Comments

The comments given in this report are intended only for guidance of design engineers and are preliminary in nature. Contractors bidding on or undertaking the works should, in this light, decide on their own investigations, as well, as their own interpretations of the factual borehole results, so that they may draw their own conclusions as to how the subsurface conditions may affect them.

The information contained in this report in no way reflects on the environmental aspects of soil. Should specific information be required, additional testing may be necessary.

Should you have any questions, please do not hesitate to contact this office.

Figures



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scale 1:10 000	PROJECT: PROPOSED LANDFILL SITE CITY OF IQALUIT, IQALUIT, NU	project no. OTT-00248813-A0
date May 2019		design SA / checked IT
drawn by J.R.	TITLE: SITE LOCATION PLAN	FIG 1

Filename: r:\240000\248000\248813-a0 iqaluit waste transfer station\ge\248813-ge-wtf 2019-05.dwg
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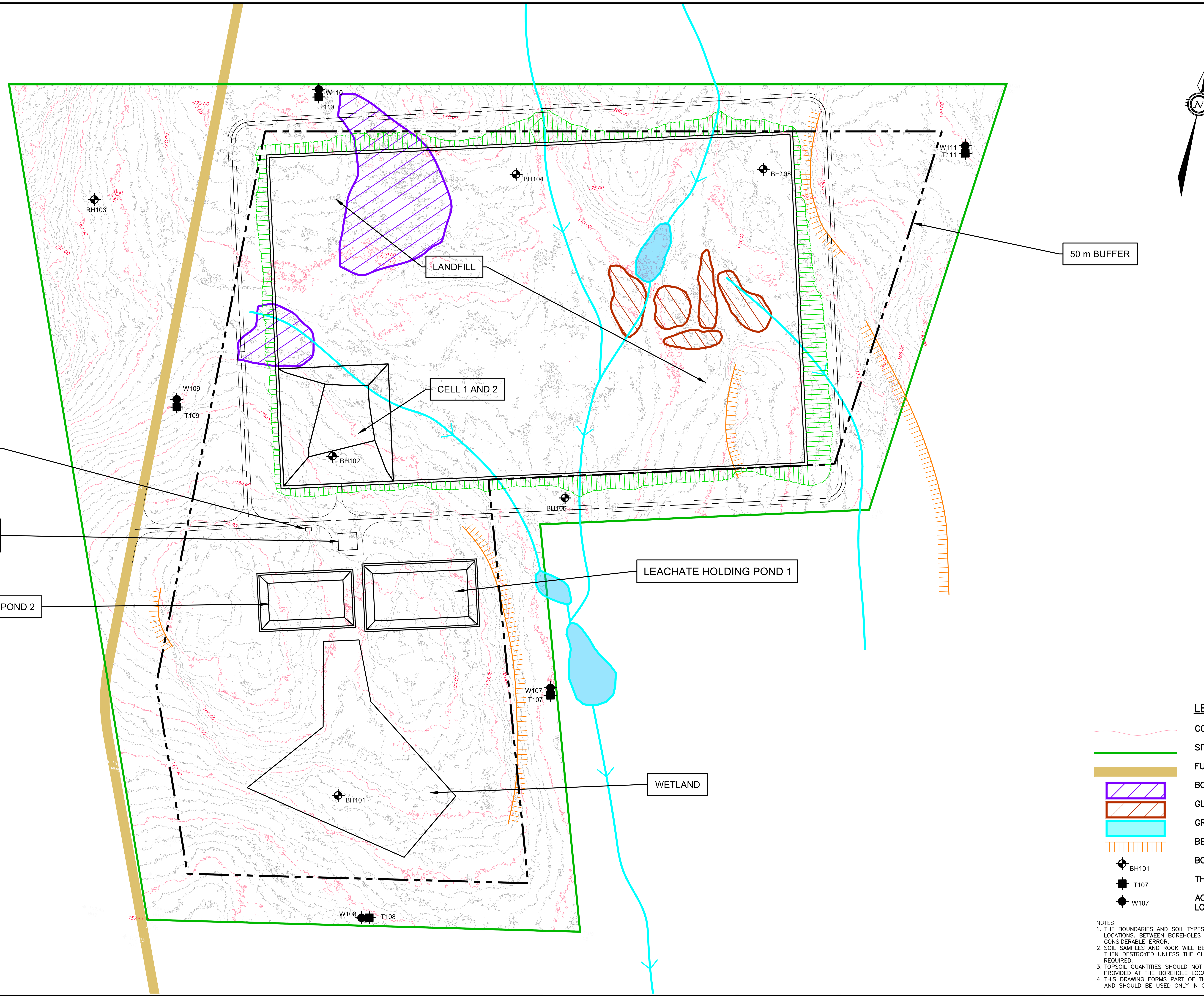

LEGEND

- CONTOUR EVERY 5.0m
- SITE BOUNDARY
- FUTURE ROAD
- BOULDER FIELD
- GLACIOFLUVIAL TERRACE
- GROUND WATER AND PONDING
- BEDROCK OUTCROP
- BH101 — BOREHOLE NUMBER AND LOCATION
- T107 — THERMISTOR NUMBER AND LOCATION
- W107 — ACTIVE WATER STATION NUMBER AND LOCATOIN

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. THIS DRAWING FORMS PART OF THE REPORT PROJECT NUMBER AS REFERENCED AND SHOULD BE USED ONLY IN CONJUNCTION WITH THIS REPORT.

NOTE:
REFERENCE DRAWING — PROPOSED CONDITIONS SITE PLAN, SHEET NO. 2 BY DILLON CONSULTING, RECEIVED ON MAY 7, 2019

CAUTION
THE POSITION OF ALL POLE LINES, CONDUITS, WATERMAINS, SEWERS AND OTHER UNDERGROUND AND OVERGROUND UTILITIES AND STRUCTURES IS NOT NECESSARILY SHOWN ON THE CONTRACT DRAWINGS, AND WHERE SHOWN, THE ACCURACY OF THE POSITION OF SUCH UTILITIES AND STRUCTURES IS NOT GUARANTEED. BEFORE STARTING WORK, DETERMINE THE EXACT LOCATION OF ALL SUCH UTILITIES AND STRUCTURES AND ASSUME ALL LIABILITY FOR DAMAGE TO THEM.

SCALE: 0 20m 40m 80m — HORIZONTAL 1:2000

NORTH

DESIGNED BY

REVIEWED BY

CLIENT: CITY OF IQALUIT, IQALUIT, NUNAVUT. X0A 0H0	BASEPLAN: SAB DESIGN: --- CHECKED: ---	PROJECT: PROPOSED IQALUIT LANDFILL, CITY OF IQALUIT, NUNAVUT.	PROJECT No.: OTT-248813-A0 SURVEY: exp DATE: APRIL 2019
exp. EXP Services Inc. t: +1.613.688.1899 | f: +1.613.225.7330 2650 Queensview Drive, Unit 100 Ottawa, ON K2B 8H6 Canada www.exp.com • BUILDINGS • EARTH & ENVIRONMENT • ENERGY • • INDUSTRIAL • INFRASTRUCTURE • SUSTAINABILITY •	CAD: MN PROJECT MANAGER: IT APPROVED: IT	TITLE: BOREHOLE LOCATION PLAN	DRAWING No.: FIG 2

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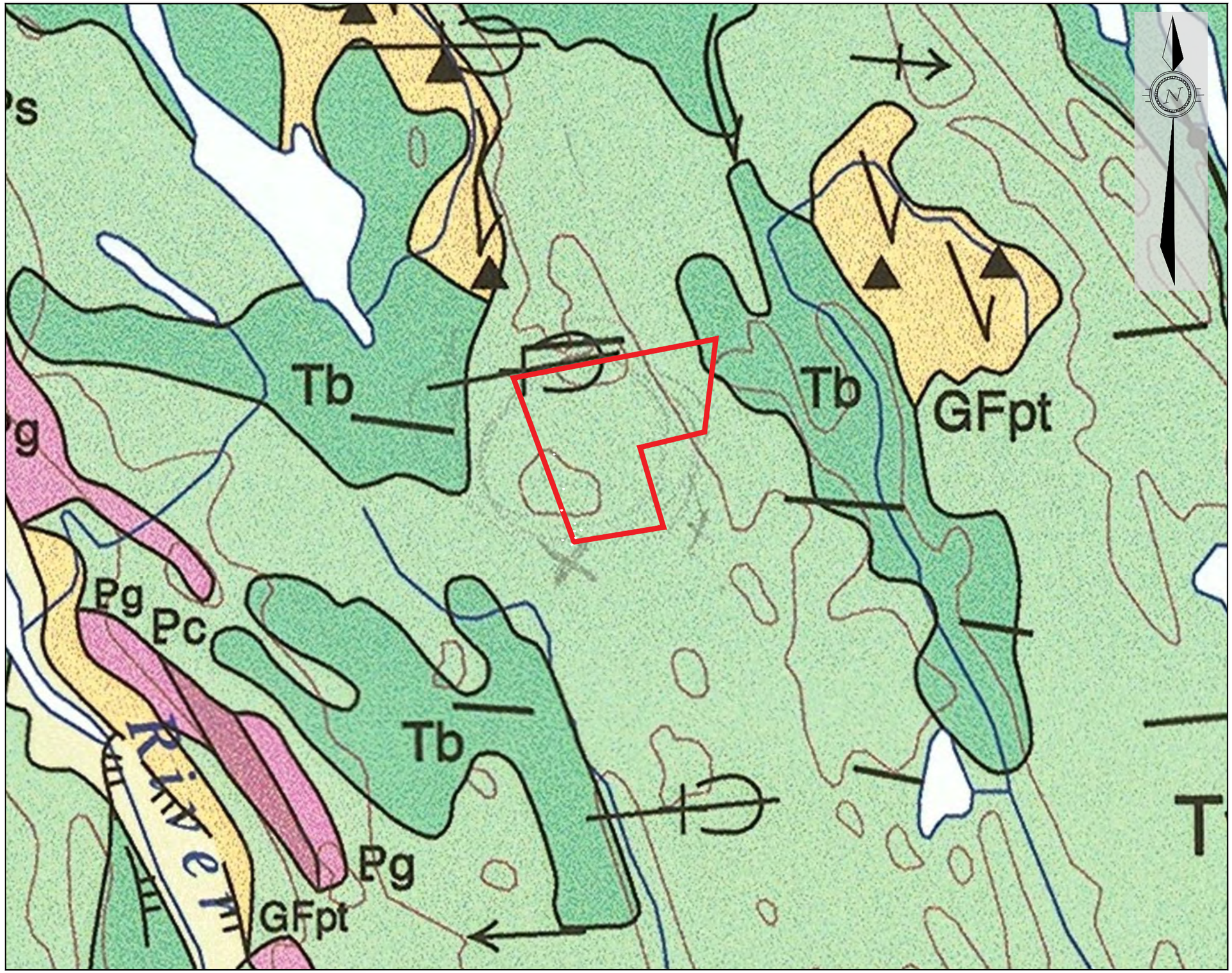

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HODGSON, D.A. 2003 SURFICIAL GEOLOGY, FROBISHER BAY, BAFFIN ISLAND, NUNAVUT; GEOLOGICAL SURVEY OF CANADA, MAP 2042A

LEGEND

Fpt	FLUVIAL DEPOSIT: GRAVEL, SAND, BOULDERS, SILT
GFpt	GLACIALFLUVIAL OUTWASH: STRATIFIED GRAVEL AND SAND
Tb	TILL BLANKET: 1.0 - 10.0 m THICK
Tv	TILL VENEER 0.5 - 2.0 m THICK
Pc	MARBLE
Pg	MONZOGRANITE OF PALEOPROTEROZOIC CUMBERLAND BATHOLITH
	PROPOSED LOCATION OF LAND FILL

SCALE
0 200m 400m 800m
HORIZONTAL 1:20,000

CLIENT
CITY OF IQALUIT

PROJECT
PROPOSED LANDFILL FACILITY

TITLE
SURFICIAL GEOLOGY

date	MAY 2019	project no.	OTT-00248813-A0
design by	S.A.	drawing no.	FIG 3
prepared by	J.R.		
reviewed by	S.A.		

Filename: r:\24000\00248000\248813-a0 iqaluit waste transfer station\gis\wts- fig 4 surf geol 2019-05.dwg
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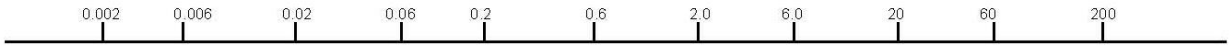
Notes On Sample Descriptions

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.

ISSMFE SOIL CLASSIFICATION

CLAY	SILT			SAND			GRAVEL			COBBLES	BOULDERS
	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE		



EQUIVALENT GRAIN DIAMETER IN MILLIMETRES

CLAY (PLASTIC) TO	FINE	MEDIUM	CRS.	FINE	COARSE
SILT (NONPLASTIC)	SAND			GRAVEL	

UNIFIED SOIL CLASSIFICATION

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 101

Project No: OTT-00248813-B0

Project: Geotechnical Investigation - Proposed Landfill Facility. 8 Kms NW of the City of Iqaluit

Location: City of Iqaluit, Nunavut

Figure No. 4

Page. 1 of 1

Date Drilled: 'March 24 to April 4, 2019

Drill Type:

Datum: Estimated Geodetic Elevation

Logged by: S.B Checked by: S.K.A

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

GWL	SYMBOL	SOIL DESCRIPTION	Geodetic Elevation m	Depth
		TUNDRA ~50 mm	172.5	0
		SAND & GRAVEL (SW) Fine to coarse with cobbles and boulders, grey-brown, moist, frozen. No visible ice (Nf)	172.4	
				1
			170.7	
		BEDROCK Mozogranite of Cumberland Batholith		2
				3
				4
			167.7	
		Borehole Terminated at 4.8 m Depth		

Standard Penetration Test N Value: 20 40 60 80

Shear Strength: 50 100 150 200 kPa

Combustible Vapour Reading (ppm): 250 500 750

Natural Moisture Content % Atterberg Limits (% Dry Weight): 20 40 60

SAMPLES

Natural Unit Wt. kN/m³

LOG OF BOREHOLE BH LOGS - 248813-B0.GPJ TROW OTTAWA.GDT 7/26/19

NOTES:
1. Borehole/Test Pit data requires Interpretation by exp. before use by others
2. Borehole backfilled upon completion.
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. This Figure is to read with exp. Services Inc. report OTT-00248813-B0

WATER LEVEL RECORDS		
Elapsed Time	Water Level (m)	Hole Open To (m)

CORE DRILLING RECORD			
Run No.	Depth (m)	% Rec.	RQD %

Log of Borehole BH 102

Project No: OTT-00248813-B0

Project: Geotechnical Investigation - Proposed Landfill Facility. 8 Kms NW of the City of Iqaluit

Location: City of Iqaluit, Nunavut

Figure No. 5

Page. 1 of 1

Date Drilled: 'March 24 to April 4, 2019

Drill Type:

Datum: Estimated Geodetic Elevation

Logged by: S.B Checked by: S.K.A

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

GWL	SYMBOL	SOIL DESCRIPTION	Geodetic Elevation m	Depth
		SILTY SAND & GRAVEL (SM) Fine to coarse with cobbles and boulders, brown, moist, frozen. No visible ice (Nf)	172.5	0
		BEDROCK Mozogranite of Cumberland Batholith	170.1	2
		Borehole Terminated at 6.0 m Depth	166.5	6

Standard Penetration Test N Value: 20 40 60 80

Shear Strength kPa: 50 100 150 200

Combustible Vapour Reading (ppm): 250 500 750

Natural Moisture Content % Atterberg Limits (% Dry Weight): 20 40 60

SAMPLES

Natural Unit Wt. kN/m³

LOG OF BOREHOLE BH LOGS - 248813-B0.GPJ TROW OTTAWA.GDT 7/26/19

NOTES:
1. Borehole/Test Pit data requires Interpretation by exp. before use by others
2. Borehole backfilled upon completion.
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. This Figure is to read with exp. Services Inc. report OTT-00248813-B0

WATER LEVEL RECORDS

Elapsed Time	Water Level (m)	Hole Open To (m)

CORE DRILLING RECORD

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

Log of Borehole BH 103

Project No: OTT-00248813-B0

Project: Geotechnical Investigation - Proposed Landfill Facility. 8 Kms NW of the City of Iqaluit

Location: City of Iqaluit, Nunavut

Figure No. 6

Page. 1 of 1

Date Drilled: 'March 24 to April 4, 2019

Drill Type:

Datum: Estimated Geodetic Elevation

Logged by: S.B Checked by: S.K.A

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

GWL	SYMBOL	SOIL DESCRIPTION	Geodetic Elevation m	Depth	Standard Penetration Test N Value / Shear Strength kPa	Combustible Vapour Reading (ppm) / Natural Moisture Content % / Atterberg Limits (% Dry Weight)	SAMPLES	Natural Unit Wt. kN/m³
		WEATHERED BEDROCK	161.9	0				
		BEDROCK Mozogranite of Cumberland Batholith	161.3	1				
				2				
			158.9	3				
		Borehole Terminated at 3.0 m Depth						

Standard Penetration Test N Value: 20 40 60 80

Shear Strength: 50 100 150 200 kPa

Combustible Vapour Reading (ppm): 250 500 750

Natural Moisture Content % Atterberg Limits (% Dry Weight): 20 40 60

NOTES:
1. Borehole/Test Pit data requires Interpretation by exp. before use by others
2. Borehole backfilled upon completion.
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. This Figure is to read with exp. Services Inc. report OTT-00248813-B0

WATER LEVEL RECORDS

Elapsed Time	Water Level (m)	Hole Open To (m)

CORE DRILLING RECORD

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

LOG OF BOREHOLE BH LOGS - 248813-B0.GPJ TROW OTTAWA.GDT 7/26/19

Log of Borehole BH 104

Project No: OTT-00248813-B0

Project: Geotechnical Investigation - Proposed Landfill Facility. 8 Kms NW of the City of Iqaluit

Location: City of Iqaluit, Nunavut

Figure No. 7

Page. 1 of 1

Date Drilled: 'March 24 to April 4, 2019

Drill Type:

Datum: Estimated Geodetic Elevation

Logged by: S.B Checked by: S.K.A

Split Spoon Sample ⊠ | Auger Sample ◧ | SPT (N) Value ○ | Dynamic Cone Test —— | Shelby Tube ■ | Shear Strength by Vane Test +S

Combustible Vapour Reading □ | Natural Moisture Content × | Atterberg Limits ⊢○ | Undrained Triaxial at % Strain at Failure ⊕ | Shear Strength by Penetrometer Test ▲

GWL	SYMBOL	SOIL DESCRIPTION	Geodetic Elevation m	Depth
		SILTY SAND & GRAVEL (SM-SW) Fine to coarse, frequent cobbles and boulders, grey-brown, moist, frozen. No visible ice (Nf)	173.5	0
		BEDROCK Mozogranite of Cumberland Batholith	169.5	4
		Borehole Terminated at 6.0 m Depth	167.5	6

Standard Penetration Test N Value: 20 40 60 80

Shear Strength kPa: 50 100 150 200

Combustible Vapour Reading (ppm): 250 500 750

Natural Moisture Content % Atterberg Limits (% Dry Weight): 20 40 60

SAMPLES | Natural Unit Wt. kN/m³

NOTES:
1. Borehole/Test Pit data requires Interpretation by exp. before use by others
2. Borehole backfilled upon completion.
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. This Figure is to read with exp. Services Inc. report OTT-00248813-B0

WATER LEVEL RECORDS

Elapsed Time	Water Level (m)	Hole Open To (m)

CORE DRILLING RECORD

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

LOG OF BOREHOLE BH LOGS - 248813-B0.GPJ TROW OTTAWA.GDT 7/26/19

Log of Borehole BH 105

Project No: OTT-00248813-B0

Project: Geotechnical Investigation - Proposed Landfill Facility. 8 Kms NW of the City of Iqaluit

Location: City of Iqaluit, Nunavut

Figure No. 8

Page. 1 of 1

Date Drilled: 'March 24 to April 4, 2019

Drill Type:

Datum: Estimated Geodetic Elevation

Logged by: S.B Checked by: S.K.A

Split Spoon Sample ⊠ | Auger Sample ◧ | SPT (N) Value ○ | Dynamic Cone Test —— | Shelby Tube ■ | Shear Strength by Vane Test +S

Combustible Vapour Reading □ | Natural Moisture Content × | Atterberg Limits ⊢○ | Undrained Triaxial at % Strain at Failure ⊕ | Shear Strength by Penetrometer Test ▲

GWL	SYMBOL	SOIL DESCRIPTION	Geodetic Elevation m	Depth
		SAND & GRAVEL (SP) POoorly graded, fine to coarse with cobbles and boulders, brown, moist, frozen. No visible ice (Nf)	178.8	0
				1
		BEDROCK Mozogranite of Cumberland Batholith	177.3	2
				3
				4
			173.8	5
		Borehole Terminated at 5.0 m Depth		

Standard Penetration Test N Value: 20 40 60 80

Shear Strength: 50 100 150 200 kPa

Combustible Vapour Reading (ppm): 250 500 750

Natural Moisture Content % Atterberg Limits (% Dry Weight): 20 40 60

SAMPLES

Natural Unit Wt. kN/m³

NOTES:
1. Borehole/Test Pit data requires Interpretation by exp. before use by others
2. Borehole backfilled upon completion.
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. This Figure is to read with exp. Services Inc. report OTT-00248813-B0

WATER LEVEL RECORDS

Elapsed Time	Water Level (m)	Hole Open To (m)

CORE DRILLING RECORD

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

LOG OF BOREHOLE BH LOGS - 248813-B0.GPJ TROW OTTAWA.GDT 7/26/19

Log of Borehole BH 106

Project No: OTT-00248813-B0

Project: Geotechnical Investigation - Proposed Landfill Facility. 8 Kms NW of the City of Iqaluit

Location: City of Iqaluit, Nunavut

Figure No. 9

Page. 1 of 1

Date Drilled: 'March 24 to April 4, 2019

Drill Type:

Datum: Estimated Geodetic Elevation

Logged by: S.B Checked by: S.K.A

Split Spoon Sample ⊠ | Auger Sample ◧ | SPT (N) Value ○ | Dynamic Cone Test —— | Shelby Tube ■ | Shear Strength by Vane Test +S

Combustible Vapour Reading □ | Natural Moisture Content × | Atterberg Limits ⊢○ | Undrained Triaxial at % Strain at Failure ⊕ | Shear Strength by Penetrometer Test ▲

GWL	SYMBOL	SOIL DESCRIPTION	Geodetic Elevation m	Depth
		TUNDRA ~50 mm	166.1	0
		SAND & GRAVEL (SM) Fine to coarse with cobbles and boulders, grey, moist, frozen. No visible ice (Nf)	166.0	
				1
			164.1	2
		BEDROCK Mozogranite of Cumberland Batholith		3
			162.1	4
		Borehole Terminated at 4.0 m Depth		

Standard Penetration Test N Value: 20 40 60 80

Shear Strength kPa: 50 100 150 200

Combustible Vapour Reading (ppm): 250 500 750

Natural Moisture Content % Atterberg Limits (% Dry Weight): 20 40 60

SAMPLES

Natural Unit Wt. kN/m³

LOG OF BOREHOLE BH LOGS - 248813-B0.GPJ TROW OTTAWA.GDT 7/26/19

NOTES:
1. Borehole/Test Pit data requires Interpretation by exp. before use by others
2. Borehole backfilled upon completion.
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. This Figure is to read with exp. Services Inc. report OTT-00248813-B0

WATER LEVEL RECORDS		
Elapsed Time	Water Level (m)	Hole Open To (m)

CORE DRILLING RECORD			
Run No.	Depth (m)	% Rec.	RQD %

Log of Borehole BH TW107

Project No: OTT-00248813-B0

Project: Geotechnical Investigation - Proposed Landfill Facility. 8 Kms NW of the City of Iqaluit

Location: City of Iqaluit, Nunavut

Figure No. 10

Page. 1 of 1

Date Drilled: 'March 24 to April 4, 2019

Drill Type:

Datum: Estimated Geodetic Elevation

Logged by: S.B Checked by: S.K.A

Split Spoon Sample ⊠ | Auger Sample ◧ | SPT (N) Value ○ | Dynamic Cone Test —— | Shelby Tube ■ | Shear Strength by Vane Test +S

Combustible Vapour Reading □ | Natural Moisture Content × | Atterberg Limits ⊢○⊣ | Undrained Triaxial at % Strain at Failure ⊕ | Shear Strength by Penetrometer Test ▲

GWL	SYMBOL	SOIL DESCRIPTION	Geodetic Elevation m	Depth
		TUNDRA ~50 mm	164.8	0
		SAND & GRAVEL	164.7	
		With cobbles and boulders. No visible ice (Nf)		1
				2
				3
			161.2	
		BEDROCK		
		Mozogranite of Cumberland Batholith		4
				5
				6
			158.0	
		Borehole Terminated at 6.8 m Depth		7

Standard Penetration Test N Value: 20 40 60 80

Shear Strength kPa: 50 100 150 200

Combustible Vapour Reading (ppm): 250 500 750

Natural Moisture Content % / Atterberg Limits (% Dry Weight): 20 40 60

SAMPLES | Natural Unit Wt. kN/m³

LOG OF BOREHOLE BH LOGS - 248813-B0.GPJ TROW OTTAWA.GDT 7/26/19

NOTES:
1. Borehole/Test Pit data requires Interpretation by exp. before use by others
2. Thermister with multi-beads installed to 7.0 m depth and Standpipe installed to 2.4 m depth in the borehole upon completion
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. This Figure is to read with exp. Services Inc. report OTT-00248813-B0

WATER LEVEL RECORDS

Elapsed Time	Water Level (m)	Hole Open To (m)
June 3, 2019	Dry	

CORE DRILLING RECORD

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

Log of Borehole BH TW108

Project No: OTT-00248813-B0

Project: Geotechnical Investigation - Proposed Landfill Facility. 8 Kms NW of the City of Iqaluit

Location: City of Iqaluit, Nunavut

Figure No. 11

Page. 1 of 1

Date Drilled: 'March 24 to April 4, 2019

Drill Type:

Datum: Estimated Geodetic Elevation

Logged by: S.B Checked by: S.K.A

Split Spoon Sample ⊠ | Auger Sample ◧ | SPT (N) Value ○ | Dynamic Cone Test —— | Shelby Tube ■ | Shear Strength by Vane Test +S

Combustible Vapour Reading □ | Natural Moisture Content × | Atterberg Limits ⊢○⊣ | Undrained Triaxial at % Strain at Failure ⊕ | Shear Strength by Penetrometer Test ▲

GWL	SYMBOL	SOIL DESCRIPTION	Geodetic Elevation m	Depth
		TUNDRA AND FROZEN SOIL ~150 mm	164	0
		SAND & GRAVEL	163.8	
		With cobbles and boulders. No visible ice (Nf)		1
				2
			161.3	
		BEDROCK		3
		Mozogranite of Cumberland Batholith		4
				5
				6
			157.0	7
		Borehole Terminated at 7.0 m Depth		

Standard Penetration Test N Value: 20 40 60 80

Shear Strength kPa: 50 100 150 200

Combustible Vapour Reading (ppm): 250 500 750

Natural Moisture Content % / Atterberg Limits (% Dry Weight): 20 40 60

SAMPLES

Natural Unit Wt. kN/m³

LOG OF BOREHOLE BH LOGS - 248813-B0.GPJ TROW OTTAWA.GDT 7/26/19

NOTES:
1. Borehole/Test Pit data requires Interpretation by exp. before use by others
2. Thermister with multi-beads installed to 7.0 m depth and Standpipe installed to 2.4 m depth in the borehole upon completion.
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. This Figure is to read with exp. Services Inc. report OTT-00248813-B0

WATER LEVEL RECORDS

Elapsed Time	Water Level (m)	Hole Open To (m)
June 3, 2019	0.2	

CORE DRILLING RECORD

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

Log of Borehole BH TW109

Project No: OTT-00248813-B0

Project: Geotechnical Investigation - Proposed Landfill Facility. 8 Kms NW of the City of Iqaluit

Figure No. 12

Page. 1 of 1

Location: City of Iqaluit, Nunavut

Date Drilled: 'March 24 to April 4, 2019

Drill Type:

Datum: Estimated Geodetic Elevation

Logged by: S.B Checked by: S.K.A

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

GWL	SYMBOL	SOIL DESCRIPTION	Geodetic Elevation m	Depth
			169.6	0
		TUNDRA ~150 mm	169.4	
		SAND & GRAVEL With frequent cobbles and boulders, frozen. No visible ice (Nf)	169.4	
				1
				2
			167.2	
		BEDROCK Mozogranite of Cumberland Batholith		3
				4
				5
				6
			163.4	
		Borehole Terminated at 6.2 m Depth		7

Standard Penetration Test N Value: 20 40 60 80

Shear Strength kPa: 50 100 150 200

Combustible Vapour Reading (ppm): 250 500 750

Natural Moisture Content % Atterberg Limits (% Dry Weight): 20 40 60

SAMPLES

Natural Unit Wt. kN/m³

LOG OF BOREHOLE BH LOGS - 248813-B0.GPJ TROW OTTAWA.GDT 7/26/19

NOTES:
1. Borehole/Test Pit data requires Interpretation by exp. before use by others
2. Thermister with multi-beads installed to 7.0 m depth and Standpipe installed to 2.4 m depth in the borehole upon completion.
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. This Figure is to read with exp. Services Inc. report OTT-00248813-B0

WATER LEVEL RECORDS

Elapsed Time	Water Level (m)	Hole Open To (m)
June 3, 2019	0.2	

CORE DRILLING RECORD

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

Log of Borehole BH TW110

Project No: OTT-00248813-B0

Project: Geotechnical Investigation - Proposed Landfill Facility. 8 Kms NW of the City of Iqaluit

Location: City of Iqaluit, Nunavut

Figure No. 13

Page. 1 of 1

Date Drilled: 'March 24 to April 4, 2019

Drill Type:

Datum: Estimated Geodetic Elevation

Logged by: S.B Checked by: S.K.A

Split Spoon Sample ⊠
Auger Sample ◧
SPT (N) Value ○
Dynamic Cone Test ——
Shelby Tube ■
Shear Strength by Vane Test +S

Combustible Vapour Reading □
Natural Moisture Content ×
Atterberg Limits ⊢○
Undrained Triaxial at % Strain at Failure ⊕
Shear Strength by Penetrometer Test ▲

GWL	SYMBOL	SOIL DESCRIPTION	Geodetic Elevation m	Depth
		TUNDRA AND FROZEN SOIL ~150 mm	174.2	0
		SAND & GRAVEL Frequent boulders, frozen. No visible ice (Nf)	174.0	
		BEDROCK Mozogranite of Cumberland Batholith	171.8	2
		Borehole Terminated at 6.0 m Depth	168.2	6

Standard Penetration Test N Value: 20 40 60 80
Shear Strength kPa: 50 100 150 200
Combustible Vapour Reading (ppm): 250 500 750
Natural Moisture Content % Atterberg Limits (% Dry Weight): 20 40 60
SAMPLES
Natural Unit Wt. kN/m³

LOG OF BOREHOLE BH LOGS - 248813-B0.GPJ TROW OTTAWA.GDT 7/26/19

NOTES:
1. Borehole/Test Pit data requires Interpretation by exp. before use by others
2. Thermister with multi-beads installed to 7.0 m depth and Standpipe installed to 2.4 m depth in the borehole upon completion.
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. This Figure is to read with exp. Services Inc. report OTT-00248813-B0

WATER LEVEL RECORDS

Elapsed Time	Water Level (m)	Hole Open To (m)
June 3, 2019	Dry	

CORE DRILLING RECORD

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

Log of Borehole BH TW111

Project No: OTT-00248813-B0

Project: Geotechnical Investigation - Proposed Landfill Facility. 8 Kms NW of the City of Iqaluit

Location: City of Iqaluit, Nunavut

Figure No. 14

Page. 1 of 1

Date Drilled: 'March 24 to April 4, 2019

Drill Type:

Datum: Estimated Geodetic Elevation

Logged by: S.B Checked by: S.K.A

Split Spoon Sample ⊠ | Auger Sample ◧ | SPT (N) Value ○ | Dynamic Cone Test —— | Shelby Tube ■ | Shear Strength by Vane Test +S

Combustible Vapour Reading □ | Natural Moisture Content × | Atterberg Limits ⊢○ | Undrained Triaxial at % Strain at Failure ⊕ | Shear Strength by Penetrometer Test ▲

GWL	SYMBOL	SOIL DESCRIPTION	Geodetic Elevation m	Depth
			190	0
▽		**TUNDRA AND FROZEN SOIL** ~100 mm	189.9	
		SAND & GRAVEL	189.8	
		Frequent boulders, frozen. No visible ice (Nf)		1
			188.6	
		BEDROCK		
		Mozogranite of Cumberland Batholith		2
				3
				4
				5
			184.5	
		Borehole Terminated at 5.5 m Depth		

Standard Penetration Test N Value: 20 40 60 80

Shear Strength: 50 100 150 200 kPa

Combustible Vapour Reading (ppm): 250 500 750

Natural Moisture Content % Atterberg Limits (% Dry Weight): 20 40 60

SAMPLES

Natural Unit Wt. kN/m³

NOTES:
1. Borehole/Test Pit data requires Interpretation by exp. before use by others
2. Thermister with multi-beads installed to 5.5 m depth and Standpipe installed to 2.4 m depth in the borehole upon completion.
3. Field work supervised by an EXP representative.
4. See Notes on Sample Descriptions
5. This Figure is to read with exp. Services Inc. report OTT-00248813-B0

WATER LEVEL RECORDS

Elapsed Time	Water Level (m)	Hole Open To (m)
June 3, 2019	0.2	

CORE DRILLING RECORD

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

LOG OF BOREHOLE BH LOGS - 248813-B0.GPJ TROW OTTAWA.GDT 7/26/19

EXP Services Inc.
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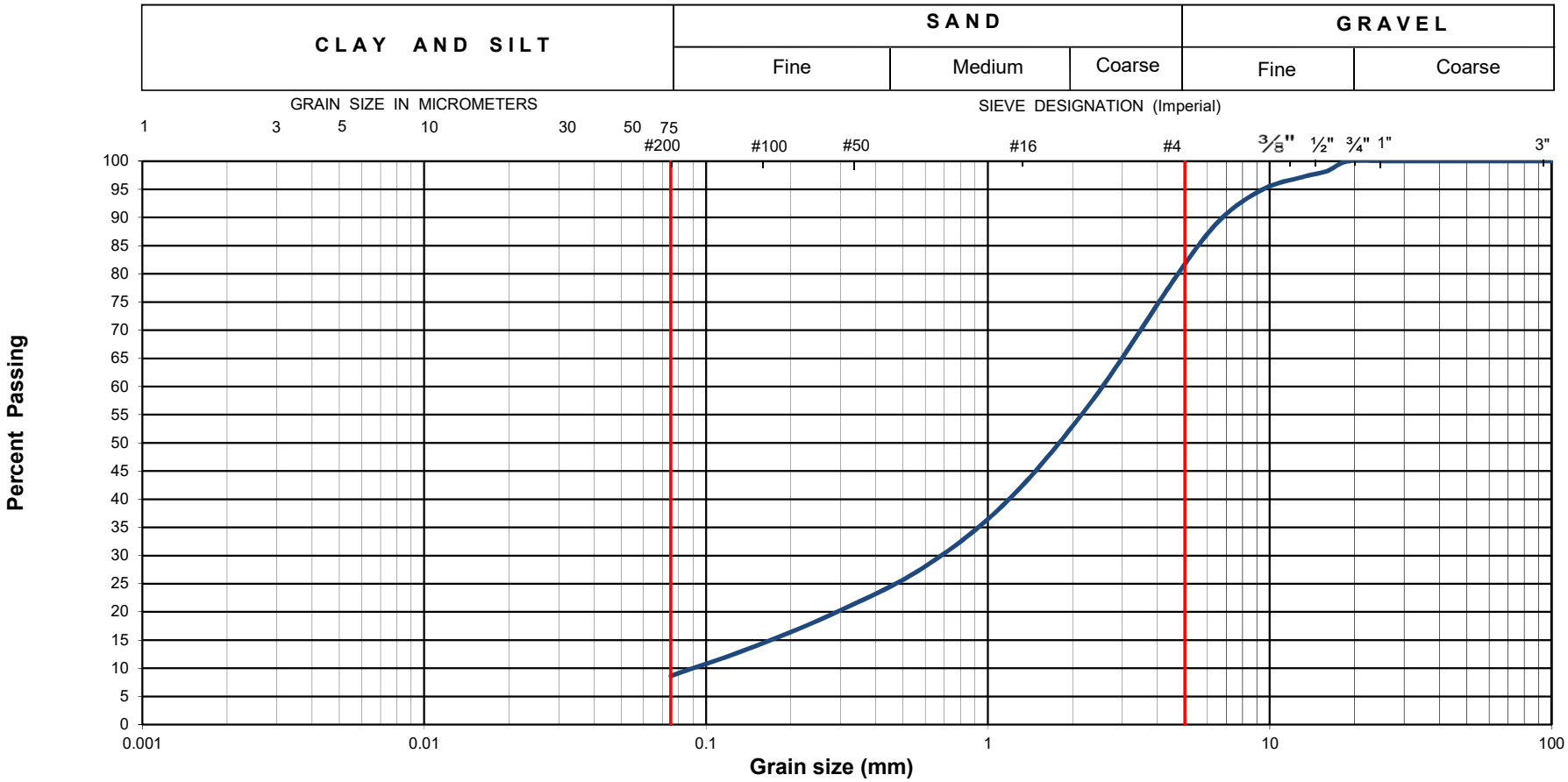
Ottawa, ON K2B 8H6

Grain-Size Distribution Curve
Method of Test For Sieve Analysis of Aggregate
ASTM C-136

Unified Soil Classification System



EXP Project No.:	**OTT-00248813-A0**	**Project Name :**	**Preliminary Geotechnical Investigation, New Landfill Site**						
Client :	**City of Iqaluit**	**Project Location :**	**Iqaluit, NU**						
Date Sampled :	**March 2019**	**Borehole No:**	**BH101**	**Sample:**	**S1**	**Depth (m) :**	**0-1**		
Sample Composition :		**Gravel (%)**	**19**	**Sand (%)**	**72**	**Silt & Clay (%)**	**9**	**Figure :**	**15**
Sample Description :		**Well Graded Sand, some Gravel (SW)**							

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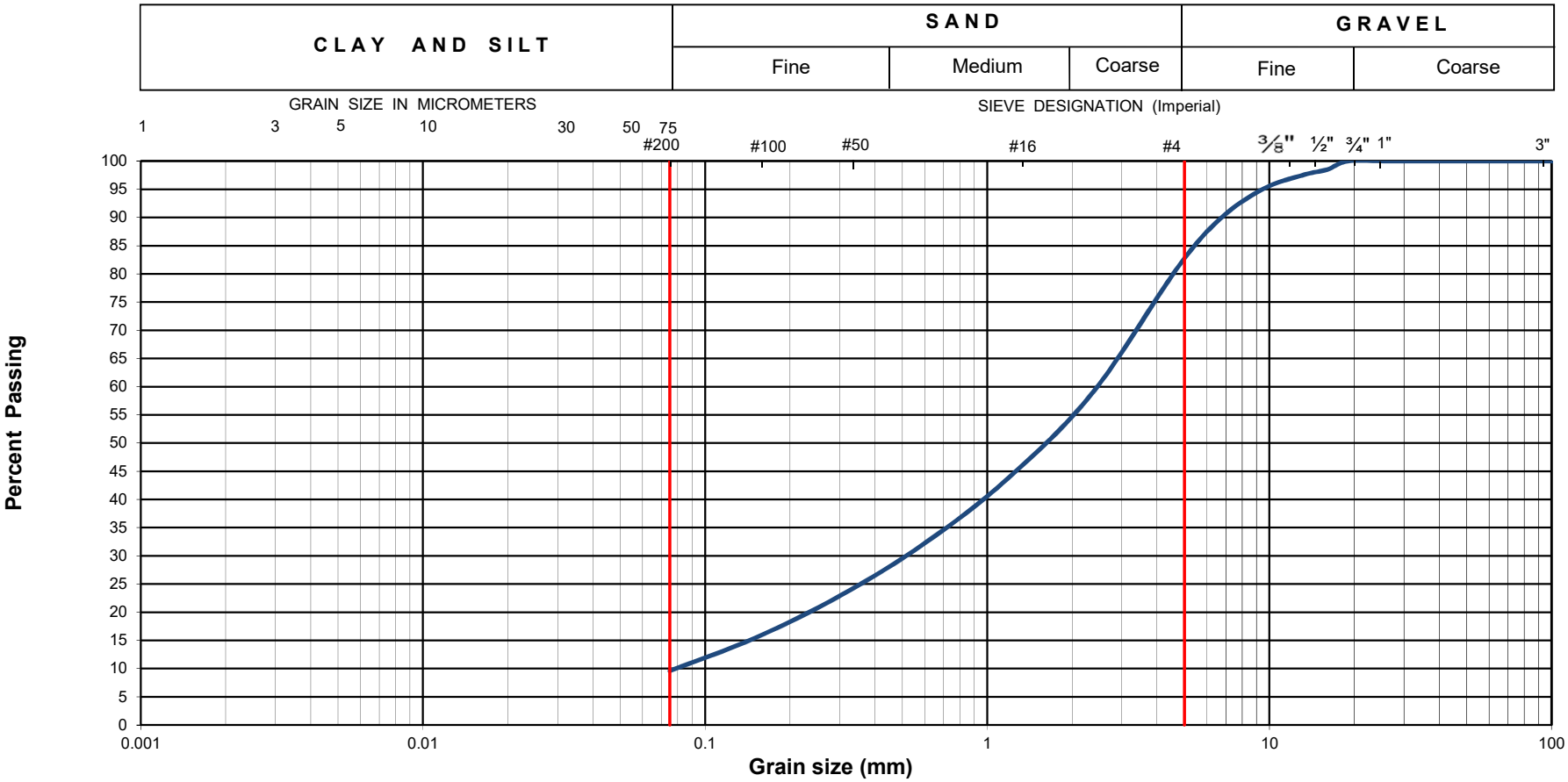
Grain-Size Distribution Curve
Method of Test For Sieve Analysis of Aggregate
ASTM C-136

Unified Soil Classification System



EXP Project No.:	**OTT-00248813-A0**	**Project Name :**	**Preliminary Geotechnical Investigation, New Landfill Site**						
Client :	**City of Iqaluit**	**Project Location :**	**Iqaluit, NU**						
Date Sampled :	**March 2019**	**Borehole No:**	**BH101**	**Sample:**	**S2**	**Depth (m) :**	**1-2**		
Sample Composition :		**Gravel (%)**	**17**	**Sand (%)**	**73**	**Silt & Clay (%)**	**10**	**Figure :**	**16**
Sample Description :		**Well Graded Sand, some Gravel (SW)**							

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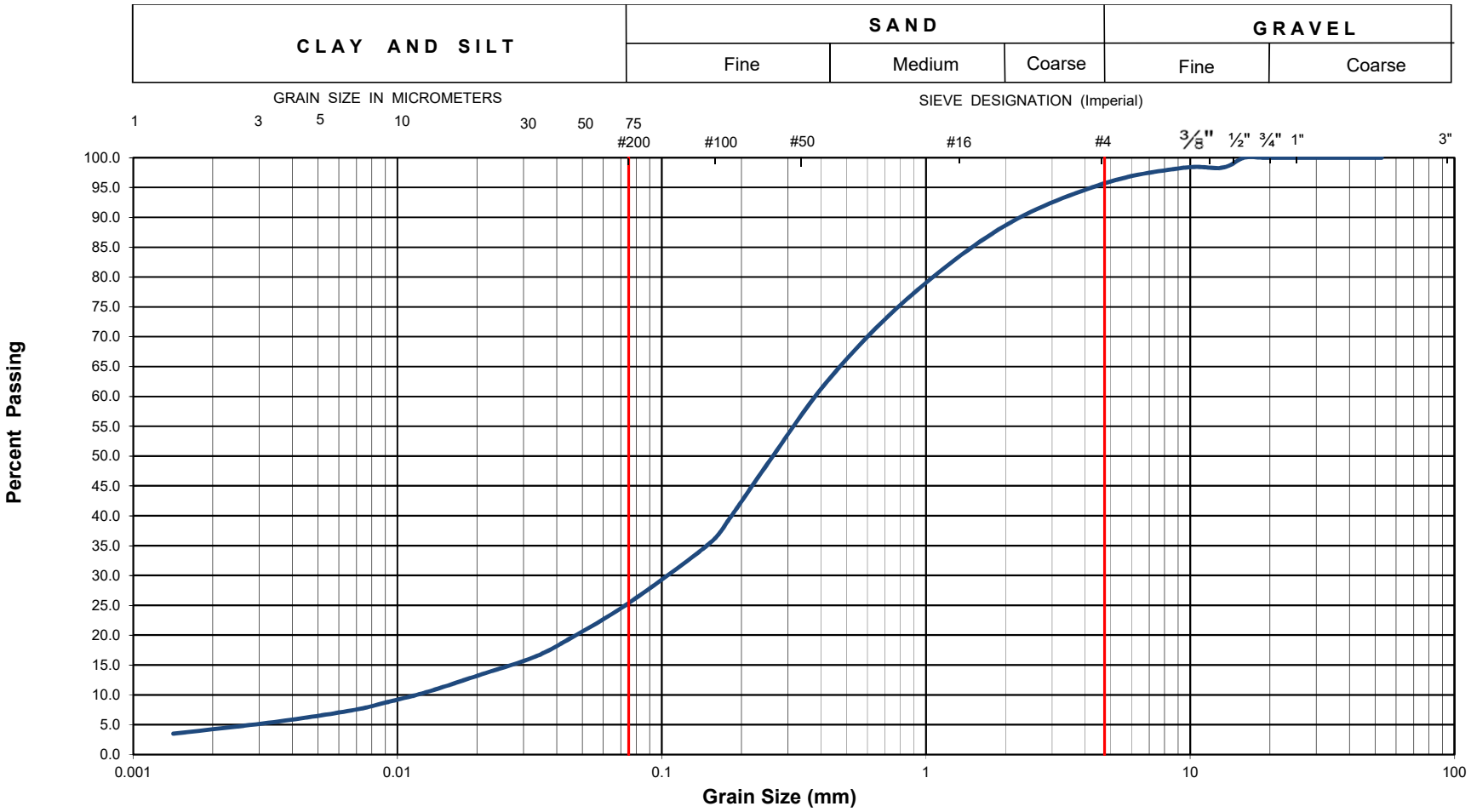
Grain-Size Distribution Curve
Method of Test For Particle Size Analysis of Soil
ASTM C-136/ASTM D422

Unified Soil Classification System



EXP Project No.:	**OTT-00248813-A0**	**Project Name :**	**Preliminary Geotechnical Investigation, New Landfill Site**						
Client :	**City of Iqaluit**	**Project Location :**	**Iqaluit, NU**						
Date Sampled :	**April 8, 2019**	**Borehole No:**	**BH102**		**Sample No.:**	**S1**		**Depth (m) :**	**0-1.0**
Sample Description :		**% Silt and Clay**	**25**	**% Sand**	**71**	**% Gravel**	**4**	**Figure :**	**17**
Sample Description :		**Silty Sand (SM)**							

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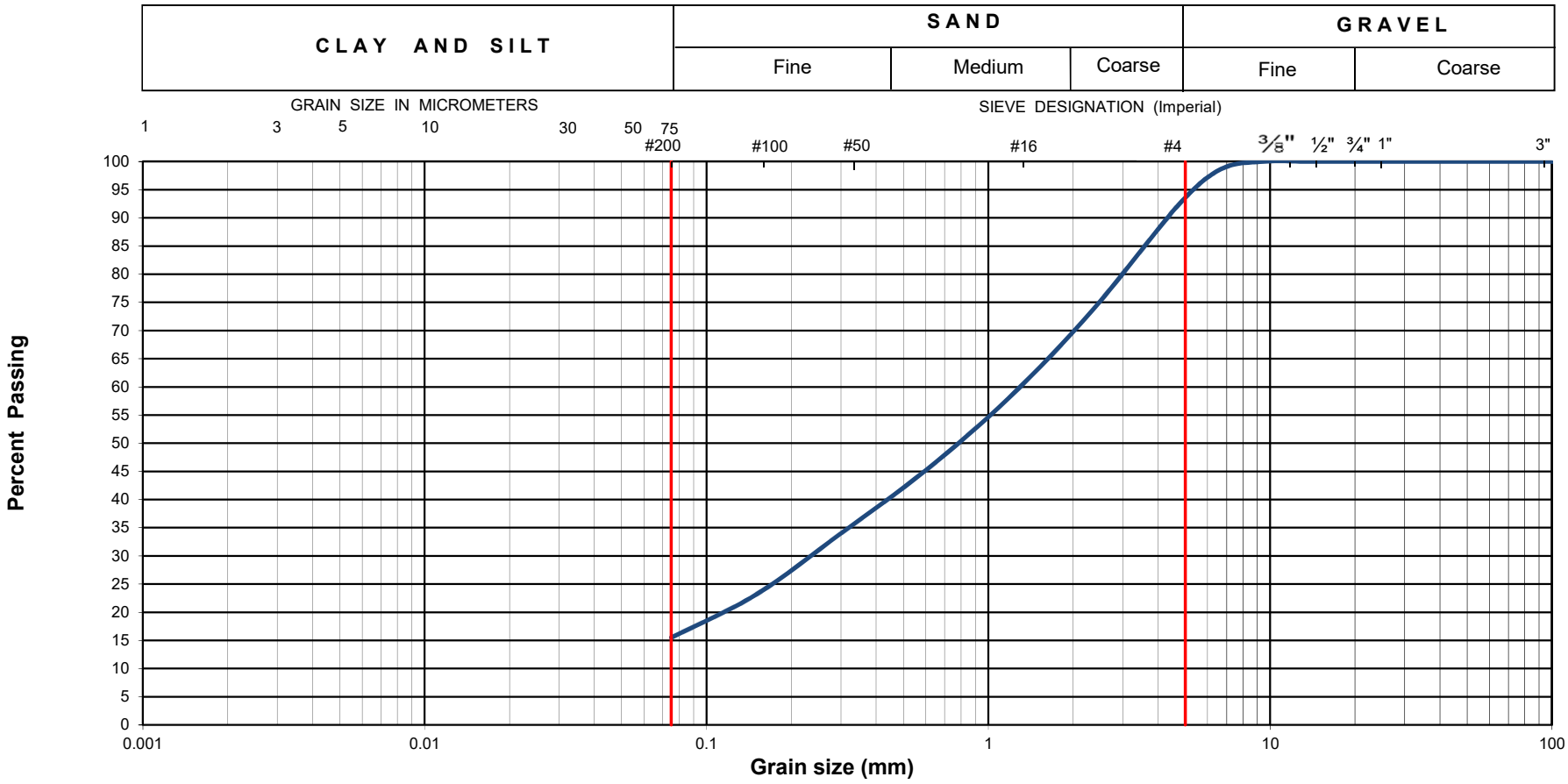
Grain-Size Distribution Curve
Method of Test For Sieve Analysis of Aggregate
ASTM C-136

Unified Soil Classification System



EXP Project No.:	**OTT-00248813-A0**	**Project Name :**	**Preliminary Geotechnical Investigation, New Landfill Site**						
Client :	**City of Iqaluit**	**Project Location :**	**Iqaluit, NU**						
Date Sampled :	**March 2019**	**Borehole No:**	**BH102**	**Sample:**	**S2**	**Depth (m) :**	**1-2**		
Sample Composition :		**Gravel (%)**	**6**	**Sand (%)**	**78**	**Silt & Clay (%)**	**16**	**Figure :**	**18**
Sample Description :		**Silty Sand (SM)**							

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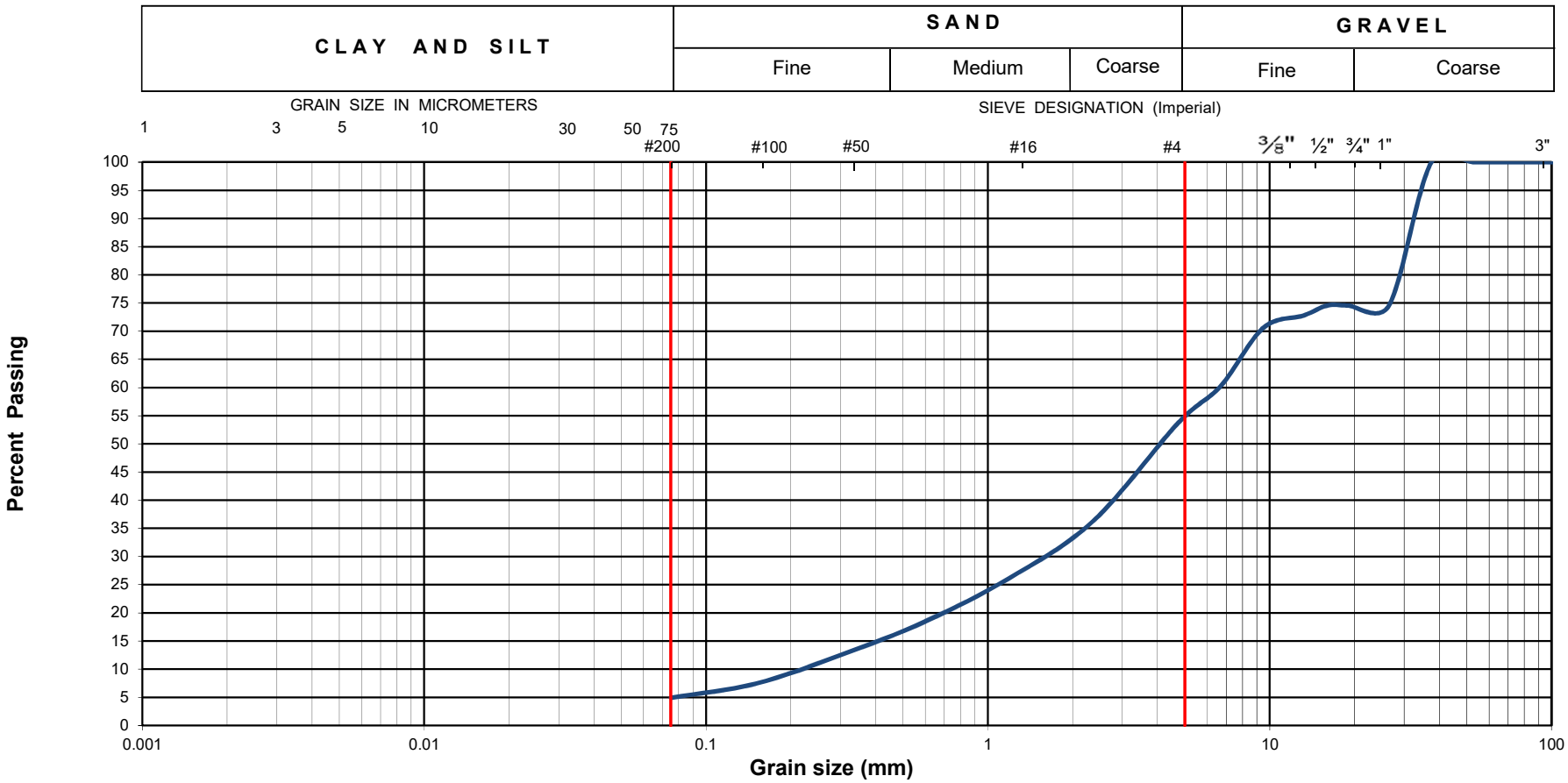
Grain-Size Distribution Curve
Method of Test For Sieve Analysis of Aggregate
ASTM C-136

Unified Soil Classification System



EXP Project No.:	**OTT-00248813-A0**	**Project Name :**	**Preliminary Geotechnical Investigation, New Landfill Site**						
Client :	**City of Iqaluit**	**Project Location :**	**Iqaluit, NU**						
Date Sampled :	**March 2019**	**Borehole No:**	**BH104**	**Sample:**	**S1**	**Depth (m) :**	**0-1**		
Sample Composition :		**Gravel (%)**	**45**	**Sand (%)**	**50**	**Silt & Clay (%)**	**5**	**Figure :**	**19**
Sample Description :		**Well Graded Sand-Gravel Mixture (SW)**							

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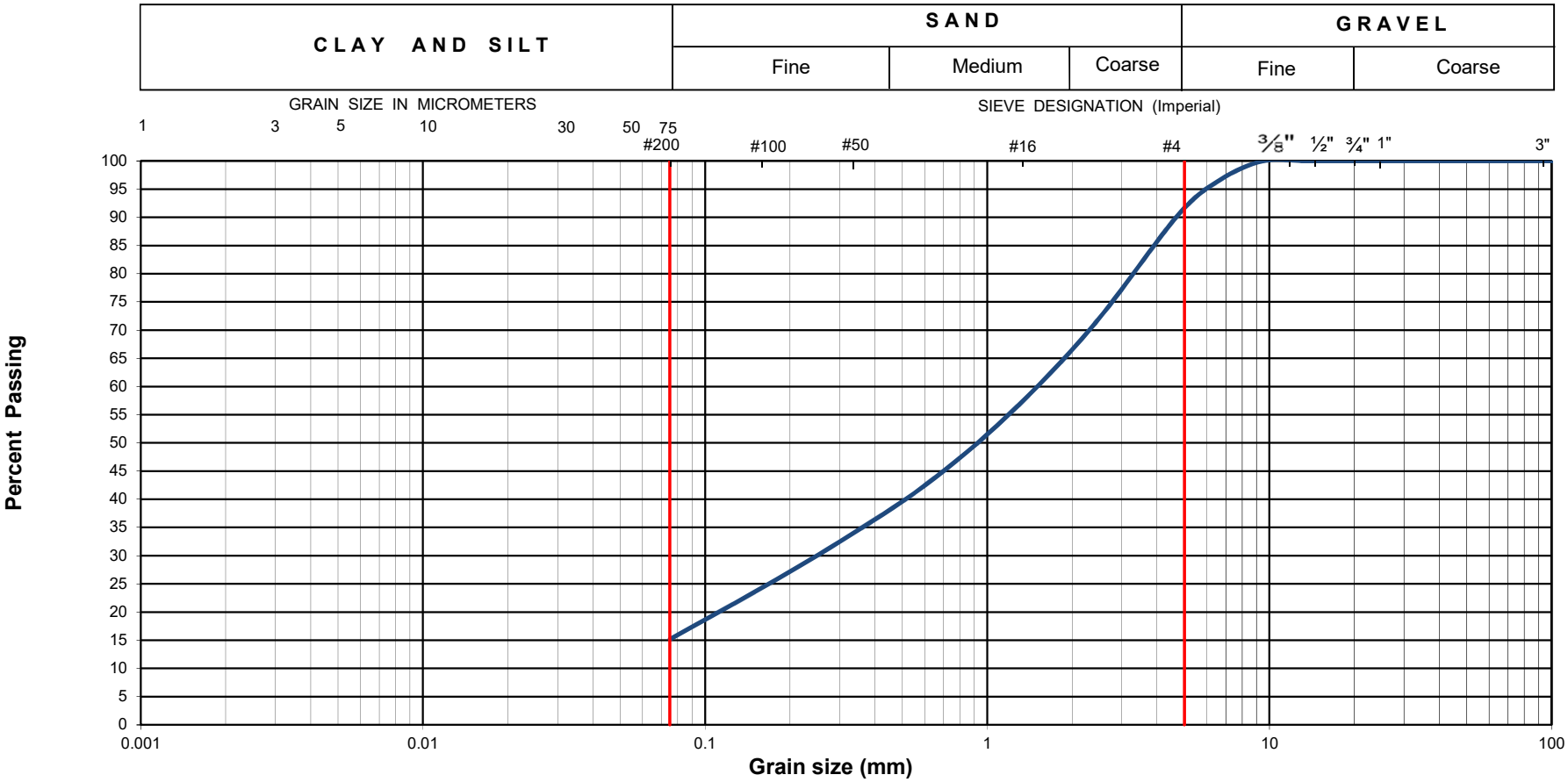
Grain-Size Distribution Curve
Method of Test For Sieve Analysis of Aggregate
ASTM C-136

Unified Soil Classification System



EXP Project No.:	**OTT-00248813-A0**	**Project Name :**	**Preliminary Geotechnical Investigation, New Landfill Site**						
Client :	**City of Iqaluit**	**Project Location :**	**Iqaluit, NU**						
Date Sampled :	**March 2019**	**Borehole No:**	**BH104**		**Sample:**	**S3**		**Depth (m) :**	**2-3**
Sample Composition :		**Gravel (%)**	**8**	**Sand (%)**	**77**	**Silt & Clay (%)**	**15**	**Figure :**	**20**
Sample Description :		**Silty Sand (SM)**							

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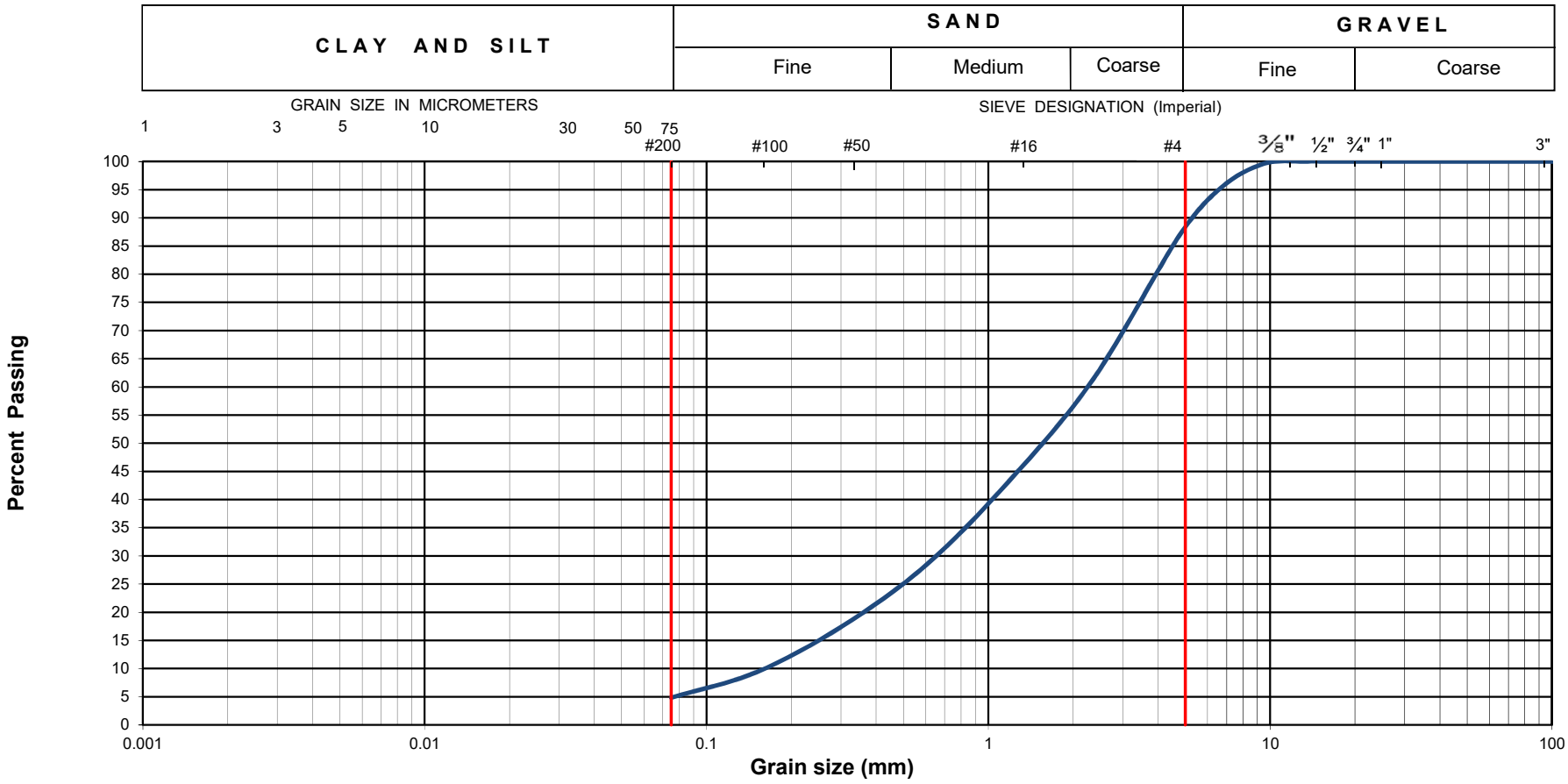
Grain-Size Distribution Curve
Method of Test For Sieve Analysis of Aggregate
ASTM C-136

Unified Soil Classification System



EXP Project No.:	**OTT-00248813-A0**	**Project Name :**	**Preliminary Geotechnical Investigation, New Landfill Site**					
Client :	**City of Iqaluit**	**Project Location :**	**Iqaluit, NU**					
Date Sampled :	**March 2019**	**Borehole No:**	**BH104**	**Sample:**	**S4**		**Depth (m) :**	**3-4**
Sample Composition :		**Gravel (%)**	**11**	**Sand (%)**	**84**	**Silt & Clay (%)**	**5**	**Figure :** **21**
Sample Description :		**Poorly Graded Sand, some Gravel (SP)**						

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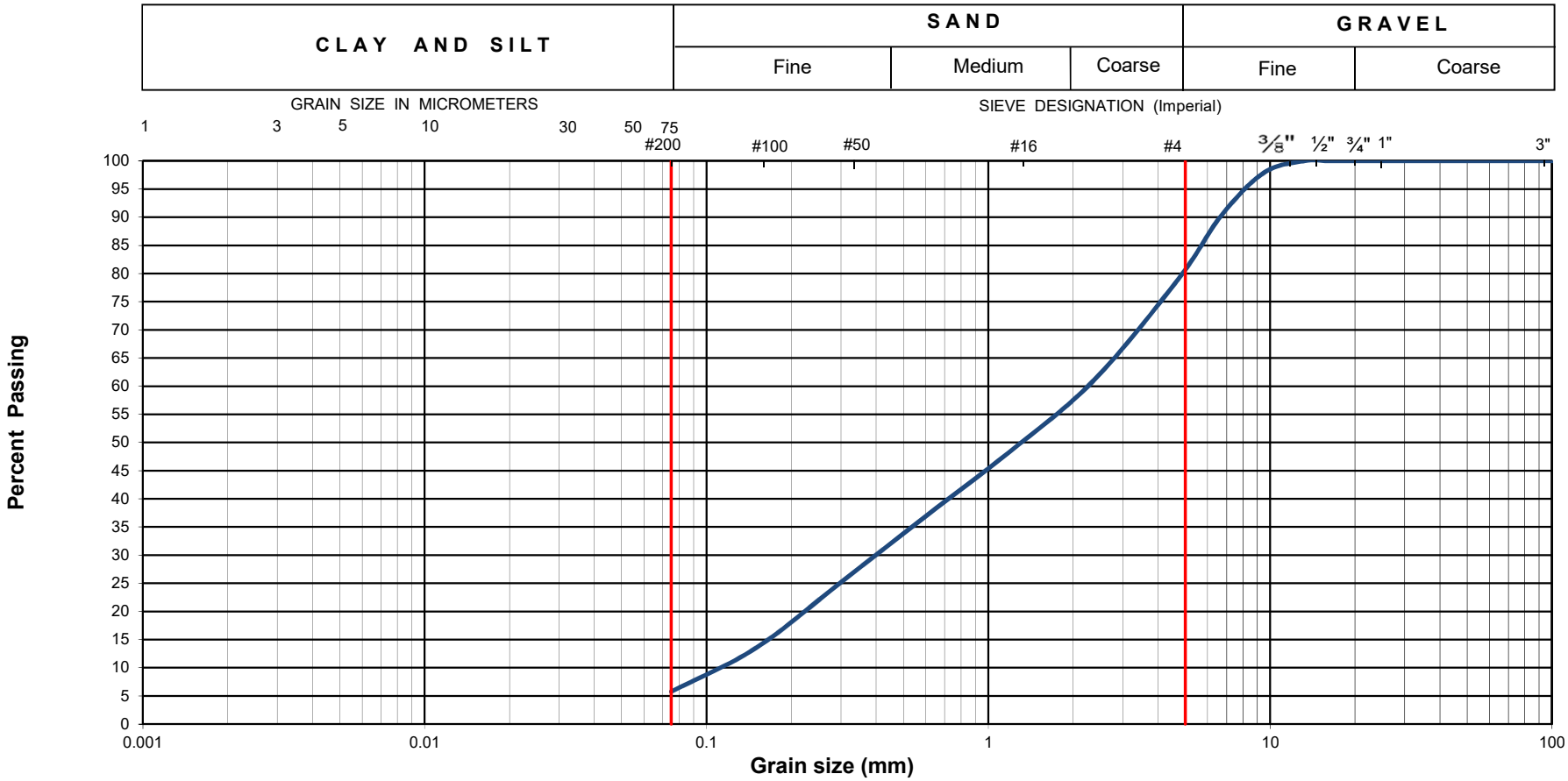
Grain-Size Distribution Curve
Method of Test For Sieve Analysis of Aggregate
ASTM C-136

Unified Soil Classification System



EXP Project No.:	**OTT-00248813-A0**	**Project Name :**	**Preliminary Geotechnical Investigation, New Landfill Site**						
Client :	**City of Iqaluit**	**Project Location :**	**Iqaluit, NU**						
Date Sampled :	**March 2019**	**Borehole No:**	**BH105**		**Sample:**	**S1**		**Depth (m) :**	**0-1**
Sample Composition :		**Gravel (%)**	**20**	**Sand (%)**	**74**	**Silt & Clay (%)**	**6**	**Figure :**	**22**
Sample Description :		**Poorly Graded Sand, some Gravel (SP)**							

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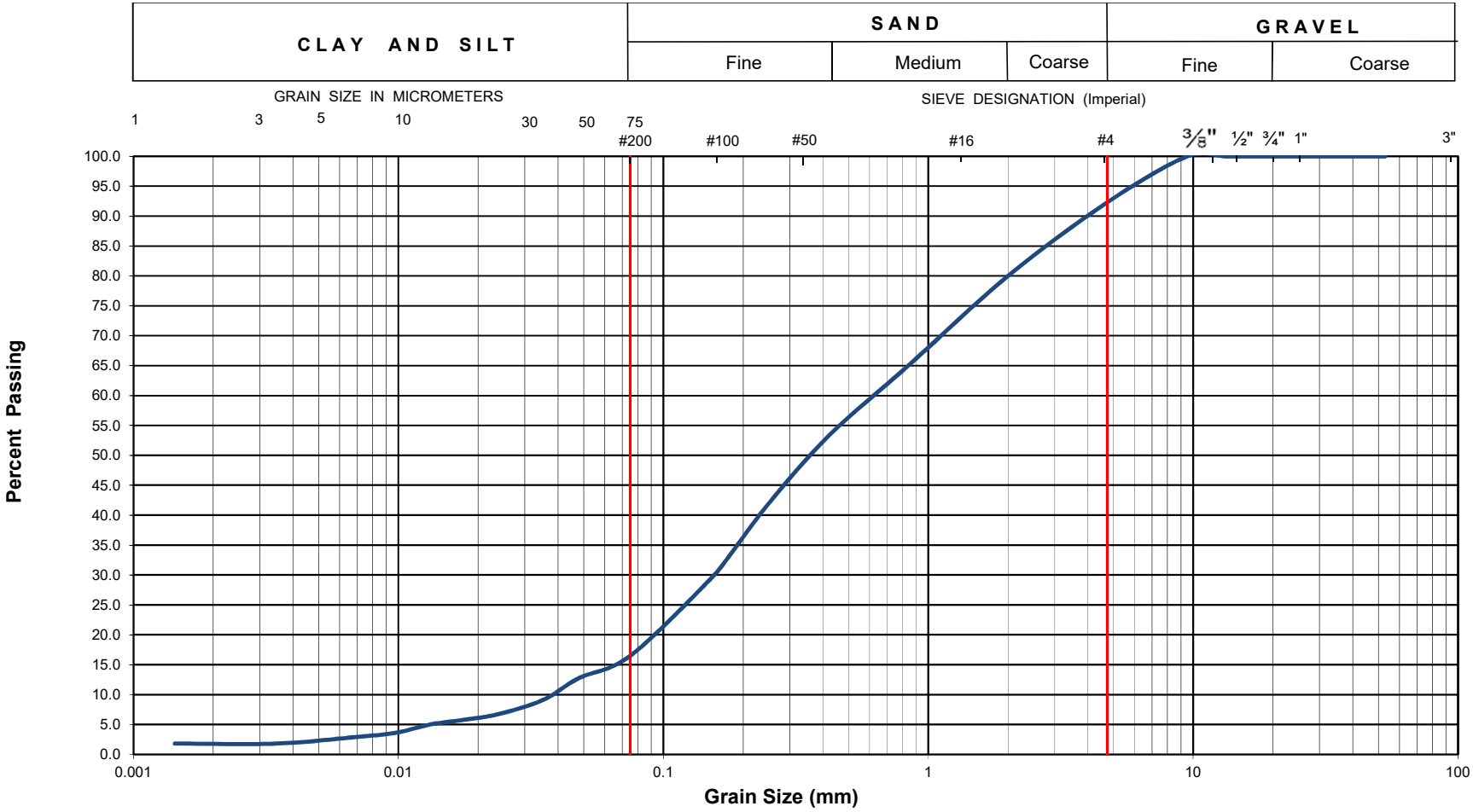
Grain-Size Distribution Curve
Method of Test For Particle Size Analysis of Soil
ASTM C-136/ASTM D422

Unified Soil Classification System



EXP Project No.:	**OTT-00248813-A0**	**Project Name :**	**Prelminary Geotechnical Investigation, New Landfill Site**						
Client :	**City of Iqaluit**	**Project Location :**	**Iqaluit, NU**						
Date Sampled :	**April 8, 2019**	**Borehole No:**	**BH106**		**Sample No.:**	**S1**		**Depth (m) :**	**0-1**
Sample Description :		**% Silt and Clay**	**17**	**% Sand**	**75**	**% Gravel**	**8**	**Figure :**	**23**
Sample Description :		**Silty Sand (SM)**							

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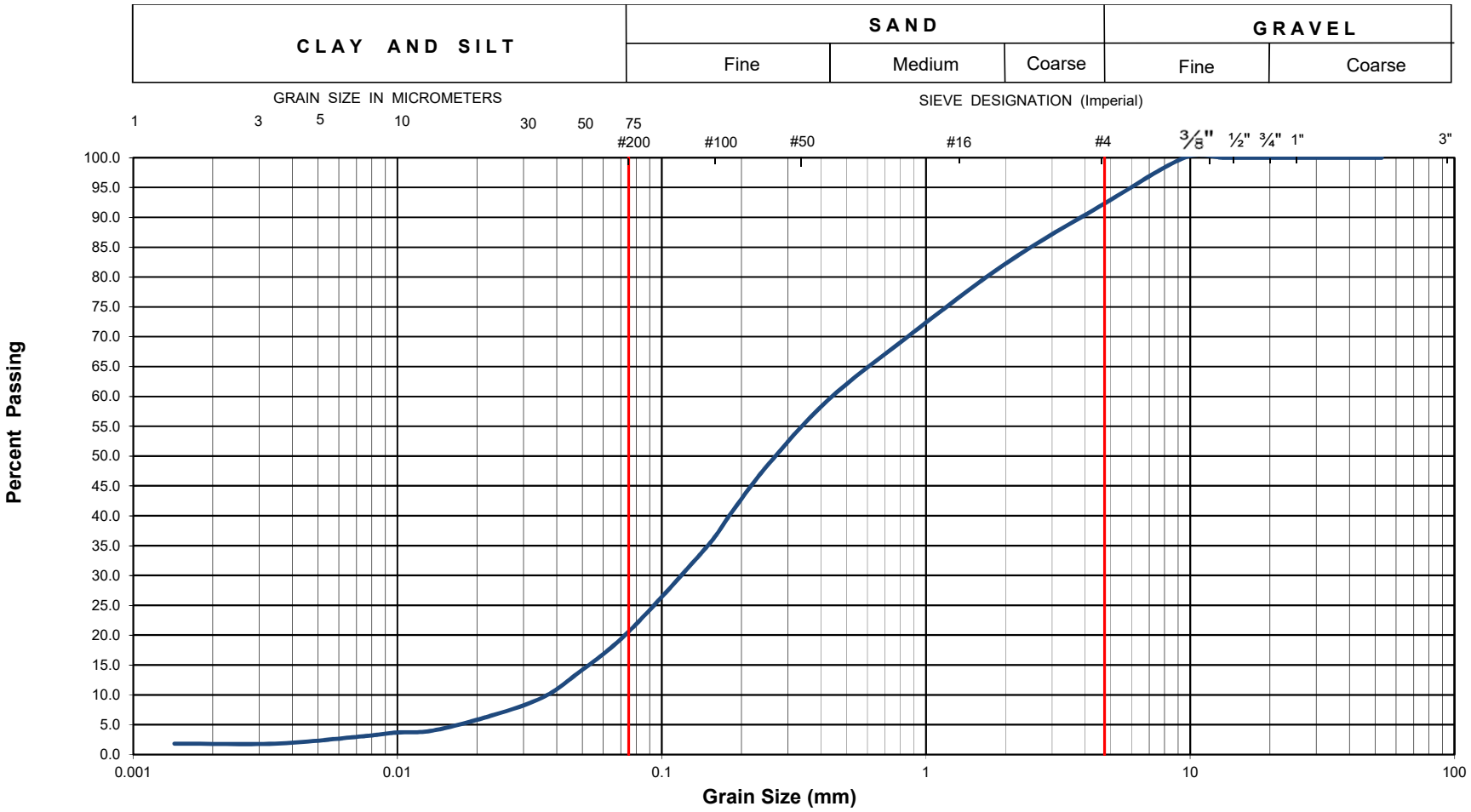
Grain-Size Distribution Curve
Method of Test For Particle Size Analysis of Soil
ASTM C-136/ASTM D422

Unified Soil Classification System



EXP Project No.:	**OTT-00248813-A0**	**Project Name :**	**Preliminary Geotechnical Investigation, New Landfill Site**						
Client :	**City of Iqaluit**	**Project Location :**	**Iqaluit, NU**						
Date Sampled :	**April 8, 2019**	**Borehole No:**	**BH106**		**Sample No.:**	**S2**		**Depth (m) :**	**1-2**
Sample Description :		**% Silt and Clay**	**21**	**% Sand**	**71**	**% Gravel**	**8**	**Figure :**	**24**
Sample Description :		**Silty Sand (SM)**							

Appendix A: Photographs Collected During Drilling (March and April 2019)

Photo 1 – Typical Air Track Mounted on a Mechanical Shovel and Compressor

Photo 2 – Borehole Drilling Operation - Typical

Photo 3 – Borehole Drilling Operation - Typical

Photo 4 – Temperature and Groundwater Monitoring Installation in TH110/W-110 (Typical)

Photo 4 – Temperature Monitoring in TH-110 - Typical

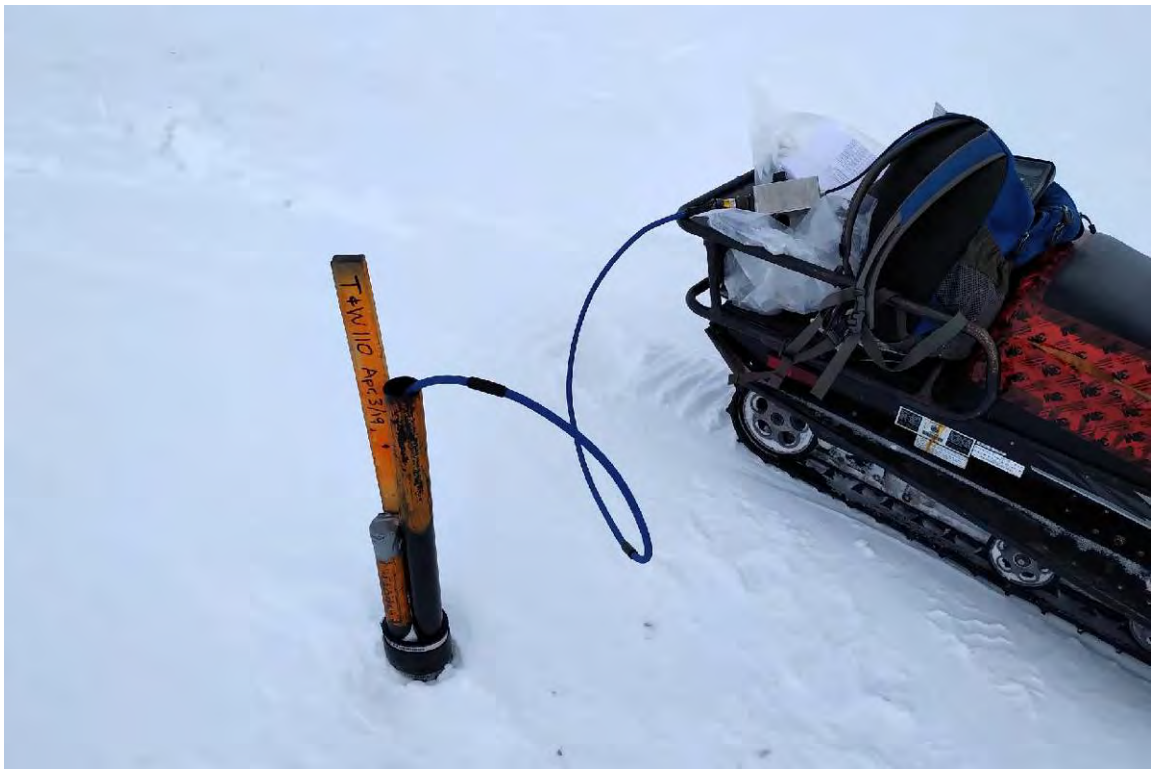


Photo 5 – Temperature Monitoring in TH-110 - Typical

Appendix B: Results of Chemical Tests on Soil Samples

AGAT Laboratories

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

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

ATTENTION TO: Ismail M. Taki

PROJECT: OTT-248813-A0

AGAT WORK ORDER: 19Z453898

SOIL ANALYSIS REVIEWED BY: Amanjot Bhela, Inorganic Supervisor

DATE REPORTED: Apr 26, 2019

PAGES (INCLUDING COVER): 5

VERSION*: 2

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

*NOTES
VERSION 2:Revised report issued April 26, 2019.

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

AGAT Laboratories

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

Certificate of Analysis

AGAT WORK ORDER: 19Z453898

PROJECT: OTT-248813-A0

CLIENT NAME: EXP SERVICES INC

ATTENTION TO: Ismail M. Taki

SAMPLING SITE:Loyalist, Ont

SAMPLED BY:exp

Inorganic Chemistry (Soil)

DATE RECEIVED: 2019-04-05 **DATE REPORTED: 2019-04-26**

Parameter	Unit	G / S	RDL	SAMPLE DESCRIPTION: BH1 SS2 2. 5'-4.5'	BH15 SS2 2. 5'-4.5'	BH17 SS3 5'-7'	BH22 SS3 5. 5'-8.5'	BH26 SS3 5. 5'-7.5'	BH31 SS3 5'-7'	BH39 SS4 7. 5'-9.5'	BH48 SS2 3'-5'
SAMPLE TYPE:				Soil	Soil	Soil	Soil	Soil	Soil	Soil	Soil
DATE SAMPLED:				2019-03-12	2019-03-13	2019-03-15	2019-03-20	2019-03-19	2019-03-22	2019-03-18	2019-03-19
				114353	114355	114356	114357	114358	114359	114360	114361
pH (2:1)	pH Units		N/A	7.94	7.99	8.18	7.99	8.19	8.17	8.27	8.01
Electrical Conductivity (2:1)	mS/cm		0.005	0.179	0.284	0.190	0.177	0.250	0.199	0.226	0.196
Sulphate (2:1)	%		0.0002	0.0006	0.0070	0.0034	0.0034	0.0072	0.0038	0.0048	0.0030

Parameter	Unit	G / S	RDL	SAMPLE DESCRIPTION: BH67 SS3 5'-7'	BH74 SS4 7. 5'-9.5'
SAMPLE TYPE:				Soil	Soil
DATE SAMPLED:				2019-03-13	2019-03-14
				114362	114363
pH (2:1)	pH Units		N/A	8.09	8.22
Electrical Conductivity (2:1)	mS/cm		0.005	0.435	0.128
Sulphate (2:1)	%		0.0002	0.0063	0.0019

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

114353-114363 EC, pH and Sulphate were determined on the DI water extract obtained from the 2:1 leaching procedure (2 parts DI water:1 part soil).
Revised on 2019 April 26
Revision: This is a revision of a previous report issued on 2019 April 12. At client's request, the concentration units for sulphate have been changed from µg/g to %.

Certified By:

AGAT Laboratories

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Quality Assurance

CLIENT NAME: EXP SERVICES INC

AGAT WORK ORDER: 19Z453898

PROJECT: OTT-248813-A0

ATTENTION TO: Ismail M. Taki

SAMPLING SITE:Loyalist, Ont

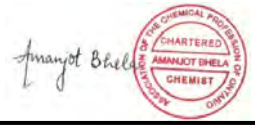
SAMPLED BY:exp

Soil Analysis

RPT Date: Apr 26, 2019			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)	120874		8.15	8.19	0.5%	N/A	100%	90%	110%	NA			NA		
Electrical Conductivity (2:1)	120771		0.214	0.222	3.7%	< 0.005	104%	90%	110%	NA			NA		
Sulphate (2:1)	118571		0.0014	0.0016	13.3%	<0.00002	98%	70%	130%	107%	70%	130%	112%	70%	130%

Comments: NA signifies Not Applicable.

Certified By:



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Method Summary

CLIENT NAME: EXP SERVICES INC

AGAT WORK ORDER: 19Z453898

PROJECT: OTT-248813-A0

ATTENTION TO: Ismail M. Taki

SAMPLING SITE:Loyalist, Ont

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
Electrical Conductivity (2:1)	INOR-93-6036	McKeague 4.12, SM 2510 B	EC METER
Sulphate (2:1)	INOR-93-6004	McKeague 4.12 & SM 4110 B	ION CHROMATOGRAPH

AGAT Laboratories

76882 CWIC

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)

Report Information:

Company: Exp Services
Contact: Ismail Tak:
Address: 2650 Queensview dr Suite 100
Ottawa ON K2B 8H6
Phone: 613-688-1899 Fax:
Reports to be sent to:
1. Email:
2. Email:

Project Information:

Project: OTT-252122
Site Location: Loyalist Ont
Sampled By: exp
AGAT Quote #: PO:
Please note: If quotation number is not provided, client will be billed full price for analysis.

Invoice Information:

Bill To Same: Yes ☒ No ☐
Company:
Contact:
Address:
Email:

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

Laboratory Use Only

Work Order #: 19745389 8

Cooler Quantity: plastic bag
Arrival Temperatures: 20.3 | 20.1 | 20.3
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

Sample Matrix Legend

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

Sample Identification	Date Sampled	Time Sampled	# of Containers	Sample Matrix	Comments/ Special Instructions	Field Filtered - Metals, Hg, CrVI (Y/N)	O. Reg 153: Metals and Inorganics	pH	Sulfide	Electro Conductivity
BH 1 ss 2 2.5'-4.5'	Mar 12/19							✓	✓	✓
BH 15 ss 2 2.5'-4.5'	Mar 13									
BH 17 ss 3 5'-7'	Mar 15									
BH 22 ss 3 5.5'-8.5'	Mar 20									
BH 26 ss 3 5.5'-7.5'	Mar 19									
BH 31 ss 3 5'-7'	Mar 22									
BH 39 ss 4 7.5'-9.5'	Mar 18									
BH 48 ss 2 3'-5'	Mar 19									
BH 67 ss 3 5'-7'	Mar 13									
BH 74 ss 4 7.5'-9.5'	Mar 14									

Samples Relinquished By (Print Name and Sign)	Date	Time	Samples Received By (Print Name and Sign)	Date	Time
Ryan Di Giuseppe	Mar 14/19	5:00pm		19-04-05	9h28
Blow to FedEx	19-04-05	16h00		19/4/16	11 30

Page 1 of 1

N°: T078139

Document ID: DIV-78-1511-015

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

Date Issued: March 16, 2018

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