

Geotechnical Investigation Sewage Lagoon Hamlet of Kimmirut, Nunavut

Prepared for:

Bhabesh Roy CGS Projects - GN P.O. Box 379 Pond Inlet, Nunavut X0A 0S0

Trow Associates Inc.

154 Colonnade Road South Ottawa, Ontario K2E 7J5 Telephone: (613) 225-9940 Facsimile: (613) 225-7337

E-mail: ottawa@trow.com Web Site: www.trow.com

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Executive Summary

A geotechnical investigation was undertaken at the site of the existing sewage lagoon and landfill in the Hamlet of Kimmirut, Nunavut. This work was requested by the Government of Nunavut on July 9, 2007.

Kimmirut's sewage disposal system comprises of a sewage lagoon and wetland located down gradient from the lagoon discharge. The sewage lagoon consists of a natural pond type depression with control berm located on the south side. A diversion berm has been constructed south of the sewage lagoon. These facilities were built in 1999/2000 but never used. The landfill site is located up gradient of the sewage lagoon. It is proposed to upgrade these facilities prior to their use. The purpose of the investigation was to assess the stability of the lagoon berm slopes. In addition, an appreciation of the geotechnical conditions present in the lagoon, at the landfill site and at the location of the diversion berm was also required.

The investigation consisted of drilling eleven boreholes at the sewage lagoon site (Borehole 1 to 5, 5A, 5B, 6, 6A, 7 and 8), three boreholes at the landfill site (Boreholes 9, 10 and 11) and two boreholes on the diversion berm located on the east side of the stream.

The investigation revealed that the sewage lagoon berm consists of sand and gravel fill which extends to 2.2 m to 2.8 m depth. The predominant natural soil at the site is silty sand and gravel with some cobbles. It extends to a depth of 0.3 m to 2.7 m. The silty sand and gravel in the lagoon area is underlain by highly fractured gneiss bedrock. The exception to this is Borehole 5A where massive granite bedrock was encountered.

The overburden in the bottom of the lagoon also comprises of silty sand and gravel and extends to 1.6 m to 2.7 m depth. It is underlain by a layer of topsoil or clayer silty sand to 1.85 m to 2.9 m depth beneath which fractured gneiss bedrock was encountered.

In the landfill site, the predominant surficial soil is also silty sand and gravel which extends to 1.2 m to 1.8 m depth. It is underlain by micaceous marble bedrock with pyroxene.

The two boreholes drilled at the diversion berm revealed that the overburden comprises of 1.1 m to 1.2 m of sand and gravel fill. It is underlain by micaceous marble bedrock.

The stability of the lagoon berm was investigated. The berm has a crest width of 2 m to 2.5 m approximately and upstream (inside) and downstream (outside) slopes of 3H:1V and 2.5:1V approximately. The stability of slope analysis revealed that the upstream slope has an acceptable factor of safety under completely submerged conditions under static as well as seismic loading. The slope is expected to be stable provided that the berm is not over topped and it is not subjected to a rapid drawdown condition. The downstream slope with its present inclination of 2.5H:1V does not have adequate factor of safety against potential slope failure. It is therefore recommended that this slope should also be flattened to an inclination of 3H:1V.



The crest width of the berm may be increased by placement of fill on the face of the outside slope, since that slope is to be flattened to 3H:IV. Prior to placement of the additional fill, all the topsoil should be removed from the area. The berm slope should be benched with 300 mm high steps. Sand and gravel fill should then be placed in 300 mm lift abutting the vertical cuts and compacted to at least 95 percent of standard Proctor maximum dry density. The placement and compaction of the fill can in this way be undertaken to the crest of the berm and the final slope graded to 3H:1V.

It is noted that potential for extensive erosion and/or failure of the berm exists if subjected to rapid drawdown condition or allowed to over top. If the berm is to be subjected to rapid drawdown conditions, the inside slope should be flattened to 4H:1V. It is recommended that a spillway should be incorporated in the berm to prevent its over topping.

Limited investigation undertaken in the landfill site has revealed that the bedrock in this area is massive micaceous marble. However, the type of bedrock at the site is variable and at majority of the locations cored, the bedrock was fractured. It is therefore recommended that an additional investigation should be undertaken at the landfill site to obtain a better understanding of the bedrock quality if the bedrock is to be used as an impervious liner. The diversion berm is built with sand and gravel fill. The height of the berm ranges from 1.1 to 1.2 m. It is underlain by micaceous marble bedrock.

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



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1.0 Introduction

A geotechnical investigation was undertaken at the site of an existing sewage lagoon and landfill site located in the Hamlet of Kimmirut, Nunavut. This work was authorized by Government of Nunavut on July 9, 2007.

Kimmirut's sewage disposal system comprises of a sewage lagoon and wetland consisting of a narrow tundra valley that runs down gradient from the lagoon discharge. A small diversion berm has been constructed south of the sewage lagoon to help pool water, decrease drainage and minimize the transport of materials downstream. The sewage lagoon comprises of a natural pond type depression with a control berm located on the south side. The design requirements of the berm called for a crest width of 3 m and upstream and downstream slope of 3H:IV. These facilities were built in 1999/2000 but never used. It is proposed to investigate these facilities to ensure that they comply with current legislation prior to their use.

Trow terms of reference for the geotechnical investigation were as follows:

- (1) Establish geotechnical profile of lagoon berm and in the lagoon and landfill areas
- (2) Assess stability of the slopes of existing berm of the lagoon and suggest remedial measures to stabilize the berm;
- (3) Establish the geotechnical profile at the location of the landfill site; and
- (4) Determine geotechnical conditions at the location of the berm constructed to divert flow into the stream.

The comments and recommendations given in this report are based on the assumption that the above-described design concept will proceed into construction. If changes are made either in the design phase or during construction, this office must be retained to review these modifications. The result of this review may be a modification of our recommendations or it may require additional field or laboratory work to check whether the changes are acceptable from a geotechnical viewpoint.



2.0 Procedure

2.1. Drilling and Soil Sampling

The fieldwork for the geotechnical investigation was undertaken between July 21 and 26, 2007 with Hilti drill rig, winch and hammer. The fieldwork was supervised by a representative of Trow Associates Inc. (Trow) on a full time basis.

The fieldwork consisted of drilling 14 boreholes to depths varying between 0.3 m and 5.1 m (Boreholes 1 to 5, 5A, 5B, 6A, 6B and 7 to 11 inclusive). The locations of the boreholes are shown on Site Plan, Figures 1 to 3 inclusive.

The boreholes were initially advanced by performing continuous standard penetration tests and retrieving the soil samples. However, the boreholes could only be advanced by this method in unfrozen soil to a depth of 0.3 m to 2.5 m below which frost was encountered. The boreholes were then cased and advanced by core drilling techniques with the Hilti drill rig. Water was used as flushing medium. During core drilling a careful record of colour of wash water, wash water return and any sudden drops of the drill rods was kept.

Thermisters were installed in Boreholes 1 and 12 to monitor the ground temperatures.

Water level observations were made in the boreholes during the course of the fieldwork. Standpipes were installed in selected boreholes to establish the groundwater table at the site, all the soil samples were visually examined in the field for textural classification, preserved in plastic bags and identified. The boreholes were logged. Similarly, the rock core was placed in the core boxes, identified and logged. On completion of drilling, all the soil samples were transported to the Trow laboratory in the City of Ottawa (previously City of Nepean).

The locations and elevations of the boreholes were established by representative of Trow Associates Inc. The elevations of the borehole refer to the Geodetic datum.

All the soil samples and rock core were visually examined in the laboratory by a geotechnical engineer and borehole logs prepared. The engineer also assigned the laboratory testing. The laboratory testing consisted of performing natural moisture content on all the samples and grain size analysis, on selected soil samples. In addition, unconfined compressive strength tests were performed on selected rock core samples.



3.0 Site and Soil Description

The sewage lagoon is located approximately 3 kms west of the community of Kimmirut. It drains southwoods through Tulisit Lake towards Pleasant Inlet. The drainage flows towards the southwest away from Lake Fundo, the community's water supply shed. The sewage lagoon has been constructed in a natural valley by constructing a berm on the south side.

A detailed description of the subsurface and groundwater conditions encountered in the fourteen boreholes drilled at the site have been given in Borehole Logs, Figures 4 to 19 inclusive. The boreholes logs and related information depict subsurface conditions only at the specific locations and time 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.

3.1. Geotechnical Conditions at Sewage Lagoon Berm Location

Boreholes 1 to 5, 5A, 5B, 6 and 6A were drilled on top of the sewage lagoon berm and close to the toe of the berm. Surficial topsoil was encountered in Boreholes 3, 4, 5A, 5B, 6 and 6A and varied in thickness from 50 mm to 100 mm. The topsoil in these boreholes is underlain by silty sand stratum with trace of some gravel and occasional cobbles. It extends to a depth of 0.3 m to 1.1 m (Elevation 90.3 m to 93.5 m). The results of grain size analyses performed on two soil samples obtained from close to the north toe of the berm are given on Figures 21 and 22. These figures indicate that the surficial natural soil at the site consists of 6 to 12 percent clay and silt, 66 to 79 percent sand and 15 to 22 percent gravel.

The surficial soil in Borehole 1 and 2 drilled on top of the berm encountered fill which extended to a depth of 2.2 m to 2.8 m (Elevation 94.4 m to 95.0 m). These observations indicate that the height of the berm varies from 2.2 m to 2.8 m. The fill consist of silty sand and gravel with cobbles and boulders. A grain size analysis performed on the fill sample obtained from Borehole 2 is given on Figure 20. This figure indicates the fill composition of 6 percent silt, 33 percent sand and 61 percent gravel. It is noted that the fill also contains cobbles and boulders which could not be sampled with the split spoon barrel.

The fill in Borehole 1 is underlain by a layer of topsoil to 2.9 m depth (Elevation 94.3 m).

Refusal to drilling was met in all the boreholes at a depth of 0.3 m to 2.9 m (Elevation 90.3 m to Elevation 94.3 m). Boreholes 1 to 3 and 5B were advanced further by core drilling techniques to 3.5 m to 5.1 m depth. They revealed that refusal in the case of Borehole 1 to 3 inclusive was met on biotite gneiss bedrock. The bedrock contains granitic intrusions and is heavily fractured. A Total Core Recovery (TCR) and Rock Quality Designation (RQD) of 59 to 100 percent and 0 to 78 percent respectively was obtained when core drilling the bedrock. On this basis, the bedrock



quality may be defined as very poor to good quality. The unconfined compressive strength of the gneiss varies from 19.2 MPa to 97.5 MPa (Table I).

In Borehole 5B, the overburden is underlain by massive granite bedrock. The granite is biotite rich. The bedrock is of poor to fair quality. Its unconfined compressive strength is 104 MPa. (Table I).

Table I
Unconfined Compressive Strength Tests on Rock Cores

Borehole #	[2] [4] [4] [4] [4] [4] [4] [4] [4] [4] [4		Unit Weight kg/m3	Unconfined Compressive Strength (MPa)
1	3.87	Gneiss, Fractured	2726	97.5
2	2.90	Gneiss, Heavily Fractured	2566	19.2
3	1.52	Gneiss, Fractured	2824	45.3
5	3.20	Granite, Massive	2644	104.0
7	3.63	Gneiss, Fractured	2635	58.9
7	4.70	Gneiss, Fractured	2719	76.0
8	8 2.62 Gneiss, Fractured		2674	124.5
10	2.10	Marble, Massive	2696	51.5
12	1.37	Marble, Slightly Fractured	2752	66.3

Thermisters were installed in Boreholes 1 and 12 to measure ground temperatures. The results are given on Table II.

Table II
Ground Temperature Measurements

		Observed Temperature Readings									
Borehole #	Depth (m)		July 15, 2007	July 16, 2007	July 17, 2007						
		7:30 a.m.	8:30 a.m.	4:30 p.m.	8:30 a.m.	11:45 a.m.					
1	3.6	0°C		0°C	0°C	0°C					
	2.7	0°C	Manufacture (Control of Control o	0°C	0°C	0°C					
	1.8	3°C		3°C	4°C	4°C					
	0.9	7°C		8°C	7°C	8°C					
12	2.7		6°C	4°C	4°C	4°C					
ATL VERNAL VERSETT LALVER AND	1.8		7°C	5°C	5°C	5°C					
	0.9		8°C	8°C	8°C	8°C					
	0		13°C	14°C	23°C	23°C					



A review of Table II indicates that the active layer in the vicinity of Borehole 1 is in the order of 2.7 m. However, close to Borehole 12, it is somewhat greater than 2.7 m.

3.2. Geotechnical Conditions in Lagoon (Boreholes 7 and 8)

Boreholes 7 and 8 were drilled in the bottom of the lagoon between the water's edge in the lagoon and the toe of the berm. These boreholes (Figures 13 and 14) revealed that beneath 100 mm to 115 mm of topsoil, silty sand extends to a depth of 1.6 m to 2.7 m (Elevation 91.4 m to 92.5 m). A grain size analysis performed on a sample of this stratum from Borehole 8 revealed a soil composition of 10 percent clay and silt, 72 percent sand and 18 percent gravel (Figure 23).

The silty sand in Borehole 7 is underlain by a layer of topsoil to 2.9 m depth (Elevation 91.2 m). In Borehole 8, the silty sand is underlain by clayey silty sand which extends to 1.8 m depth (Elevation 92.3 m).

The topsoil or the clayey silty sand are underlain by biotite rich gneiss bedrock which extends to the entire depth investigated in both the boreholes i.e. 3.9 m and 5.1 m depth (Elevation 89 to 90.2 m). The bedrock contains fine to coarse grained granitic intrusions. It is fractured.

A Total Core Recovery and Rock Quality Designation of 70 to 100 percent and 0 to 75 percent respectively was obtained when core drilling the bedrock. On this basis, the bedrock quality may be described as very poor to fair. Unconfined compressive strength tests performed on selected rock core samples yielded a strength of 58.9 MPa to 124.5 MPa.

3.3. Geotechnical Conditions at Proposed Landfill Site (Boreholes 9 to 11)

Borehole 9, 10 and 11 were drilled at the site of the proposed landfill in order to obtain an appreciation of the geotechnical conditions in this area. These borehole (Figures 15 to 17) revealed that beneath 0 to 175 mm of topsoil, silty sand extends to the entire depth investigated in Boreholes 9 and 11 i.e. 1.2 m depth (Elevation 99.9 m to 100.2 m) and to 1.8 m depth in Borehole 10 (Elevation 99.3). A typical gradation of this stratum is shown on Figure 24. The soil comprises of 25 percent clay and silt, 67 percent sand and 8 percent gravel.

The silty sand in Borehole 10 is underlain by marble bedrock to the entire depth investigated i.e. 3.7 m (Elevation 97.4 m). The marble contains mica and pyroxene. It is massive. A Total Core Recovery of 97 percent and Rock Quality Designation of 88 percent was obtained when core drilling the bedrock. On this basis, the bedrock quality may be described as very good. Its unconfined compressive strength is 51.5 MPa (Table I).

3.4. Geotechnical Conditions in Diversion Berm (Boreholes 12 and 13)

Boreholes 12 and 13 were drilled on top of the Diversion berm located southeast of the southerly (smaller) pond as shown on Figure 3. These boreholes revealed that the berm fill extends to 1.1 m to 1.2 m depth. The fill comprises of silty sand and gravel with some cobbles and occasional



boulders. It comprises of 15 percent clay and silt, 48 percent sand and 37 percent gravel (Figure 25).

The fill is underlain by micaceous marble bedrock with pyroxene crystals. It is of very poor to good quality (RQD of 76 to 88 percent). Its unconfined compressive strength was established as 66.3 MPa (Table I).



4.0 Geotechnical Considerations

4.1. Lagoon Berm

The slopes of the existing berm of the lagoon were surveyed. The survey revealed that the upstream (inside) slope of the berm is at an overall inclination of 3H:1V approximately whereas the outer slope (downstream) is at an inclination of 2.5H:1V approximately.

The stability of the slopes was analyzed by using Bishop's Modified Method. Slope/W. Geoslope office, Version 4.23 Computerized system was used to assess stability of the slopes. One cross-section of the berm (Cross-Section AA) was analysed. The location of the Cross-Section A-A is shown on Figure 1. The cross-section has been plotted on Figure 1. The cross-section was surveyed by Trow Associates Inc. and was used for the slope stability analyses.

The following assumptions were made in the slope stability analyses:

- (1) The crest of the berm is at Elevation 96.5 m whereas the toe of the berm on the upstream side is at Elevation 93.4 m approximately whereas it is at Elevation 91.4 m on the downstream side. The crest width of the berm is 2 m to 2.5 m. The inside slope of the berm is at an inclination of 3H:1V whereas the outside slope of the berm is at a slope of 2.5H:1V.
- (2) The berm has been constructed with sand and gravel fill which contains some cobbles and occasional boulders. The berm is founded on gneiss bedrock.
- (3) The engineering properties of the silty sand fill are as follows:
 - Total Unit Weight ($\gamma = 21 \text{ kN/m}^3$)
 - Effective angle of internal friction $(\emptyset^1) = 35$ degrees
 - Effective cohesion (c')= 0 kPa
- (4) The water level in the pond will be at Elevation 96.8 m approximately or lower and that the berm would not be overtopped at any time. Also, the berm would not be subjected to rapid drawdown condition.

The slopes of the berm were analysed for the following conditions:

Downstream Slope	(i)	Fully submerged condition			
	(ii)	Fully submerged condition plus seismic loading			
Upstream Slope	(i)	Steady state seepage condition			
	(ii)	Steady state seepage condition plus seismic loading			
Downstream Slope	(i)	Rapid drawdown condition			
	(ii)	Rapid drawdown condition with seismic loading			



The results of the computer analyses have been summarized in Table III:

Table III
Results of Slope Stability Analysis of the Lagoon Berm

Slope Identification	Slope Inclination			Figure#	Comments
Upstream Slope (inside)	3H:IV Completed submerged (existing)		2.03	26	
		Completed submerged with seismic loading	1.45	27	•
Downstream Slope (outside)			1.40	28	Inadequate factor of safety
		Steady state seepage and seismic loading	1.12	29	
Downstream Slope (outside)	3H:IV	Steady state seepage condition	1.74	30	
		Steady state seepage condition plus seismic loading	1.31	31	
Upstream Slope	Upstream Slope 3H:IV Rapid drawdown condition		1.35	32	Inadequate factor of safety
		Rapid drawdown condition with seismic loading	1.12	33	
Upstream Slope	4H:IV	Rapid drawdown condition	1.96	34	
		Rapid drawdown with seismic loading	1.46	35	

A review of the above table indicates that the upstream slope has a factor of safety of 2.03 under static loading conditions and a factor of safety of 1.45 under seismic loading conditions. The existing downstream slope when subjected to steady state seepage conditions has a factor of safety of 1.40 under static loading conditions and 1.08 under seismic loading conditions.

Based on the conventional practice in the industry, a minimum factor of safety of 1.5 and 1.1 respectively is required for static and dynamic loading conditions. On this basis, the existing upstream slope is considered to be stable under the completely submerged conditions. The existing downstream slope (~2.5H:1V) has a lower factor of safety under static conditions than



required. Therefore, the analysis was repeated with the downstream slope of 3H:1V and yielded acceptable factors of safety (1.74, Figure 31). It is therefore concluded that the berm slopes would be stable if constructed at an inclination of 3H:1V. It is noted that this assumes that the upstream slope will not be subjected to rapid drawdown conditions.

It is noted that the crest width of the berm is less than the design requirements of 3 m. Therefore the berm would required widening. The widening may be achieved by extending the berm on the outside of the lagoon, since this slope receives flattening to 3H:IV.

It is noted that the overall slope inclination of the inside slope is at 3H:1V approximately although the slope is somewhat flatter in the upper 1 m and somewhat steeper thereafter. It is recommended that this slope should be regraded to a uniform 3H:1V slope.

The material is to be used for widening of the berm may consist of silty sand and gravel similar to that used in the original construction. All the topsoil should be removed from the area to be filled. The existing slope of the berm on the side to be widened should be stepped into 0.3 m high steps. Sand and gravel fill should then be placed in 0.3 m thick layers to abut the existing slope and each layer should be compacted to at least 95 percent of standard Proctor maximum dry density. The placement and compaction of the fill can in this manner be undertaken to match the top of the existing berm and the new slope graded to an inclination of 3H:1V.

It is noted that the computed slopes of 3H:1V would be stable provided that the berm is not overtopped and is not subjected to a rapid drawdown condition. Potential exist for considerable erosion and possibly failure of the berm if overtopped. Overtopping of the dam may be prevented by construction of a proper spillway structure which is capable of handling the overflow.



5.0 Rapid Drawdown Condition

The upstream slope was also analysed for rapid drawdown condition. A factor of safety of 1.35 was obtained under static loading conditions (Figure 32) and 1.12 under seismic loading conditions (Figure 33). Additional analyses were undertaken to determine the slope that would be stable under these conditions. The analysis indicates that a 4H:1V slope would have a factor of safety of 1.96 under static loading conditions and 1.46 under seismic loading conditions. It is therefore concluded that if the berm would be subjected to a rapid drawdown condition, the stable upstream slope would be 4H:1V. It is noted that it is unlikely that this condition would be encountered in practice. The reason for this is that in warmer climates, the practice is to discharge the effluent from the lagoons once a year during spring runoff. Under these conditions, there could be potential rapid drawdown of the lagoon. However, in the Arctic Region, the berm and the effluent freeze during the winter months and the berm becomes impervious. The effluent and the berm gradually thaw in the spring and summer months. Since seepage cannot take place out of the berms until they thaw, the rate of flow of the effluent from the lagoon is very slow. Consequently, in practice, a rapid drawdown condition will not be achieved.



6.0 Landfill Site

The three borehole (Boreholes 9 to 11) drilled in the proposed landfill site area have revealed that the silty sand overburden is underlain by massive, micaceous marble bedrock. It is noted that the bedrock was core drilled in only one borehole. The type and quality of bedrock varies extensively on the site. At the berm location, the bedrock was heavily fractured, gneiss. It is recommended that a more detailed investigation should be undertaken in the landfill site area especially if consideration is being given to not using a synthetic liner.



7.0 Diversion Berm

The investigation (Boreholes 12 & 13) has revealed that the height of the berm is 1.1 m to 1.2 m. The berm is founded on micaceous marble bedrock. The berm slopes are currently considered to be stable.



8.0 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.

Trow Associates Inc.

Surinder K. Aggarwal, M.S.

Senior Project Manager

Geotechnical & Materials Engineering Services

S.K. AGGARWA

Ismail M. Taki, M.Eng, P. Eng.

Manager/Assistant Branch Manager

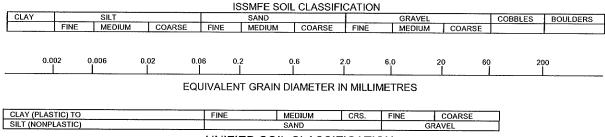
Geotechnical & Material Engineering Services



Figures

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 Society for Soil Mechanics and Foundation Engineering. Laboratory grain size analyses provided by Trow Associates 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.



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.



Project No:	OTGE00018881B								•						
Project:	Geotechnical Investigation-Sewage L	agoon &	La	ndfill						Figure	_	. 4			
Location:	Hamlet of Kimmirut, Nunavut									Sheet	No	of	_1_		
Date Drilled	: 'July 12, 2007			Solit S	Spoon S	amnle	<u> </u>	Σ	a	Combi	uctible Va	pour Rea	dina		
Drill Type:			_	Auger	Sample	9	•					e Content	-		X
Datum:	GEODETIC		-		N) Valu nic Con		t) -		erg Limits ined Triax		H		- 0
Logged by:	Checked by:		-		Tube				•	% Stra	iin at Failu Strength	ıre			0
Loggod by.	Officed by			Shear Vane	Streng Test	h by		+ s	-	Penetr	ometer To	est			A
S Y S M B L O		Geodetic	Ţ.)	Standard	Pene	tration	Test N Va	alue			pour Read		S	
G M W B O I	SOIL/ROCK DESCRIPTION	Elevation m	F	l Shea	20 r Streng	40 th		60	80 kPa	Na Atte	250 ; atural Mois rberg Limil	500 7 sture Conte Is (% Dry V	750 ent % Weight)	SAED-JES	Unit Weight kN/m ³
FIL		97.2"	(-	50	100) ·	150 :	200	1::::		20 :	30	S	MANIII
Silty bou	v sand and gravel, some cobbles and lders, brown, moist to wet (very dense)				17										
	()									×					
														\mathbb{H}	
\bowtie								3313							
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	-	-	2	12	: :			3343					-2-4-1-5	1	
				0						×					Í
Eroz	ren below 2.5 m depth	_		1111							11411				
₩ 1102	en below 2.5 m depth	94.4		20/	225 mn . Ф	1 : : - : :		3333	- 1-1-1-1-	×	-1000]	
SILT	grey, organic /	94.3													
NYX BED	ROCK	1	3											H	
intru	grained biotite rich gneiss, granitic sions, heavily fractured, grey and pink			9 (-1-)					1111111	0 (11 0 0 (11 0				Н	ĺ
_(very	poor to fair quality)	-				• • • •	- 1-2-2-	3.5.13	- 1 - 2 - 3 - 3 - 3 - 3 - 3 - 3 - 3 - 3 - 3					11	
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	_	1	4									1111		H	
									1000	\$ 1-1-5 \$ 1-1-5		- 6-1-5-6- - 6-1-5-6-		H	
>	_													Ш	
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										÷ :- : : :				11	
Bore	ehole Terminated @ 5.13 m Depth	92.1	5											Ц	
	more remainated @ 5.13 m Depth														

NOTES: 1. Borehole/Test Pit data requires Interpretation by Trow before use by others
2. Borehole backfilled upon completion

Borehole Terminated @ 5.13 m Borehole Terminated @ 5.13 m NOTES: 1. Borehole/Test Pit data requires Interpretation by Trow before use by others 2. Borehole backfilled upon completion 3. Fieldwork supervised by a Trow representative 4. See Notes on Sample Descriptions 5. This Figure is to read with Trow Associates Inc. report
<u></u>
NOTES: 1. Borehole/Test Pit data requires Interpretation by Trow before use by others
2. Borehole backfilled upon completion
3. Fieldwork supervised by a Trow representative
4. See Notes on Sample Descriptions
5. This Figure is to read with Trow Associates Inc. report OTGE00018881B

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

CORE DRILLING RECORD											
Run No.	Depth (m)	% Rec.	RQD %								
1	2.9 - 3.28	73	0								
2	3.28 - 3.71	59	0								
3	3.71 - 4.27	80	23								
4	4.27 - 4.65	97	48								
5	4.65 - 5.13	82	58								



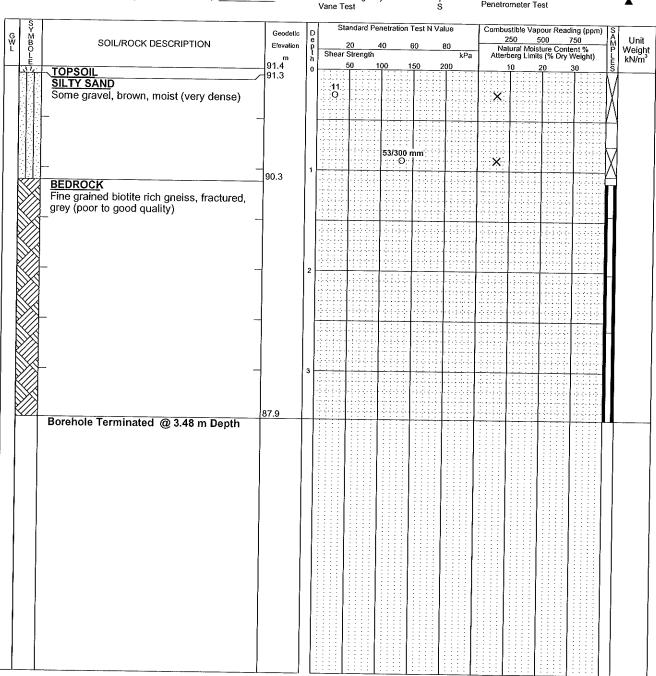
	roject roject		OTGE00018881B Geotechnical Investigation-Se	ewage Lag	goon & L	_ar	ndfill							-	5			
Lo	ocatio	on:	Hamlet of Kimmirut, Nunavut										Sheet	No.	of _	1		
Da	ate D	rilled:	'July 13, 2007				Split Sp	000	n Samp	le	×	 1	Combi	ustible V	apour Read	ing		
	ill Ty					-	Auger	Sar	nple]	Natura	ıl Moistu	e Content			×
	atum:		GEODETIC			-	SPT (N Dynam		alue Cone Te	st		· -	Undrai	erg Limit ined Tria	xial at	ŀ		-
	gged		Checked by:	•		-	Shelby Shear		be ength by	,	-1	-	Shear	iin at Fai Strength	by			⊕
	33						Vane T				 		Penetr	ometer 7	Test			
G W L	SYMBO		SOIL/ROCK DESCRIPTION		Geodelic Elevation	D e p		20	4	netration T		80		250	apour Readir 500 75 isture Conter ilts (% Dry W	50	- M P	Unit Weight
	XXX	FILL			97.2 ^m	h		50	_	00 19	50	kPa 200	Atte	10	20 3	eignt) 0	ES	kN/m³
	₩	Silty	sand with gravel, cobbles and lers, brown, wet (very dense)						24:									
	\bowtie	_ bould	lers, brown, wer (very dense)				-2.4.1.							×				
																	-	
	₩																	
		_				1					-2-1-1					-> (- -)		
	₩						-3-4-1-1											
	₩	_		-						- 58 - O			×					
	₩																	
	\bowtie	_				2					4411	- 11111	X				H	
		BEDI	ROCK		95.0													
		Fine	grained biotite rich gneiss, hea ired, grey and pink (very poor	avily to good _			-5 (-1-)									4014		
	M	qualit		to good			33.13									3413	Н	
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		_		_		4	-2	-									11	
	X	Dava	hala Tarminatad @ 4.45 m. F	20mth	92.8	ļ.										+ + + + + + + + + + + + + + + + + + +	П	
		Боге	hole Terminated @ 4.45 m C	Jepin														
3/9/07																		
GPJ TROW OTTAWA.GDT 23/9/07																		
AWA.C																		
V OTT.																		
TROV																		
g.																		
"	TES: Borehole	e/Test Pit	data requires Interpretation by Trow		WATER	٦L	EVEL F	REC	CORDS	3			CC	DRE DR	ILLING RE	CORE)	
LOG	efore u	se by oth	ed upon completion	Elaps Time		L	Water evel (m		}	lole Ope To (m)	en	Run No.	De (n	pth n)	% Red		R	QD %
되 되	-31311016	o odoknik	sa apon completion	Comple			ore wat			- \/		1 2	2.21	- 2.46 - 2.57	70 100			0
3.F			ised by a Trow representative									3	2.57	- 2.69	90			0
Ц 4.9 О 5 Т			mple Descriptions read with Trow Associates Inc. report									5	2.69 · 3.71 ·	- 3.71 - 4.45	75 100			36 78
9["	OTGEOC	0018881E	read with Trow Associates Inc. report 3				-											

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

	CORE DR	RILLING RECOR	RD
Run No.	Depth (m)	% Rec.	RQD %
1	2.21 - 2.46	70	0
2	2.46 - 2.57	100	0
3	2.57 - 2.69	90	0
4	2.69 - 3.71	75	36
5	3.71 - 4.45	100	78



Project No:	OTGE00018881B	9 0.		<u>, </u>	TI	IUY
Project:	Geotechnical Investigation-Sewage	Lagoon & L	andfill		Figure No. 6 Sheet No. 1 of 1	
Location:	Hamlet of Kimmirut, Nunavut					
Date Drilled: Drill Type:	'July 13, 2007		Split Spoon Sample Auger Sample	⊠ (1 0	Combustible Vapour Reading Natural Moisture Content	
Datum:	GEODETIC		SPT (N) Value Dynamic Cone Test	0	Atterberg Limits - Undrained Triaxial at	——⊖ ⊕
Logged by:	Checked by:		Shelby Tube Shear Strength by Vane Test	+ s	% Strain at Failure Shear Strength by Penetrometer Test	▲
S Y W W B	SOIL/ROCK DESCRIPTION	Geodelic Elevation	Standard Penetration To		Combustible Vapour Reading (ppm) 250 500 750 Natural Moisture Content %	S A M Unit



NOTES:

1. Borehole/Test Pit data requires Interpretation by Trow before use by others

2. Borehole backfilled upon completion

TROW OTTAWA.GDT 23/9/07

GP.

3. Fieldwork supervised by a Trow representative

4. See Notes on Sample Descriptions

LOG OF 5. This Figure is to read with Trow Associates Inc. report OTGE00018881B

WAT	ER LEVEL RECO	ORDS
Elapsed Time	Water Level (m)	Hole Open To (m)
Completion	Core water	, , , , , , , , , , , , , , , , , , ,

	CORE DR	RILLING RECO	RD
Run No.	Depth (m)	% Rec.	RQD %
1	1.12 - 1.45	92	33
2	1.45 - 2.03	87	40
3	2.03 - 2.59	95	50
4	2.59 - 3.48	93	77



	ject No:	OTGE00018881B	Log				•				Figure No.	7		U¥
	ject:	Geotechnical Investigation-S		on & L	.and	dfill						1 of		
	cation:	Hamlet of Kimmirut, Nunavul	t	****									_	
		: 'July 13, 2007				Split Spo Auger S		nple		⊠	Combustible Natural Mois	Vapour Reading)	□ X
	l Type:					SPT (N)	Value))	Atterberg Lin		\vdash	- ô
	um:	GEODETIC				Oynamic Shelby T		Гest		- ■	Undrained Ti % Strain at F			\oplus
_og	ged by:	Checked by	·			Shear Si /ane Te		by	-	├ S	Shear Streng Penetromete			•
G W L	S Y M B O L	SOIL/ROCK DESCRIPTION	E	Seodelic levation	D e p t h	Shear	:0 Strength		60	80 kPa	250 Natural N Atterberg L	Vapour Reading 500 750 Moisture Content imits (% Dry Wei		S M M Wei Wei kN/
, <u>7</u>	TOF	PSOIL ND	93		0		0	100	150	200	10	20 30		-
•	Fine brov	e to coarse grained, some grave vn (dense)				15 0					*			$\langle $
••	Refu Dep	usal to Split Spoon sampling	@ 0.6 m	.9										1
														A CONTRACT C
NOTE Bor		rit data requires Interpretation by Trow		WATER			CORE					RILLING REC		
	-	led upon completion	Elapsed Time		Le	Vater vel (m)		Hole Op To (m)		Run No.	Depth (m)	% Rec.	R	RQD %
			Completion	n		Dry								
		vised by a Trow representative ample Descriptions												
.000		read with Trow Associates Inc. report												



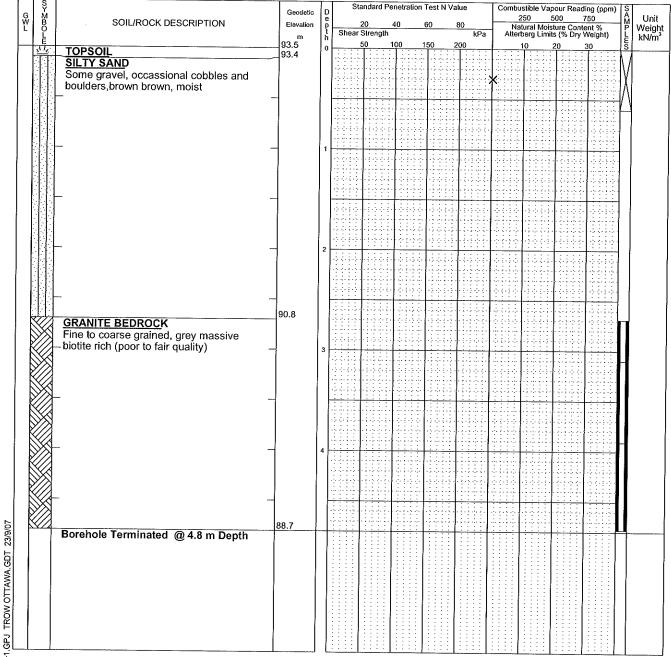
Projec	et No: OTGE00018881B	.og oi		, , , ,	CI	1010	<u>'</u>	_					ГО	,
Projec	***************************************	age Lagoon & l	_and	fill					Figure	-	8			
Location	on: Hamlet of Kimmirut, Nunavut								Sheet	t No.	of			
Date D	Prilled: 'July 12, 2007		_ s	Split Spo	on Sam	ple		—— ⊠	Comb	ustible V	apour Rea	dina		С
Drill Ty	/pe:			luger Sa SPT (N)			-		Natura		re Content	•	:	` }
Datum	GEODETIC		D	ynamic	Cone T	est		_	Undra	ined Tria in at Fail	xial at	1		Œ
Logged	d by: Checked by:		s	ihelby T ihear St 'ane Te	rength b	у		+ s	Shear	Strength rometer 1	by			4
S		Geodetic				netration			Comb	ustible Va	apour Readi	ng (ppm) [S]	
G M B C L C L	SOIL/ROCK DESCRIPTION	Elevation m	e p	Shear S	0 d	40 (60	80 kPa		250		'50	I Al	W k
Ē	SILTY SAND	93.8	0	5	0 1	00 1	50	200	1.111.	10		30	Š,	
	Organics, some gravel, dark brown Refusal to Split Spoon Sampling @	93.5	·		- - - - - - - - - -									_
IOTES:	Depth													
.Borehole/	/Test Pit data requires Interpretation by Trow e by others	WATER Elapsed		EL REG		lole Ope	<u></u>	Run			LLING RE			_
.Borehole	backfilled upon completion		Leve	el (m) Try	-	To (m)	-	No.	Dep (m))	% Rec.	·	RQD	_
Fieldwork	supervised by a Trow representative													
	s on Sample Descriptions													
OTGE000	re is to read with Trow Associates Inc. report 018881B													



Projec	et No: OTGE00018881B	-og or i	_	O.	G I	10	1 G .	<u>J</u>	_				-	T		U
Projec		ewage Lagoon & I	Lar	ndfill						Figur	e No.		9			
Locati										Shee	et No.	_1	of	_1_		
Date D	Willed: Huby 12, 2007			Split Sp		'omala			 71				_			_
Drill Ty			-	Auger \$	Sampl	е .			⊠ D				our Rea Content	-)
Datum	. GEODETIC		-	SPT (N Dynami				(_		berg Lii ained T		l at		<u> </u>	
Logge	· · · · · · · · · · · · · · · · · · ·			Shelby Shear S		th by			■ L	% Str	rain at f r Stren	Failure	€			0
				Vane T	est	ui by		9	F S		tromete					4
G M W B L O	SOIL/ROCK DESCRIPTION	Geodetic Elevation	Dep		andaro 20	Penetra 40	ation Te		alue 80	í	250	50	0 7	ing (pp.n 750	n) S A M	
L O L		93.4	h	Shear	Streng 50	th 100	150		kPa 200	Att	Vatural i erberg l 10	Moistu Limits (20	re Conto (% Dry \	ent % Weight) 30	SAMPLES	y k
	SILTY SAND Some organics, dark brown		١												Ĭ	T
												×			Ĭ	V
	Refusal to Split Spoon sampling (92.8 @ 0.6 m												1 1 1		1
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Borehole/	Test Pit data requires Interpretation by Trow e by others	WATER		/EL RE /ater	CORI		Onon	4	Dua I					CORD		
Borehole I	backfilled upon completion		Lev	rel (m) Ory	4	Hole (- -	Run No.	Dep (m		"	% Rec.	_	RQ	ים!
Fieldwork	supervised by a Trow representative	,	٠	- • y												
	on Sample Descriptions															



Project No:		OI E		<u> </u>		Ŧ	r	J٧
Project:	OTGE00018881B Geotechnical Investigation-Sewage L	.agoon & L	andfill		Figure No	10 of 1		
Location: Date Drilled:	Hamlet of Kimmirut, Nunavut 'July 13, 2007		Split Spoon Sample					_
Drill Type:			Auger Sample SPT (N) Value		Combustible Vapou Natural Moisture Co Atterberg Limits	•	—	⊔ X ⊕
Datum:	GEODETIC		Dynamic Cone Test —— Shelby Tube		Undrained Triaxial a	at	•	⊕
Logged by:	Checked by:		Shear Strength by Vane Test	+ s	Shear Strength by Penetrometer Test			•
G M B O L E	SOIL/ROCK DESCRIPTION	Geodetic Etevation m 93.5	Standard Penetration Test I 20 40 60 Shear Strength 50 100 150	80 kPa 200	Combustible Vapour 250 500 Natural Moisture Atterberg Limits (9	750 Content %		Uni Weig kN/n
Y TOP	SOIL	93.4	" : : : : : : : : : : : : : : : : : : :	11 1111		Ĭ	: 1	



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Ţ	NOTES:
띴	Borehole/Test Pit data requires Interpretation by Trow
OGSBH	before use by others
ŏ	bolore ase by officia
_	O Desertate to a CUL 1
ш	Borehole backfilled upon completion
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우	
üί	
₢	3. Fieldwork supervised by a Trow representative

5. This Figure is to read with Trow Associates Inc. report OTGE00018881B

4. See Notes on Sample Descriptions

	Elapsed	Water	Hole Open
Į	Time	Level (m)	To (m)
١	Completion	Core water	
١			
ļ			
I			
İ			
١			
1			

WATER LEVEL RECORDS

	CORE DE	RILLING RECO	RD
Run No.	Depth (m)	% Rec.	RQD %
1	2.69 - 3.1	100	28
2	3.1 - 3.91	78	66
3	3.91 - 4.78	74	51
L			



Proj Proj		No: OTGE00018881B : Geotechnical Investigation-S	- S occupant	or	dfill							Figure	No.		11			
Loca				<u>-ui</u>	iuiii						_	Sheet	No.	1	of .	1_		
		illad: Uulu 12 2007			0 111 0													_
) Drill					Split Spo Auger S			ile				Combi. Natura	istible V I Moistu			ing		×
Datu		OFORFIO			SPT (N) Dynamic			st		0		Atterbe	erg Limi ned Tria		nt.	F		- €
				-	Shelby 1	Tube	е						in at Fa	ilure				0
-og(yeu	by: Checked by:	<u> </u>		Shear S Vane Te		igth by	′		+ s		Penetr						•
G	S Y		Geodelic	D	Sta	inda	rd Per	etration	Test	l N Va	lue		ustible V 250	apour 500	Readin	ig (ppm)	S	Τ
G ₩ L	SYM BOL	SOIL/ROCK DESCRIPTION	Elevation m	e p t h	Shear		ngth	0	60		80kPa	Na Atter	itural Mo berg Lir	isture nits (%	Conter Dry W	nt % /eight)	SAMPLES	W.
74	E 1,/	TOPSOIL	93.7	0		50 : .	10	00	150	: : :	00		10	20	3	0	S	+
		SILTY SAND Organics, some gravel, brown			33.13		3 3 1 1 1 3 3 3 3 3 3 3 3 3 3 3 3 3 3 3	- 0- (-) 0 - 0- (-) 0	0 3 0 3				X		134	4414	\triangle	
		Refusal to Split Spoon Sampling	93.2 @ 0.5 m	-		-											-	ļ
		Depth																
						:												
İ						:												
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						1												
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OTE	S:			l			1		<u> </u>		<u> </u>						JJ.	
.Bore	ehole	/Test Pit data requires Interpretation by Trow ee by others	WATER		VEL RE	ECC		lole Or	oen	-	Run	CO			NG RE	CORD		QD
.Bore	ehole	backfilled upon completion	Time Completion		evel (m) Dry		<u> </u>	To (m			No.	(m		L '		-		
Field	lwork	s supervised by a Trow representative			,													
		s on Sample Descriptions																
	Figu	re is to read with Trow Associates Inc. report 018881B					1											



Project	No: OTGE00018881B	_				•			<u> </u>						_	_	· • ·	v
Project:		owago Lagoon 9 I	۱ ۵۰	adfi								Figure	No.		1:	2		
Location			Lai	IUII	<u>!!</u>							Sheet	No.		1_ of	f <u>1</u>		
	lled: 'July 13, 2007																	
			_			oon Sa ample		le		X ID				-	our Re			(
Drill Typ			-	SP	T (N)	Value	•			0		Atterbe			Conte	п.	 	_(
Datum:	GEODETIC		-		namic elby T	: Cone Tube	e Te	st	i	_		Undrai % Stra	ined 1 iin at	Friaxia Failur	al at re			(
ogged	by: Checked by:	·		She Var	ear Si ne Te	rength st	h by			+ s		Shear Penetr						4
S		Geodetic	Ъ	Γ	Sta	ndard	Pen	etration '	Test N \	/aiue		Combi	ustible	Vapo	our Rea	ding (ppn	n) Ş	Т
G M W B L O	SOIL/ROCK DESCRIPTION	Elevation	e p			0 Strengt	4(} (60	80	kPa	Na Atte	250 atural rberg	50 Moiste Limits	ure Con	750 Itent % Weight)	SAMPLES	V
3/2	TOPSOIL	93.8	h O	:::		io 	10	0 1	50	200	::	1::::	10		0	30	. E S	
	TOPSOIL Silty sand					30 O). j. 					>	<				\mathbb{I}	
10		93.2		1 1							<u> </u>						: //	ļ
	TOPSOIL FROZEN SILTY SAND	93.1			14 O										,		∇	1
	Refusal to Split Spoon Sampling	92.9 @ 0.9 m	╀		172			?!?? !!!!	13 13 13		† † † 	11111					1	_
	Depth																	
																		ļ
							:											
							:											
OTES: Borehole/Te	est Pit data requires Interpretation by Trow	WATER	LE'	VEL	REG	CORE	os	<u>-</u>				COF	RE D	RILI	ING R	ECORD)	_
petore use	by others ackfilled upon completion	Elapsed	٧	Vate	91		Ho	le Ope Го (m)	n	Run No.		Dept (m)	th	T	% Re		RQ	۱D
		Completion		Dry				· • (111)		110.	+	(111)	<u>'</u>	+				
	upervised by a Trow representative																	
	on Sample Descriptions																	
OTGE0001	is to read with Trow Associates Inc. report 3881B																	

	WAI	ER LEVEL RECC	DRDS
İ	Elapsed Time	Water Level (m)	Hole Open To (m)
	Completion	Dry	

	CORE DE	RILLING RECO	RD
Run No.	Depth (m)	% Rec.	RQD %



Project No: OTGE00018881B Figure No. Project: Geotechnical Investigation-Sewage Lagoon & Landfill Sheet No. 1 of 1 Location: Hamlet of Kimmirut, Nunavut Date Drilled: 'July 16, 2007 Split Spoon Sample \boxtimes Combustible Vapour Reading Auger Sample × Natural Moisture Content Drill Type: SPT (N) Value 0 Atterberg Limits 0 Dynamic Cone Test Datum: **GEODETIC** Undrained Triaxial at Ф % Strain at Failure Shelby Tube Logged by: Checked by: Shear Strength by Shear Strength by + s Penetrometer Test Combustible Vapour Reading (ppm) Standard Penetration Test N Value Geodetic 250 500 750 Natural Moisture Content % Atterberg Limits (% Dry Weight) Unit Ğ W L SOIL/ROCK DESCRIPTION Elevation Weight kN/m3 Shear Strength kPa TOPSOIL SILTY SAND 94.0 9 X Some gravel, organics, trace clay, dark brown, moist Frozen below 1.2 m depth 91.4 SILTY SAND 91.2 Organics, black BEDROCK Fine grained biotite rich gneiss with fine grained granitic intrusions, fractured, grey and pink 89.0 Borehole Terminated @5.1 m Depth

NOTES: 1. Borehole/Test Pit data requires Interpretation by Trow before use by others 2. Borehole backfilled upon completion

3. Fieldwork	supervised by	a Trow re	presentative

TROW OTTAWA.GDT 23/9/07

4. See Notes on Sample Descriptions
5. This Figure is to read with Trow Associates Inc. report OTGE000188818

WAT	ER LEVEL RECO	RDS
Elapsed Time	Water Level (m)	Hole Open To (m)
Completion	Core water	

	CORE DR	RILLING RECO	RD
Run No.	Depth (m)	% Rec.	RQD %
1	3.35 - 3.94	96	50
2	3.94 - 4.42	84	61
3	4.42 - 5.08	100	73



Project No:	OTGE00018881B								Eiguro N	do	1.1			
Project:	Geotechnical Investigation-Sewage La	igoon & L	.ar	ıdfill					Figure N					
Location:	Hamlet of Kimmirut, Nunavut								Sheet N	NO	I OT	<u> </u>		
Date Drilled:	'July 16, 2007			Split Spo	on Sam	ple	\boxtimes		Combus	tible Vap	our Read	ling		
Drill Type:			_	Auger Sa SPT (N)			II)		Natural Atterber		Content	L		X ⊕
Datum:	GEODETIC			Dynamic	Cone T	est			Undrain % Strain	- ed Triaxi		•		Φ
Logged by:	Checked by:			Shelby T Shear St Vane Te	rength b	у	+ S		Shear S Penetro	trength b	у			•
S Y Y M B L O	SOIL/ROCK DESCRIPTION	Geodetic Elevation	D e p				Test N Value		2:	50 5	our Readin	50	SAMPLIES	Unit Weight
Ę .		94.1	h o	Shear S	Strength		50 200	kPa			lure Conte s (% Dry W 20 3	/eight) i0	. ההמ	kN/m³
SIL1 Som	SOIL 'Y SAND e gravel, occassional cobbles and ders, dark brown, moist	94.0	U	4 O						×			\bigvee	
	-		1	. 8 O						×			\bigvee	
	_	92.6		14 O			-3-12-2-2		×			0010	X	
Som BED	YEY SILTY SAND e gravel, grey ROCK grained biotite rich gneiss with coarse ⁻	92.3	2						×				П	
grair	ned granitic intrusions, fractured, grey pink (very poor to fair quality)													
	_		3											
	_													
Bore	ehole Terminated @ 3.89 m Depth	90.2		-2-1-2-1				-1-1						
	Shole Ferminated & 5.55 in Beptin	Managed Associations on	The second secon											

NOTES: 1. Borehole/Test Pit data requires Interpretation by Trow before use by others

2. Borehole backfilled upon completion

3. Fieldwork supervised by a Trow representative4. See Notes on Sample Descriptions

5. This Figure is to read with Trow Associates Inc. report
OTGE00018881B

WAT	ER LEVEL RECC	RDS
Elapsed Time	Water Level (m)	Hole Open To (m)
Completion	Core water	

	CORE DF	RILLING RECO	RD
Run No.	Depth (m)	% Rec.	RQD %
1	1.85 - 1.98	70	0
2	1.98 - 2.18	100	0
3	2.18 - 2.59	88	75
4	2.59 - 3.02	94	59
5	3.02 - 3.33	83	0
6	3.33 - 3.89	82	58



Drill Type	lled: 'July 15, 2007		La		-	ble]	Combu	No. stible V Moistui	1 of		(
Datum: Logged b	GEODETIC Oy: Checked by:		_	Shelby 1	rength by		+ s	•	Undrair % Strair Shear S Penetro	n at Fail Strength	ure by		(
SY MB OLE	SOIL/ROCK DESCRIPTION	Geodetic Elevatior m 101.6	n p	Sta	ndard Per 0 4 Strength		Fest N Va		Na Atterl	50	pour Readin 500 75 sture Conter its (% Dry W	it % leight)	SAMPLES
	SILTY SAND Some gravel, trace organics, dark bro wet	1	0	110		00 1				×	20 31	U	
	Refusal to Split Spoon Sampling @	100.4	1	-24-1-2-	26 O				>				
Borehole bar Fieldwork su	est Pit data requires Interpretation by Trow by others ckfilled upon completion upervised by a Trow representative on Sample Descriptions	Elapsed Time Completion		EVEL RE Water evel (m) Dry	Н	ole Ope To (m)	n	Run No.	COF Depti (m)		LLING REG		RQD

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

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



	00018881B chnical Investigation-Se	ewade Ladoon S	R, Iα	ndfill					Figure	No	16				
	et of Kimmirut, Nunavut		.я IС	ariQIIII						Sheet	No	of	_1_		
Date Drilled: 'July 1	5 2007			Split S	noon S	Samo	do	ı	 1	Combi	ntible V-	mour Po-	dina		_
Orill Type:				Split S Auger	Sampl	le	ne		}	Natural	Moistur	pour Read e Content	oing		X
atum: GEOD				SPT (N Dynam			est		•		rg Limits ied Triax		ł		— ⊕
ogged by:	Checked by:			Shelby Shear			,	■]	Shear S	n at Faili Strength	by			⊕
				Vane 1		, o ,		Ś		Penetro	meter T	est			-
SV SC	IL/ROCK DESCRIPTION	Geode Elevati	tic	D S	tandar 20		netration 7		lue 80	1 2	50	pour Readi 500 7	50	SAM	
	NETCON BEGONIA FIGH	101.1		t Shea	Stren 50	gth			kPa 200	1	turai Moi: berg Limi 10	sture Conte its (% Dry V 20	nt % Veight) 30	SAMPLES	k k
<u>™</u> TOPSOIL Silty sand ar	nd gravel, some cobble	s and / 101.0		4										V	
SILTY SANI														∖	
Some organ moist	ics, trace gravel, dark b	rown, –													
\bigotimes				9 O							×		->	\mathbb{I}	
-		-		1										A	
			011	00 mm					\					\forall	
Frozen helov	w 1.5 m depth	-	371	Φ	1::									1	
BEDROCK		99.4												H	
	able with pyroxene, ma	ssive,		2										П	
grey, mediui	ii giainet			301											
				44.1									\$ 500 C		
						<u>.</u>	3.3.5	.5.3.3.3							
		+	;	3	1										
				3010			1111					1000			
		\dashv		10.00.00			V 1 1 2 1 1					1 1 1 1 1 1		$\ \ $	
Borehole Te	erminated @ 3.7 m De	97.4 pth												╀┦	
					<u> </u>				<u> </u>			<u> </u>		Ц	
OTES: Borehole/Test Pit data requ before use by others	ires Interpretation by Trow		ERI	EVEL F	ECO							LLING RE			
Borehole backfilled upon c	ompletion	Elapsed Time		Water Level (m		-	lole Ope To (m)		Run No.	Dept (m)		% Red).		ΣD
Fieldwerk		Completion		core wat	ات ا				1	1.8 - :	3.1	97			88
Fieldwork supervised by a See Notes on Sample Desc															
	Frow Associates Inc. report														



Project No:	OTGE00018881B	- 09	01	_	OI ·	GH		- -	_	- 1					•	•	JΥ
Project:	Geotechnical Investigation-Se	ewage Lag	oon & L	and	dfill					-	Figure No. Sheet No.			17	1		
Location:	Hamlet of Kimmirut, Nunavut									Sne	eeti	VO.		_ or _	<u>!</u>		
Date Drilled: \(\)	July 15, 2007			_	Split Spe	oon Sar	nple	⅓	Co	mbus	tible \	Vapour	r Readir	ıg			
Drill Type:					Auger S SPT (N)				D			Moisti g Lim	ure Co its	ntent	ŀ		X →
Datum: 0	GEODETIC				Dynamic Shelby 1	Cone	Test	_	_	Un	drain	-	axial a	t	Ī		⊕
Logged by: _	Checked by:				Shear S Vane Te	trength	by	-	- }- S	Sh	ear S	trengt meter	h by				•
S			Geodetic	n			enetration	Test N V	alue	Co				Reading		S	Lini
SYMBOLE	SOIL/ROCK DESCRIPTION		Elevation m 101.1	e p t h	Shear:	20 Strength	100	60 150	80 kF 200	a Pa	Nati Atterb	50 ural M erg Lii 0	500 oisture mits (% 20	750 Content Dry Wei	%	SAMPLUS	Uni Weig kN/n
TOPS	and and gravel, some cobbles	and A	100.9	0	3 0				200							Ň	
\boulde	ers, brown, moist to wet (very	dense) /											^			M	
- Some moist	organics, trace gravel, dark b	rown, –															
					4414	30 O						×				M	
Frozen	below 0.9 m depth	-		1												Μ	
Boreh	ole Terminated @ 1.2 m De	epth	99.9	+	Y Y 11 1											H	
		and the state of t															
		1															
	· · · · · · · · · · · · · · · · · · ·		.,								: :	<u> </u>					
NOTES: 1.Borehole/Test Pit d	ata requires Interpretation by Trow		WATER	R LE	VEL RI	ECOR	os				COF	RE DI	RILLIN	NG RE	CORD		
before use by other	rs	Elapse	ed	1	Vater		Hole O		Run	1	Dept	h		6 Rec.			QD %
2. Borehole backfilled	upon completion	Time Complet		Le	vel (m) Dry	+	To (m	1)	No.		<u>(m)</u>				+		
3. Fieldwork supervise	ed by a Trow representative					-											
4. See Notes on Samp																	
5. This Figure is to rea OTGE00018881B	ad with Trow Associates Inc. report																
O TOLOUTION IB		L											L				



Project No: OTGE00018881B Figure No. Project: Geotechnical Investigation-Sewage Lagoon & Landfill Sheet No. 1 of 1 Location: Hamlet of Kimmirut, Nunavut Date Drilled: 'July 14, 2007 Split Spoon Sample Ø Combustible Vapour Reading Auger Sample × Natural Moisture Content Drill Type: SPT (N) Value 0 Atterberg Limits Ю Dynamic Cone Test Datum: **GEODETIC** Undrained Triaxial at 0 % Strain at Failure Shelby Tube Shear Strength by Penetrometer Test Logged by: Checked by:_ Shear Strength by Vane Test Combustible Vapour Reading (ppm) Standard Penetration Test N Value Geodetic 250 500 750

Natural Moisture Content %
Atterberg Limits (% Dry Weight) Unit . М В О SOIL/ROCK DESCRIPTION Elevation Weight kN/m³ Shear Strength m 61.1 Silty sand with gravel and cobbles, brown, moist to wet 15 O 59.9 **BEDROCK** Micaeous marble with pyroxene, coarse grained, slightly fractured, (very poor to good quality) Refusal to Split Spoon sampling @ 2.8 m Depth

NOTES: 1. Borehole/Test Pit data requires Interpretation by Trow before use by others
2. Borehole backfilled upon completion

3. Fleidwork supervised	ру а	row representative	

4. See Notes	on Sample	Descriptions

LOG OF BOREHOLE LOGSBH-1.GPJ TROW OTTAWA.GDT 23/9/07	į		
A.GDT			
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O MC			
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Ŧı	NΟ	TES:	
GSB	1.8	orehol	le/Test Pit data requires Interpretation by Trow use by others
LE L	2.E	orehol	le backfilled upon completion
윘			
S S	3.F	ieldwo	ork supervised by a Trow representative
핅	4.S	ee No	tes on Sample Descriptions
907	5.T C	his Fig	gure is to read with Trow Associates Inc. report 0018881B

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

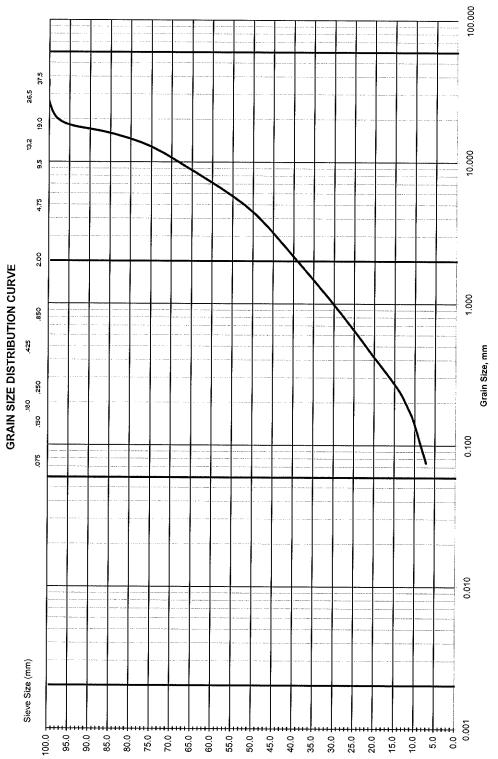
CORE DRILLING RECORD												
Run No.	Depth (m)	% Rec.	RQD %									
1	1.2 - 1.7	88	65									
2	1.7 - 2.18	76	0									
3	2.18 - 2.77	83	83									



	•		OTGE00018881B		O					•		'	Figure	No.		19		•	-
	oject		Geotechnical Investigation-Se		goon & L	.ar	ndfill						Shee	t No.		1_ of	1		
Lo	catio	n:	Hamlet of Kimmirut, Nunavut																
Da	te Di	illed:	'July 14, 2007			-	•	-	on San	ple	[2					oour Rea	ding		
Dri	II Ty _l	oe:				-	-		mple Value			[]	Atterb			Content		 	X ⊸⊖
Da	tum:		GEODETIC	· · · · · · · · · · · · · · · · · · ·			Dyna Shell		Cone 1 ube	est		-	Undra % Stra						\oplus
Log	gged	by:	Checked by:		_			ar St	ength	ру	-	- - - 	Shear Penet						A
G W L	SYMBOLE		SOIL/ROCK DESCRIPTION		Geodetic Elevation m 61.5	Deplh	She	2) trength	enetration 40	Test N V 60 150	alue 80 kPa 200		250	5 Moist Limit	our Readi 500 7 ture Conte s (% Dry V	50	n) SA MP LES	Unit Weigh kN/m³
		FILL Silty:	sand with gravel, brown, moist		01.5	0	5 O							×					
		Piece depth	of fabric liner at approximate (_		1		2	1						×				_
3/9/07		Refus	sal to Split Spoon Sampling	@ 1.1 m	60.4	The state of the s		- Individual Communication Com											
00 OF BOREHOLE LOG 3. E. 4. Se 5. Lt.	orehole efore us orehole eldwork ee Note nis Figu	e by oth backfille s supervi	d upon completion sed by a Trow representative mple Descriptions ead with Trow Associates Inc. report	Elaps Time Comple	<u> </u>		EVEL Wate evel (er (m)	CORL	S Hole Op To (m		Run No.	De	DRE pth	DRIL	LLING R			QD %

十Trow



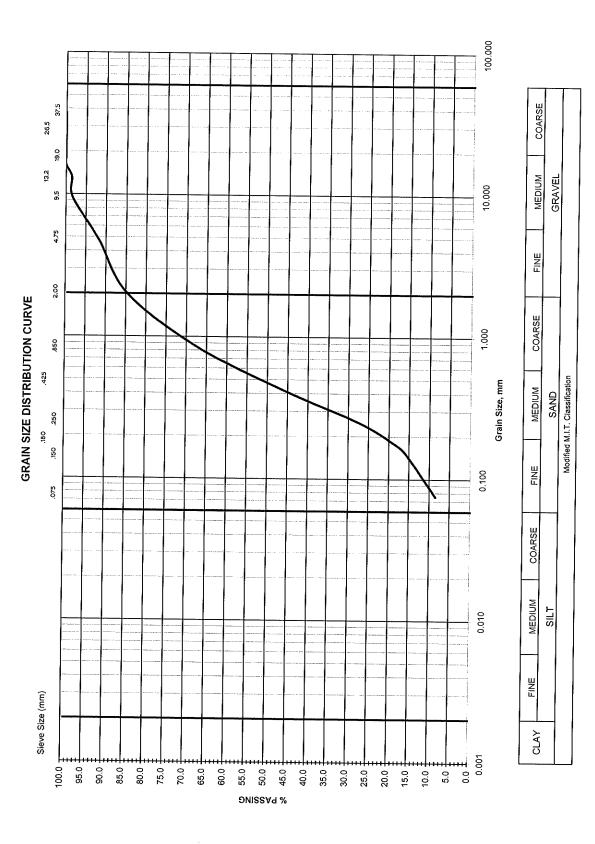


% PASSING

1000	GRAVEL			SAND			SILT	
COARSE	MEDIUM	FINE	COARSE	MEDIUM	FINE	COARSE	MEDIUM	HNE HNE

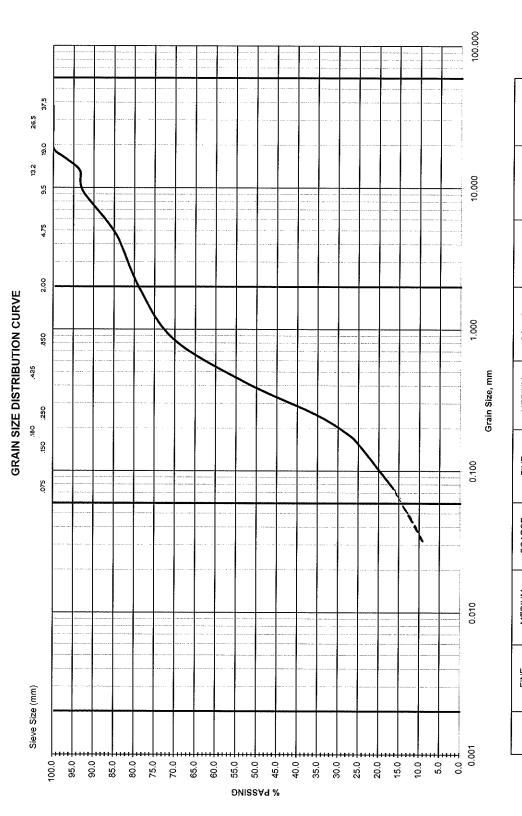
PROJECT:	OTGE00018881B	NAME & I	LOCATION:	Sewage Lag	Sewage Lagoon and Landfill Facility - Hamlet of Kimmirut, Nunavut	- Hamlet	of Kimmirut, Nunavut	
DATE SAMPLED:	.D: 15-Jul-07		BOREHOLE No.:	2	SAMPLE No.:	SS2	SS2 DEPTH(m):	1.3 to 1.9
SAMPLE DESCRIPTION	:RIPTION:	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,		Sano	Sandy Gravel. Trace Clay			

FIGURE: 21



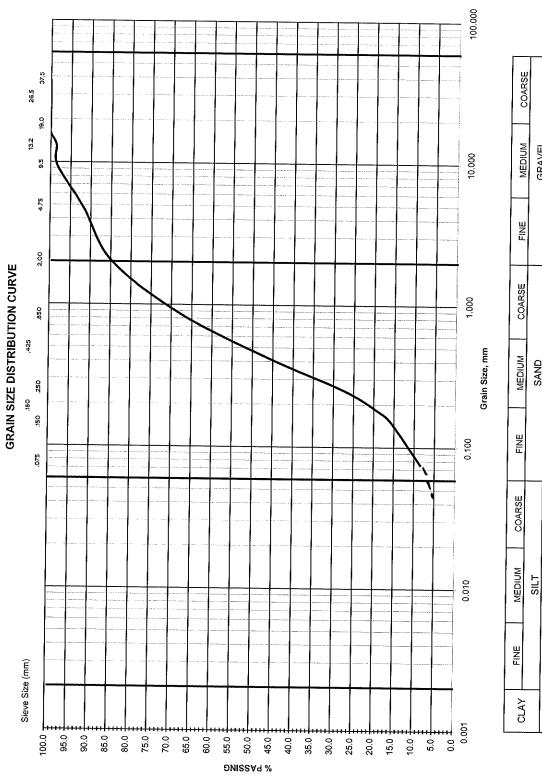
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of Kimmirut Nunayut	יייייייייייייייייייייייייייייייייייייי	DFPTH / m):		
- Hamlet		SS1A		
Sewage Lagoon and Landfill Facility - Hamlet of Kimminut Nunswut		SAMPLE No.:		Sand, Some Gravel, Trace Silt
Sewage La		2 A		Sand,
IME & LOCATION:	1 000	BOKEHOLE NO:		
Ž.	1.0	/O-Inc-7/		
OTGE00018881/			IDTION:	
PROJECT :	DATE SAMDIED	ביייים ביייים ביייים	SAMP! A JESCHIOTION	

22 FIGURE:



	GRAVEL
Modified M.I.T. Classification	SAND ed M.I.T. Classification
Modific	Modific
	SILT





							2 6 6 6	0.00 0.0		
COARSE					Sewage Lagoon and Landfill Facility - Hamlet of Kimminst Numanut	ווווווו ענ, ואמוומיעונ	DEDTH / m /-	/ /		į
MEDIOM	10/1/07	72,420			Jamiet of Kir	Idillict Of IXI	SS10			
TINE					fill Facility - 1			1	race Silt	ומכר סוור
COARSE					on and Land		SAMPLE No:		Sand, Some Gravel Trace Silt	
MEDIOIN	SAND		Modified M.I.T. Classification		Sewage Lago		- 2A		Sand. S	
1111			2		AME & LOCATION:		BOXEHOLE No.:			
	SILT				NAME & I	1	_		i	
					PROJECT : OTGE00018881A	70 1:1 01	0-106-21	TIONI-		
3					0	יקם ופו	VIT LED.	COLONIA	1000	
					PROJECT	DATE SAMPLED.	ל ל	SAMPLE DESCRIPTION:		

100.000 24 37.5 26,5 FIGURE: 0.6 13,2 10.000 9.5 4.75 2,00 GRAIN SIZE DISTRIBUTION CURVE 1.000 .850 425 Grain Size, mm 250 08t. 0.100 .075 0.010 Sieve Size (mm)

75.0 #

65.0

60.0

55.0 50.0 % PASSING

85.0 # 80.0

95.0 90.0

COARSE				Sewage Lagoon and Landfill Facility - Hamlet of Kimmirut, Nunavut	FQ
MEDIUM	GRAVEI			lamlet of Kin	
II.				fill Facility - h	CANDER NO.
COARSE				oon and Land	CAMBI
MEDIUM	SAND	Modified M.I.T. Classification	, ,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	Sewage Lag	40
FINE		Modified N			. oN
COARSE				NAME & LOCATION:	RORFHOI F No.
MEDIUM	SILT			NAME &	-0.2
FINE				JTGE00018881A	15-11
 A V	C			Ď	ED:
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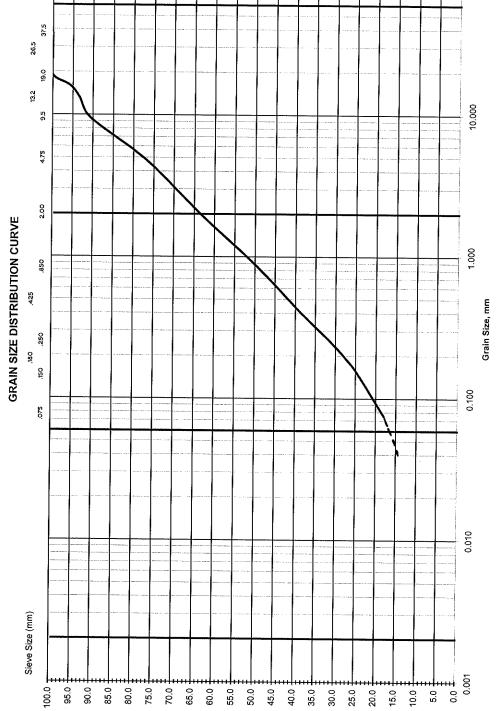
35.0 ₹

40.0

45.0 =

PROJECT:	OTGE00018881A	NAME & LOCATION:	Sewage La	Sewage Lagoon and Landfill Facility - Hamlet of Kimmirut, Nunavut	Hamlet o	f Kimmirut, Nunavut	
DATE SAMPLED:	:D: 15-Jul-07	BOREHOLE No.:	10	SAMPLE No.:	SS2	DEPTH (m):	0.6 to 1.2
SAMPLE DESCRIPTION	RIPTION:		Silt	Silty Sand, Trace Gravel			

FIGURE: 25



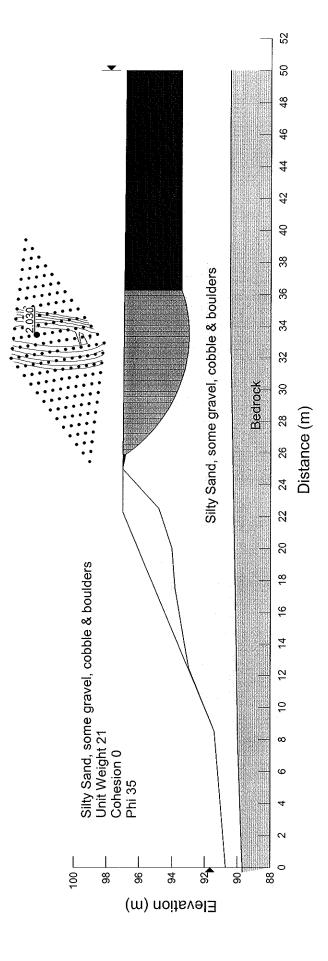
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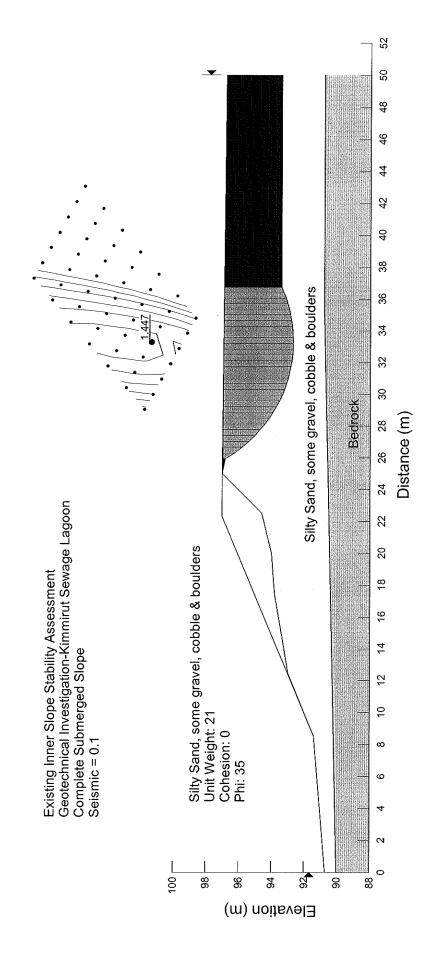
SILT COARSE		į								
SAND GRAVEL Modified M.I.T. Classification	CLAY	II N	MEDIUM	COARSE	FINE	MEDIUM	COARSE	ENE ENE	MEDIUM	COARSE
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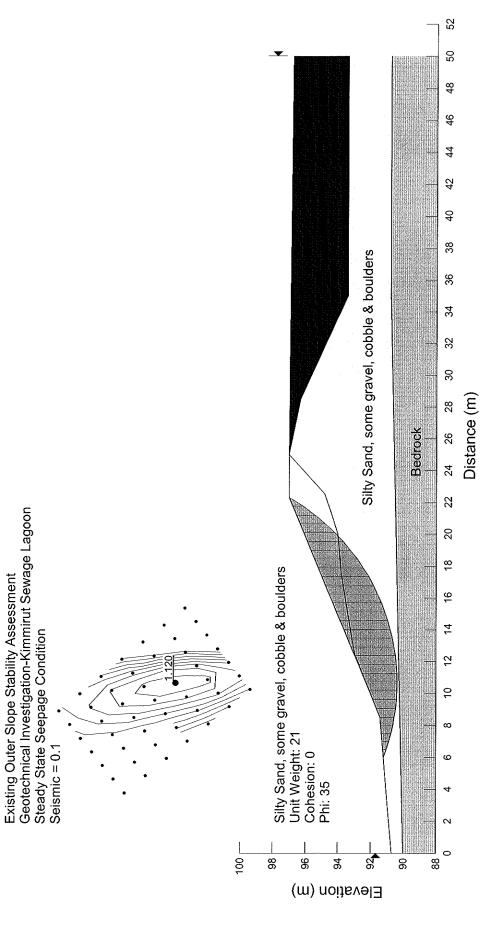
PROJECT:	OTGE00018881A	NAME & L	E & LOCATION:	Sewage Lac	Sewage Lagoon and Landfill Facility - Hamelt of Kimmirut Nunavut	v - Hamelt	of Kimmirut Nunavut	
בייניייייייייייייייייייייייייייייייייי	.0.7							
DATE SAINFLED	:D:		BOKEHOLE No.:	13	SAMPLE No.:	553	DEPTH (m):	0 40 0 5 20
ACITOGO STORY	DEDITION:						- 1	0.000
	NOT LES			2.3	Aranally Cand Comes City			
				O. O.	reny dana, donne din			

Existing Inner Slope Stability Assessment Geotechnical Investigation-Kimmirut Sewage Lagoon Complete Submerged Slope

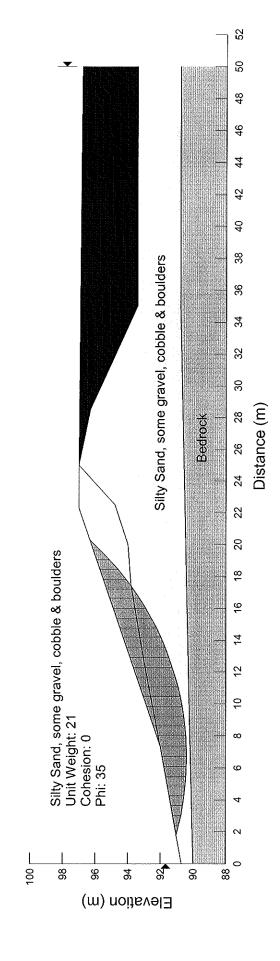




Silty Sand, some gravel, cobble & boulders Bedrock Distance (m) Existing Outer Slope Stability Assessment Geotechnical Investigation-Kimmirut Sewage Lagoon Steady State Seepage Condition Silty Sand, some gravel, cobble & boulders Unit Weight: 21 Cohesion: 0 Phi: 35 ∞ Elevation (m)



Outer Slope @ 3H:1V Stability Assessment Geotechnical Investigation-Kimmirut Sewage Lagoon Staedy State Seepage Condition



Silty Sand, some gravel, cobble & boulders Bedrock Distance (m) Outer Slope @ 3H:1V Stability Assessment Geotechnical Investigation-Kimmirut Sewage Lagoon Steady State Seepage Condition Seismic = 0.1 Silty Sand, some gravel, cobble & boulders Unit Weight: 21 Cohesion: 0 Phi: 35 ω Elevation (m)

Silty Sand, some gravel, cobble & boulders Distance (m) Bedrock Existing Inner Slope Stability Assessment Geotechnical Investigation-Kimmirut Sewage Lagoon Rapid Drawdown Case Silty Sand, some gravel, cobble & boulders Unit Weight: 21 Cohesion: 0 Phi: 35 N Elevation (m)

Existing Inner Slope Stability Assessment Geotechnical Investigation-Kimmirut Sewage Lagoon Rapid Drawdown Case Seismic = 0.1

