Trow

Geotechnical Investigation
Sewage Lagoon
Hamlet of Kimmirut, Nunavut

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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 clayey 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 #	Depth (m)	Rock Description	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	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

Borehole #	Depth (m)	Observed Temperature Readings				
		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		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
	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 ($\gamma = 21$ 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	Loading	Computed Factor of Safety	Figure #	Comments
Upstream Slope (inside)	3H:IV (existing)	Completed submerged	2.03	26	
		Completed submerged with seismic loading	1.45	27	
Downstream Slope (outside)	~2.5H:1V (existing)	Steady state seepage condition	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	3H:IV (existing)	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.

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Sept 25/07
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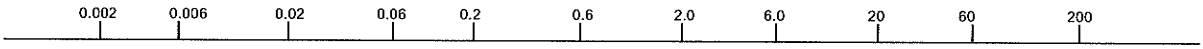
Figures

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.

ISSMFE SOIL CLASSIFICATION

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



EQUIVALENT GRAIN DIAMETER IN MILLIMETRES

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

UNIFIED SOIL CLASSIFICATION

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

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

Log of Borehole 1

Trow

Project No: OTGE00018881B

Project: Geotechnical Investigation-Sewage Lagoon & Landfill

Location: Hamlet of Kimmirut, Nunavut

Figure No. 4

Sheet No. 1 of 1

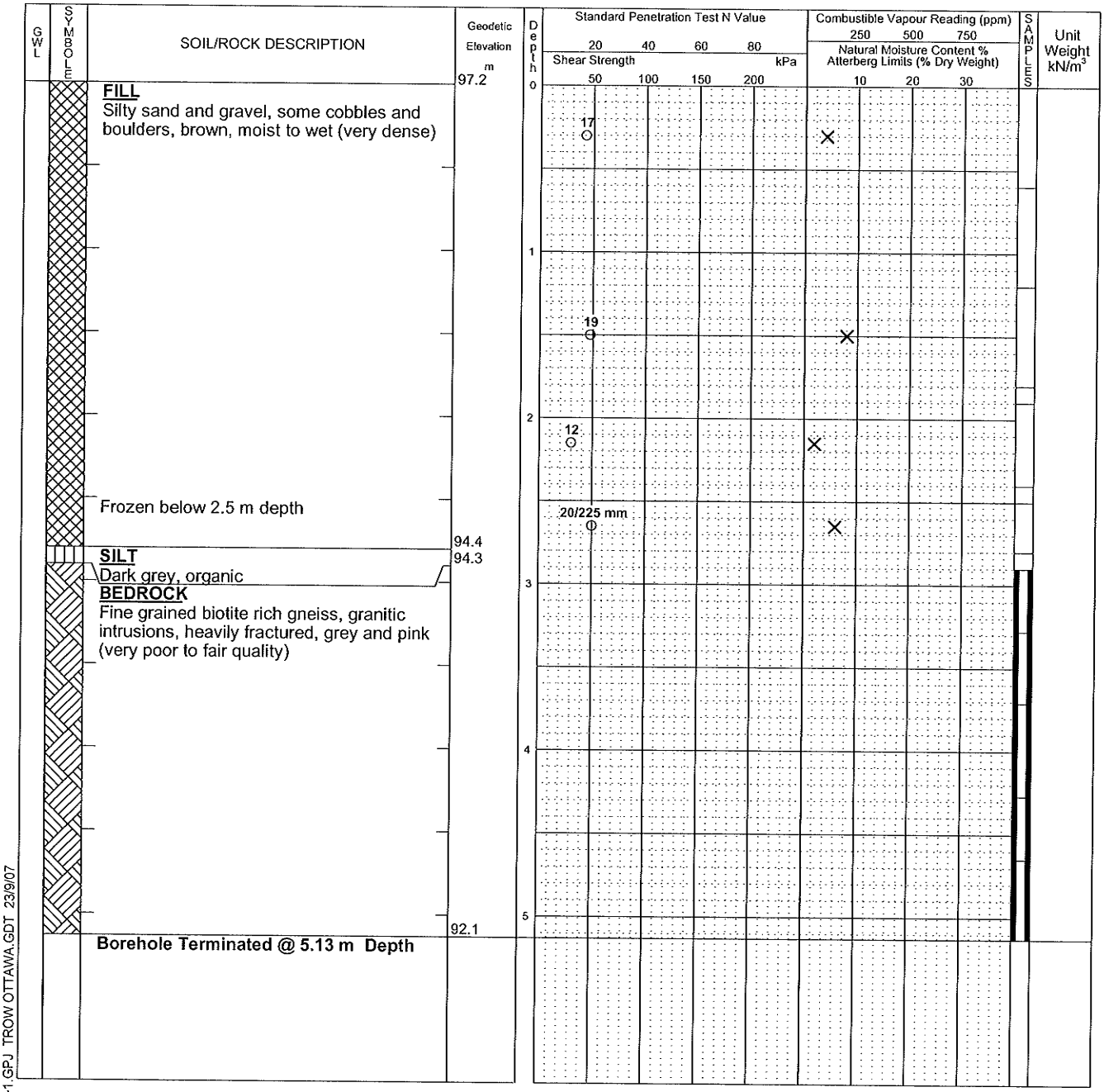
Date Drilled: 'July 12, 2007

Drill Type:

Datum: GEODETIC

Logged by: _____ Checked by: _____

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



LOG OF BOREHOLE LOGSBH-1.GPJ TROW OTTAWA.GDT 23/9/07

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

Log of Borehole 2

Trow

Project No: OTGE00018881B

Project: Geotechnical Investigation-Sewage Lagoon & Landfill

Location: Hamlet of Kimmirut, Nunavut

Figure No. 5

Sheet No. 1 of 1

Date Drilled: 'July 13, 2007

Drill Type:

Datum: GEODETIC

Logged by: Checked by:

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/ROCK DESCRIPTION	Geodetic Elevation m	Depth
		FILL Silty sand with gravel, cobbles and boulders, brown, wet (very dense)	97.2	0
			95.0	2
		BEDROCK Fine grained biotite rich gneiss, heavily fractured, grey and pink (very poor to good quality)		
			92.8	4
		Borehole Terminated @ 4.45 m Depth		

Standard Penetration Test N Value: 20 40 60 80
Shear Strength: 50 100 150 200 kPa
Combustible Vapour Reading (ppm): 250 500 750
Natural Moisture Content % Atterberg Limits (% Dry Weight): 10 20 30
SAMPLES
Unit Weight kN/m³

24 (○ at 1 m)
58 (○ at 2 m)
× at 1 m
× at 2 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 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	2.21 - 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

LOG OF BOREHOLE LOGSBH-1.GPJ TROW OTTAWA.GDT 23/9/07

Log of Borehole 3

Trow

Project No: OTGE00018881B

Project: Geotechnical Investigation-Sewage Lagoon & Landfill

Location: Hamlet of Kimmirut, Nunavut

Figure No. 6

Sheet No. 1 of 1

Date Drilled: 'July 13, 2007

Drill Type:

Datum: GEODETIC

Logged by: Checked by:

Split Spoon Sample	⊠	Combustible Vapour Reading	□
Auger Sample	◧	Natural Moisture Content	×
SPT (N) Value	O	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	SYMBOLE	SOIL/ROCK DESCRIPTION	Geodetic Elevation m	Depth
		TOPSOIL	91.4	0
		SILTY SAND	91.3	
		Some gravel, brown, moist (very dense)		
			90.3	1
		BEDROCK		
		Fine grained biotite rich gneiss, fractured, grey (poor to good quality)		2
			87.9	3
		Borehole Terminated @ 3.48 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): 10 20 30

SAMPLES

Unit Weight kN/m³

11

53/300 mm

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	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

LOG OF BOREHOLE LOGSBH-1.GPJ TROW OTTAWA.GDT 23/9/07

Log of Borehole 4

Trow

Project No: OTGE00018881B

Project: Geotechnical Investigation-Sewage Lagoon & Landfill

Location: Hamlet of Kimmirut, Nunavut

Figure No. 7

Sheet No. 1 of 1

Date Drilled: 'July 13, 2007

Drill Type:

Datum: GEODETIC

Logged by: _____ Checked by: _____

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	SYMBOLE	SOIL/ROCK DESCRIPTION	Geodetic Elevation m	Depth m	Standard Penetration Test N Value (20 40 60 80) / Shear Strength (50 100 150 200 kPa)	Combustible Vapour Reading (ppm) (250 500 750) / Natural Moisture Content % Atterberg Limits (% Dry Weight) (10 20 30)	SAMPLES	Unit Weight kN/m³
		TOPSOIL	93.5					
		SAND Fine to coarse grained, some gravel, dark brown (dense)	93.4		15 ○	×		
		Refusal to Split Spoon sampling @ 0.6 m Depth	92.9					

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	Dry	

CORE DRILLING RECORD

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

LOG OF BOREHOLE LOGSBH-1.GPJ TROW OTTAWA.GDT 23/9/07

Log of Borehole 5

Trow

Project No: OTGE00018881B

Project: Geotechnical Investigation-Sewage Lagoon & Landfill

Location: Hamlet of Kimmirut, Nunavut

Figure No. 8

Sheet No. 1 of 1

Date Drilled: 'July 12, 2007

Drill Type:

Datum: GEODETIC

Logged by: _____ Checked by: _____

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/ROCK DESCRIPTION	Geodetic Elevation m	Depth m	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) 10 20 30	SAMPLES	Unit Weight kN/m³
		SILTY SAND Organics, some gravel, dark brown	93.8	0		×		
		Refusal to Split Spoon Sampling @ 0.3 m Depth	93.5					

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	Dry	

CORE DRILLING RECORD

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

LOG OF BOREHOLE LOGSBH-1.GPJ TROW OTTAWA.GDT 23/9/07

Log of Borehole 5A

Trow

Project No: OTGE00018881B

Project: Geotechnical Investigation-Sewage Lagoon & Landfill

Location: Hamlet of Kimmirut, Nunavut

Figure No. 9

Sheet No. 1 of 1

Date Drilled: 'July 12, 2007

Drill Type:

Datum: GEODETIC

Logged by: _____ Checked by: _____

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	SYMBOLE	SOIL/ROCK DESCRIPTION	Geodetic Elevation m	Depth
		SILTY SAND Some organics, dark brown	93.4	
		Refusal to Split Spoon sampling @ 0.6 m Depth	92.8	

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): 10 20 30

SAMPLES

Unit Weight kN/m³

LOG OF BOREHOLE LOGSBH~1.GPJ TROW OTTAWA.GDT 23/9/07

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	Dry	

CORE DRILLING RECORD

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

Log of Borehole 5B

Trow

Project No: OTGE00018881B

Project: Geotechnical Investigation-Sewage Lagoon & Landfill

Location: Hamlet of Kimmirut, Nunavut

Figure No. 10

Sheet No. 1 of 1

Date Drilled: 'July 13, 2007

Drill Type:

Datum: GEODETIC

Logged by: _____ Checked by: _____

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/ROCK DESCRIPTION	Geodetic Elevation m	Depth
		TOPSOIL	93.5	0
		SILTY SAND Some gravel, occassional cobbles and boulders,brown brown, moist	93.4	
			90.8	
		GRANITE BEDROCK Fine to coarse grained, grey massive biotite rich (poor to fair quality)		3
			88.7	4
		Borehole Terminated @ 4.8 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): 10 20 30

SAMPLES

Unit Weight kN/m³

LOG OF BOREHOLE LOGSBH-1.GPJ TROW OTTAWA.GDT 23/9/07

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	2.69 - 3.1	100	28
2	3.1 - 3.91	78	66
3	3.91 - 4.78	74	51

Log of Borehole 6

Trow

Project No: OTGE00018881B

Project: Geotechnical Investigation-Sewage Lagoon & Landfill

Location: Hamlet of Kimmirut, Nunavut

Figure No. 11

Sheet No. 1 of 1

Date Drilled: 'July 13, 2007

Drill Type:

Datum: GEODETIC

Logged by: _____ Checked by: _____

Split Spoon Sample	⊠	Combustible Vapour Reading	□
Auger Sample	◧	Natural Moisture Content	×
SPT (N) Value	o	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/ROCK DESCRIPTION	Geodetic Elevation m	Depth m	Standard Penetration Test N Value / Shear Strength kPa	Combustible Vapour Reading (ppm) / Natural Moisture Content % / Atterberg Limits (% Dry Weight)	SAMPLES	Unit Weight kN/m³
		TOPSOIL	93.7	0	20 40 60 80 / 50 100 150 200 kPa	250 500 750 / 10 20 30		
		SILTY SAND Organics, some gravel, brown	93.6			×		
		Refusal to Split Spoon Sampling @ 0.5 m Depth	93.2					

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	Dry	

CORE DRILLING RECORD

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

LOG OF BOREHOLE LOGSBH-1.GPJ TROW OTTAWA.GDT 23/9/07

Log of Borehole 6A

Trow

Project No: OTGE00018881B

Project: Geotechnical Investigation-Sewage Lagoon & Landfill

Location: Hamlet of Kimmirut, Nunavut

Figure No. 12

Sheet No. 1 of 1

Date Drilled: 'July 13, 2007

Drill Type:

Datum: GEODETIC

Logged by: Checked by:

Split Spoon Sample	⊠	Combustible Vapour Reading	□
Auger Sample	◧	Natural Moisture Content	×
SPT (N) Value	o	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/ROCK DESCRIPTION	Geodetic Elevation m	Depth m	Standard Penetration Test N Value / Shear Strength kPa	Combustible Vapour Reading (ppm) / Natural Moisture Content % / Atterberg Limits (% Dry Weight)	SAMPLES	Unit Weight kN/m³
		TOPSOIL	93.8					
		TOPSOIL Silty sand	93.8		30	×		
		TOPSOIL FROZEN	93.2					
		SILTY SAND	93.1		14	×		
		Refusal to Split Spoon Sampling @ 0.9 m Depth	92.9					

LOG OF BOREHOLE LOGSBH-1.GPJ TROW OTTAWA.GDT 23/9/07

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	Dry	

CORE DRILLING RECORD

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

Log of Borehole 7

Trow

Project No: OTGE00018881B

Project: Geotechnical Investigation-Sewage Lagoon & Landfill

Location: Hamlet of Kimmirut, Nunavut

Figure No. 13

Sheet No. 1 of 1

Date Drilled: 'July 16, 2007

Drill Type:

Datum: GEODETIC

Logged by: _____ Checked by: _____

Split Spoon Sample	⊠	Combustible Vapour Reading	□
Auger Sample	◨	Natural Moisture Content	×
SPT (N) Value	o	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/ROCK DESCRIPTION	Geodetic Elevation m	Depth
		TOPSOIL	94.1	0
		SILTY SAND Some gravel, organics, trace clay, dark brown, moist	94.0	
		Frozen below 1.2 m depth		1
				2
			91.4	
		SILTY SAND Organics, black	91.2	
		BEDROCK Fine grained biotite rich gneiss with fine grained granitic intrusions, fractured, grey and pink		3
				4
			89.0	5
		Borehole Terminated @5.1 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): 10 20 30

SAMPLES

Unit Weight kN/m³

9 (o) at 0.5 m; 12 (o) at 1.0 m; 12 (o) at 1.5 m

× at 0.5 m; × at 1.0 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 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	3.35 - 3.94	96	50
2	3.94 - 4.42	84	61
3	4.42 - 5.08	100	73

LOG OF BOREHOLE LOGSBH-1.GPJ TROW OTTAWA.GDT 23/9/07

Log of Borehole 8

Trow

Project No: OTGE00018881B

Project: Geotechnical Investigation-Sewage Lagoon & Landfill

Location: Hamlet of Kimmirut, Nunavut

Figure No. 14

Sheet No. 1 of 1

Date Drilled: 'July 16, 2007

Drill Type:

Datum: GEODETIC

Logged by: Checked by:

Split Spoon Sample	⊠	Combustible Vapour Reading	□
Auger Sample	◧	Natural Moisture Content	×
SPT (N) Value	o	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/ROCK DESCRIPTION	Geodetic Elevation m	Depth
		TOPSOIL	94.1	0
		SILTY SAND Some gravel, occassional cobbles and boulders, dark brown, moist	94.0	
		CLAYEY SILTY SAND Some gravel, grey	92.6	
		BEDROCK Fine grained biotite rich gneiss with coarse grained granitic intrusions, fractured, grey and pink (very poor to fair quality)	92.3	2
		Borehole Terminated @ 3.89 m Depth	90.2	3

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): 10 20 30

SAMPLES

Unit Weight kN/m³

4 8 14

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	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

LOG OF BOREHOLE LOGSBH-1.GPJ TROW OTTAWA.GDT 23/9/07

Log of Borehole 9

Trow

Project No: OTGE00018881B

Project: Geotechnical Investigation-Sewage Lagoon & Landfill

Location: Hamlet of Kimmirut, Nunavut

Figure No. 15

Sheet No. 1 of 1

Date Drilled: 'July 15, 2007

Drill Type:

Datum: GEODETIC

Logged by: _____ Checked by: _____

Split Spoon Sample	⊠	Combustible Vapour Reading	□
Auger Sample	▯▯	Natural Moisture Content	×
SPT (N) Value	o	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/ROCK DESCRIPTION	Geodetic Elevation m	Depth m	Standard Penetration Test N Value / Shear Strength kPa	Combustible Vapour Reading (ppm) / Natural Moisture Content % / Atterberg Limits (% Dry Weight)	SAMPLES	Unit Weight kN/m³
		SILTY SAND Some gravel, trace organics, dark brown, wet	101.6	0	18, 26			
		Refusal to Split Spoon Sampling @ 1.2 m Depth	100.4	1				

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	Dry	

CORE DRILLING RECORD

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

LOG OF BOREHOLE LOGSBH-1.GPJ TROW OTTAWA.GDT 23/9/07

Log of Borehole 10

Trow

Project No: OTGE00018881B

Project: Geotechnical Investigation-Sewage Lagoon & Landfill

Location: Hamlet of Kimmirut, Nunavut

Figure No. 16

Sheet No. 1 of 1

Date Drilled: 'July 15, 2007

Drill Type:

Datum: GEODETIC

Logged by: Checked by:

Split Spoon Sample	⊠	Combustible Vapour Reading	□
Auger Sample	▮	Natural Moisture Content	×
SPT (N) Value	O	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	SYMBOLE	SOIL/ROCK DESCRIPTION	Geodetic Elevation m	Depth
		TOPSOIL	101.1	0
		Silty sand and gravel, some cobbles and boulders, brown, moist to wet (very dense)	101.0	
		SILTY SAND		
		Some organics, trace gravel, dark brown, moist		
		Frozen below 1.5 m depth		1
			99.4	
		BEDROCK		2
		Micaeous mable with pyroxene, massive, grey, medium grained		
			97.4	3
		Borehole Terminated @ 3.7 m Depth		

Standard Penetration Test N Value: 20 40 60 80

Shear Strength: 50 100 150 200 kPa

Combustible Vapour Reading (ppm): 250 500 750

Natural Moisture Content % Atterberg Limits (% Dry Weight): 10 20 30

SAMPLES

Unit Weight kN/m³

4 O

9 O

0/100 mm O

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	1.8 - 3.7	97	88

LOG OF BOREHOLE LOGSBH-1.GPJ TROW OTTAWA.GDT 23/9/07

Log of Borehole 11

Trow

Project No: OTGE00018881B

Project: Geotechnical Investigation-Sewage Lagoon & Landfill

Location: Hamlet of Kimmirut, Nunavut

Figure No. 17

Sheet No. 1 of 1

Date Drilled: 'July 15, 2007

Drill Type:

Datum: GEODETIC

Logged by: _____ Checked by: _____

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/ROCK DESCRIPTION	Geodetic Elevation m	Depth m	Standard Penetration Test N Value / Shear Strength kPa	Combustible Vapour Reading (ppm) / Natural Moisture Content % / Atterberg Limits (% Dry Weight)	SAMPLES	Unit Weight kN/m³
		TOPSOIL Silty sand and gravel, some cobbles and boulders, brown, moist to wet (very dense)	101.1	0	20 40 60 80 / 50 100 150 200	250 500 750 / 10 20 30		
		SILTY SAND Some organics, trace gravel, dark brown, moist	100.9		3 ○	×		
		Frozen below 0.9 m depth			30 ○	×		
			99.9	1				
		Borehole Terminated @ 1.2 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 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	Dry	

CORE DRILLING RECORD

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

LOG OF BOREHOLE LOGSBH-1.GPJ TROW OTTAWA.GDT 23/9/07

Log of Borehole 12

Trow

Project No: OTGE00018881B

Project: Geotechnical Investigation-Sewage Lagoon & Landfill

Location: Hamlet of Kimmirut, Nunavut

Figure No. 18

Sheet No. 1 of 1

Date Drilled: 'July 14, 2007

Drill Type:

Datum: GEODETIC

Logged by: Checked by:

Split Spoon Sample	⊠	Combustible Vapour Reading	□
Auger Sample	▯	Natural Moisture Content	×
SPT (N) Value	O	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	SYMBOLE	SOIL/ROCK DESCRIPTION	Geodetic Elevation m	Depth
		FILL Silty sand with gravel and cobbles, brown, moist to wet	61.1	0
			59.9	1
		BEDROCK Micaeous marble with pyroxene, coarse grained, slightly fractured, (very poor to good quality)		
			58.3	2
		Refusal to Split Spoon sampling @ 2.8 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): 10 20 30

SAMPLES

Unit Weight kN/m³

11 O

15 O

LOG OF BOREHOLE LOGSBH-1.GPJ TROW OTTAWA.GDT 23/9/07

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	1.2 - 1.7	88	65
2	1.7 - 2.18	76	0
3	2.18 - 2.77	83	83

Log of Borehole 13

Trow

Project No: OTGE00018881B

Project: Geotechnical Investigation-Sewage Lagoon & Landfill

Location: Hamlet of Kimmirut, Nunavut

Figure No. 19

Sheet No. 1 of 1

Date Drilled: 'July 14, 2007

Drill Type:

Datum: GEODETIC

Logged by: _____ Checked by: _____

Split Spoon Sample	⊠	Combustible Vapour Reading	□
Auger Sample	◧	Natural Moisture Content	×
SPT (N) Value	o	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/ROCK DESCRIPTION	Geodetic Elevation m	Depth m	Standard Penetration Test N Value / Shear Strength kPa (20 40 60 80; 50 100 150 200)	Combustible Vapour Reading (ppm) (250 500 750) / Natural Moisture Content % Atterberg Limits (% Dry Weight) (10 20 30)	SAMPLES	Unit Weight kN/m³
		FILL Silty sand with gravel, brown, moist	61.5	0	5	×		
		Piece of fabric liner at approximate 0.6 m depth			21	×		
			60.4	1				
		Refusal to Split Spoon Sampling @ 1.1 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 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	Dry	

CORE DRILLING RECORD

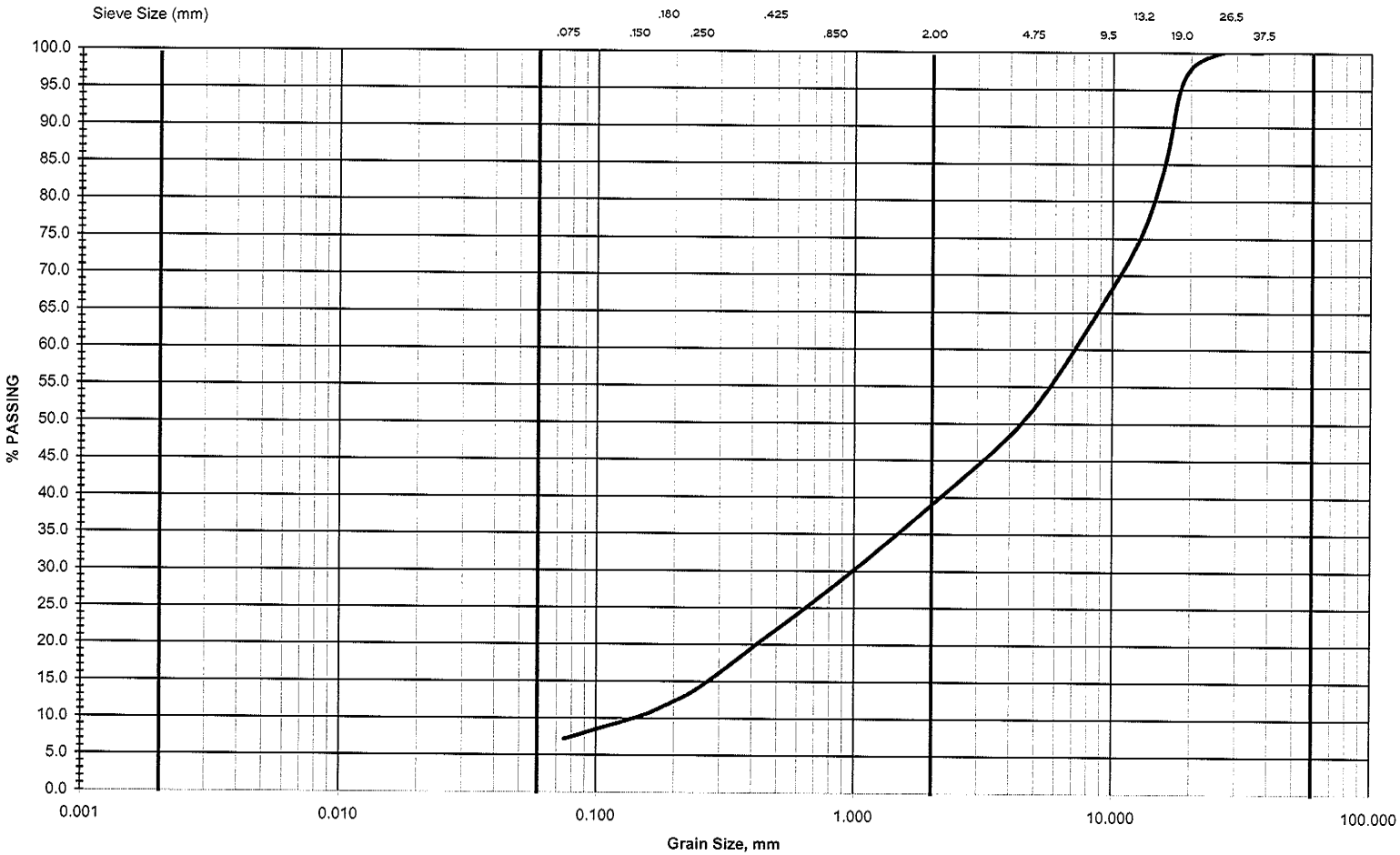
Run No.	Depth (m)	% Rec.	RQD %

LOG OF BOREHOLE LOGSBH-1.GPJ TROW OTTAWA.GDT 23/9/07

Trow

FIGURE: 20

GRAIN SIZE DISTRIBUTION CURVE



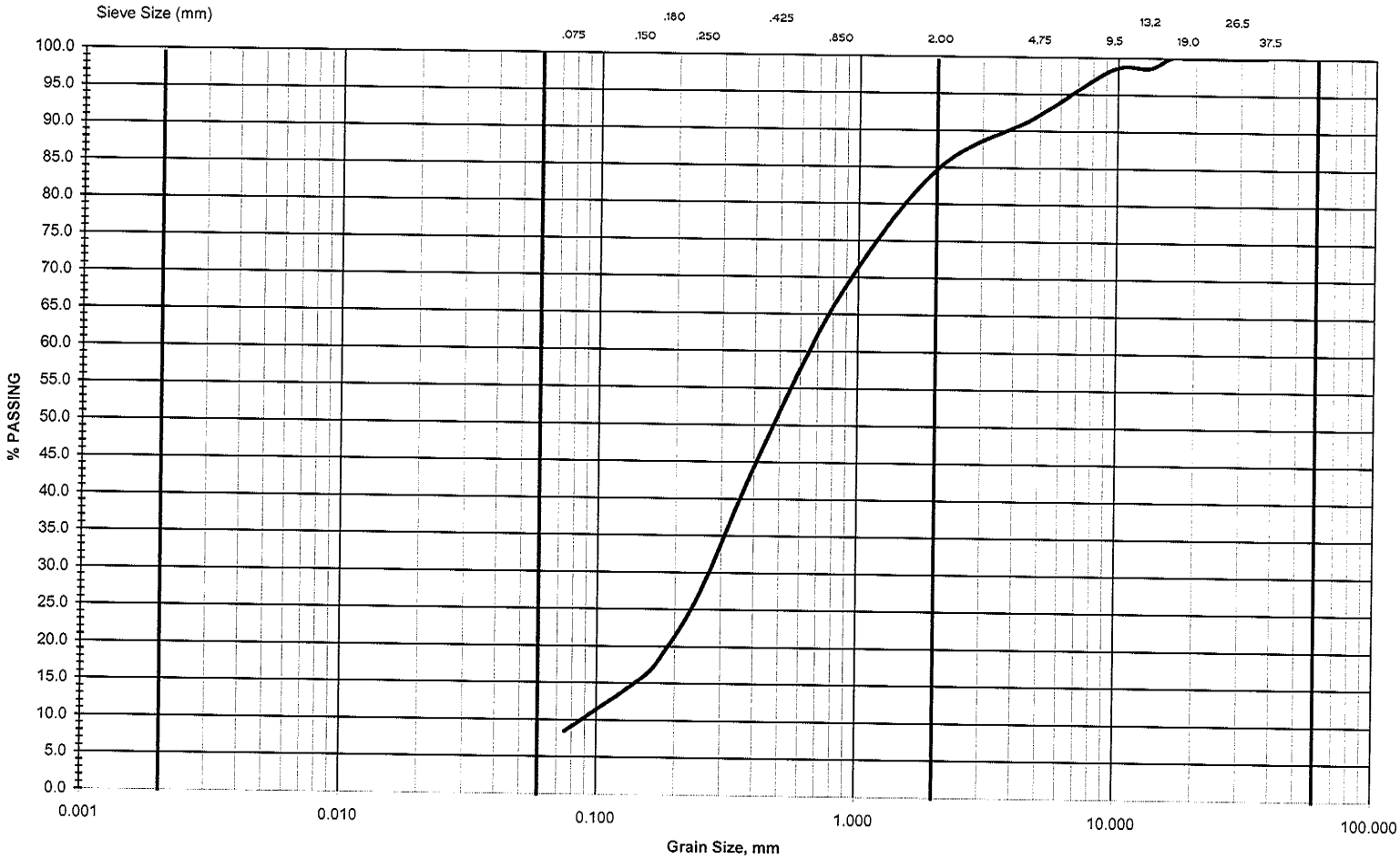
CLAY	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE
	SILT			SAND			GRAVEL		
Modified M.I.T. Classification									

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

Trow

FIGURE: 21

GRAIN SIZE DISTRIBUTION CURVE



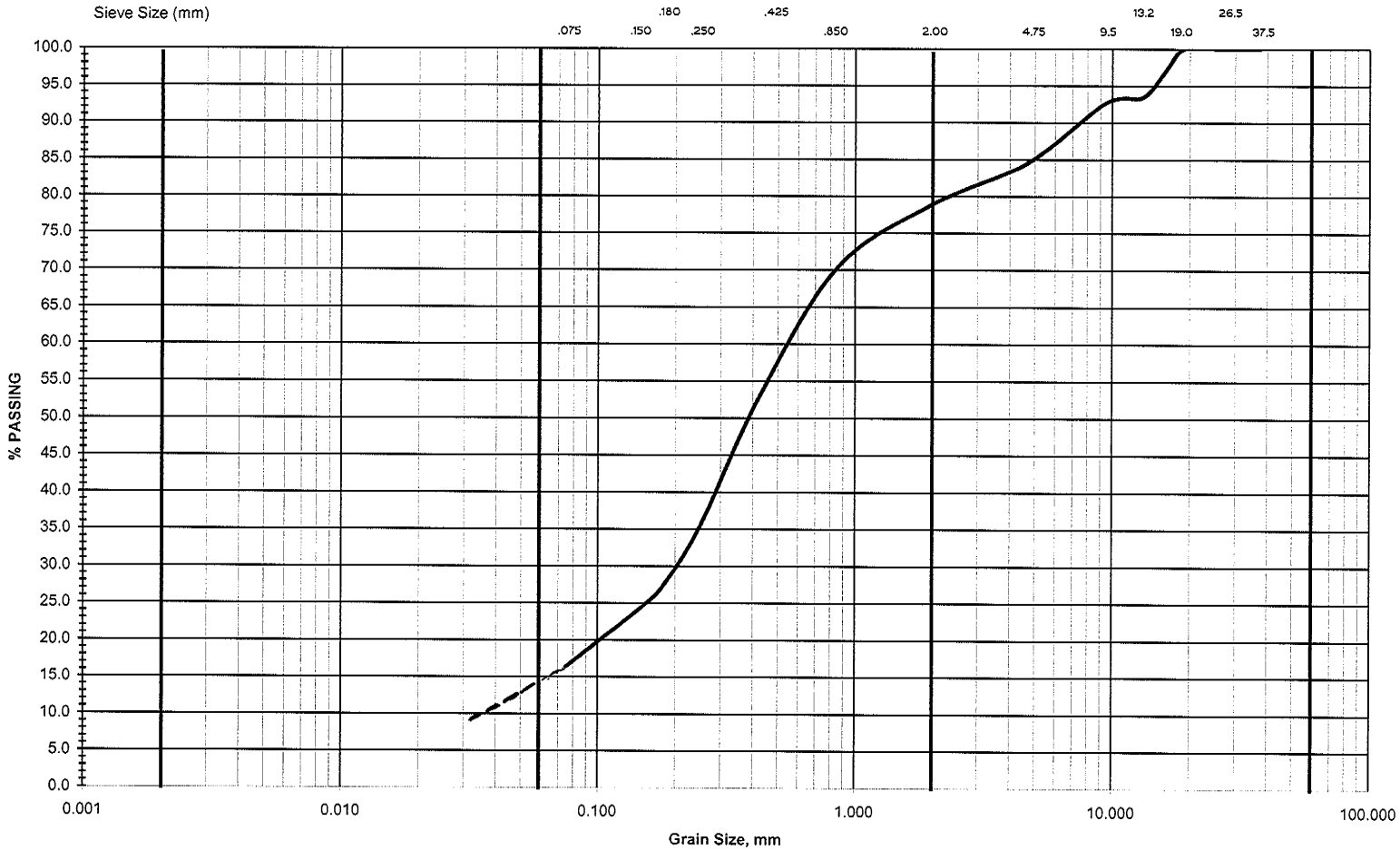
CLAY	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE
	SILT			SAND			GRAVEL		
Modified M.I.T. Classification									

PROJECT :	**OTGE00018881A**	NAME & LOCATION:	**Sewage Lagoon and Landfill Facility - Hamlet of Kimmirut, Nunavut**		
DATE SAMPLED:	12-Jul-07	BOREHOLE No.:	**5A**	SAMPLE No.: **SS1A**	DEPTH (m): **0 to 0.6**
SAMPLE DESCRIPTION:	**Sand, Some Gravel, Trace Silt**				

Trow

FIGURE: 22

GRAIN SIZE DISTRIBUTION CURVE



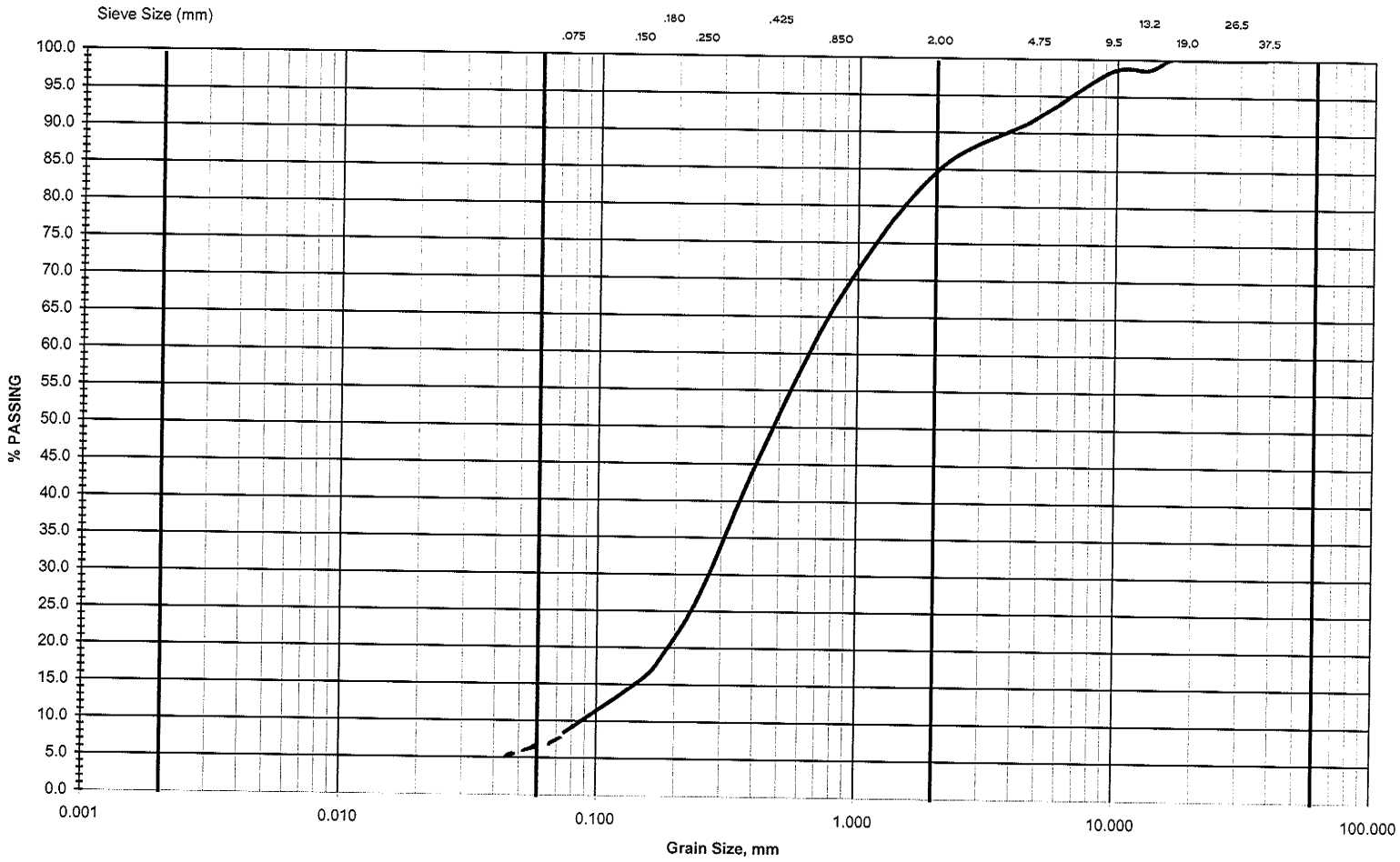
CLAY	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE
	SILT			SAND			GRAVEL		
Modified M.I.T. Classification									

PROJECT :	**OTGE00018881A**	NAME & LOCATION:	**Sewage Lagoon and Landfill Facility - Hamlet of Kimmirut, Nunavut**				
DATE SAMPLED:	13-Jul-07	BOREHOLE No.:	**6A**	SAMPLE No.:	**SS2**	DEPTH (m):	**0.6 to 0.9**
SAMPLE DESCRIPTION:	**Gravelly Sand, Some Silt**						

Trow

FIGURE: 23

GRAIN SIZE DISTRIBUTION CURVE



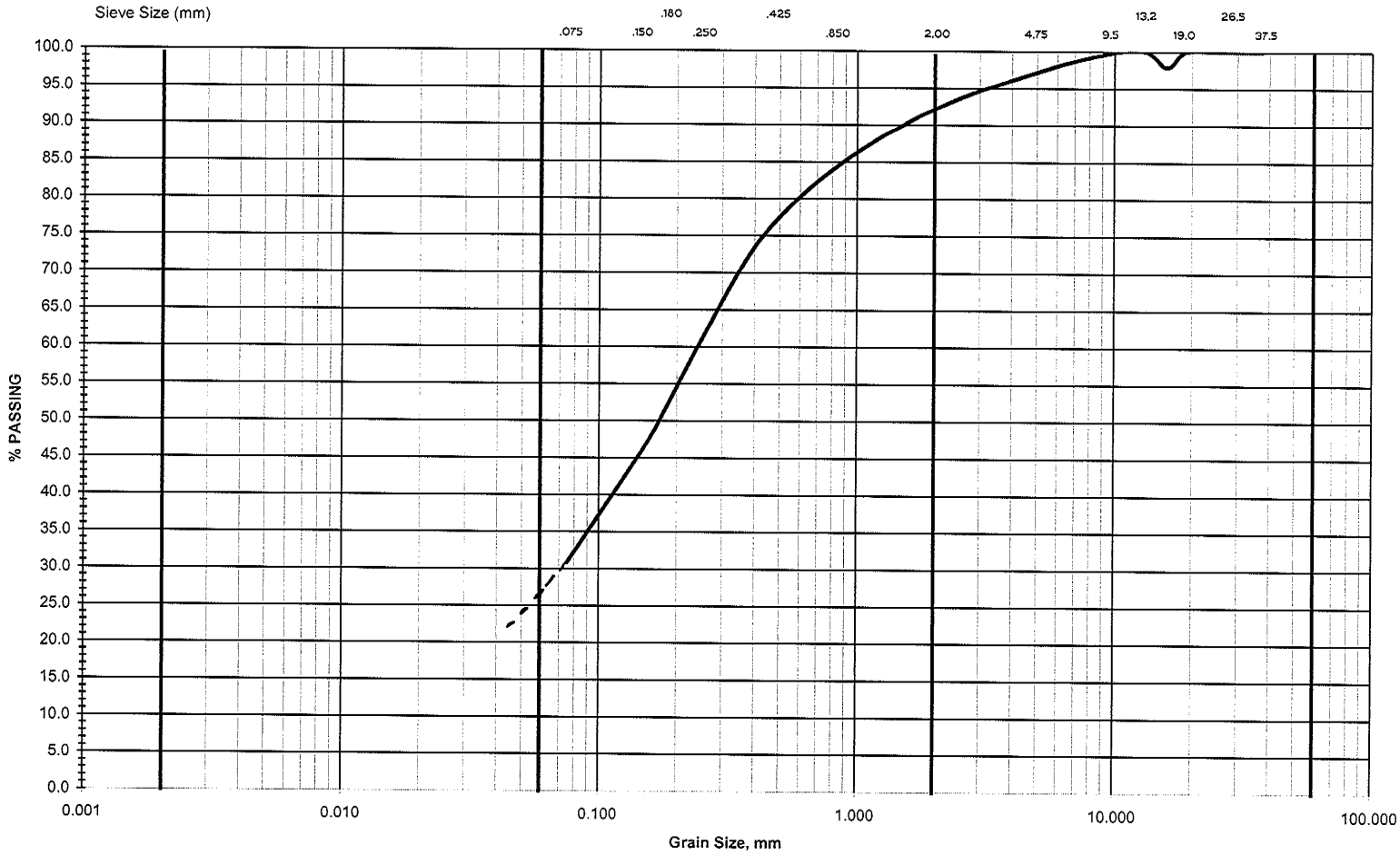
CLAY	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE
	SILT			SAND			GRAVEL		
Modified M.I.T. Classification									

PROJECT :	**OTGE00018881A**	NAME & LOCATION:	**Sewage Lagoon and Landfill Facility - Hamlet of Kimmirut, Nunavut**		
DATE SAMPLED:	12-Jul-07	BOREHOLE No.:	**5A**	SAMPLE No.: **SS1A**	DEPTH (m): **0 to 0.6**
SAMPLE DESCRIPTION:	**Sand, Some Gravel, Trace Silt**				

Trow

FIGURE: 24

GRAIN SIZE DISTRIBUTION CURVE



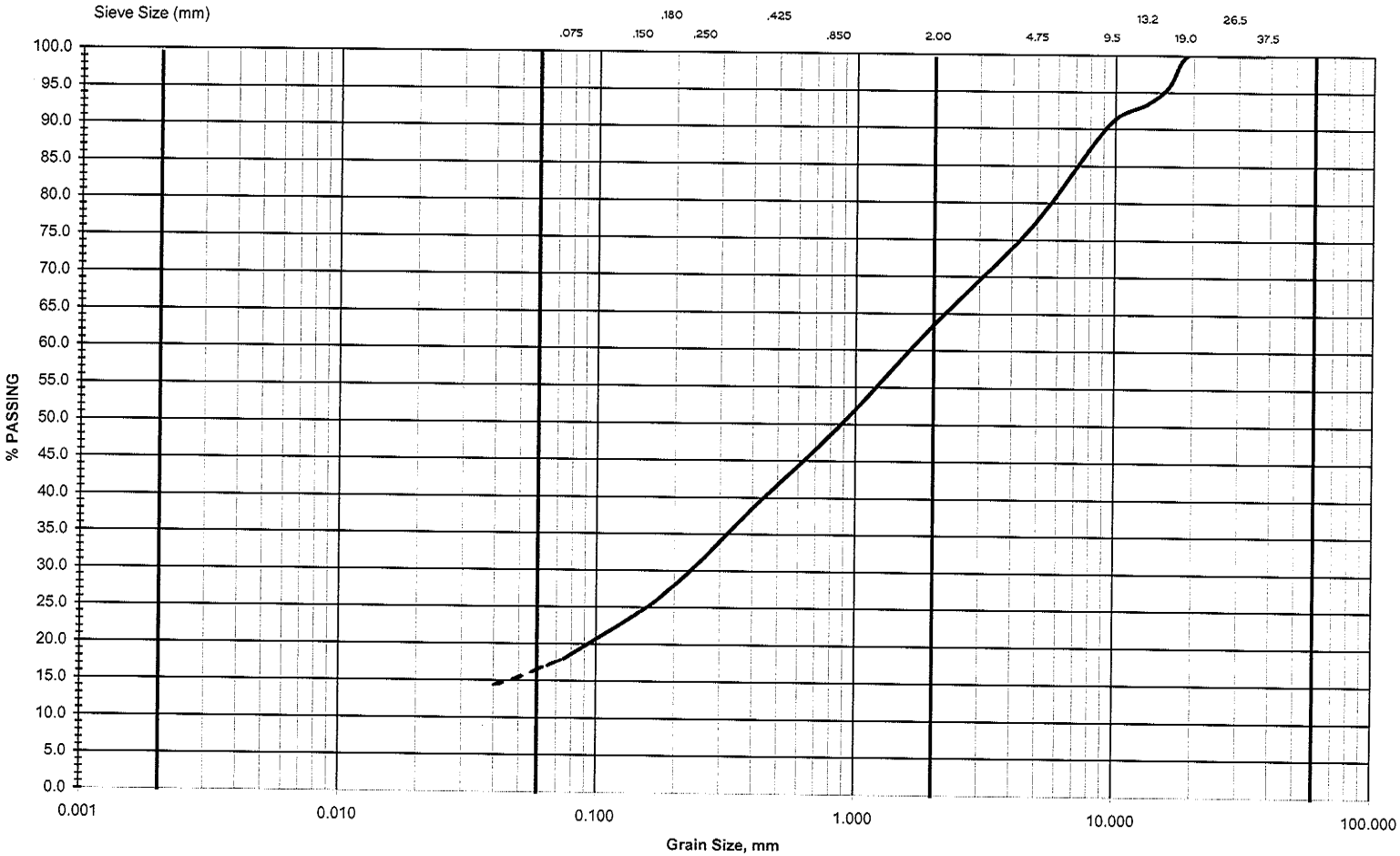
CLAY	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE
	SILT			SAND			GRAVEL		
Modified M.I.T. Classification									

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

Trow

FIGURE: 25

GRAIN SIZE DISTRIBUTION CURVE



CLAY	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE	FINE	MEDIUM	COARSE
	SILT			SAND			GRAVEL		
Modified M.I.T. Classification									

PROJECT :	**OTGE00018881A**	NAME & LOCATION:	**Sewage Lagoon and Landfill Facility - Hamelt of Kimmirut, Nunavut**				
DATE SAMPLED:	12-Jul-07	BOREHOLE No.:	**13**	SAMPLE No.:	**SS1**	DEPTH (m):	**0 to 0.6 m**
SAMPLE DESCRIPTION:	**Gravelly Sand, Some Silt**						

Figure 26

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

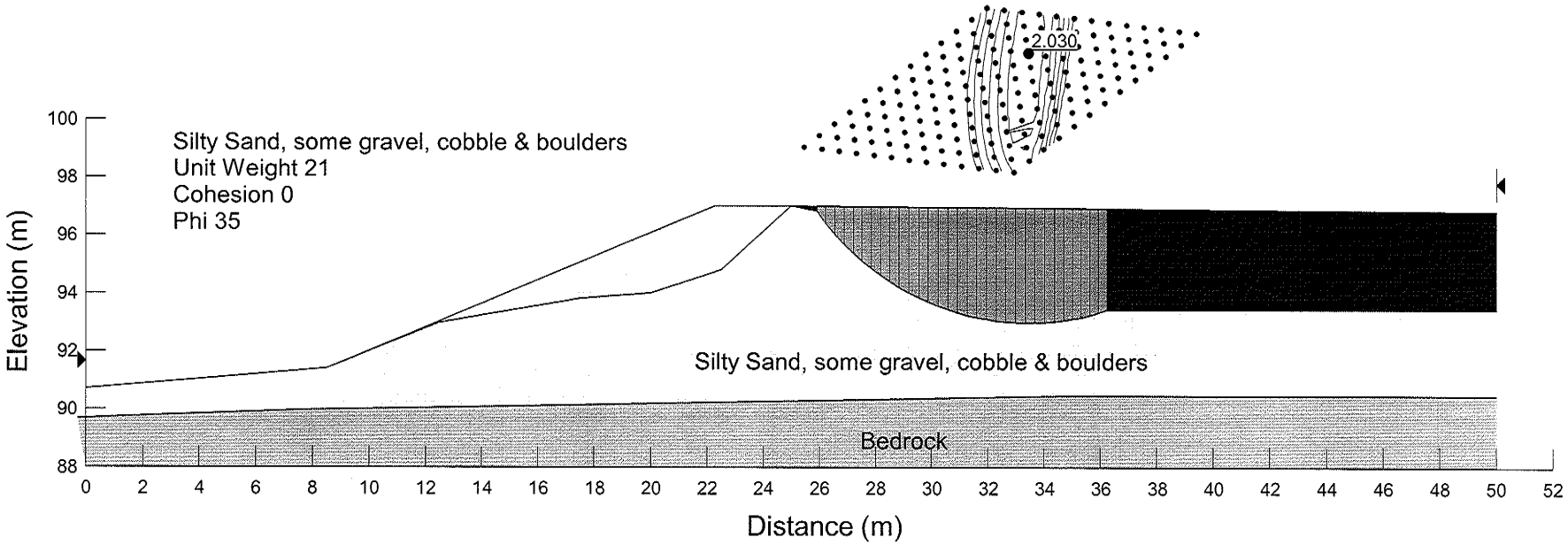


Figure 27

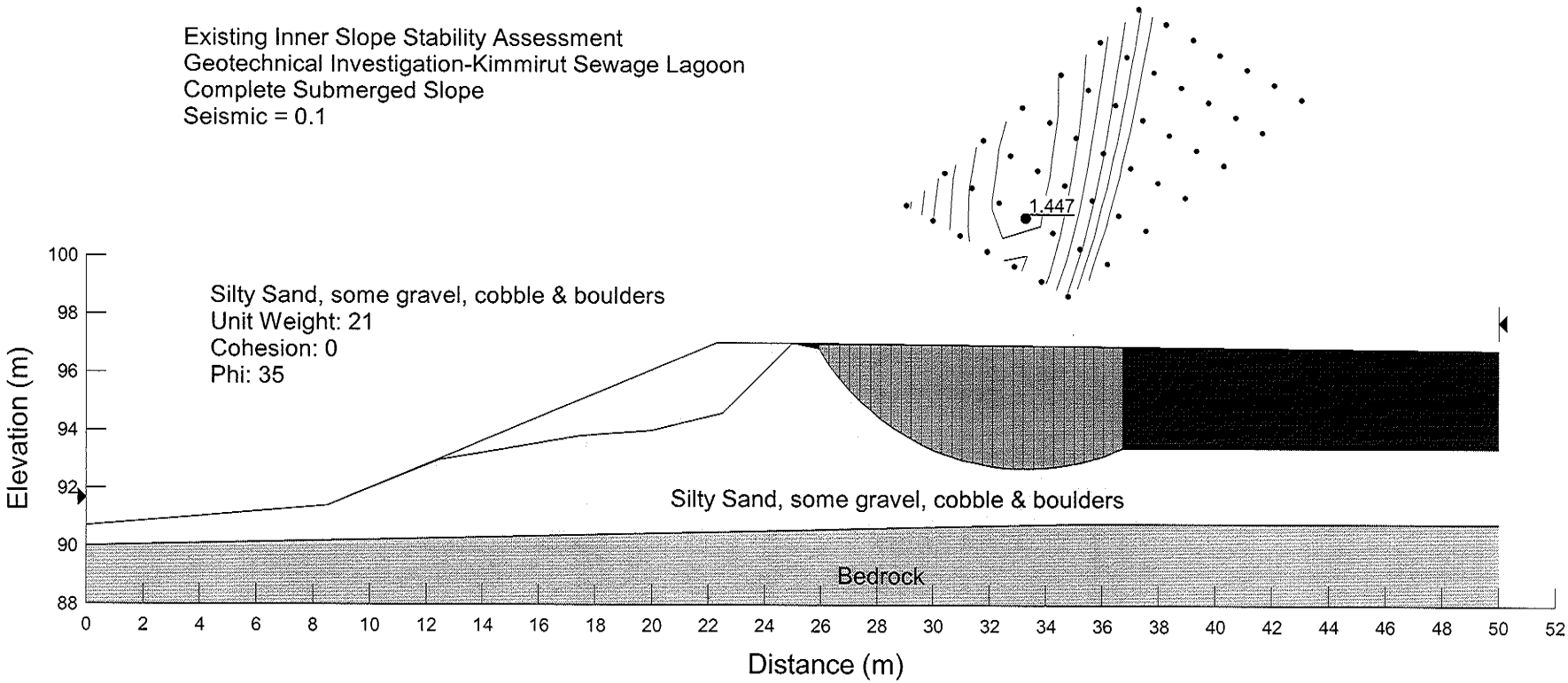

Existing Inner Slope Stability Assessment
Geotechnical Investigation-Kimmirut Sewage Lagoon
Complete Submerged Slope
Seismic = 0.1
1.447
Silty Sand, some gravel, cobble & boulders
Unit Weight: 21
Cohesion: 0
Phi: 35
Silty Sand, some gravel, cobble & boulders
Bedrock
Elevation (m)
100
98
96
94
92
90
88
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52
Distance (m)

Figure 28

Existing Outer Slope Stability Assessment
Geotechnical Investigation-Kimmirut Sewage Lagoon
Steady State Seepage Condition

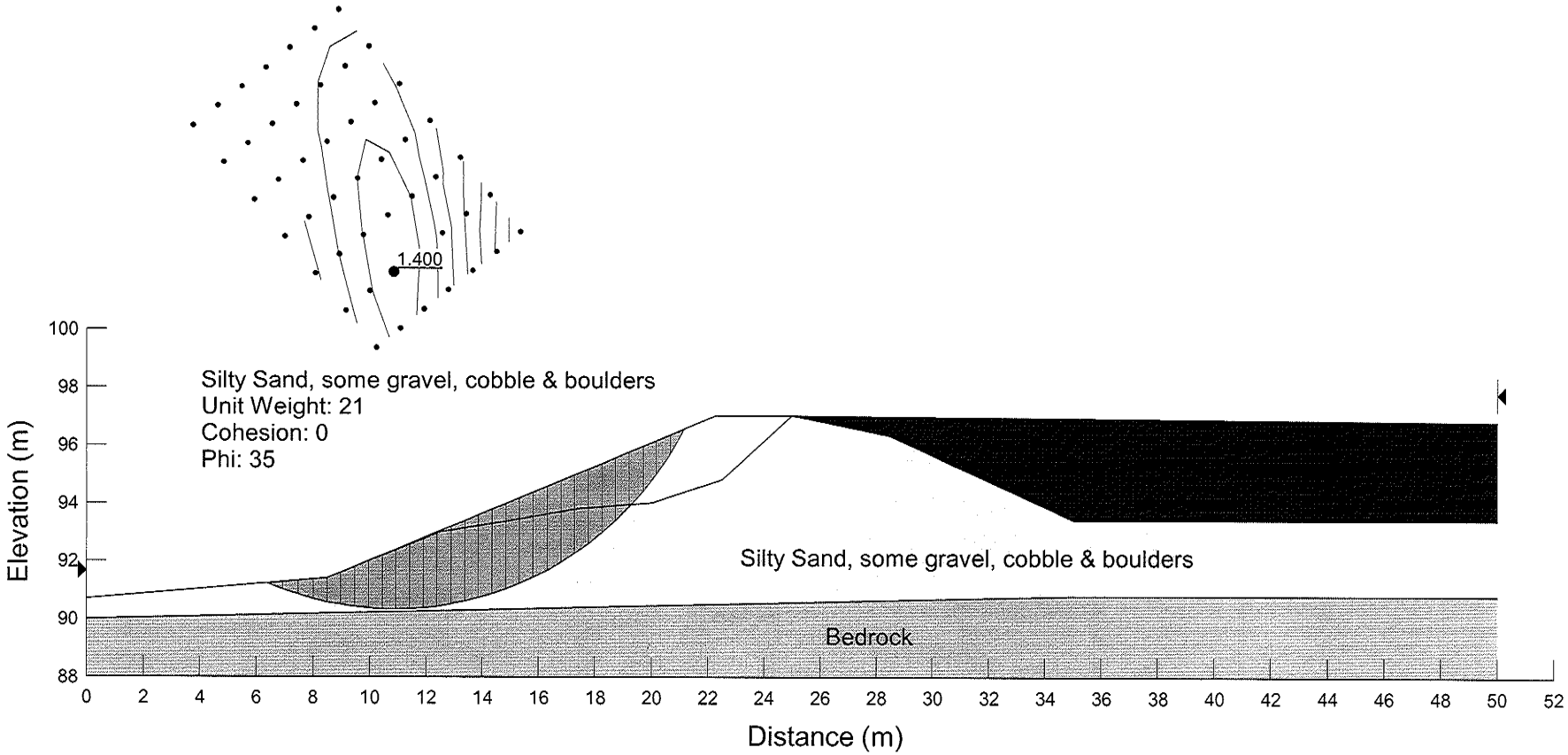
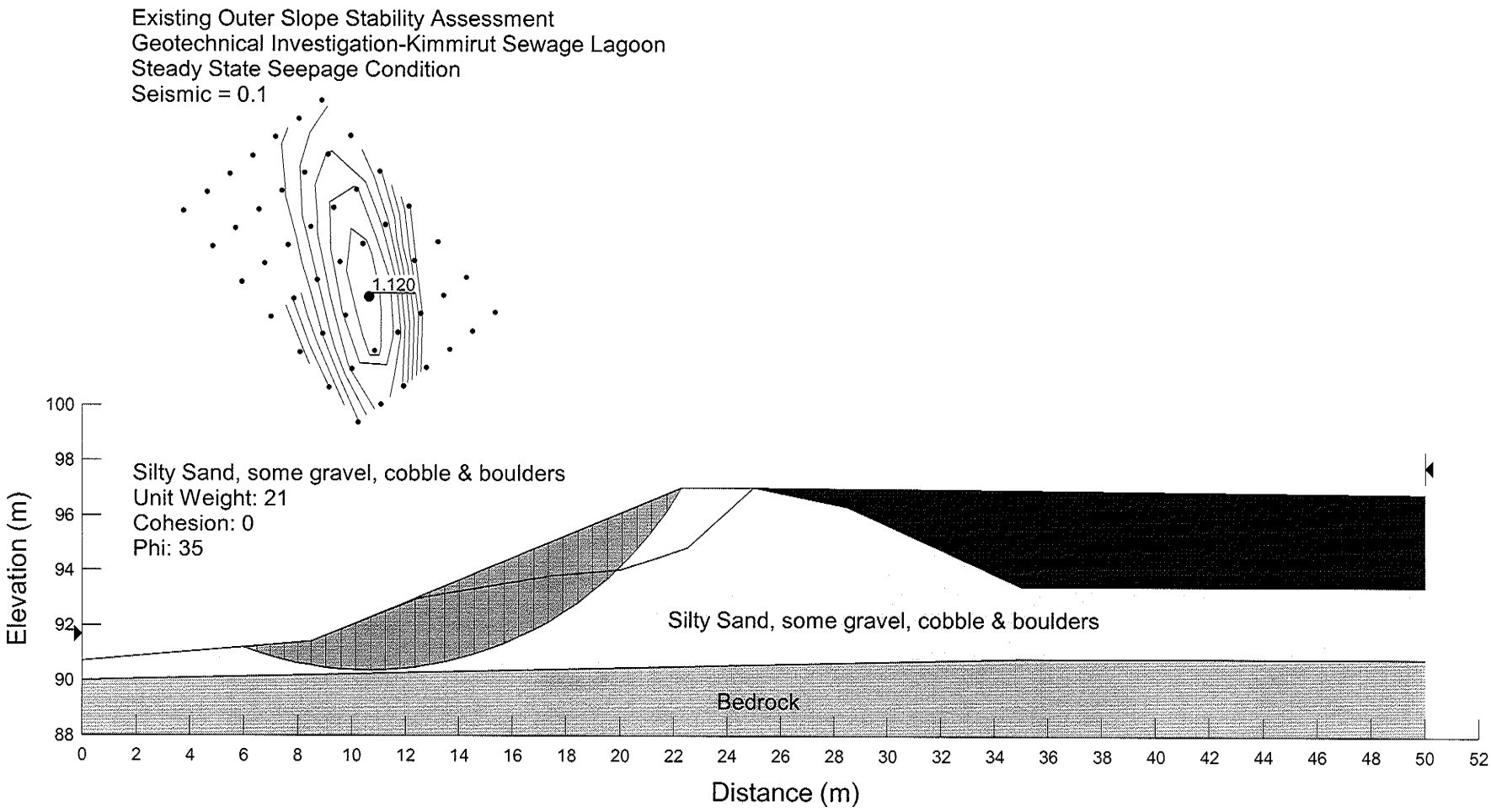
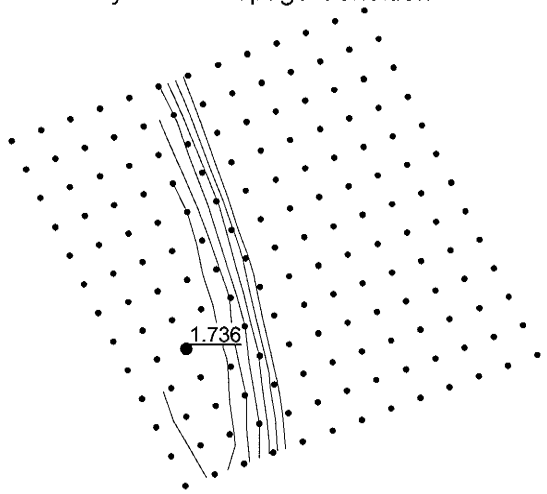
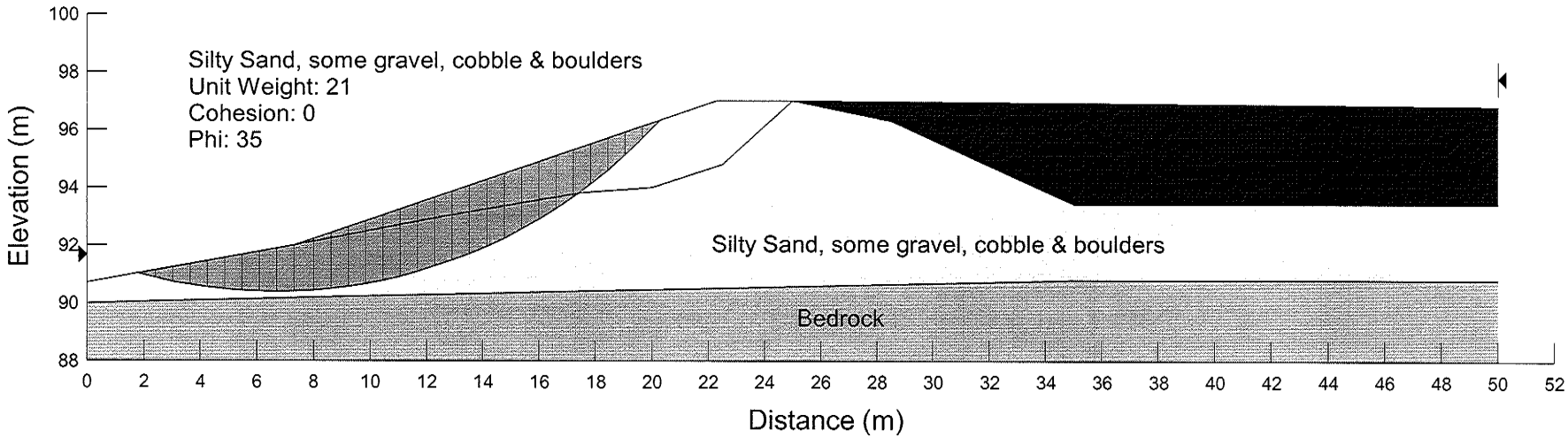


Figure 29

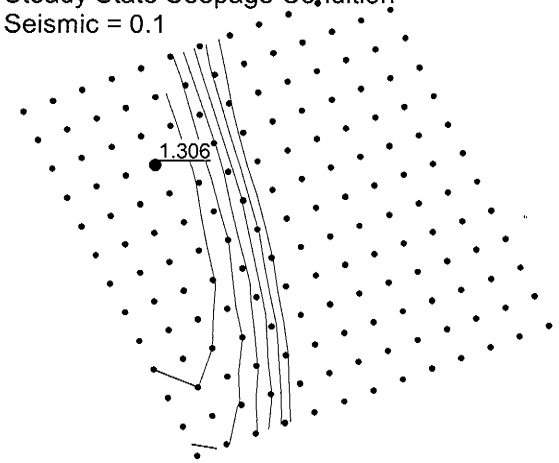

Existing Outer Slope Stability Assessment
Geotechnical Investigation-Kimmirut Sewage Lagoon
Steady State Seepage Condition
Seismic = 0.1
1.120
Silty Sand, some gravel, cobble & boulders
Unit Weight: 21
Cohesion: 0
Phi: 35
Silty Sand, some gravel, cobble & boulders
Bedrock
Elevation (m)
Distance (m)
100
98
96
94
92
90
88
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
44
46
48
50
52

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





Outer Slope @ 3H:1V Stability Assessment
Geotechnical Investigation-Kimmirut Sewage Lagoon
Steady State Seepage Condition
Seismic = 0.1



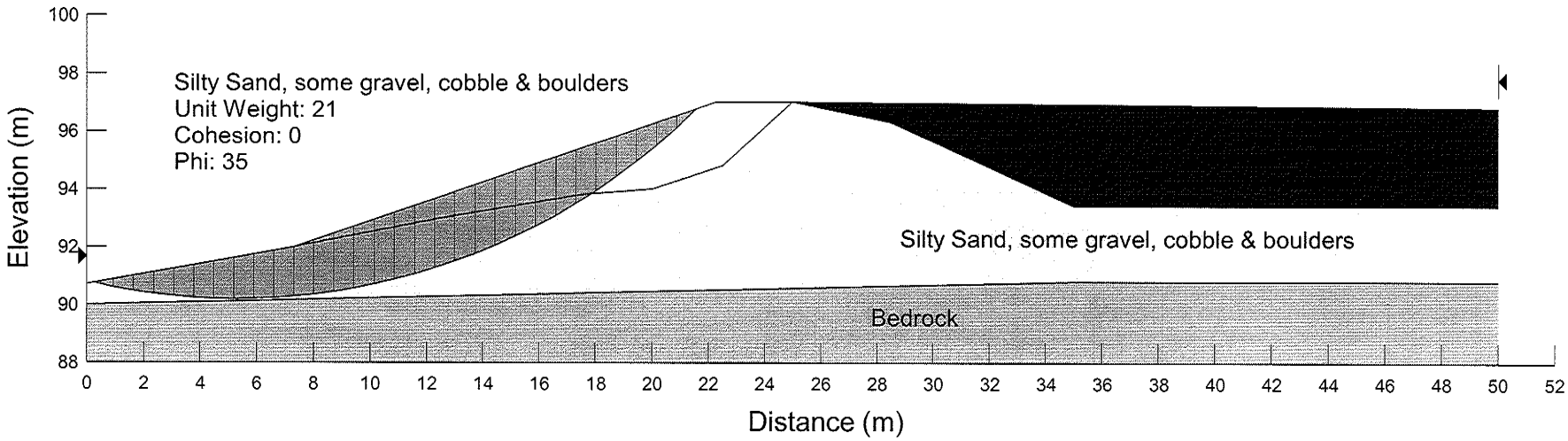


Figure 32

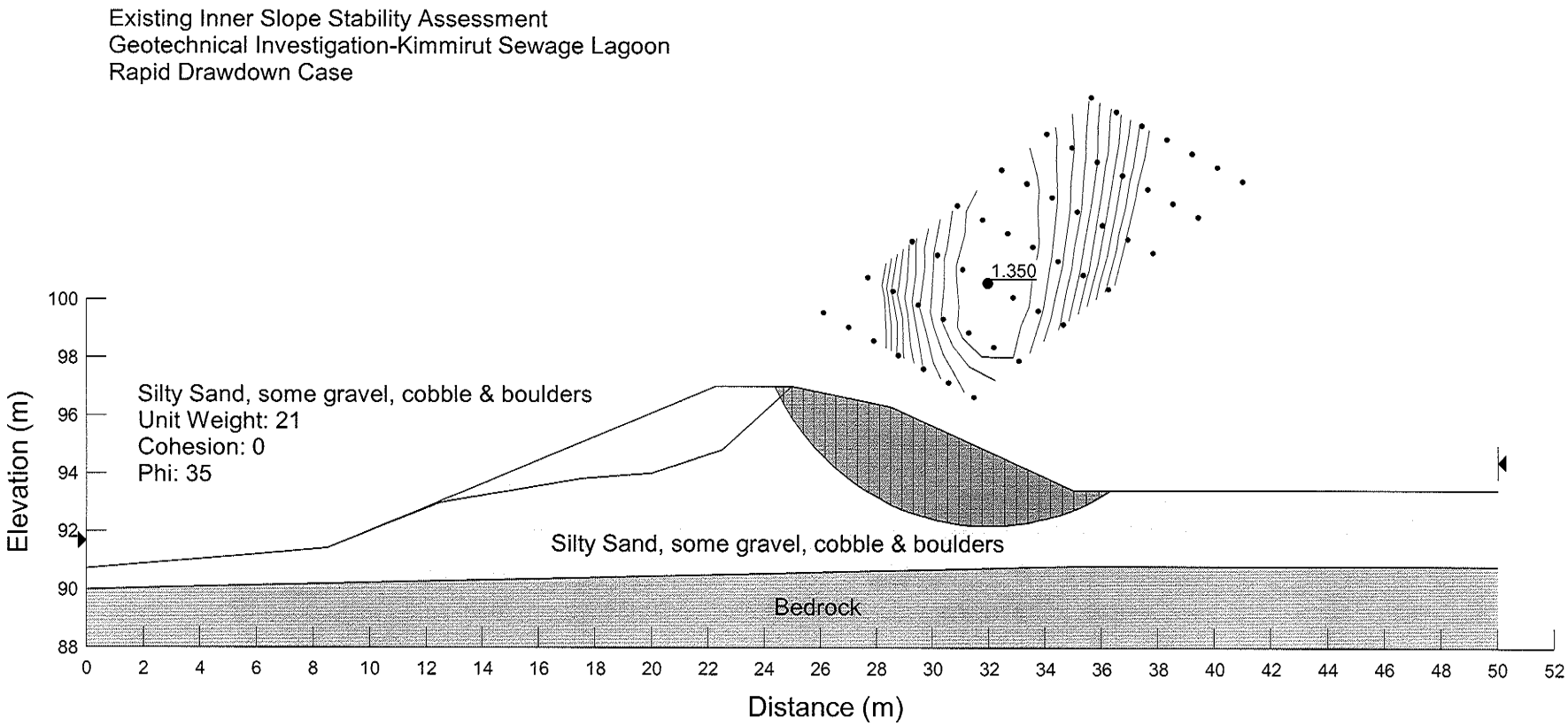
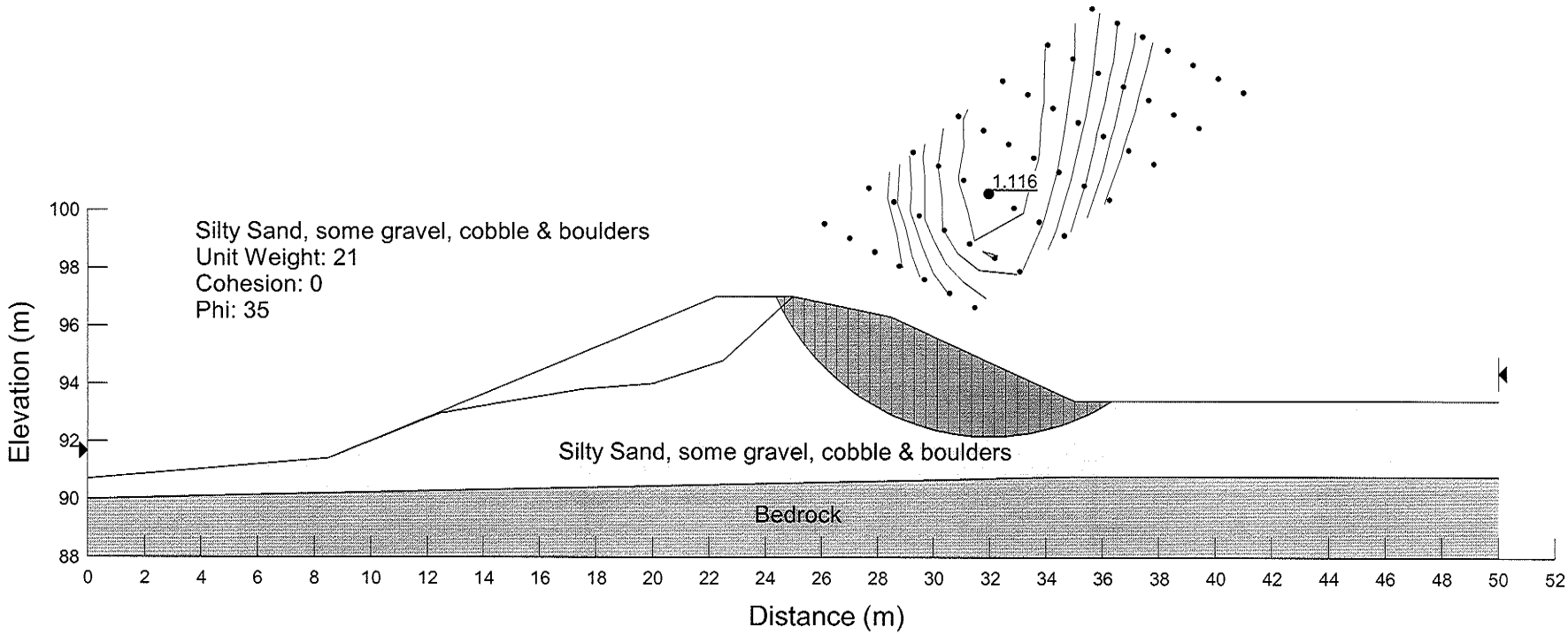

Existing Inner Slope Stability Assessment
Geotechnical Investigation-Kimmirut Sewage Lagoon
Rapid Drawdown Case
1.350
Silty Sand, some gravel, cobble & boulders
Unit Weight: 21
Cohesion: 0
Phi: 35
Silty Sand, some gravel, cobble & boulders
Bedrock
Elevation (m)
Distance (m)
100
98
96
94
92
90
88
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
44
46
48
50
52

Figure 33

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



OTGE00018881B

Figure 34

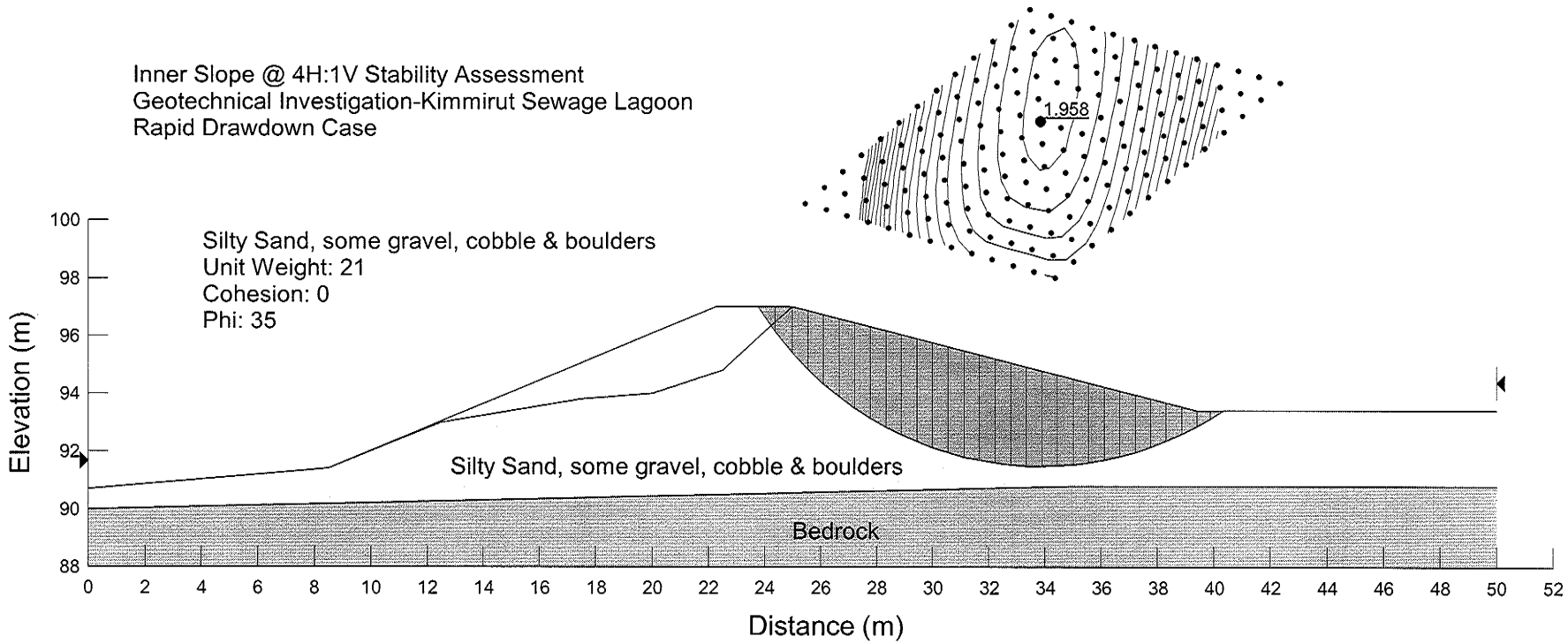
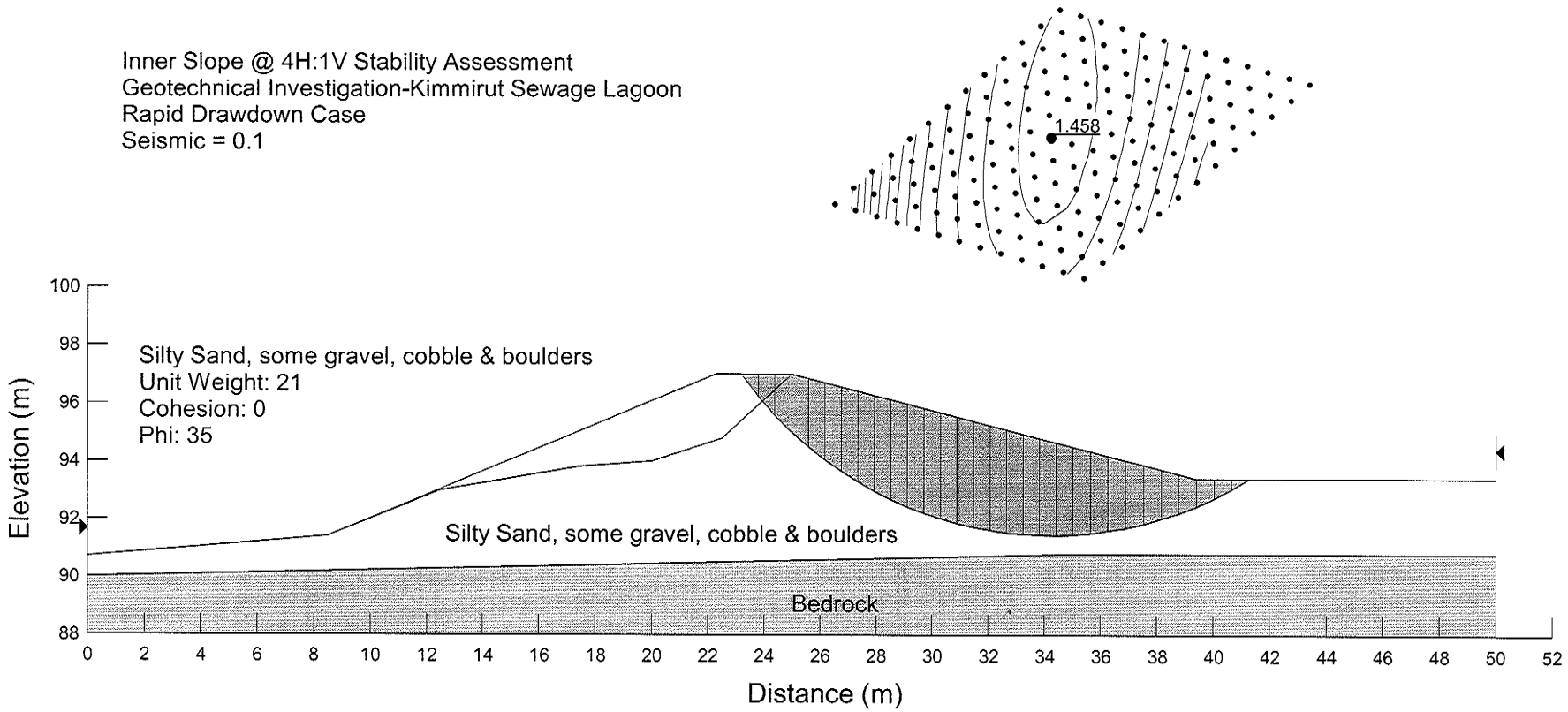


Figure 35


Inner Slope @ 4H:1V Stability Assessment
Geotechnical Investigation-Kimmirut Sewage Lagoon
Rapid Drawdown Case
Seismic = 0.1
1.458
Silty Sand, some gravel, cobble & boulders
Unit Weight: 21
Cohesion: 0
Phi: 35
Silty Sand, some gravel, cobble & boulders
Bedrock
Elevation (m)
Distance (m)
100
98
96
94
92
90
88
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
34
36
38
40
42
44
46
48
50
52