# Government of Nunavut

## Geotechnical Investigation

**Type of Document**
Final

**Project Name**
Proposed Sewage Lagoon Upgrades
Hall Beach, Nunavut

**Project Number**
OTT-00215839-A0

**Prepared By:**

**exp** Services Inc.
100-2650 Queensview Drive
Ottawa, ON K2B 8H6
Canada

**Date Submitted**
January 22, 2014

# Government of Nunavut

## Geotechnical Investigation

**Type of Document:**
Final

**Project Name:**
Proposed Sewage Lagoon Upgrades, Hall Beach, Nunavut

**Project Number:**
OTT-00215839-A0

**Prepared By:**


**exp** Services Inc.
100-2650 Queensview Drive
Ottawa, ON K2B 8H6
Canada
T: 613-688-1899
F: 613-225-7337
www.exp.com


REGISTERED PROFESSIONAL ENGINEER
J.A. SMITH
LICENSEE
21-JAN-14
NWT/NU


Jason A. Smith, P.Eng
Senior Project Manager, Geotechnical Services
Earth and Environment
Professional License #: L2106

Surinder K. Aggarwal, M.Sc., P.Eng.
Senior Project Manager, Geotechnical Services
Earth and Environment
Professional License #: L1359


**Date Submitted:**
January 22, 2014

# Legal Notification

This report was prepared by **exp** Services Inc. for the account of **Government of Nunavut.**

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**) has carried out a geotechnical investigation at the site of the existing sewage lagoon just outside the Hamlet of Hall Beach, Nunavut. This work was authorized by the Government of Nunavut (GN) on October 16, 2013.

The current Hall Beach sewage lagoon comprises of two cells oriented in a north south direction. The south cell and north cell are commonly referred to as Cell 1 and Cell 2, respectively. Despite remedial measures taken in 2010 (partial lining of the inside slopes) Cell 1 has reportedly been leaking noticeably at its southeast corner since 2008. This has led to partial failure of the south berm. The purpose of the geotechnical investigation was to support the design and possible construction of four currently proposed options to rehabilitate and expand the existing lagoon structure. The proposed options vary in overall footprint, with possible expansion areas identified to the north and south of the existing cells. The proposed berm heights vary between 4.0 m and 5.5 m, with side slopes of 3H:1V inside (upstream) and 3.5H:1V outside (downstream). It is proposed to render newly constructed/expanded cells impervious by fully lining each cell with a synthetic liner.

The investigation consisted of drilling three boreholes to 3.1 m to 6.1 m depth using an electrical drill and excavating nine test pits to 2.0 m to 2.6 m depth using a Komatsu 300 excavator. The overburden and underlying bedrock was core drilled and sampled continuously. A multi-bead thermistor string was installed in Borehole No. 1 to monitor the ground temperature.

In general, the investigation revealed that the overburden soils at the site comprise of surficial silty sandy gravel, underlain by clay and by bedrock. Many of the test pits excavated throughout the current base of Cell 1 encountered less sand and silt in the gravel layer. At these locations the gravel layer was black in colour and contained traces of silt and sand intermixed with some organics/sewage below 0.6 m to 2.3 m depth. Bedrock was confirmed in Borehole No. 1 (center of existing Cell 1) at a depth of 2.9 m below current grade. Based on previous nearby geotechnical investigations, it is anticipated that bedrock is at a similar depth throughout the entire area of interest to this investigation, likely at about 3 m to 5 m below original grade. The overburden soils were observed to contain very little to no excess ice. Groundwater (primarily comprised of sewage water) was encountered at depths ranging from 1.2 m to 2.3 m in the borehole and most of the test pits located throughout the existing base of Cell 1.

The berm embankments are to be constructed using locally available sand and gravel. It is recommended that the entire zone of influence for the new cells, berm expansions and/or liner installations, should be stripped of any existing sludge, garbage, surficial organic/peat layer and/or any other soft saturated materials encountered to expose a structurally stable subgrade of either unfrozen or frozen well-graded soils. Where the existing berms of Cell 1 are to be re-used/raised, any sections of the berms known to have experienced slope failures and/or undermining, should be removed to approved material/subgrade and reconstructed.

Any over-excavation should be backfilled to pre-existing grades within one day of the excavation to limit the time of exposure of the underlying permafrost soils. It is recommended that the embankment fill be well-graded sand and gravel having a maximum size of about 150 mm and moisture content within about

2% of the optimum moisture content. Embankment fill should be placed in maximum 300 mm thick lifts and compacted to at least 95 percent Standard Proctor maximum dry density. The synthetic liner should be provided with a suitable bedding (such as sand) as specified by the manufacturer. The upper end of the liner (at the crest of the berm) should be buried in an approximately 0.6 m deep trench and backfilled with well-compacted embankment fill.

Some additional geotechnical investigative work may be prudent at the site; including test pits excavated throughout the proposed expansion footprint for Cell 1 and Cell 3. The intention of the test pits would be to further evaluate the extent of garbage and/or soft surficial soils present throughout these areas to better understand potential over-excavation that will be required for each option. Test pits excavated into the sides of the existing berm located north of the current cells would be helpful to evaluate its composition and compactness. The test pits should be carried out after the spring freshet.

Permafrost degradation is expected beneath the lagoon cells and will result in differential thaw settlements of the lagoon and the berms. However, the site soils encountered during our investigation were not observed to be ice-rich, were primarily coarse grained and bedrock is anticipated to be within 3 m to 5 m of the current site grades. Therefore, it is not expected that thaw settlement beneath the lagoon will be significant and the use of fully lined lagoon cells is considered suitable at the site.

A slope stability analysis was performed in order to determine if the proposed berm heights and slopes would be stable. For the purpose of the analysis, it was assumed that the overburden at the site is not frozen and that locally available silty sandy gravel material will be used to construct the berms. The slope stability analysis was performed using the Geoslope computer program and Morgenstern-Price method. For slope stability analysis, the most critical proposed cross-section of the berms (north berm of Option 2) was used. It is considered that the results for this location will also be applicable to the other proposed berm cross-sections. The analysis was performed for static as well as seismic loading. It revealed that the required factors of safety of 1.5 in the case of static loading and 1.1 m the case of seismic loading will be satisfied with upstream slopes of 3H:1V and downstream slopes of 3.5H:1V for the reservoir. A slope stability analysis for the rapid drawdown condition was also undertaken using Seep W and Geoslope computer programs. The analysis revealed that the berm slopes will be stable (factor of safety of 1.1) provided that the lagoon is drained in 5 or more days. The slope stability results assume that sufficiently sized toe drains would be provided to prevent the phreatic surface from day lighting at the downstream face of the berms and that over topping of the berms will not occur.

The above and other related considerations have been discussed in greater detail in the report.

# Table of Contents

**Page**

# List of Tables

**Page**



# List of Figures

# 1 Introduction

**Exp** Services Inc. (**exp**) has carried out a geotechnical investigation at the site of the existing sewage lagoon just outside the Hamlet of Hall Beach, Nunavut. The current Hall Beach sewage lagoon comprises of two cells oriented in a north south direction. The south cell and north cell are commonly referred to as Cell 1 and Cell 2, respectively. Cell 1 has reportedly been leaking noticeably at its southeast corner since 2008. In 2010, remedial measures were taken to prevent leakage of the lagoon by lining the inside slope of the berm at the location of the leakage. In 2012, another leak developed adjacent to the previously repaired area and resulted in partial failure of the berm. The purpose of the geotechnical investigation was to:

1.) Establish the geotechnical profile at the site of Cell 1 as it was reported that the cell may have partially been built on an abandoned garbage dump located in the vicinity of the lagoon;
2.) Make design and construction recommendations from a geotechnical perspective for the four options currently being considered for the remediation and expansion of the sewage lagoon.

This work was authorized by the Government of Nunavut (GN) on October 16, 2013.

The comments and recommendations given in this report are based on the assumption that the design concepts discussed herein 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.

## 1.1 Project Background

On June 20, 2013, representatives from **exp** carried out an initial site visit and assessment of the existing Cell 1. The purpose of the site visit was to attempt to observe the cause(s) of the leak and provide preliminary recommendations for remedial measures. The observations and recommendations resulting from our June 20, 2013 site visit were summarized in a letter to Mr. Bill Westwell, entitled Assessment of Sewage Lagoon Cell 1, Hamlet of Hall Beach, Nunavut and dated June 27, 2012. During the site visit it was observed that the outside slope of the south berm had partially failed just above the toe and slid. The observed slope failure was located adjacent to and west of the liner placed in 2010. Adjacent to the outside toe of the berm at the slope failure, an approximately 50 $m^2$ area had settled about 0.5 m and exposed some garbage to the surface. Based on these observations, it was assumed that the seepage of water and washing of fine grained soils through the voids present in the garbage was the primary cause of the observed slope failure and settlement.

Based on a recent conversation with the contractor that constructed the current lagoon structure, the proposed footprint was shifted at the time of construction to avoid an existing garbage dump as much as possible. The contractor reports that the garbage dump is located near the outside toe of the south berm; however, the base of each berm was reportedly founded on native soils. These claims have not been confirmed as part of this investigation and are presented solely for information.

# 2 Procedure

The geotechnical investigation was carried out between November, 14 and 20, 2013 (inclusive). A total of three boreholes and nine test pits were put down throughout the existing Cell 1 footprint and proposed expansion footprints to the north and south of the existing cells. The borehole and test pit locations are shown on the appended Figure 2, Borehole and Test Pit Location Plan.

The boreholes were put down to depths ranging from 3.1 m to 6.1 m using a portable electric drill rig. Frozen soils and bedrock were cored using the drill rig and sampled continuously. The test pits were excavated to depths ranging from 2.0 m to 2.6 m using a Komatsu 300 excavator. Soil samples were obtained from each test pit at regular intervals. Each test pit was left open for at least 1 hour to observe groundwater levels, then backfilled using excavated material and lightly compacted with the excavator bucket.

The drilling and test pitting operation was supervised on a full-time basis by a geotechnician from **exp**. The samples were visually examined and logged in accordance with the modified MIT soil classification system and ASTM D 2488 (*Standard Practice for Description and Identification of Soils, Visual-Manual Procedure*). The samples were then stored in moisture tight containers for transportation to the **exp** laboratory for further classification and testing. Similarly, the rock core was placed in core boxes, identified, logged and shipped. Laboratory testing included determination of natural moisture contents of all the soil samples and grain-size analyses and Atterberg limits of select soil samples.

Upon completion of drilling, a multi-bead thermistor string was installed to 5.0 m below the current site grade in Borehole No. 1. The thermistor string was installed in a PVC pipe that had been placed to the bottom of the open borehole. The annulus between the outside of the pipe and the borehole was backfilled to the surface with sand. The remaining boreholes were backfilled to the surface with drill cuttings. The borehole locations were established relative to the existing berms. The elevations of the boreholes were established from a contour plan available for the site, and therefore are considered to be approximate. These elevations refer to the geodetic datum.

# 3 Site and Soil Description

The Hamlet of Hall Beach is located on the east shore of the Melville Peninsula at latitude 68°46' N and longitude 81°13'W. The current sewage lagoon (site) is located about 1 km north of the community and about 200 m inland from Foxe Basin.

A detailed description of the subsurface soil and groundwater/ground ice conditions encountered at the borehole and test pit locations are given on the attached Borehole and Test Pit Logs, Figures 3 to 14, inclusive. The borehole/test pit logs and related information depict subsurface conditions only at the specific locations and times indicated. Subsurface conditions and water levels at other locations may differ from conditions at the locations where sampling was conducted. The passage of time may also 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 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.

The principal strata encountered at the site are summarized in Table No. I:

**Table No. I: Borehole and Test Pit Summary**

| Borehole/ Test Pit No. | Elev. (m) | Total Depth (m) | Soil Stratigraphy Depth (m) | | | Depth to Groundwater (m) |
|---|---|---|---|---|---|---|
| | | | GRAVEL | CLAY | BEDROCK | |
| BH1 | 5.6 | 6.1 | 0.0 – 2.5 | 2.5 – 2.9 | Below 2.9 | 2.3 |
| BH2 | 6.7 | 3.7 | 0.0 – 2.4 | Below 2.4 | - | - |
| BH3 | 6.0 | 3.1 | Below 0.0 | - | - | - |
| TP1 | 5.6 | 2.0 | Below 0.0 | - | - | 1.2 |
| TP2 | 5.7 | 2.0 | Below 0.0 | - | - | - |
| TP3 | 5.5 | 2.0 | Below 0.0 | - | - | 1.4 |
| TP4 | 5.5 | 2.3 | Below 0.0 | - | - | 2.0 |
| TP5 | 5.5 | 2.1 | Below 0.0 | - | - | 2.0 |
| TP6 | 5.6 | 2.5 | 0.0 – 1.8 | Below 1.8 | - | 1.7 |
| TP7 | 5.7 | 2.5 | 0.0 – 1.5 | Below 1.5 | - | 1.4 |
| TP8 | 5.7 | 2.6 | 0.0 – 2.0 | Below 2.0 | - | 1.7 |
| TP9 | 5.6 | 2.0 | Below 0.0 | - | - | - |

## 3.1 Silty Sandy Gravel to Gravel

A layer of light grey silty sandy gravel to gravel with some silt, and sand fill/till was encountered at the surface in all three boreholes and all nine test pits. No distinct transition from fill to till was observed during our investigation. Borehole Nos. 1 and 2, and Test Pits Nos. 6, 7 and 8 continued through the entire gravel thickness, which was observed to range from 1.5 m to 2.5 m in these boreholes and test pits. The gravel was observed to be underlain by clay at these locations. The remaining boreholes and test pits were terminated within the gravel at depths ranging from 2.0 m to 3.1 m. The test pits were terminated due to practical refusal in frozen soils, or due to inflow of sewage water. Some cobbles and boulders were observed/interpreted throughout the layer.

In Borehole No. 1 the clay content of the gravel layer was observed to increase with depth.

In the majority of the test pits put down throughout the current base of Cell 1, the sand and silt content of the gravel layer was observed to decrease drastically below depths ranging from 0.6 m to 2.3 m. Below this depth, the gravel becomes black and contained trace silt and sand interspersed with some organics/sewage.

The majority of the gravel layer was observed to be frozen and poorly to well bonded with no excess ice (Nf to Nbn). An approximately 0.3 m thick portion of the layer in Borehole No. 1 was observed to be unfrozen from about 2.3 m to 2.5 m depth (directly above the underlying clay layer). An approximately 1.2 m thick portion of the layer in Borehole No. 2 was observed to contain trace visible ice inclusions (Vx 5% to 10% by volume) from about 1.2 m to 2.4 m depth.

Natural moisture contents of samples collected from this layer ranged between 2.5% and 15.1%, with an average value of 6.6% (based on 36 samples). One sample collected from the upper most 1.0 m of this layer in TP1 had an elevated natural moisture content of 33.2%. Grain-size analyses performed on eight samples from this layer yielded 38% to 96% gravel, 3% to 35% sand and 1% to 36% silt and clay size particles based on the modified MIT soil classification system (Figure 15 to 22). The silt and clay sized particles were assessed and determined to be non-plastic.

## 3.2 Clay

A layer of green to grey clay with trace sand to some gravel, some sand was observed below the gravel layer in Borehole Nos. 1 and 2, and Test Pit Nos. 6, 7 and 8. Borehole No. 1 continued through the entire clay thickness, which was observed to be 0.4 m and underlain by bedrock. The remaining borehole and three test pits were terminated within this layer at depths ranging from 2.5 m to 3.7 m.

The layer was observed to be frozen and poorly to well bonded with no excess ice (Nf to Nbn).

Natural moisture contents of samples collected from this layer ranged between 11% and 21%, with an average value of 18% (based on 5 samples). Grain-size analyses performed on two samples from this layer yielded 0% to 10% gravel, 3% to 5% sand and 85% to 97% silt and clay size particles (Figures 23 and 24). The silt and clay sized particles were assessed by Atterberg Limits and determined to be low plasticity clay, with a plastic limit (PL) of about 18% and liquid limit (LL) of about 36%.

## 3.3 Bedrock

Bedrock was encountered in Borehole No. 1 at a depth of 2.9 m below the current grade. The bedrock was observed to be grey limestone. Bedrock was not encountered within the depth investigated in any of the remaining boreholes or test pits.

## 3.4 Groundwater

Groundwater levels were not observed in Borehole Nos. 2 and 3, or Test Pits No. 2 and 9. Groundwater levels were observed in the remaining boreholes and test pits, at depths ranging from 1.2 m to 2.3 m. The groundwater observed at these locations was primarily sewage water.

It is anticipated that groundwater flow will take place through the active layer during warmer months (during thaw) and groundwater levels will fluctuate with seasonal weather trends.

## 3.5 Permafrost and Climate

Based on available permafrost mapping, Hall Beach is located well within the zone of continuous permafrost. Based on a review of environment Canada average monthly air temperatures from 1981 to 2010, the Mean Annual Air Temperature (MAAT) is -13.8ºC, the freezing index is -5441ºC-days and the thawing index is 402ºC-days.

# 4 Ground Temperature

A thermistor string was installed in Borehole No. 1 on November 18, 2013. The thermistor string was installed to 5.0 m depth, with thermistors located at 1 m intervals. Ground temperature readings taken during the fieldwork are given on Table No. II.

**Table No. II: Ground Temperature Readings**

| Borehole No. | Thermister Depth (m) | Ground Temperature °C Date & Elapsed Time Since Installation | | | |
|---|---|---|---|---|---|
| | | Nov. 19, 2013 1:30 p.m. | Nov. 20, 2013 10:35 a.m. | Nov. 21, 2013 11:00 a.m. | Nov. 22, 2013 11:00 a.m. |
| 1 | 0 | -26.5 | -24.3 | -30.1 | -32.5 |
| | 1 | -5.9 | -8.0 | -10.6 | -10.8 |
| | 2 | -4.5 | -5.1 | -5.5 | -5.1 |
| | 3 | -3.3 | -3.9 | -4.1 | -4.4 |
| | 4 | -4.4 | -4.7 | -4.9 | -5.0 |
| | 5 | -5.5 | -5.6 | -5.6 | -5.7 |

# 5 Cause of Leakage of Cell 1

Garbage was not encountered in any of the nine test pits excavated throughout the current base of Cell 1. However, grain-size analyses performed on samples obtained from the test pits indicate that portions of the natural soils in the area are very coarse and as a result very permeable. This has resulted in leakage through and possibly underneath some of the berms. The leakage resulted in washing out of the fines, thereby making the material even more permeable. This process continued until such time that the water flow was sufficient to cause erosion and failure of part of the south berm.

# 6 Proposed Options for Lagoon Expansion

It is understood that four options to rehabilitate and expand the sewage lagoon are currently being evaluated. The elements of geotechnical concern for each of these options are as follows:

***Option 1 – Rehabilitate and Expand Existing Cell 1:*** For this option the overall footprint of Cell 1 will be expanded to the south by removing the south berm, lengthening the east and west berms and constructing a new south berm. The height of the Cell 1 berms would be increased by about 1.8 m to Elev. 9.8 m. This would result in a maximum berm height of about 4.0 m and require that the footprint of the existing east and west berms be increased inward/outward to accommodate the new berm height/slopes.

***Option 2 – Abandon Existing Cell 1 and Construct New Cell 3:*** For this option Cell 1 would be abandoned and backfilled. A new Cell 3 would be constructed north of the existing Cell 2. The proposed top of berm elevation for the new Cell 3 is Elev. 10.3 m. This would result in a maximum berm height of about 5.0 m.

***Option 3 – Rehabilitate and Expand Cell 1 and Construct New Cell 3:*** For this option the overall footprint of Cell 1 would remain relatively unchanged. The height of the Cell 1 berms would be increased by 1.8 m to Elev. 9.8 m. This would result in a maximum berm height of 4.0 m and require that the footprint of the existing berms be increased inward/outward to accommodate the new berm height/slopes.

The Cell 1 capacity would not be increased as much as in Option 1; therefore, it would also be required to construct a new Cell 3 to the north of the existing Cell 2. The overall footprint/capacity of Cell 3 for this option would be smaller/less than Option 2, as Cell 1 would remain operational. The proposed top of berm elevation for the new Cell 3 would remain at Elev. 10.3 m. This would result in a maximum berm height of about 5.0 m.

***Option 4 – Rehabilitate and Expand Cell 1 and Construct an Overflow Weir into Cell 2:*** For this option the overall footprint of Cell 1 would remain relatively unchanged, similar to Option 3. However, the height of the Cell 1 berms would be increased by 2.3 m to Elev. 10.3 m. This would result in a maximum berm height of about 4.5 m and larger footprints for the existing berms. An overflow weir would be installed in the existing berm between the two cells.

## 6.1 General

Based on the available information, the site is considered suitable for any of the four currently proposed design options outlined above. However, from a geotechnical perspective, Option 2 is considered to be the most economical. The reasons for this are:

1.) The integrity of part of the east and south berms of Cell 1 has been compromised by seepage and failure of the slope and would require reconstruction.

2.) Increasing the height of the Cell 1 berms would necessitate removal of the garbage that is reported present south of the south berm; and

3.) It is currently not known if garbage is present under the existing south berm since this could not be investigated due to time limitations.

It is understood that the locally available construction materials are primarily sand and gravel, similar to the surficial soils observed at the test pit and borehole locations. Therefore, constructing low permeability cores or liners using locally available silt or clay will not be feasible at the site. It will be necessary to render the lagoon cells impervious by another method and it is understood that fully lined cells are preferred.

It is noted that some additional geotechnical investigative work may be prudent at the site, especially if Options 1, 3 or 4 are being considered. Options 1, 3 and 4 would require excavation and replacement of some or all of the garbage currently present to the south of the existing Cell 1. Investigation would also be required to ensure that garbage is not present under the south berm. The extent of this garbage and the required over-excavation is not fully known at this time. Test pits excavated when the area is free of snow may be able to more fully delineate the extent of the garbage of interest. Additionally, the properties of the existing berm located just north of Cell 2 are not known. Test pits excavated throughout the proposed footprint for Cell 3 and into the sides of the existing berm would be helpful to further evaluate potential over-excavation of soft surficial soils during construction and the possibility of using the existing berm either as is, or as a borrow source for construction.

## 6.2 Geothermal Considerations and Thaw Settlement

Detailed geothermal analysis of the lagoon structure was not part of our current scope of work. However, based on past experience with other sewage lagoon designs throughout zones of continuous permafrost, we have made the following assumptions related to permafrost degradation/aggradation that should be considered during design:

- Existing permafrost beneath the interior base of the cells will thaw for tens of meters below finished grade due to the storing of sewage within the cells. This thaw may be shallower but will extend for some distance behind/under the inside toes of all berms.
- Drifting snow along the outside toes of exterior berms will serve as increased insulation during the winter months and result in additional permafrost thaw for some distance in front of and behind/under the outside toes of exterior berms.
- Permafrost thaw will be less approaching the core of each berm due to the increased soil cover.
- The depth of permafrost degradation (thaw) will vary substantially over the sewage lagoon footprint.

Permafrost degradation will result in differential settlements of the lagoon and the berms. The magnitude of thaw settlement is a function of the type of soil, density, ice content and the depth of thaw. Thaw settlement of ice-rich soils present beneath a fully lined lagoon cell can cause the liner to strain beyond its capacity and fail.

The site soils encountered during our investigation were not observed to be ice-rich. Furthermore, the bedrock surface was about 2.9 m below current grade in Borehole No. 1 (center of existing Cell 1). Other nearby geotechnical investigations encountered similar conditions. It is anticipated that the overburden is not ice-rich and bedrock is within 3 m to 5 m throughout the area of interest. Therefore, the use of fully lined lagoon cells is considered suitable at the site.

# 7 Site Preparation

## 7.1 Excavation

It is recommended that the prepared footprint of new cells and/or berm expansions, extend at least 2 m beyond the slope toe. The expanded footprint should be stripped of any existing sludge, garbage, surficial organic/peat layer and/or any other soft saturated materials encountered to expose a structurally stable subgrade of either unfrozen or frozen well-graded soils approved by qualified geotechnical personnel. Where the existing berms of Cell 1 are to be re-used/raised, any sections of the berms known to have experienced slope failures and/or undermining, should be removed to approved material/subgrade and reconstructed.

It is recommended that any over-excavation 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, likely resulting in soft soil conditions throughout the base and requiring over-excavation to remove the soft soils.

## 7.2 Water Control

It is anticipated that controlling surface and groundwater flow through the site may be a challenge given the surrounding wetlands, observed site soils and general tendency of groundwater to travel along the surface of the permafrost during thaw. It is possible that the existing access road running along the west side of the site will limit water inflow from this direction considerably. However, diversion ditches having positive outlet may need to be established up gradient of the site to minimize the amount of surface and groundwater entering the excavation(s).

Any water that does enter the excavation(s) should be gathered via swales/ditches having positive outlet or led to adequately sized sumps equipped with pumps for immediate removal offsite. Discharge of collected water should be conducted and controlled in a manner that does not induce erosion or transport of sediment, and is in accordance with all applicable government requirements.

## 7.3 Embankment Fill

Once the site has been prepared as outlined above, embankment fill should be placed to the desired grades. Embankment fill for the base of each cell and containment berms should comprise of well-graded silty sand and gravel having a maximum size of 150 mm.

The embankment fill shall be placed in maximum of 300 mm lifts and compacted to at least 95% of the standard Proctor maximum dry density (SPMDD) determined for the material. This will typically require that the material be within about 2% of its optimum moisture content at the time of placement.

Depending on the exposed soils, the placement and compaction of the initial lift(s) of material throughout over-excavations 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, but 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 SPMDD as outlined above and this may require that the initial lifts be allowed to drain over the course of several days.

## 7.4 Synthetic Liner

Synthetic liners offer advantages to provide primary containment in cold regions. They are useful in locations where fine-grained soils are not available to construct a natural low permeability liner and containment structure. They are also insensitive to climate warming and will be effective in both frozen and unfrozen conditions. They have good performance where the ground is stable and not subject to subsidence due to thawing of permafrost. Most liner materials require burial for several reasons including ultraviolet light protection, traffic protection and ice run-up or gouging protection.

It is noted that a number of liners have been used in the past in permafrost regions to make sewage lagoons constructed with granular materials impervious. These materials include polyvinylchloride (PVC), reinforced polyethylene (RPE), polypropylene (PP) and synthetic clay liners. RPE liners are normally preferred for lining sewage lagoons as they can withstand very low temperatures, have high tear strength and are highly resistant to chemicals.

The liner should be provided with a suitable bedding (such as sand) as specified by the manufacturer. The upper end of the liner (at the crest of the berm) should be buried in an approximately 0.6 m deep trench and backfilled with well-compacted embankment fill.

# 8 Permanent Slopes

Based on site preparation and embankment fill gradation/placement as outlined above, as well as the slope stability analyses outlined below, the proposed embankment slopes of 3.5H:1V (outside) and 3H:1V (inside) are considered acceptable at the site.

All slopes should be provided with suitable erosion protection. The inside (upstream) face of each berm may be subject to some wave action during the summer months and ice impact/run-up during winter. This should be considered when designing erosion protection. Additionally, the inside and outside slopes will be subject to seasonal freeze/thaw action. Frost susceptible soils placed within this zone may slough as a result, causing slope stability issues over time.

## 8.1 Slope Stability

Although it is understood that a synthetic liner will be installed along the upstream slope to render it impervious, there is potential that a steady-state seepage condition may develop in the berms if the liner is damaged. Therefore, the slope stability analyse presented below was based on unfrozen soils.

The stability of slopes was analyzed using Slope W, Geoslope Office, version 7.2 computer program using Morgenstern-Price Method. One cross-section taken through the proposed northern berm of Cell 3 (Option 2) was analyzed. The cross-section was chosen based on the height of berm being proposed and least favorable surrounding grades. It is considered to be the most critical berm of all the options proposed.

The berm was analysed using effective stress analysis with static loading and total stress analysis with seismic loading. Total stress analysis for static loading conditions was not undertaken since the factors of safety would be the same as for effective stress analysis. The following assumptions were made for slope stability analysis:

1.) The crest of the berm will be at Elevation 10.2 m whereas the base of the lagoon will be at Elevation 5.7 m. The crest width of the berm will be 8 m. The upstream and downstream slopes of the berms were analysed for slopes of 3H:1V and 3.5H:1V respectively.

2.) The water level in the lagoon will be maintained at Elevation 9.2 m or lower and that the berm will not be overtopped at any time. Overtopping of the berm(s) may be prevented by construction of a proper spillway structure.

3.) Sufficiently sized toe drains will be provided along the downstream toe of each berm in order to prevent the phreatic surface from day lighting at the downstream slope of the berm.

4.) The berms will be constructed in accordance with the recommendations outlined above.

5.) The soils below the berms are unfrozen to the bedrock surface.

6.) The engineering properties of the various soil strata were assumed as given on Table No. III based on previous experience in the region and literature research.

**Table No. III: Engineering Properties of Soils Used in Slope Stability Analysis**

| Soil Type | Unit Weight (kN/m3) | Effective Cohesion c' (kPa) | Effective Angle of Internal Friction $\phi$ (degrees) |
|---|---|---|---|
| Silty sandy gravel fill | 20 | 0 | 34 |
| Silty sandy gravel | 21 | 0 | 33 |

The results of the slope stability analysis are given on Table IV.

**Table No. IV: Computed Factors of Safety for Outside and Inside Berm Slopes**

| Slope Inclination | Slope Identification | Loading Condition | Computed Factor of Safety |
|---|---|---|---|
| 3.5H:1V | Downstream slope | Effective stress analysis | 1.59 |
| | | Total stress analysis + seismic loading | 1.15 |
| 3H:1V | Upstream slope | Effective stress analysis | 1.89 |
| | | Total stress analysis + seismic loading | 1.21 |

Based on current practice in the industry, a minimum factor of safety of 1.5 is required for static loading conditions and a factor of safety of 1.1 is required for seismic loading conditions. A review of Table No. IV indicates that a 3H:IV upstream slope and 3.5H:IV downstream slope would satisfy the requisite factors of safety. Therefore, those slopes may be used in the design of the berms.

### 8.1.1 Rapid Drawdown Condition

The upstream slope of the chosen berm cross-section was also analysed for rapid drawdown condition. The analysis was based on Morgenstern-Price Method coupled with the Seep W computer program to simulate the rapid drawdown condition. The following permeability values were assumed for the analysis:

Silty sandy gravel fill .................. 1 x $10^{-8}$ m/sec

Silty sandy gravel ...................... 3 x $10^{-8}$ m/sec

Bedrock..................................... 5 x $10^{-8}$ m/sec

The factor of safety of the slope was computed assuming that the lagoon will be emptied over a period of 5 days. The results indicate that the lowest factor of safety for the 3H:1V slope as a result of emptying the lagoon in this way will be 1.15. This factor of safety will be the minimum on emptying of the lagoon and is expected to increase thereafter as the excess pore pressure in the berm dissipates with time. The typical acceptable factor of safety for rapid drawdown condition is 1.1. Therefore, this factor of safety is considered acceptable for the temporary condition.

# 9 General Comments

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

The information contained in this report is not intended to reflect on environmental aspects of the soils. Should specific information be required, including for example, the presence of pollutants, contaminants or other hazards in the soil, additional testing may be required.

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

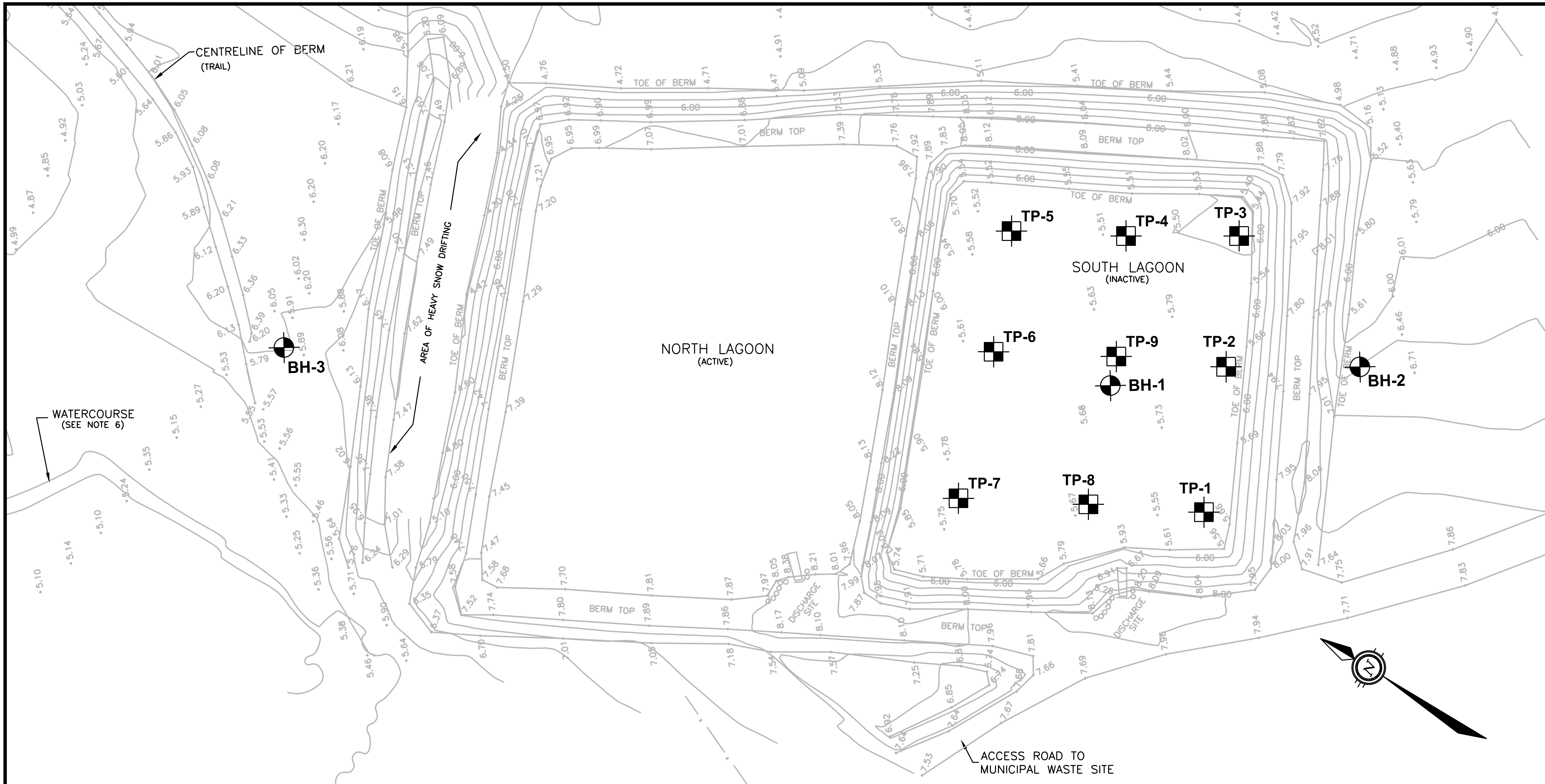
# Figures




**exp** Services Inc. www.exp.com

t: +1.613.688.1899 | f: +1.613.225.7337
2650 Queensview Drive, Suite 100
Ottawa, ON K2B 8H6, Canada

| | | |
|---|---|---|
| scale 1:10,000 | CLIENT: GOVERNMENT OF NUNAVUT | project no. OTT-00215839-A0 |
| date JANUARY 2014 | TITLE: SITE LOCATION PLAN HALL BEACH, NUNAVUT | FIG 1 |
| drawn by P. GHAFFARI | | |




NOTES :

1. THE BOUNDARIES AND SOIL TYPES HAVE BEEN ESTABLISHED ONLY AT TEST PIT AND BOREHOLE LOCATIONS. BETWEEN TEST PIT AND BOREHOLES THEY ARE ASSUMED AND MAY BE SUBJECT TO CONSIDERABLE ERROR.
2. SOIL SAMPLES WILL BE RETAINED IN STORAGE FOR THREE MONTHS AND THEN DESTROYED UNLESS THE CLIENT ADVISES THAT AN EXTENDED TIME PERIOD IS REQUIRED.
3. TOPSOIL QUANTITIES SHOULD NOT BE ESTABLISHED FROM THE INFORMATION PROVIDED AT THE TEST PIT AND BOREHOLE LOCATIONS.
4. TEST PIT AND 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 WHYTE, McELMON & ASSOCIATES LTD., PROJECT No 47A-15-1, DATED NOVEMBER 12, 2013.

0 10m 20m 40m

HORIZONTAL 1:1000

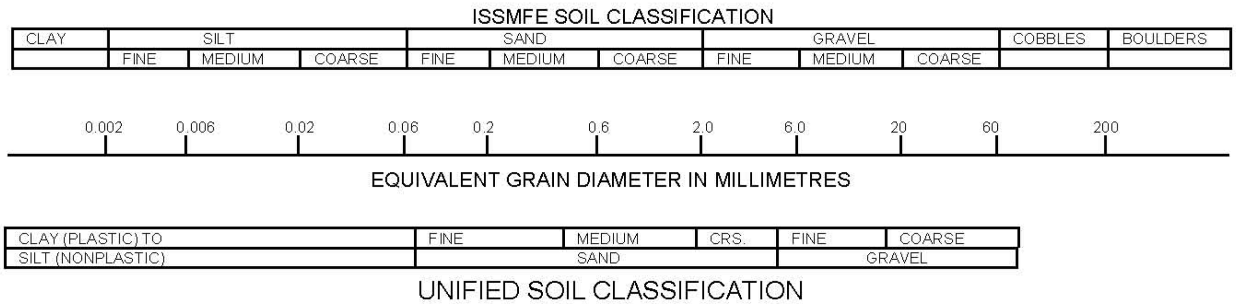
exp Services Inc. www.exp.com
t: +1.613.688.1899 | f: +1.613.225.7337
2650 Queensview Drive, Suite 100
Ottawa, ON K2B 8H6, Canada

| | | | |
|---|---|---|---|
| scale: 1:1000 | CLIENT: GOVERNMENT OF NUNAVUT | | project no. OTT-00215839-A0 |
| design: J.S. | checked: I.T. | TITLE: TEST PIT & BOREHOLE LOCATION PLAN HALL BEACH, NUNAVUT | date: JANUARY 2014 |
| drawn by: P. GHAFFARI | | | drawing no. FIG 2 |

Filename: r:\2100000\215000\215839-a0 hall beach sewage lagoon feasibility study, hall beach, nu\215839-a0.dwg
Last Saved: 1/8/2014 10:21:46 AM
Last Plotted: 1/8/2014 10:31:37 AM
Plotted by: ghaffarip
Pen Table:: trow standard, july 01, 2004.ctb

# 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 Pit BH1

Project No: OTT-00215839-A0

Project: Proposed Sewage Lagoon Upgrades

Location: Hall Beach, NU

Figure No. 3

Page. 1 of 1

Date Drilled: 'November 14, 2013

Drill Type: Portable Electric Core Drill

Datum: Geodetic

Logged by: RV    Checked by: JS

| | | | |
|---|---|---|---|
| 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 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 |
|---|---|---|---|---|---|---|---|---|
| | | **FILL/TILL**<br>Light grey silty sandy GRAVEL<br>- frozen, $N_f$ to $N_{bn}$<br>- some cobbles and boulders | 5.6 | 0 | | | | |
| | | **FILL/TILL**<br>Light grey sandy GRAVEL and CLAY<br>- frozen, $N_f$ to $N_{bn}$<br>- some cobbles and boulders<br>- unfrozen black sewage sludge between 2.3 m and 2.6 m | 4.1 | | | | | |
| | | **TILL**<br>Green to grey CLAY, some gravel, some sand<br>- frozen, $N_f$ to $N_{bn}$ | 3.1 / 2.8 | | | | | |
| | | **BEDROCK**<br>Medium grey bedrock | | | | | | |
| | | End of Borehole at 6.1 m | -0.5 | 6 | | | | |

NOTES:
1. Borehole/Test Pit data requires Interpretation by exp. before use by others
2. Thermister was installed upon completion to 5.0 m.
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-00215839-A0

WATER LEVEL RECORDS

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

CORE DRILLING RECORD

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

# Log of Borehole Pit BH2

| | |
|---|---|
| Project No: | OTT-00215839-A0 |
| Project: | Proposed Sewage Lagoon Upgrades |
| Location: | Hall Beach, NU |
| Date Drilled: | 'November 19, 2013 |
| Drill Type: | Portable Electric Core Drill |
| Datum: | Geodetic |
| Logged by: | RV |
| Checked by: | JS |

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 Penetrometer Test | ▲ |
| Shear Strength by Vane Test | + S | | |

| GWL | SYMBOL | SOIL DESCRIPTION | Geodetic 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. $kN/m^3$ |
|---|---|---|---|---|---|---|---|---|
| | | 6.7 | 6.7 | 0 | | | | |
| | | **FILL/TILL** Light grey GRAVEL, some silt, some sand to silty sand GRAVEL - frozen, $N_f$ to $N_{bn}$ - some cobbles and boulders | | 1 | | × × × | | |
| | | - $V_x$ 5% to 10% below 1.5 m depth | | 2 | | × × | | |
| | | **TILL** Green to grey CLAY, some gravel, some sand - frozen, $N_f$ to $N_{bn}$ | 4.3 | 3 | | × | | |
| | | End of Borehole at 3.7 m | 3.0 | | | | | |

NOTES:
1. Borehole/Test Pit data requires Interpretation by exp. before use by others
2. Borehole was backfilled upon completion.
3. Field work supervised by an **exp** representative.
4. See Notes on Sample Descriptions
5. This Figure is to read with exp. Services Inc. report OTT-00215839-A0

WATER LEVEL RECORDS

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

CORE DRILLING RECORD

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

# Log of Borehole Pit BH3

Project No: OTT-00215839-A0

Project: Proposed Sewage Lagoon Upgrades

Location: Hall Beach, NU

Figure No. 5

Page. 1 of 1

Date Drilled: 'November 20, 2013

Drill Type: Portable Electric Core Drill

Datum: Geodetic

Logged by: RV    Checked by: JS

| | | | |
|---|---|---|---|
| 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 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/m$^3$ |
|---|---|---|---|---|---|---|---|---|
| | | **FILL/TILL** Light grey silty GRAVEL and SAND to silty sandy GRAVEL - frozen, $N_f$ to $N_{bn}$ - some cobbles and boulders | 6 | 0 | | | | |
| | | | | 1 | | | | |
| | | | | 2 | | | | |
| | | | 2.9 | 3 | | | | |
| | | End of Borehole at 3.1 m | | | | | | |

NOTES:
1. Borehole/Test Pit data requires Interpretation by exp. before use by others
2. Borehole was backfilled upon completion.
3. Field work supervised by an **exp** representative.
4. See Notes on Sample Descriptions
5. This Figure is to read with exp. Services Inc. report OTT-00215839-A0

WATER LEVEL RECORDS

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

CORE DRILLING RECORD

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

# Log of Borehole Pit TP1

Project No: OTT-00215839-A0

Project: Proposed Sewage Lagoon Upgrades

Location: Hall Beach, NU

Figure No. 6

Page. 1 of 1

Date Drilled: 'November 14, 2013

Drill Type: Komatsu 300

Datum: Geodetic

Logged by: RV    Checked by: JS

| | | | |
|---|---|---|---|
| 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 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 |
|---|---|---|---|---|---|---|---|---|
| | | | 5.6 | 0 | | | | |
| | | **FILL/TILL**<br>Light grey silty sandy GRAVEL<br>- frozen, $N_f$ to $N_{bn}$ | | | | × | | |
| | | **FILL/TILL**<br>Black GRAVEL, trace sand, trace silt<br>- intermixed with organics/sewage<br>- frozen, $N_f$ to $N_{bn}$ | 4.6 | 1 | | × | | |
| | | End of Test Pit at 2.0 m<br>- unfrozen seam of sewage water at 1.2 m depth<br>- test pit termiated due to sewage water inflow | 3.6 | 2 | | | | |

NOTES:
1. Borehole/Test Pit data requires Interpretation by exp. before use by others
2. Test pit was backfilled and lightly compacted 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-00215839-A0

WATER LEVEL RECORDS

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

CORE DRILLING RECORD

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

# Log of Borehole Pit TP2

Project No: OTT-00215839-A0

Project: Proposed Sewage Lagoon Upgrades

Location: Hall Beach, NU

Figure No. 7

Page. 1 of 1

Date Drilled: 'November 14, 2013

Drill Type: Komatsu 300

Datum: Geodetic

Logged by: RV  Checked by: JS

| | | | |
|---|---|---|---|
| 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 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/m$^3$ |
|---|---|---|---|---|---|---|---|---|
| | | **FILL/TILL** Light grey silty sandy GRAVEL - frozen, $N_f$ to $N_{bn}$ | 5.7 | 0 | | × (approx. 0.5 m); × (approx. 1.6 m) | grab samples at approx. 0.5 m and 1.6 m | |
| | | End of Test Pit at 2.0 m - due to practical refusal in frozen soil | 3.7 | 2 | | | | |

NOTES:
1. Borehole/Test Pit data requires Interpretation by exp. before use by others
2. Test pit was backfilled and lightly compacted 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-00215839-A0

WATER LEVEL RECORDS

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

CORE DRILLING RECORD

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

# Log of Borehole Pit TP3

Project No: OTT-00215839-A0

Project: Proposed Sewage Lagoon Upgrades

Location: Hall Beach, NU

Figure No. 8

Page. 1 of 1

Date Drilled: 'November 14, 2013

Drill Type: Komatsu 300

Datum: Geodetic

Logged by: RV   Checked by: JS

| | | | |
|---|---|---|---|
| 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 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 |
|---|---|---|---|---|---|---|---|---|
| | | | 5.5 | 0 | | | | |
| | | **FILL/TILL**<br>Light grey silty sandy GRAVEL<br>- frozen, $N_f$ to $N_{bn}$ | | | | × | | |
| | | | | 1 | | × | | |
| | | **FILL/TILL**<br>Black GRAVEL, trace sand, trace silt<br>- intermixed with organics/sewage<br>- frozen, $N_f$ to $N_{bn}$ | 4.1 | | | | | |
| | | End of Test Pit at 2.0 m<br>- unfrozen seam of sewage water at 1.4 m depth<br>- test pit termiated due to sewage water inflow | 3.5 | 2 | | | | |

NOTES:
1. Borehole/Test Pit data requires Interpretation by exp. before use by others
2. Test pit was backfilled and lightly compacted 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-00215839-A0

WATER LEVEL RECORDS

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

CORE DRILLING RECORD

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

# Log of Borehole Pit TP4

Project No: OTT-00215839-A0

Project: Proposed Sewage Lagoon Upgrades

Location: Hall Beach, NU

Figure No. 9

Page. 1 of 1

Date Drilled: 'November 15, 2013

Drill Type: Komatsu 300

Datum: Geodetic

Logged by: RV    Checked by: JS

| | | | |
|---|---|---|---|
| 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 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 |
|---|---|---|---|---|---|---|---|---|
| | | | 5.5 | 0 | | | | |
| | | **FILL/TILL** Light grey silty sandy GRAVEL - frozen, $N_f$ to $N_{bn}$ | | 0.5 | | × | grab | |
| | | | | 1 | | × | grab | |
| | | **FILL/TILL** Black GRAVEL, trace sand, trace silt - intermixed with organics/sewage - frozen, $N_f$ to $N_{bn}$ | 3.9 | | | | | |
| | | | | 2 | | × | grab | |
| | | End of Test Pit at 2.3 m - unfrozen seam of sewage water at 2.0 m depth - test pit termiated due to sewage water inflow | 3.2 | | | | | |

NOTES:
1. Borehole/Test Pit data requires Interpretation by exp. before use by others
2. Test pit was backfilled and lightly compacted 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-00215839-A0

WATER LEVEL RECORDS

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

CORE DRILLING RECORD

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

# Log of Borehole Pit TP5

Project No: OTT-00215839-A0
Project: Proposed Sewage Lagoon Upgrades
Location: Hall Beach, NU

Figure No. 10
Page. 1 of 1

Date Drilled: 'November 15, 2013
Drill Type: Komatsu 300
Datum: Geodetic
Logged by: RV    Checked by: JS

| | | | |
|---|---|---|---|
| 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 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 |
|---|---|---|---|---|---|---|---|---|
| | | | 5.5 | 0 | | | | |
| | | **FILL/TILL**<br>Light grey silty sandy GRAVEL<br>- frozen, $N_f$ to $N_{bn}$ | | | | | | |
| | | | | 1 | | × | Grab | |
| | | | 4.0 | | | × | Grab | |
| | | **FILL/TILL**<br>Black GRAVEL, trace sand, trace silt<br>- intermixed with organics/sewage<br>- frozen, $N_f$ to $N_{bn}$ | | | | × | Grab | |
| | | | 3.4 | 2 | | | | |
| | | End of Test Pit at 2.1 m<br>- unfrozen seam of sewage water at 2.0 m depth<br>- test pit termiated due to sewage water inflow | | | | | | |

NOTES:
1. Borehole/Test Pit data requires Interpretation by exp. before use by others
2. Test pit was backfilled and lightly compacted 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-00215839-A0

WATER LEVEL RECORDS

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

CORE DRILLING RECORD

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

# Log of Borehole Pit TP6

Project No: OTT-00215839-A0

Project: Proposed Sewage Lagoon Upgrades

Location: Hall Beach, NU

Figure No. 11

Page. 1 of 1

Date Drilled: 'November 15, 2013

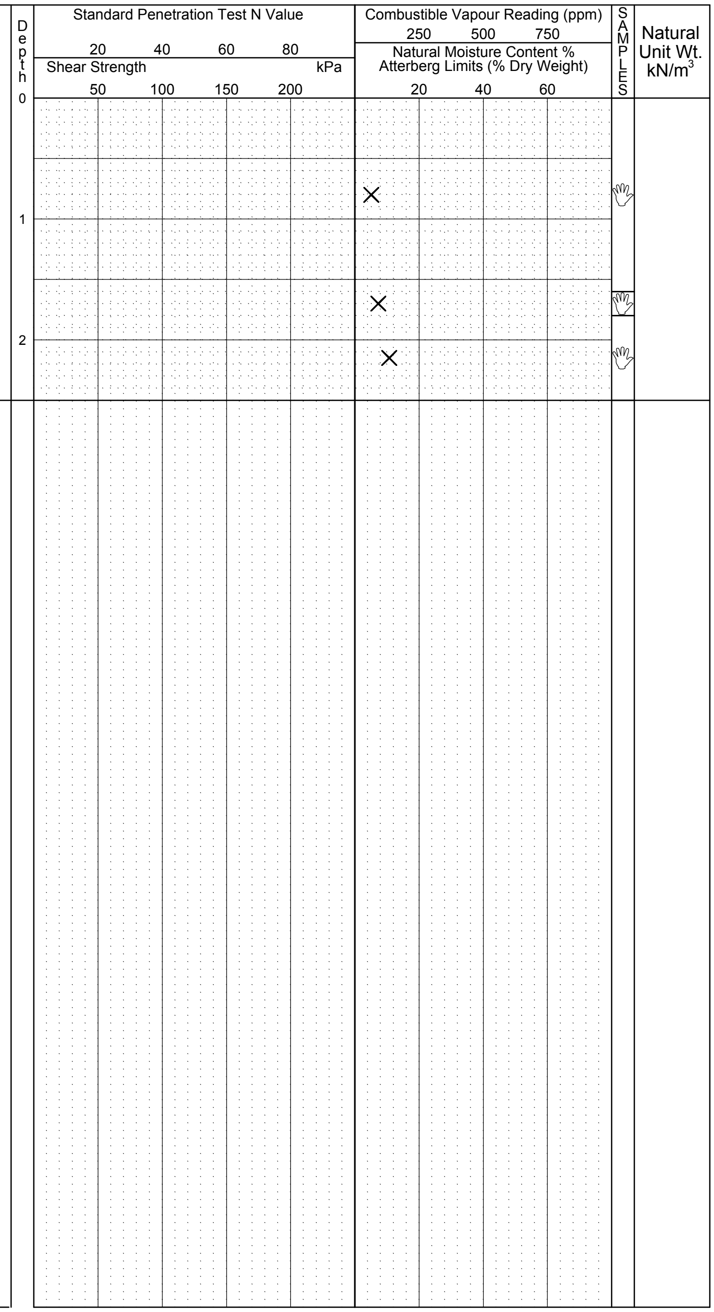
Drill Type: Komatsu 300

Datum: Geodetic

Logged by: RV    Checked by: JS

| | | | |
|---|---|---|---|
| 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 m | Depth |
|---|---|---|---|---|
| | | **FILL/TILL** Light grey silty sandy GRAVEL - frozen, $N_f$ to $N_{bn}$ | 5.6 | 0 |
| | | **FILL/TILL** Black GRAVEL, trace sand, trace silt - intermixed with organics/sewage - frozen, $N_f$ to $N_{bn}$ | 4.0 / 3.8 | |
| | | **TILL** Green to grey CLAY, some gravel, some sand - frozen, $N_f$ to $N_{bn}$ | 3.1 | |
| | | End of Test Pit at 2.5 m - unfrozen seam of sewage water at 1.7 m depth - test pit termiated due to sewage water inflow | | |






NOTES:
1. Borehole/Test Pit data requires Interpretation by exp. before use by others
2. Test pit was backfilled and lightly compacted 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-00215839-A0

WATER LEVEL RECORDS

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

CORE DRILLING RECORD

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

# Log of Borehole Pit TP7

Project No: OTT-00215839-A0

Project: Proposed Sewage Lagoon Upgrades

Location: Hall Beach, NU

Figure No. 12

Page. 1 of 1

Date Drilled: 'November 15, 2013

Drill Type: Komatsu 300

Datum: Geodetic

Logged by: RV    Checked by: JS

| | |
|---|---|
| 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 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 |
|---|---|---|---|---|---|---|---|---|
| | | | 5.7 | 0 | | | | |
| | | **FILL/TILL** Light grey silty sandy GRAVEL - frozen, $N_f$ to $N_{bn}$ | | | | × | | |
| | | | 4.4 | 1 | | | | |
| | | **FILL** Black sandy GRAVEL intermixed with organics/sewage - frozen - no visible ice | 4.2 | | | × | | |
| | | | | 2 | | × | | |
| | | **TILL** Green to grey CLAY, trace sand - frozen, $N_f$ to $N_{bn}$ | 3.2 | | | | | |
| | | End of Test Pit at 2.5 m - unfrozen seam of sewage water at 1.4 m depth - test pit termiated due to sewage water inflow | | | | | | |

NOTES:
1. Borehole/Test Pit data requires Interpretation by exp. before use by others
2. Test pit was backfilled and lightly compacted 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-00215839-A0

WATER LEVEL RECORDS

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

CORE DRILLING RECORD

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

# Log of Borehole Pit TP8

Project No: OTT-00215839-A0

Project: Proposed Sewage Lagoon Upgrades

Location: Hall Beach, NU

Figure No. 13

Page. 1 of 1

Date Drilled: 'November 15, 2013

Drill Type: Komatsu 300

Datum: Geodetic

Logged by: RV  Checked by: JS

| | | | |
|---|---|---|---|
| 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 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 |
|---|---|---|---|---|---|---|---|---|
| | | | 5.7 | 0 | | | | |
| | | **FILL/TILL**<br>Light grey silty sandy GRAVEL<br>- frozen, $N_f$ to $N_{bn}$ | | 1 | | × | grab | |
| | | **FILL/TILL**<br>Black GRAVEL, trace sand, trace silt<br>- intermixed with organics/sewage<br>- frozen, $N_f$ to $N_{bn}$ | 4.1 | | | × | grab | |
| | | **TILL**<br>Green to grey CLAY, some gravel, some sand<br>- frozen, $N_f$ to $N_{bn}$ | 3.7 | 2 | | × | grab | |
| | | End of Test Pit at 2.6 m<br>- unfrozen seam of sewage water at 1.7 m depth<br>- test pit termiated due to sewage water inflow | 3.1 | | | | | |

NOTES:
1. Borehole/Test Pit data requires Interpretation by exp. before use by others
2. Test pit was backfilled and lightly compacted 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-00215839-A0

WATER LEVEL RECORDS

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

CORE DRILLING RECORD

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

# Log of Borehole Pit TP9

Project No: OTT-00215839-A0

Project: Proposed Sewage Lagoon Upgrades

Location: Hall Beach, NU

Figure No. 14



Date Drilled: 'November 15, 2013

Drill Type: Komatsu 300

Datum: Geodetic

Logged by: RV    Checked by: JS

| | | | |
|---|---|---|---|
| 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 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 |
|---|---|---|---|---|---|---|---|---|
| | | **FILL/TILL**<br>Light grey silty sandy GRAVEL<br>- frozen, $N_f$ to $N_{bn}$ | 5.6 | 0 | | | | |
| | | | | 1 | | × (at ~1 m, approx. 5%) | grab sample | |
| | | End of Test Pit at 2.0 m<br>- due to practical refusal in frozen soil | 3.6 | 2 | | | | |

NOTES:
1. Borehole/Test Pit data requires Interpretation by exp. before use by others
2. Test pit was backfilled and lightly compacted 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-00215839-A0

WATER LEVEL RECORDS

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

CORE DRILLING RECORD

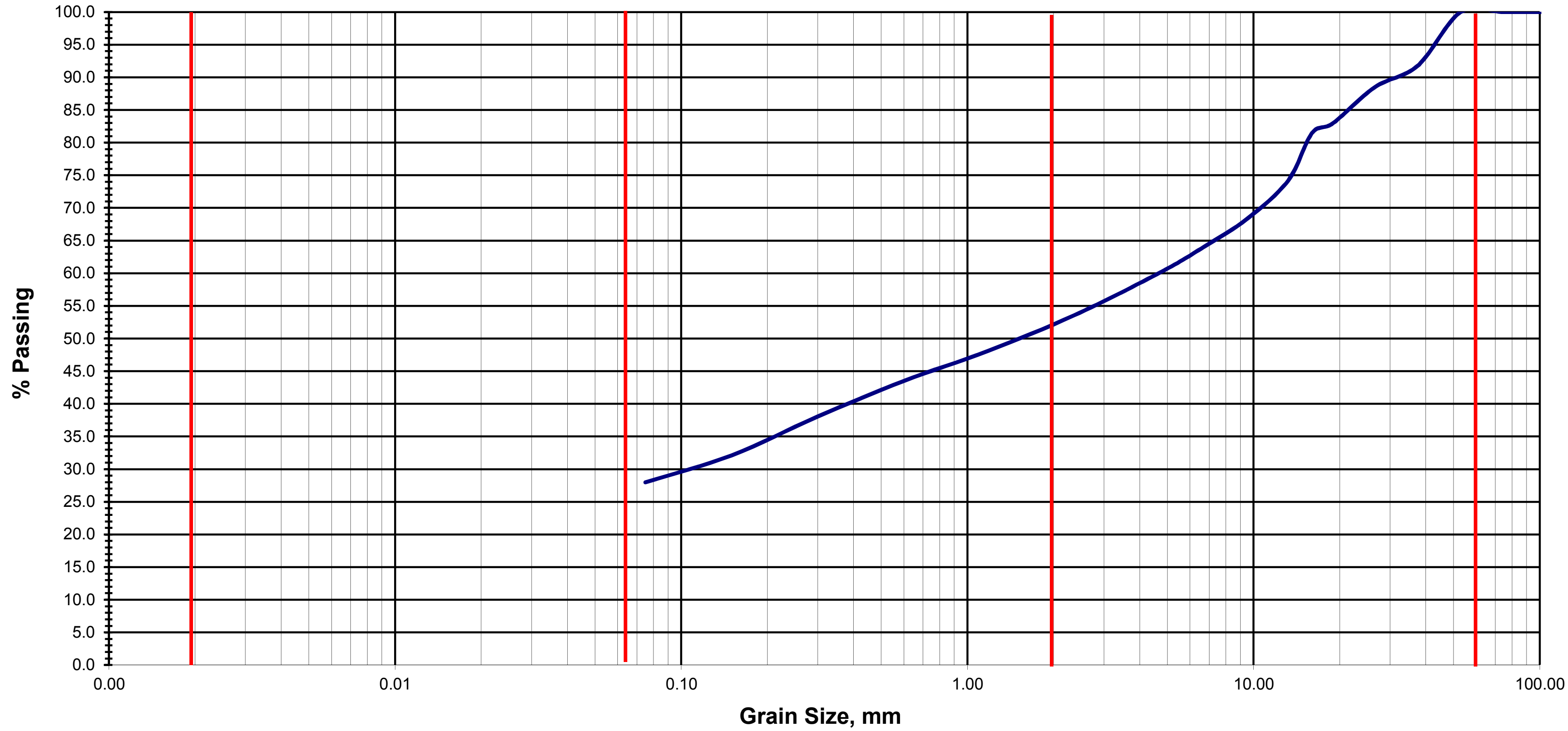
| Run No. | Depth (m) | % Rec. | RQD % |
|---|---|---|---|
| | | | |

exp Services Inc.
100-2650 Queensview Drive
Ottawa, ON K2B 8H6

# Method of Test for Sieve Analysis of Aggregate

ASTM C-136 (LS-602)

## Grain Size Distribution Curve




<table>
<tr><td rowspan="2">CLAY</td><td>Fine</td><td>Medium</td><td>Coarse</td><td>Fine</td><td>Medium</td><td>Coarse</td><td>Fine</td><td>Medium</td><td>Coarse</td><td rowspan="2"></td></tr>
<tr><td colspan="3">SILT</td><td colspan="3">SAND</td><td colspan="3">GRAVEL</td></tr>
<tr><td colspan="11">Modified M.I.T. Classification</td></tr>
</table>

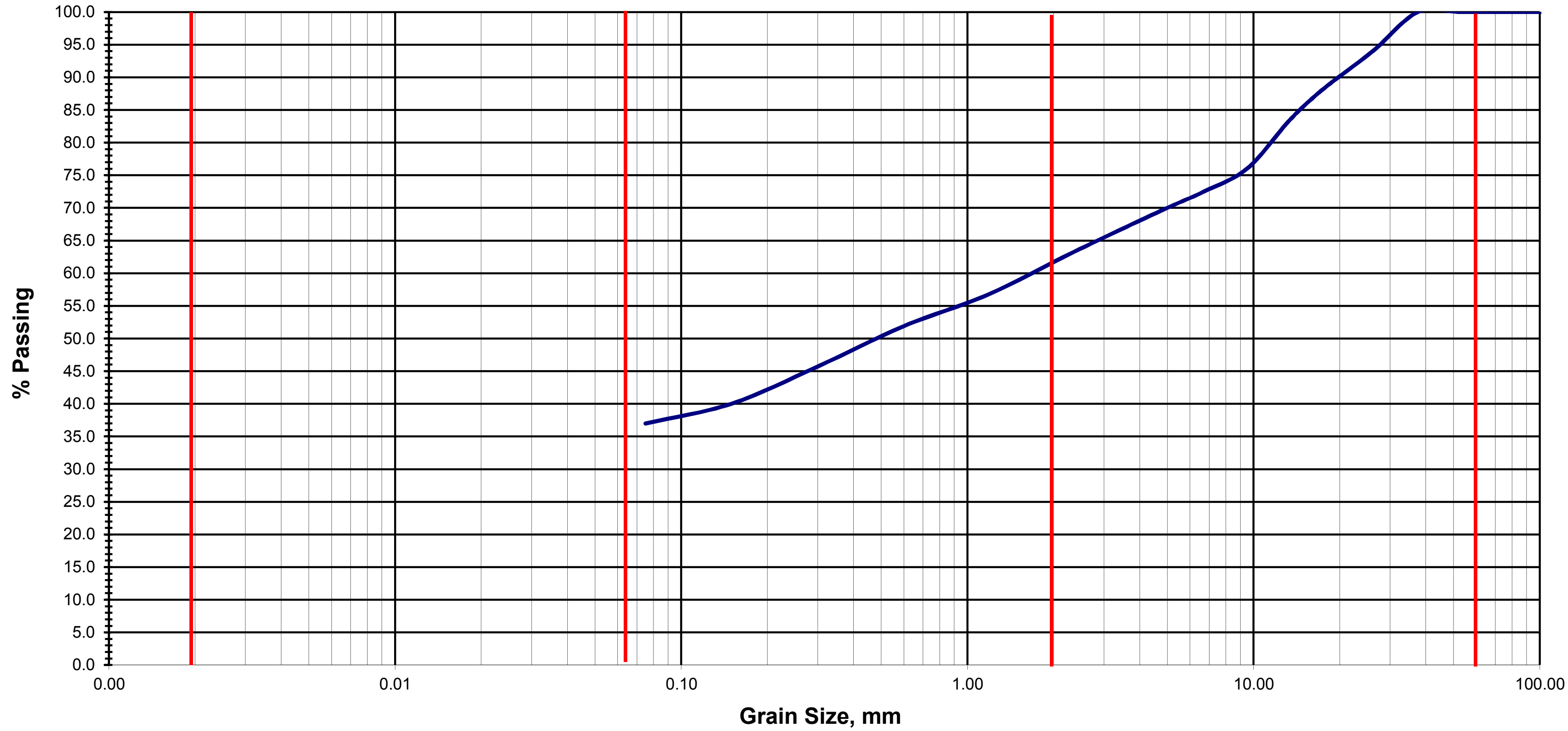
| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Exp Project No.: | OTT-00215839-A0 | Project Name : | Geotechnical Investigation, Proposed Sewage Lagoon Expansion | | | | |
| Client : | Government of Nunavut | Project Location : | Hall Beach, NU | | | | |
| Date Sampled : | November 14, 2013 | BOREHOLE | 1 | SAMPLE | run 3 | Depth (m) : | 0.3-0.6 |
| Sample Description : | silty sandy GRAVEL | | | | | Figure : | 15 |

**exp Services Inc.**
100-2650 Queensview Drive
Ottawa, ON K2B 8H6

# Method of Test for Sieve Analysis of Aggregate

ASTM C-136 (LS-602)

## Grain Size Distribution Curve



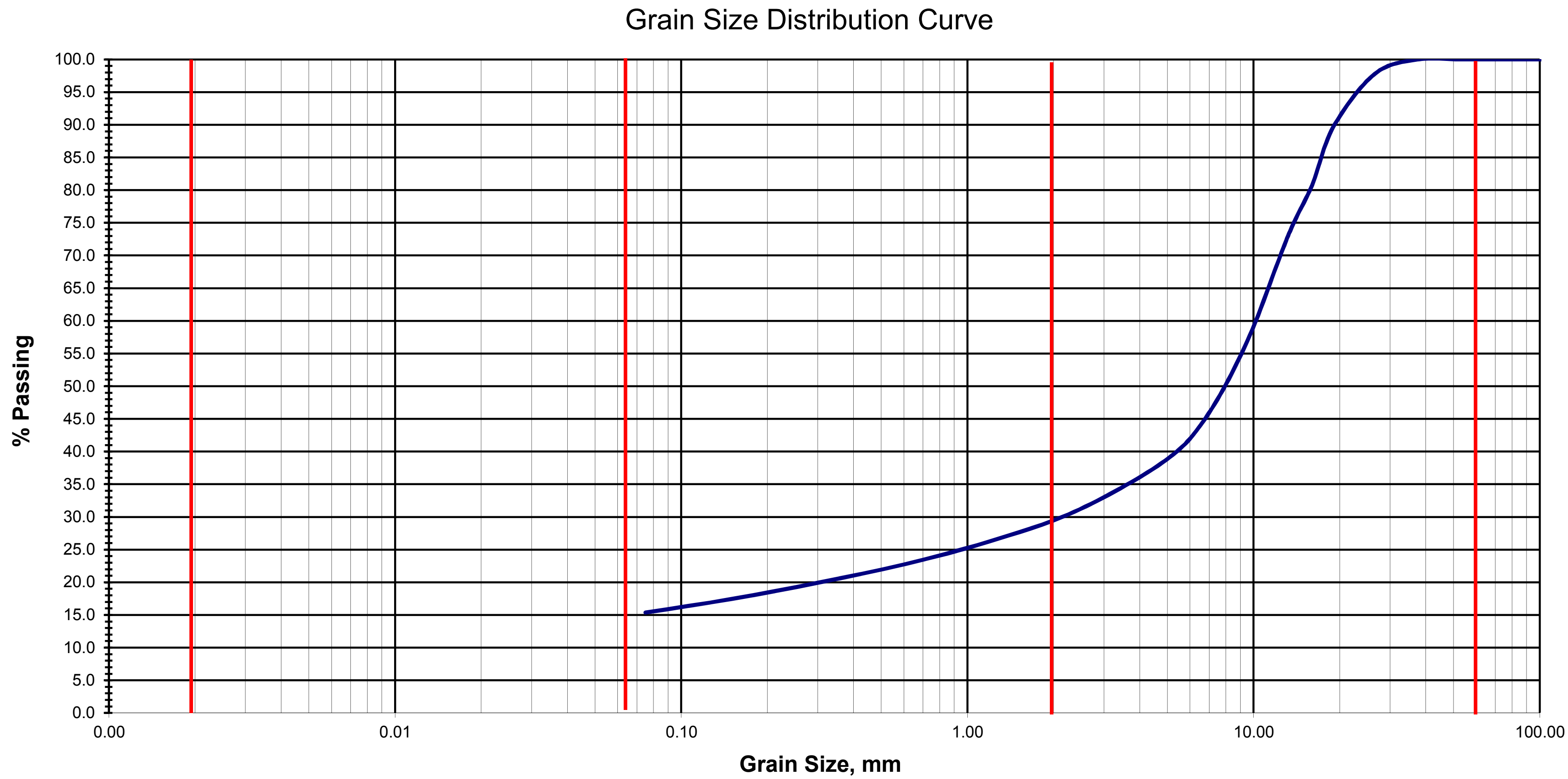

<table>
<tr><td rowspan="2">CLAY</td><td>Fine</td><td>Medium</td><td>Coarse</td><td>Fine</td><td>Medium</td><td>Coarse</td><td>Fine</td><td>Medium</td><td>Coarse</td><td rowspan="2"></td></tr>
<tr><td colspan="3">SILT</td><td colspan="3">SAND</td><td colspan="3">GRAVEL</td></tr>
<tr><td colspan="11">Modified M.I.T. Classification</td></tr>
</table>

<table>
<tr><td>Exp Project No.:</td><td>OTT-00215839-A0</td><td>Project Name :</td><td colspan="5">Geotechnical Investigation, Proposed Sewage Lagoon Expansion</td></tr>
<tr><td>Client :</td><td>Government of Nunavut</td><td>Project Location :</td><td colspan="5">Hall Beach, NU</td></tr>
<tr><td>Date Sampled :</td><td>November 15, 2013</td><td>BOREHOLE</td><td>1</td><td>SAMPLE</td><td>run 6</td><td>Depth (m) :</td><td>1.5-2.4</td></tr>
<tr><td>Sample Description :</td><td colspan="5">sandy GRAVEL and CLAY</td><td>Figure :</td><td>16</td></tr>
</table>

exp Services Inc.
100-2650 Queensview Drive
Ottawa, ON K2B 8H6

# Method of Test for Sieve Analysis of Aggregate

ASTM C-136 (LS-602)




| CLAY | Fine | Medium | Coarse | Fine | Medium | Coarse | Fine | Medium | Coarse | |
|---|---|---|---|---|---|---|---|---|---|---|
| | SILT | | | SAND | | | GRAVEL | | | |
| Modified M.I.T. Classification | | | | | | | | | | |

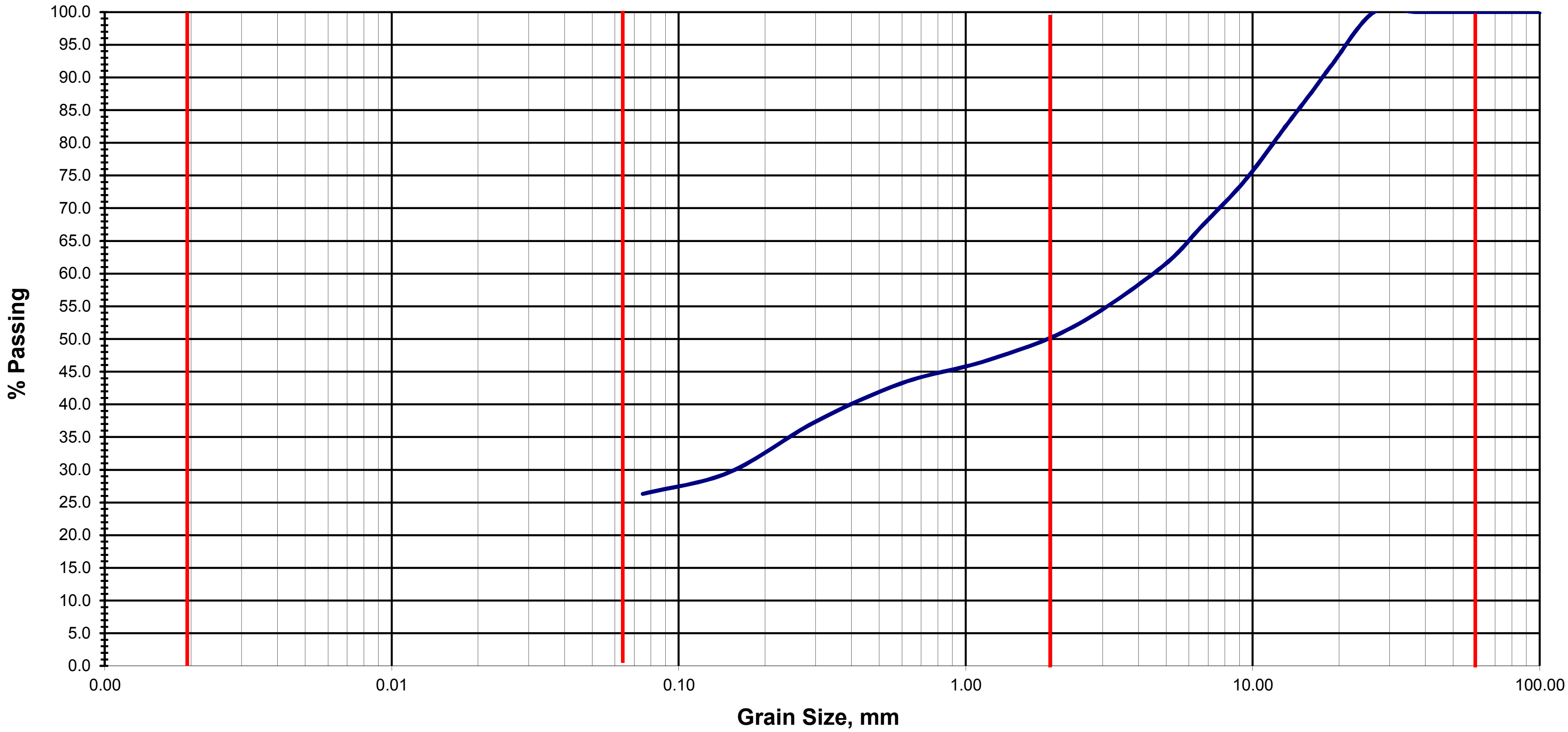
| | | | | | |
|---|---|---|---|---|---|
| Exp Project No.: | OTT-00215839-A0 | Project Name : | Geotechnical Investigation, Proposed Sewage Lagoon Expansion | | |
| Client : | Government of Nunavut | Project Location : | Hall Beach, NU | | |
| Date Sampled : | November 19, 2013 | BOREHOLE 2 | SAMPLE run 3 | Depth (m) : | 0.7-1.2 |
| Sample Description : | GRAVEL, some silt, some sand | | | Figure : | 17 |

**exp Services Inc.**
100-2650 Queensview Drive
Ottawa, ON K2B 8H6

# Method of Test for Sieve Analysis of Aggregate

ASTM C-136 (LS-602)

## Grain Size Distribution Curve




| CLAY | Fine | Medium | Coarse | Fine | Medium | Coarse | Fine | Medium | Coarse |
|---|---|---|---|---|---|---|---|---|---|
| | SILT | | | SAND | | | GRAVEL | | |
| Modified M.I.T. Classification | | | | | | | | | |

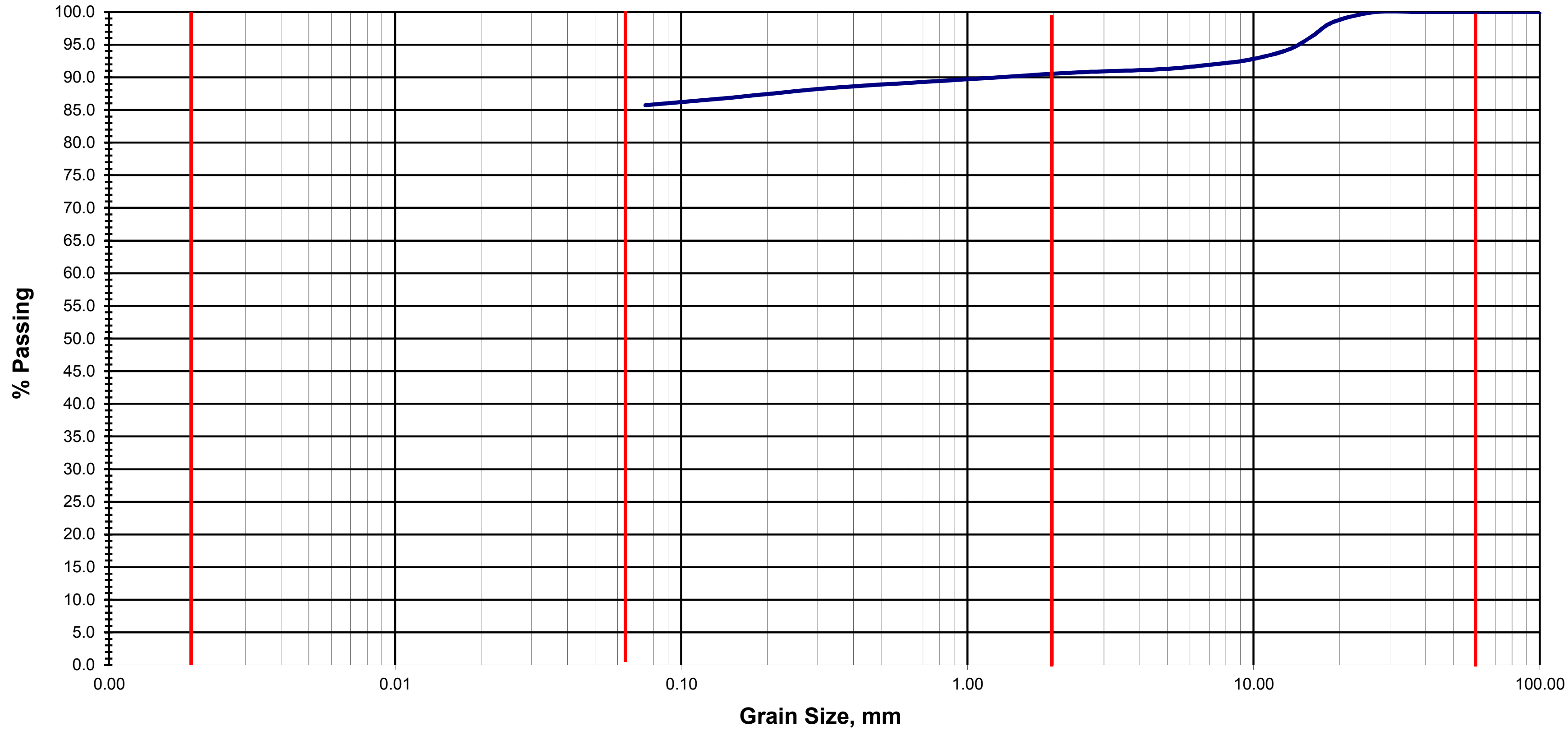
| | | | | | |
|---|---|---|---|---|---|
| Exp Project No.: | OTT-00215839-A0 | Project Name : | Geotechnical Investigation, Proposed Sewage Lagoon Expansion | | |
| Client : | Government of Nunavut | Project Location : | Hall Beach, NU | | |
| Date Sampled : | November 19, 2013 | BOREHOLE 2 | SAMPLE run 5 | Depth (m) : | 2.0-2.4 |
| Sample Description : | silty sandy GRAVEL | | | Figure : | 18 |

**exp Services Inc.**
100-2650 Queensview Drive
Ottawa, ON K2B 8H6

# Method of Test for Sieve Analysis of Aggregate

ASTM C-136 (LS-602)

## Grain Size Distribution Curve




| CLAY | Fine | Medium | Coarse | Fine | Medium | Coarse | Fine | Medium | Coarse |
|---|---|---|---|---|---|---|---|---|---|
| | SILT | | | SAND | | | GRAVEL | | |
| **Modified M.I.T. Classification** | | | | | | | | | |

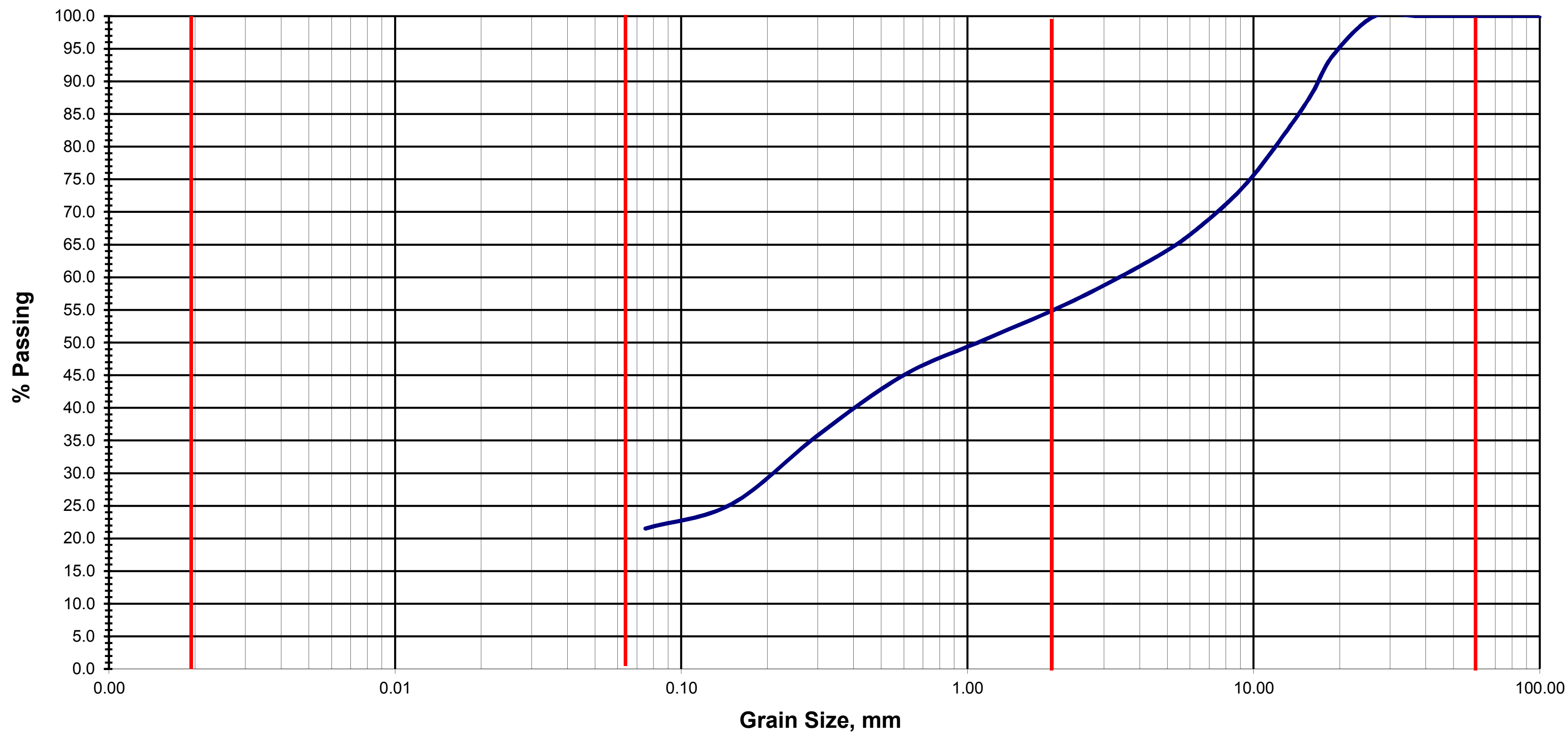
| | | | | | |
|---|---|---|---|---|---|
| **Exp Project No.:** | **OTT-00215839-A0** | **Project Name :** | **Geotechnical Investigation, Proposed Sewage Lagoon Expansion** | | |
| **Client :** | **Government of Nunavut** | **Project Location :** | **Hall Beach, NU** | | |
| **Date Sampled :** | **November 19, 2013** | **BOREHOLE** 2 | **SAMPLE** run 6 | **Depth (m) :** | **2.4-3.7** |
| **Sample Description :** | **CLAY, some gravel, some sand** | | | **Figure :** | **19** |

**exp Services Inc.**
100-2650 Queensview Drive
Ottawa, ON K2B 8H6

# Method of Test for Sieve Analysis of Aggregate

ASTM C-136 (LS-602)

## Grain Size Distribution Curve



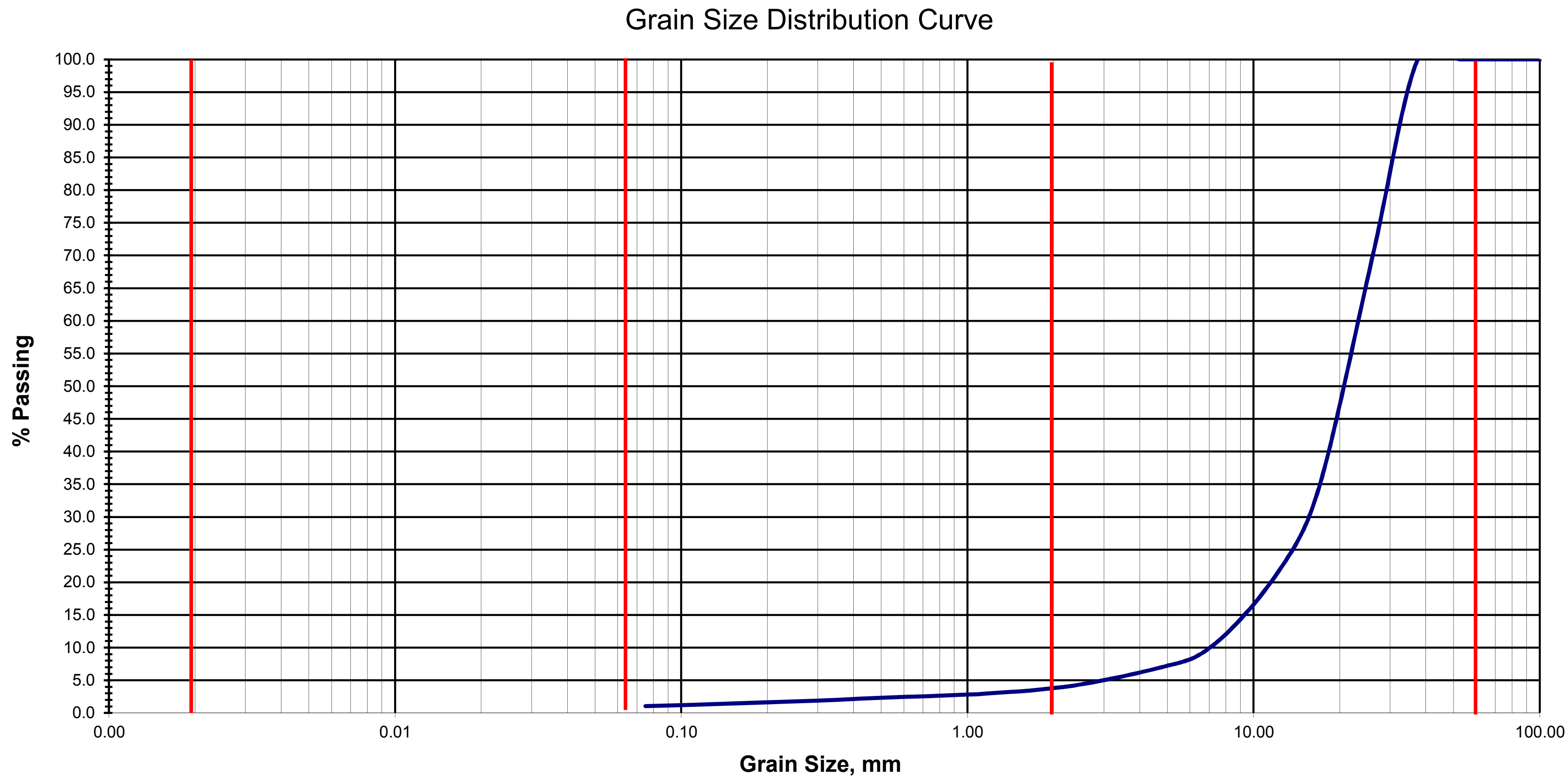

| CLAY | Fine | Medium | Coarse | Fine | Medium | Coarse | Fine | Medium | Coarse | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **SILT** | | | **SAND** | | | **GRAVEL** | | | |
| **Modified M.I.T. Classification** | | | | | | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| **Exp Project No.:** | **OTT-00215839-A0** | **Project Name :** | **Geotechnical Investigation, Proposed Sewage Lagoon Expansion** | | |
| **Client :** | **Government of Nunavut** | **Project Location :** | **Hall Beach, NU** | | |
| **Date Sampled :** | **November 20, 2013** | **BOREHOLE** 3 | **SAMPLE** run 3 | **Depth (m) :** | **0.6-1.2** |
| **Sample Description :** | **silty GRAVEL and SAND** | | | **Figure :** | **20** |

**exp Services Inc.**
100-2650 Queensview Drive
Ottawa, ON K2B 8H6

# Method of Test for Sieve Analysis of Aggregate

ASTM C-136 (LS-602)




| CLAY | Fine | Medium | Coarse | Fine | Medium | Coarse | Fine | Medium | Coarse | |
|---|---|---|---|---|---|---|---|---|---|---|
| | SILT | | | SAND | | | GRAVEL | | | |
| **Modified M.I.T. Classification** | | | | | | | | | | |

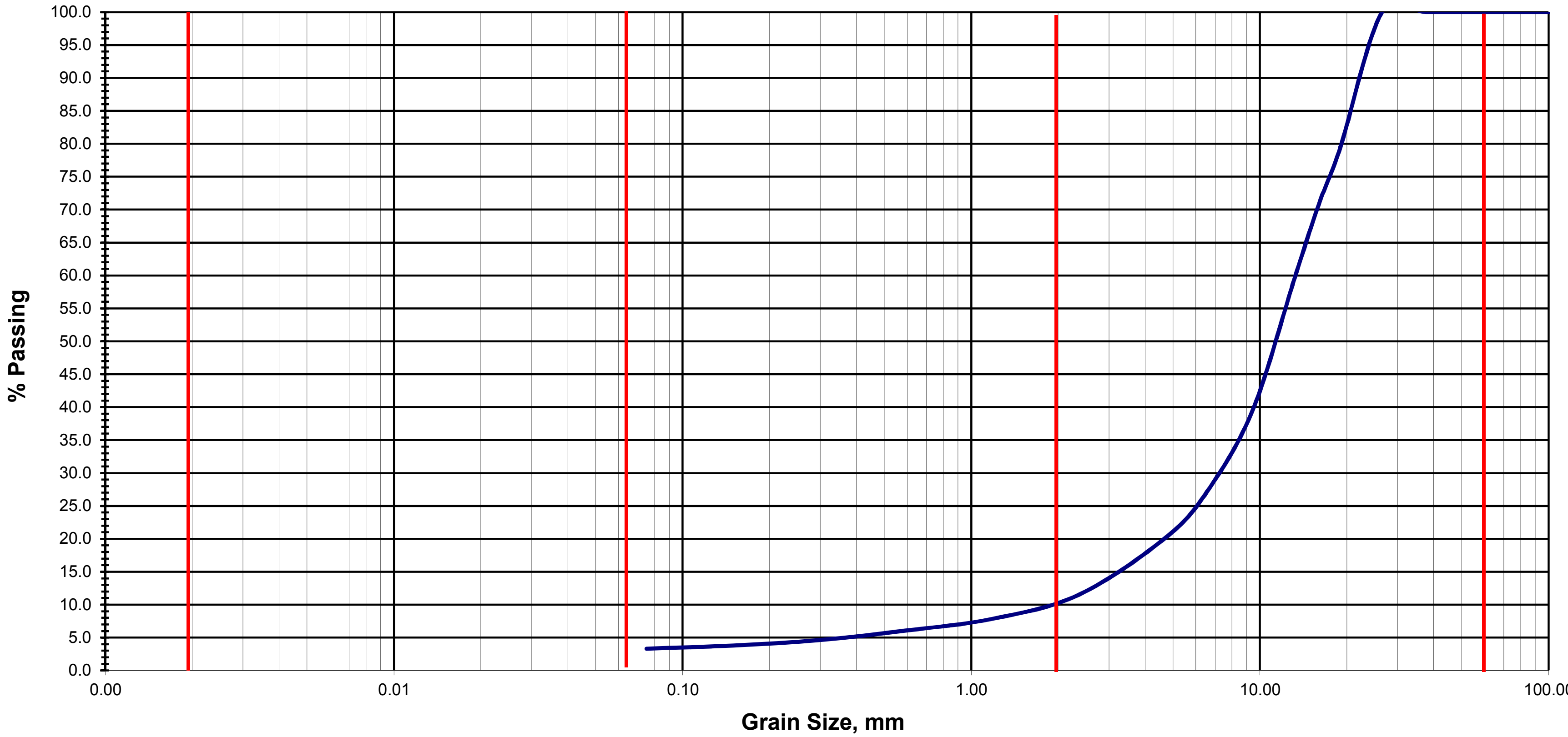
| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Exp Project No.:** | **OTT-00215839-A0** | **Project Name :** | **Geotechnical Investigation, Proposed Sewage Lagoon Expansion** | | | | |
| **Client :** | **Government of Nunavut** | **Project Location :** | **Hall Beach, NU** | | | | |
| **Date Sampled :** | **November 14, 2013** | **BOREHOLE** | **TP1** | **SAMPLE** | **G2** | **Depth (m) :** | **1.2 - 1.5** |
| **Sample Description :** | **GRAVEL, trace sand, trace silt** | | | | | **Figure :** | **21** |

**exp Services Inc.**
100-2650 Queensview Drive
Ottawa, ON K2B 8H6

# Method of Test for Sieve Analysis of Aggregate

ASTM C-136 (LS-602)

## Grain Size Distribution Curve




| CLAY | Fine | Medium | Coarse | Fine | Medium | Coarse | Fine | Medium | Coarse | |
|---|---|---|---|---|---|---|---|---|---|---|
| | SILT | | | SAND | | | GRAVEL | | | |
| Modified M.I.T. Classification | | | | | | | | | | |

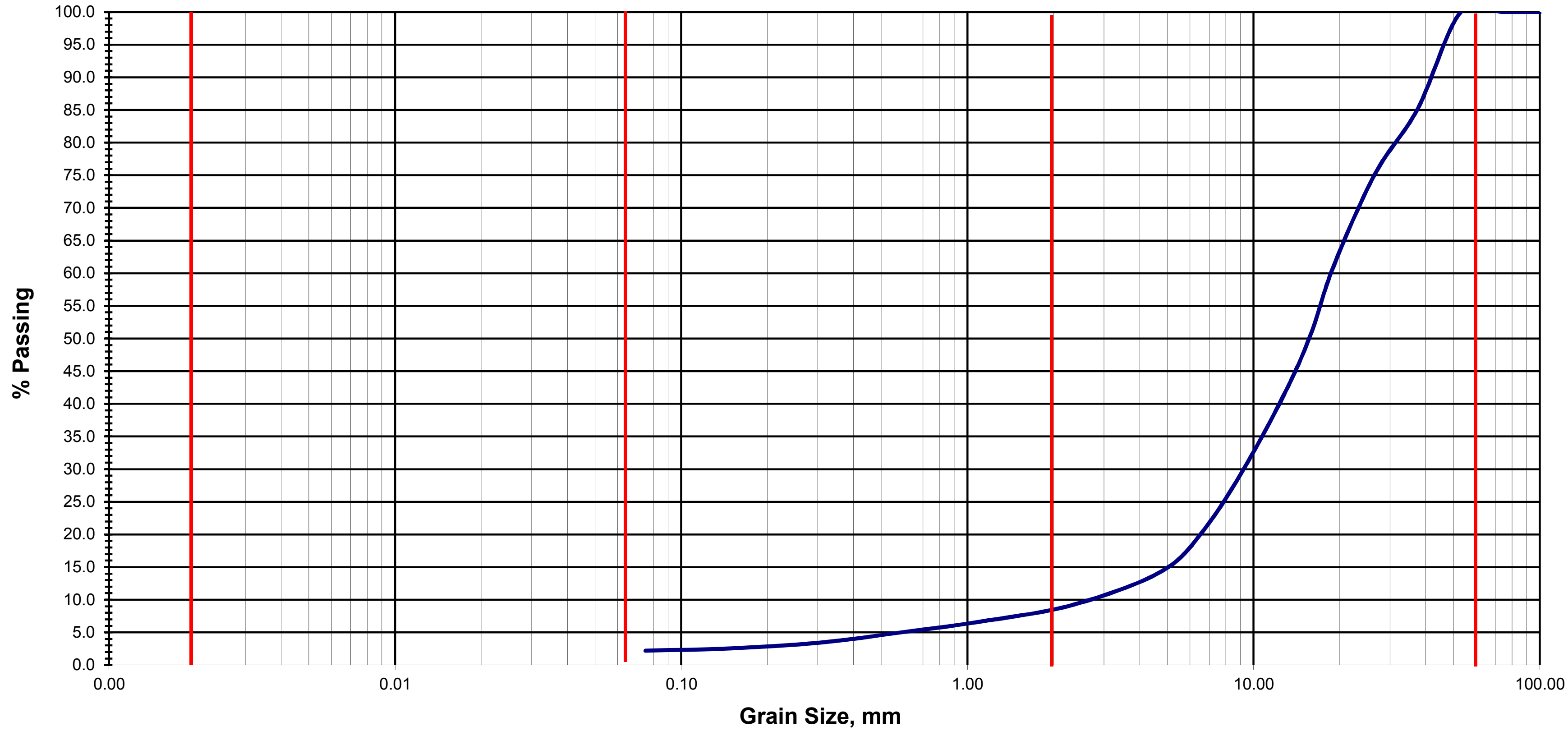
| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Exp Project No.:** | **OTT-00215839-A0** | **Project Name :** | **Geotechnical Investigation, Proposed Sewage Lagoon Expansion** | | | | |
| **Client :** | **Government of Nunavut** | **Project Location :** | **Hall Beach, NU** | | | | |
| **Date Sampled :** | **November 15, 2013** | **BOREHOLE** | **TP5** | **SAMPLE** | **G1** | **Depth (m) :** | **0.6-1.2** |
| **Sample Description :** | **GRAVEL, trace sand, trace silt** | | | | | **Figure :** | **22** |

exp Services Inc.
100-2650 Queensview Drive
Ottawa, ON K2B 8H6

# Method of Test for Sieve Analysis of Aggregate

ASTM C-136 (LS-602)

## Grain Size Distribution Curve




| CLAY | Fine | Medium | Coarse | Fine | Medium | Coarse | Fine | Medium | Coarse | |
|---|---|---|---|---|---|---|---|---|---|---|
| | SILT | | | SAND | | | GRAVEL | | | |
| Modified M.I.T. Classification | | | | | | | | | | |

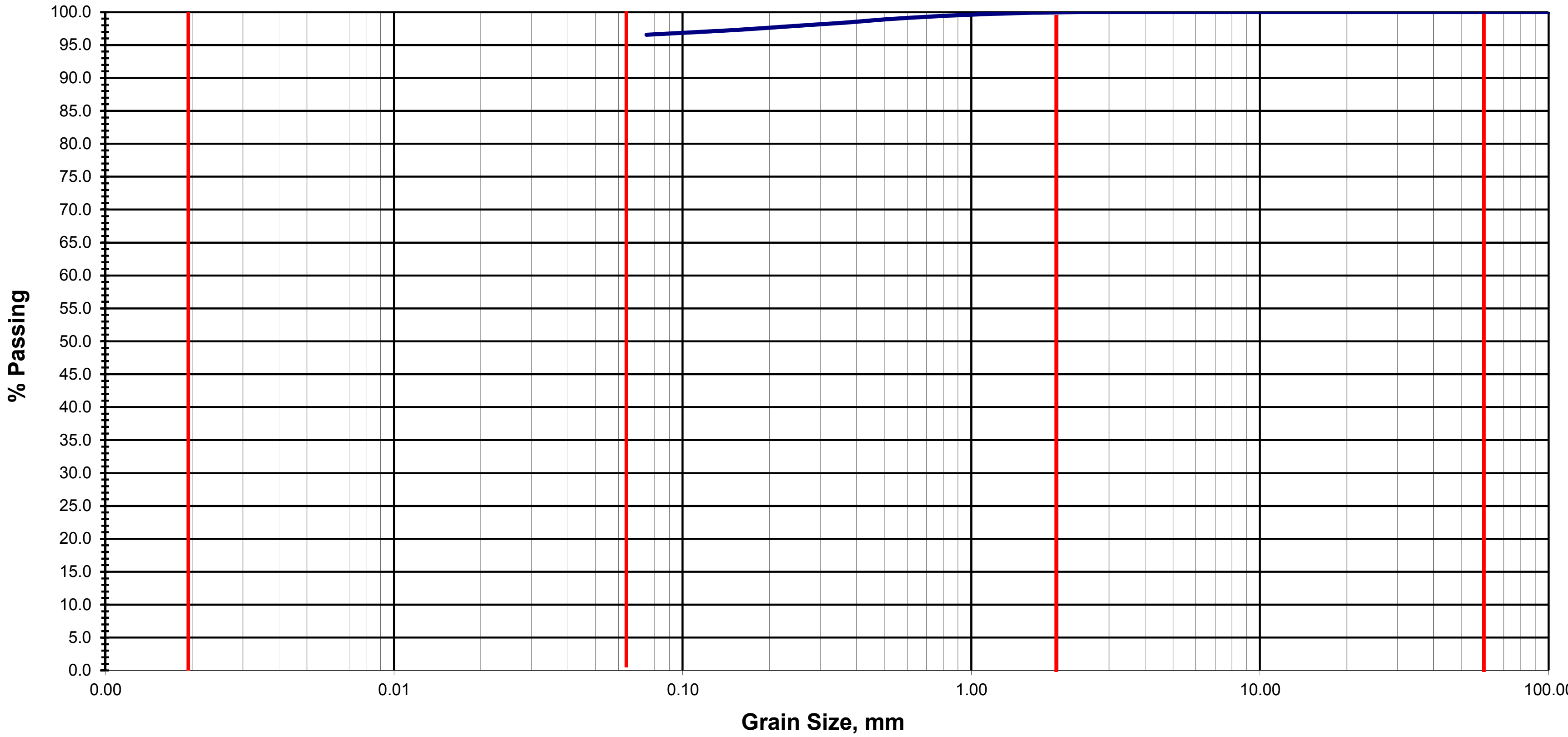
| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Exp Project No.:** | **OTT-00215839-A0** | **Project Name :** | **Geotechnical Investigation, Proposed Sewage Lagoon Expansion** | | | | |
| **Client :** | **Government of Nunavut** | **Project Location :** | **Hall Beach, NU** | | | | |
| **Date Sampled :** | **November 15, 2013** | **BOREHOLE** | **TP5** | **SAMPLE** | **G2** | **Depth (m) :** | **1.2-1.5** |
| **Sample Description :** | **GRAVEL, trace sand, trace silt** | | | | | **Figure :** | **23** |

exp Services Inc.
100-2650 Queensview Drive
Ottawa, ON K2B 8H6

# Method of Test for Sieve Analysis of Aggregate

ASTM C-136 (LS-602)

## Grain Size Distribution Curve




| CLAY | Fine | Medium | Coarse | Fine | Medium | Coarse | Fine | Medium | Coarse |
|---|---|---|---|---|---|---|---|---|---|
| | | SILT | | | SAND | | | GRAVEL | |
| Modified M.I.T. Classification | | | | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Exp Project No.:** | **OTT-00215839-A0** | **Project Name :** | **Geotechnical Investigation, Proposed Sewage Lagoon Expansion** | | | | |
| **Client :** | **Government of Nunavut** | **Project Location :** | **Hall Beach, NU** | | | | |
| **Date Sampled :** | **November 15, 2013** | **BOREHOLE** | **TP7** | **SAMPLE** | **G3** | **Depth (m) :** | **1.8-2.1** |
| **Sample Description :** | **CLAY, trace sand** | | | | | **Figure :** | **24** |

# List of Distribution

**Report Distributed To:**

Government of Nunavut – Erin Mentink, Senior Municipal Planning Officer – ementink@gov.nu.ca

Government of Nunavut – Bill Westwell, Senior Manager, Municipal Planning – bwestwell@gov.nu.ca

**Exp** Services Inc. – Steven Burden – steven.burden@exp.com