Government of Nunavut

Geotechnical Recommendations

Type of Document
FINAL

Project Name
Proposed Modifications to Sewage Lagoon
Hamlet of Whale Cove, Nunavut

Project Number
OTT-00201369-A0

Prepared By:

exp
100-2650 Queensview Drive
Ottawa, Ontario K2B 8H6
Canada

Date Submitted
September, 2012

Government of Nunavut

P.O. Bag 002
Rankin Inlet, NU
X0C 0G0

Geotechnical Recommendations

Type of Document:
FINAL

Project Name:
Proposed Modifications to Sewage Lagoons
Hamlet of Whale Cove, Nunavut

Project Number:
OTT-00201369-A0

Prepared By:

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

S.K. AGGARWAL
LICENSEE

Surinder K. Aggarwal, M.Sc., P.Eng.
Professional License # : L1359

Ismail M. Taki, M.Eng., P.Eng.
Professional License # : :L1812

Date Submitted:
September 2012

Legal Notification

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

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

Executive Summary

It is proposed to modify the existing sewage lagoon located in the Hamlet of Whale Cove, Nunavut in order to increase its capacity. The proposed modifications would comprise of raising the existing two berms (Berms A and C) and construction of three new berms (Berms B, D and E) in order to provide the requisite free board for the proposed new higher effluent level in the lagoon. The new berms are to be designed as impervious berms. The existing seepage berms (except Berm A) are to be converted to impervious berms, stability of the slopes is to be assessed, and the slopes are to be modified, if necessary, so that they are stable.

The geotechnical investigation comprised of drilling four boreholes at the site. It revealed that the bedrock is present at shallow depth over the majority of the site. The exception to this is in the vicinity of Berms A and C where overburden soils predominantly comprising of sand to sand and gravel extended to the entire depth investigated i.e. 7.2 m to 9.5 m (Elevation 12.4 to 13.9 m). Permafrost under these berms was encountered at a depth of 5.7 m below the existing ground surface. It is considered that the permafrost in this area has degraded over the years since the site was a pond prior to construction of the lagoon.

It is recommended that the new berms to be constructed (Berms B, D and E) and the existing Berm C may be constructed with upstream and downstream side slopes of 3H:1V as these slopes are expected to be stable. The existing Berm A which is to be retained as a permeable berm should be constructed with slopes of 4H:1V. The recommended berm slopes are based on the assumption that the crest width of the berms will be 4.0 m and that the berms will be constructed with crushed rock sand and gravel.

Prior to extension of the existing berms or construction of new berms, all the topsoil should be removed from area of berm construction. The existing slopes of the berms which are to be extended should be benched in 0.3 m high steps. The fill should be placed in 300 mm lift thickness and each lift compacted to 95 percent of standard Proctor maximum dry density per ASTM D698 – 07e1 Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12 400 ft lbf/ft^3 (600 kN m/m^3)). In-place density tests should be performed to ensure that the specified degree of compaction is being achieved.

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

Table of Contents

List of Tables

List of Figures

Chapter 1 –
Background Information

1 Background Information

The existing sewage lagoon located in the Hamlet of Whale Cove (Figure 1) is a natural lake that drains to wetland which is approximately 600 m long and discharges to the ocean. The sewage lagoon was constructed by installing berms in order to bridge low lying areas. These berms were constructed with a crest width of 3 to 5 m and side slopes of approximately 2H:1V. The crest of these berms varied from Elevation 21 m to Elevation 22 m. The berms were constructed with locally available materials which essentially comprises of sand and gravel or aggregate obtained by crushing bedrock. As a result, these berms are not impervious. The liquid level in the lagoon was maintained at Elevation 20.3 m (Figure 2).

It is now proposed to increase the storage capacity of the lagoon which will necessitate raising the liquid level in the lagoon to Elevation 21.1 m. In addition, a 1 metre free board is to be provided resulting in crest elevation of the berms to be Elevation 22.1 m. This would necessitate enlarging and raising the two existing berms (i.e. Berms A and C, Figure 2) and construction of three new berms (Berms B, D and E, Figure 2). It is also required to make these berms impervious. The exception to this is Berm A which is to be retained as an exfiltration berm to facilitate seepage out of this berm to the wetlands. It is proposed to install synthetic liners in the berms and to seal them in the bedrock. In the case of Berm C, where bedrock was not encountered, the berm is to be made impervious by freezing the core of the berm to the permafrost by installation of thermosyphons.

Chapter 2 – Proposed Berms

2 Proposed Berms

2.1 Berm A

It is proposed to increase the length of Berm A as necessary and to raise its crest elevation from Elevation 20.8 m to Elevation 22.1 m. Since this berm is not to be made impervious, side slopes of 4H:1V are proposed with a crest width of 4.0 m.

2.2 Berm B

A new Berm B is to be constructed at approximate location shown on Figure 2. The existing ground surface in this area is at Elevation 20.8 m to Elevation 21.0 m. Therefore, the height of the berm will vary from 1.1 m to 1.3 m. It is proposed to construct the berm in this area with a crest width of 4.0 m and side slopes of 3H:1V. It is proposed to install a synthetic liner in the berm and to anchor it into the bedrock in order to render this berm impervious.

2.3 Berm C

The existing berm in this area is at Elevation 21.7 m to Elevation 21.9 m. Consequently, this berm would be widened (4.0 m width) and raised by placing 0.2 m to 0.4 m of fill. In addition, the existing slopes of this berm are to be flattened to stable slope inclination of 3H:1V. It is proposed to make this berm impervious by freezing the soil in the berm by installing thermosyphons.

2.4 Berm D

The ground surface at the proposed location of this berm is currently at Elevation 21.9 m to Elevation 22.0 m. Therefore, this berm will be constructed by placing a maximum of 0.3 m of fill. It is proposed to construct this berm with a crest width of 4.0 m and side slopes of 3H:1V. In addition, a synthetic liner is to be installed in this berm and anchored into the underlying bedrock to make it impervious.

2.5 Berm E

The existing ground surface in this area is at Elevation 21.5 m approximately. In order to achieve a crest elevation of 22.1 m, it would be necessary to place approximately 0.6 m of fill. The berm is to be constructed with a crest width of 4.0 m and side slopes of 3H:1V. In addition, a synthetic liner is to be installed in the berm and is to be anchored into the underlying bedrock.

Chapter 3 –
Geotechnical Conditions

3 Geotechnical Conditions

A geotechnical investigation was undertaken at the existing berm site by **exp** in 2010 and the factual results presented in our report titled “Geotechnical Investigation, Factual Report, Proposed and Existing Sewage Lagoon, Hamlet of Whale Cove, Nunavut”, prepared for Government of Nunavut under Project No. OTT-00201369-A0 dated November 14, 2011.

The locations of the four boreholes drilled at the site are shown on Site Plan, Figure 2. The borehole logs have been presented as Figures 3 to 7 inclusive. A review of these figures indicates the following soil stratigraphy in descending order:

3.1 Topsoil

Approximately 330 m of topsoil was encountered in Borehole 3.

3.2 Fill

Boreholes 1 and 2 were drilled on top of the existing berms and encountered fill to 1.2 m and 1.5 m depth respectively (Elevation 19.9 m and 20.4 m). The fill consists of sand and gravel with some cobbles and silt. It has a moisture content of 6 to 14 percent. The fill comprises of 1 percent clay, 5 percent silt, 46 percent sand and 48 percent gravel (Figure 8).

3.3 Silt

The fill in Borehole 1 is underlain by a 200 mm thick layer of silt with some organics. This is possibly the original topsoil.

3.4 Sand to Sand and Gravel

The silt in Borehole 1 is underlain by sand which extends to 4.2 m depth (Elevation 16.9 m) and sandy silt which extends to 5.4 m (Elevation 15.7 m). The sand stratum contains some shells and occasional cobbles and boulders. Its moisture content varies from 14 to 22 percent. The sand stratum comprises of 2 percent clay, 11 percent silt, 68 percent sand and 19 percent gravel (Figure 9).

The sandy silt has a moisture content of 20 to 24 percent. Typically, it contains 15 percent clay, 48 percent silt, 25 percent sand and 12 percent gravel (Figure 10).

Beneath the fill in Borehole 2 and from the existing ground surface in Boreholes 3 and 4, sand and gravel to gravel was encountered and extends to 0.4 m to 4.5 m (Elevation 17.3 m to 20.7 m). The natural moisture content of this stratum varies from 9 to 20 percent. This stratum contains 4 percent silt, 3 percent sand and 93 percent gravel (Figure 11).

The sandy silt in Borehole 1 and the sand and gravel in Borehole 2 are underlain by sandy gravel which extends to the entire depth investigated in Borehole 1 (i.e. 7.2 m depth, Elevation 13.9 m) and to 5.7 m depth (Elevation 16.2 m) in Borehole 2. It has a moisture content of 10 to 15 percent. This stratum contains 0 to 1 percent clay, 0 to 14 percent silt, 1 to 27 percent sand and 58 to 91 percent gravel (Figure 12 and 13).

The sandy gravel in Borehole 2 is underlain by silt and sand stratum which extends to the entire depth investigated i.e. 9.5 m, Elevation 12.4 m. This stratum contains some clayey silt layers. Its moisture content varies from 11 to 30 percent. It comprises of 12 percent clay, 40 percent silt and 48 percent sand (Figure 14).

3.5 Bedrock

The sand and gravel in Borehole Nos. 3 and 4 is underlain by Dolomite bedrock which extends to the maximum depth investigated in the boreholes. The bedrock was of good to excellent quality based on the Rock Quality Designation results which ranged between 85 and 100 percent.

3.6 Permafrost

It is noted that permafrost was encountered at 5.7 m depth in Boreholes 1 and 2. It is considered that the permafrost has degraded over the years since the site is an old pond.

Chapter 4 – Discussion

4 Discussion

The geotechnical investigation has revealed that the bedrock at the site is present at shallow depth except in the vicinity of Berms A and C where bedrock was not encountered to the entire depth investigated. As a result, seepage through these berms cannot be prevented by installing liner in the berms and anchoring them in the bedrock. Berm A is located upstream of the wetlands and it is understood that this berm would be retained as a ‘seepage berm’. Berm C is to be made impervious by freezing the soil in the berm with the installations of thermosyphons. The bedrock is present at shallow depth in the vicinity of the proposed three new berms (Berms B, D and E). In the case of Berms B and E, liners will be installed in the berms and socketed into the bedrock. Berm D does not require a liner.

A slope stability analysis was undertaken for all the berms except for Berm D. The reason for this is that this berm would be founded on bedrock and will be only 0.5 m high in order to provide the requisite 1 m free board. In addition, the effluent level in the lagoon will be below the bottom of this shallow berm. It was therefore considered that this berm constructed with side slopes of 3H:1V will be stable and slope stability analysis is not required.

Chapter 5 –
Slope Stability Analysis

5 Slope Stability Analysis

The slope stability analysis was undertaken for four berms (Berms A to C and E) in order to determine the design upstream and downstream. It is noted that Berms B and E are to be made impervious by installation of liners in the berms and socketing these liners into bedrock. Berm C is to be made impervious by freezing the central core of the berm and the foundation soils in a permanently frozen state by installation of thermosyphons. However, the surfaces of the inside and outside slopes of the berms would be subject to seasonal freezing and thawing. Also, although the permeability of the frozen soil is very low, it is feasible that a steady state seepage condition may develop in the berm over a long period of time or due to malfunctioning of the thermosyphons. Therefore, the stability of slope analyses to compute the design side slopes of these berms were based on unfrozen soils and assuming that seepage can take place through the berms. It is considered that this assumption will also be valid for lagoons which are to be made impervious by installation of liners in the berms since these conditions may develop if the liner gets damaged or if the liner joint(s) fail.

The stability of the slopes was analysed using Bishop's Modified Method. Slope/W. Geoslope office, Version 4.23 Computerized system was used to assess stability of the slopes. The upstream and downstream slopes of Berms A, B, C and E were analysed.

The geotechnical investigation has revealed that the bedrock at the site is present at shallow depth in the vicinity of Berms B, D and E. Bedrock was not encountered to the depth investigated in the case of Berms A and C (i.e. 7.2 m and 9.5 m depth respectively).

The upstream slopes of the berms were analyzed for the following conditions:

(a) Fully submerged conditions
(b) Fully submerged conditions and seismic loading
(c) Rapid drawdown conditions
(d) Rapid drawdown conditions and seismic loading

The downstream slopes were analysed for the following conditions:

(a) Steady state seepage conditions
(b) Steady state seepage conditions and seismic loading

The following assumptions were made in slope stability analysis:

(a) The crest of all the berms will be at Elevation 22.1 m. The crest width will be 4 m.
(b) The berms will be constructed with side slopes of 3H:1V to 4H:1V. Crushed rock sand and gravel fill will be used for construction of the berms.

(c) The bottom of the sewage lagoon is at Elevation 19.9 m to 20.4 m whereas the maximum effluent level in the lagoon will be at Elevation 21.1 m.

(d) Widening and raising of the existing berms will be undertaken by placing additional material on crest of the existing berms and on the downstream side of the berms.

(e) Although all the berms, except Berm A, will be designed as impervious berms by either installation of liner in the berms socketed into the bedrock or by permanently freezing the core of the berm and the underlying natural soil, the slope stability analyses were undertaken based on the assumption that the berms have been designed 'as seepage berms'. It is noted that this condition may result if the liners get damaged in any way or if the central core of Berm A cannot be permanently maintained in a frozen state.

(f) Based on a literature search, the following engineering properties were assumed for the various materials to be used in the construction of the berms and the natural soils encountered at the site:

Table I – Geotechnical Parameters of Various Soil Stratas

Soil Type	Unit Weight (kN/m^3)	Effective Cohesion c' (kPa)	Effective Angle of Internal Friction ϕ (degrees)
Proposed Fill	22.0	0	38
Existing Fill	20.0	0	32
Organic Silt	18.0	0	20
Sandy Silt	20.0	0	25
Sand	22.0	0	30
Sandy Gravel	22.0	0	35

The results of the slope stability analyses have been presented on Table II.

Table II - Computed Factors of Safety for Upstream and Downstream Berm Slopes

Berm Identification	Slope Identification	Slope Inclination	Loading Condition	Computed Factor of Safety	Figure #
A	Upstream	3H:1V	Rapid drawdown (with topsoil layer)	0.74	15
			Rapid drawdown (topsoil layer removed)	1.30	16
			Rapid drawdown with seismic loading	1.05	17
			Submerged slope	2.38	18
			Submerged slope with seismic loading	1.76	19

Table II - Computed Factors of Safety for Upstream and Downstream Berm Slopes

Berm Identification	Slope Identification	Slope Inclination	Loading Condition	Computed Factor of Safety	Figure #
A	Upstream	4H:1V	Rapid drawdown	1.59	20
			Rapid drawdown with seismic loading	1.35	21
			Submerged slope	2.66	22
			Submerged slope with seismic loading	2.08	23
	Downstream	3H:1V	Steady state seepage	0.96	24
			Steady state seepage with seismic loading	0.87	25
		4H:1V	Steady state seepage	1.47	26
			Steady state seepage with seismic loading	1.25	27
B	Upstream	3H:1V	Rapid drawdown	2.62	28
			Rapid drawdown with seismic loading	2.25	29
			Submerged slope	2.62	30
			Submerged slope with seismic loading	2.25	31
	Downstream	3H:1V	Steady state seepage	2.13	32
			Steady state seepage with seismic loading	1.77	33
C	Upstream	3H:1V	Rapid drawdown	2.08	34
			Rapid drawdown with seismic loading	1.72	35
			Submerged slope	2.17	36
			Submerged slope with seismic loading	1.82	37
	Downstream	3H:1V	Steady state seepage	4.68	38
			Steady state seepage with seismic loading	3.31	39
E	Upstream	3H:1V	Rapid drawdown	2.71	40
			Rapid drawdown with seismic loading	2.26	41
			Submerged slope	2.71	42
			Submerged slope with seismic loading	2.26	43
	Downstream	3H:1V	Steady state seepage	3.2	44
			Steady state seepage with seismic loading	2.66	45

Based on current practice in the industry, a factor of safety of 1.5 is required for static loading conditions and a factor of safety of 1.1 for seismic loading conditions. A review of Table II indicates that the requisite factor of safety against slope failure are available if the berms are designed with upstream and downstream slopes of 3H:1V. The exception to this is Berm A in which case 4H:1V upstream and downstream slopes are required in order to obtain the requisite factors of safety.

It is recommended that the berms should be designed with side slopes of 3H:1V except for Berm A where upstream and downstream slopes should be designed with slopes 4H:1V. It is noted that these computations are based on the assumption that the berms would be constructed with crushed rock sand and gravel. If it is decided to use different materials for construction of the berms, this office should be consulted since in this case it may be necessary to re-evaluate the berm slopes. The analysis also assumes that topsoil layer will be removed from under the new berms and the extended portion of the existing berms.

Chapter 6 –
Construction Considerations

6 Construction Considerations

It is recommended that all the topsoil should be removed from under the proposed berms or from under the expanded portions of the berms. To ensure satisfactory performance of the extended berm, it would be essential to bench the existing slopes in 0.3 m high steps to receive the new fill. The new fill may then be placed in 0.3 m lift thicknesses and each lift compacted to at least 95 percent of standard Proctor maximum dry density per ASTM D698 – 07e1 Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12 400 ft lbf/ft^3 (600 kN m/m^3)). In place density tests should be performed on each lift to ensure that the specified degree of compaction has been achieved.

Chapter 7 –
Erosion Protection

7 Erosion Protection

It is noted that the computed upstream and downstream slope inclinations will be stable provided that the berms are not overtopped. Potential exists for considerable erosion and possibly failure of the berms if overtopped. Overtopping of the berms may be prevented by construction of a proper spillway structure which is capable of handling the overflow.

Chapter 8 –
General Comments

8 General Comments

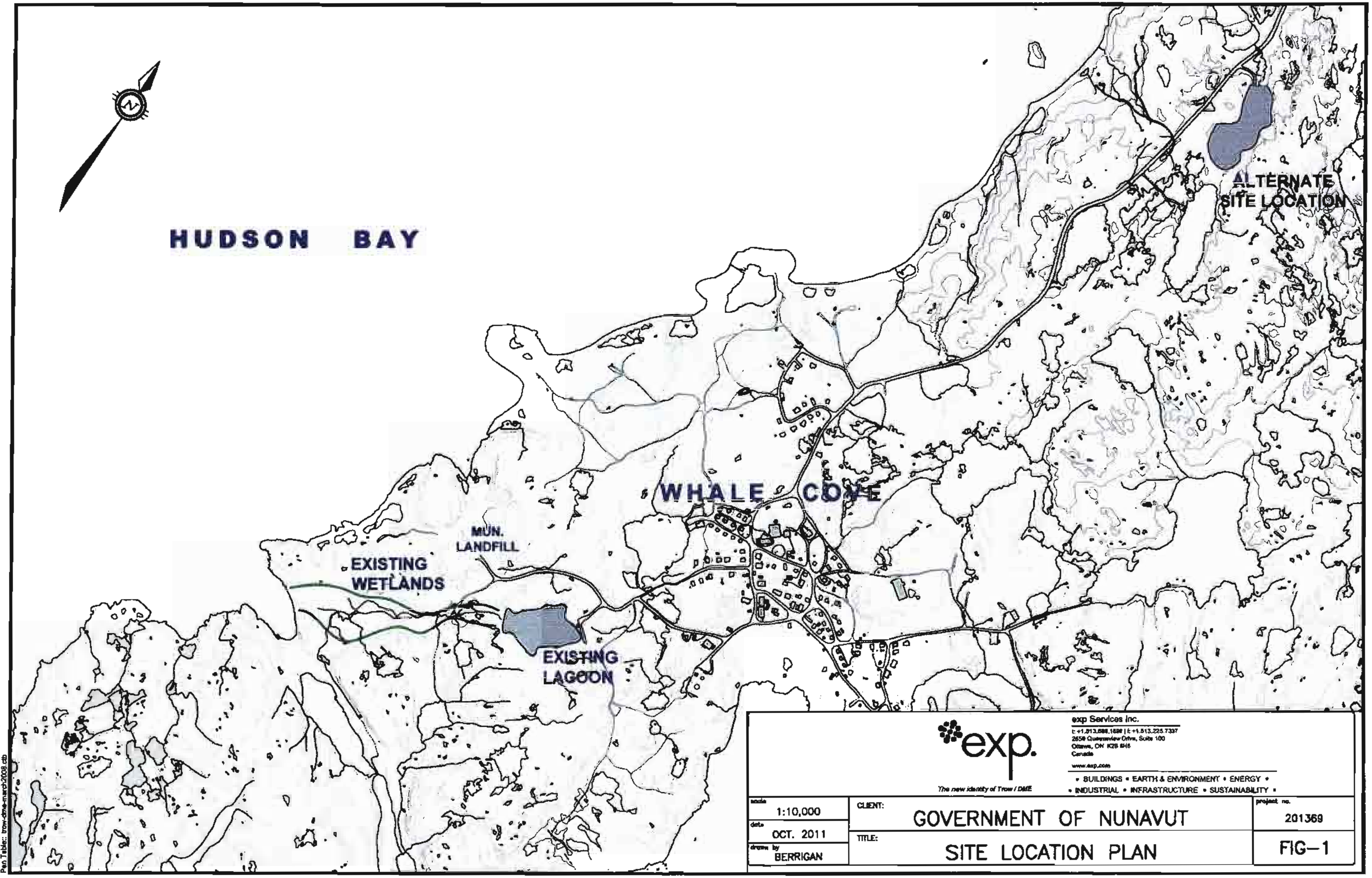
The comments given in this report are intended only for the guidance of design engineers. The number of boreholes required to determine the localized underground conditions between boreholes affecting construction costs, techniques, sequencing, equipment scheduling, etc. would be much greater than has been carried out for the design purposes. Contractors bidding on or undertaking the works should, in this light, decide on their own investigations, as well as their own interpretations of the factual borehole results, so that they may draw their own conclusions as to how the subsurface conditions may affect them.

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

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

Figures

Filename: p:\projects\civil engineering services\201000\ott-00201369-e0 - sewage lagoon wetland upgrade - whale cove - gn\dwgs\geotech\201369 - location plan-fig-1 & fig-3.dwg
Last Saved: 11/1/2011 2:26:57 PM
Last Plotted: 11/1/2011 2:28:16 PM Plotted by: abozarada
Pen Table:: trow-dme-march2008.ctb



exp.
The new identity of Trow / DME

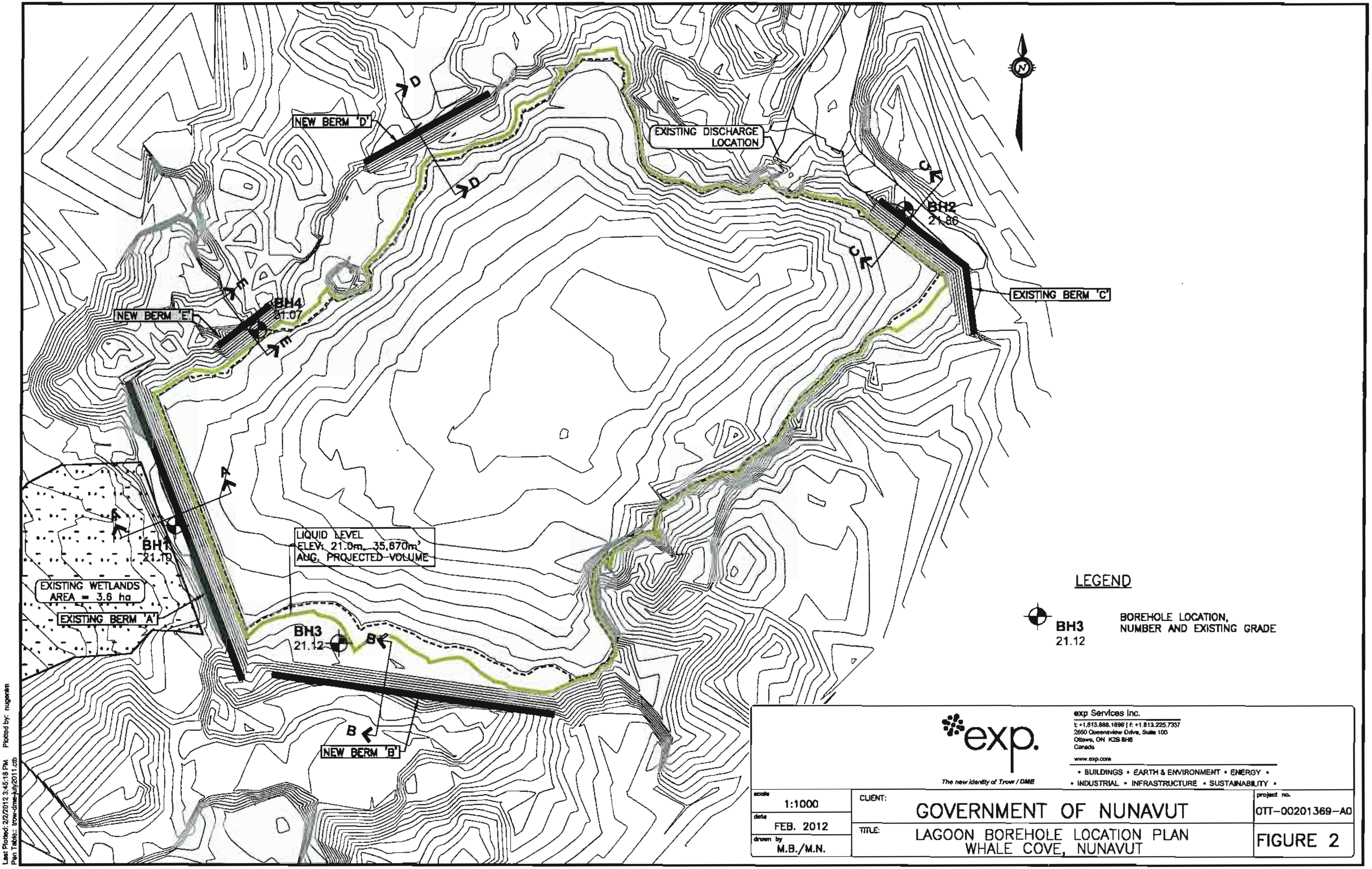
exp Services Inc.
t: +1.613.688.1899 | f: +1.613.225.7337
2650 Queensview Drive, Suite 100
Ottawa, ON K2B 8H6
Canada

www.exp.com

• BUILDINGS • EARTH & ENVIRONMENT • ENERGY •
• INDUSTRIAL • INFRASTRUCTURE • SUSTAINABILITY •

scale 1:10,000	CLIENT:	GOVERNMENT OF NUNAVUT	project no. 201369
date OCT. 2011	TITLE:	SITE LOCATION PLAN	FIG-1
drawn by BERRIGAN			

Filename: p:\projects\civil engineering services\201000\ott-00201369-a0 - sewage lagoon wetland upgrade - whale cove - gn\drawings\geotech\201369 bh plan - fig 2 rev 2012.02.dwg
Last Saved: 2/2/2012 3:42:39 PM
Last Plotted: 2/2/2012 3:45:18 PM Plotted by: nugentm
Pen Table:: trow-dme-july2011.ctb



exp.
The new identity of Trow / DME

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

• BUILDINGS • EARTH & ENVIRONMENT • ENERGY •
• INDUSTRIAL • INFRASTRUCTURE • SUSTAINABILITY •

scale
1:1000
date
FEB. 2012
drawn by
M.B./M.N.

CLIENT:
GOVERNMENT OF NUNAVUT

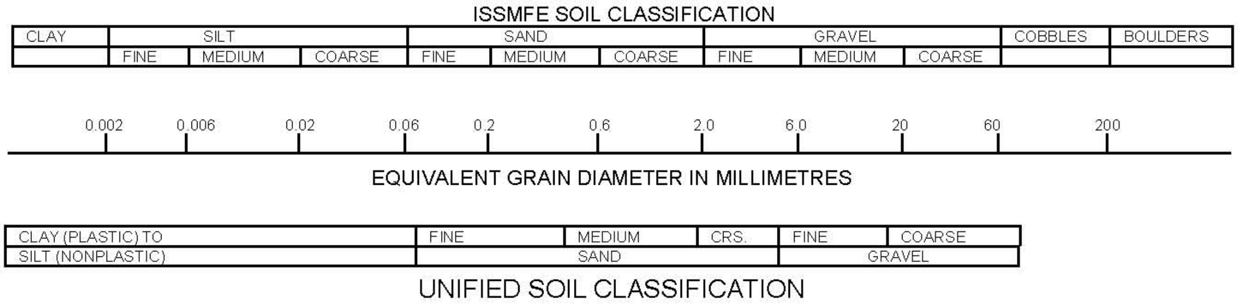
TITLE:
LAGOON BOREHOLE LOCATION PLAN
WHALE COVE, NUNAVUT

project no.
OTT-00201369-A0

FIGURE 2

Notes On Sample Descriptions

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



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

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

Log of Borehole 1

exp.

Project No: OTT-00201369-A0

Project: Geotechnical Investigation - Proposed Existing Sewage Lagoon

Location: Hamlet of Whale Cove, Nunavut

Figure No. 3

Page. 1 of 1

Date Drilled: 'September 17, 2011

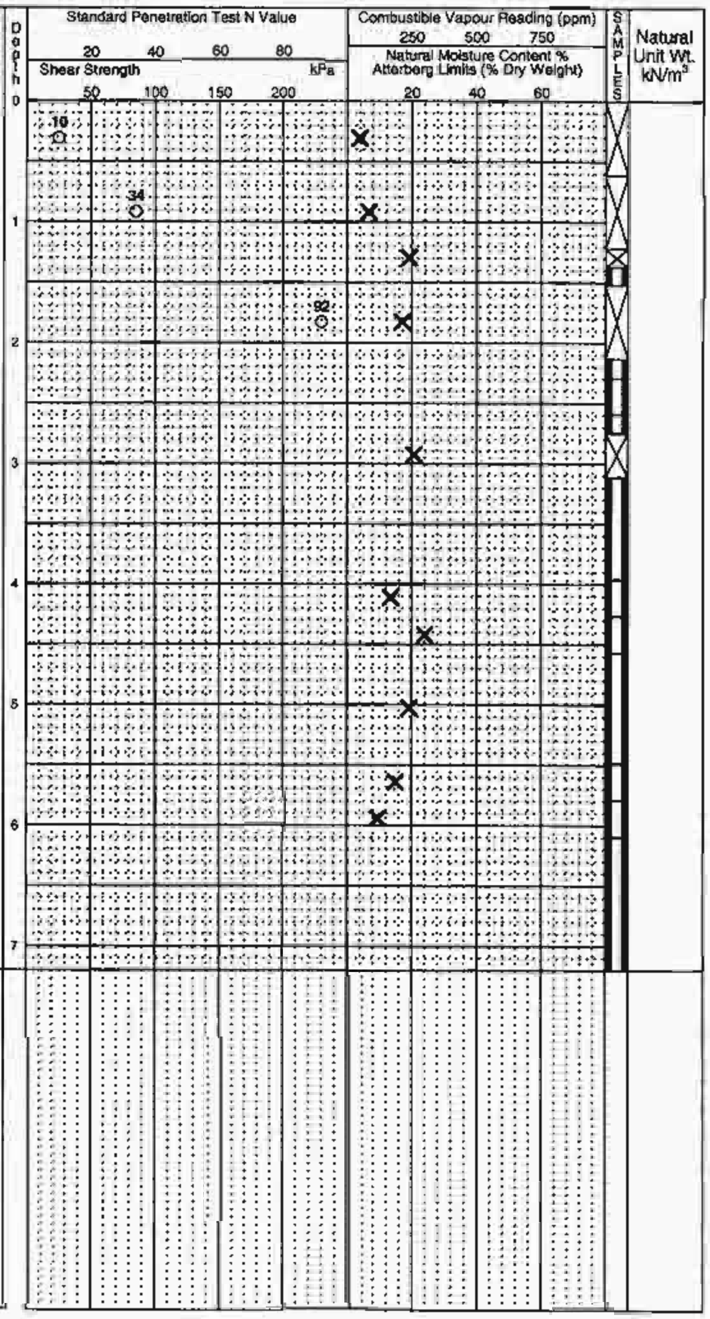
Drill Type:

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 DESCRIPTION	Geodetic m
			21.1
	▨	**FILL** Sand and gravel, fine to coarse, some cobbles, black organics, brown, moist	
			19.9
	▥	**SILT** Some organics, black, wet	
			19.7
	⁘	**SAND** Some gravel, occasional cobbles and boulders, some shells, brown, moist to wet	
			16.9
	▥	**SANDY SILT** Slightly cohesive, some shells, some fine to medium gravel, grey, moist to very wet	
			15.7
	●	**SANDY GRAVEL** Fine to coarse, frequent cobbles and boulders, grey, wet **PERMAFROST** @ 5.7 M	
			13.9
		Borehole Terminated at 7.2 m depth	



NOTES:
1. Borehole/Test Pit data requires interpretation by exp. before use by others
2. Borehole backfilled upon completion.
3. Field work was supervised by an exp representative.
4. See Notes on Sample Descriptions
5. This Figure is to read with exp. Services Inc. report OTT-00201369-A0

WATER LEVEL RECORDS

Elapsed Time	Water Level (m)	Hole Open To (m)
On Completion	No water	No Cave

CORE DRILLING RECORD

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

Log of Borehole 2

exp.

Project No: OTT-00201369-A0

Project: Geotechnical Investigation - Proposed Existing Sewage Lagoon

Location: Hamlet of Whale Cove, Nunavut

Figure No. 4

Page. 1 of 1

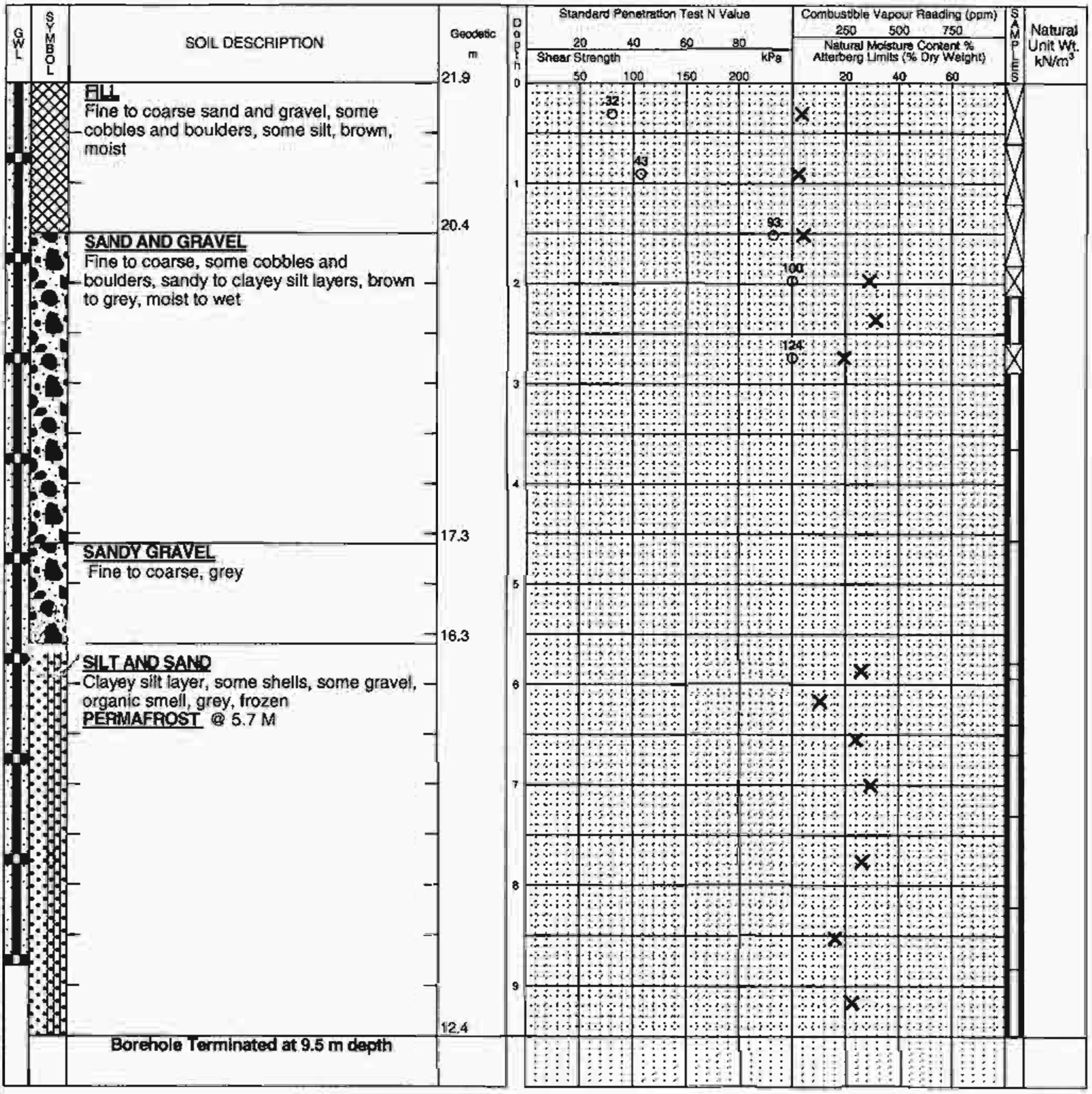
Date Drilled: 'September 16, 2011

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		



Geodetic m	SOIL DESCRIPTION
21.9	**FILL** Fine to coarse sand and gravel, some cobbles and boulders, some silt, brown, moist
20.4	**SAND AND GRAVEL** Fine to coarse, some cobbles and boulders, sandy to clayey silt layers, brown to grey, moist to wet
17.3	**SANDY GRAVEL** Fine to coarse, grey
16.3	**SILT AND SAND** Clayey silt layer, some shells, some gravel, organic smell, grey, frozen **PERMAFROST** @ 5.7 M
12.4	**Borehole Terminated at 9.5 m depth**

NOTES:

1. Borehole/Test Pit data requires interpretation by exp. before use by others
2. A thermister was installed to 8.8 m in a 25 mm PVC rigid pipe.
3. Field work was supervised by an exp representative.
4. See Notes on Sample Descriptions
5. This Figure is to read with exp. Services Inc. report OTT-00201369-A0

WATER LEVEL RECORDS

Elapsed Time	Water Level (m)	Hole Open To (m)
On Completion	No water	No Cave

CORE DRILLING RECORD

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

Log of Borehole 3

Project No: OTT-00201369-A0

Project: Geotechnical Investigation - Proposed Existing Sewage Lagoon

Location: Hamlet of Whale Cove, Nunavut

Figure No. 5

Page. 1 of 1

Date Drilled: 'September 18, 2011

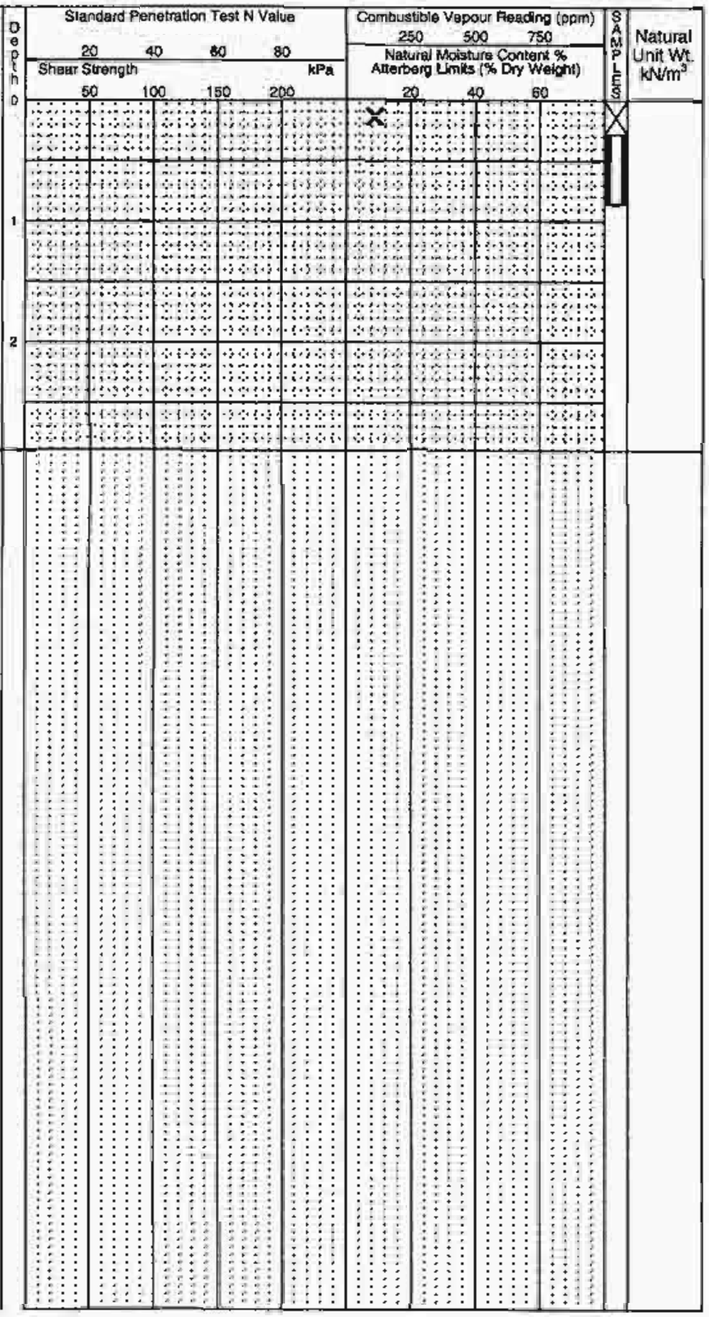
Drill Type:

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 DESCRIPTION	Geodetic m
			21.1
		TOPSOIL ~330 mm Sand and gravel, some cobbles and boulders, black to grey	
			20.2
		BEDROCK Dolomite, calcite partings, occasional vertical joints, grey (very good to excellent quality)	
			18.2
		Borehole Terminated at 2.9 m depth	



NOTES:
1. Borehole/Test Pit data requires interpretation by exp. before use by others
2. Borehole backfilled upon completion.
3. Field work was supervised by an exp representative.
4. See Notes on Sample Descriptions
5. This Figure is to read with exp. Services Inc. report OTT-00201369-A0

WATER LEVEL RECORDS

Elapsed Time	Water Level (m)	Hole Open To (m)
On Completion	No water	No Cave

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %
1	0.94 - 1.45	100	85
2	1.45 - 2.23	100	100
3	2.23 - 2.92	100	100

Log of Borehole 4

exp.

Project No: OTT-00201369-A0

Project: Geotechnical Investigation - Proposed Existing Sewage Lagoon

Location: Hamlet of Whale Cove, Nunavut

Figure No. 6

Page. 1 of 1

Date Drilled: 'September 19, 2011

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 Vane Test	+ S	Shear Strength by Penetrometer Test	▲

GWL	SYMBOL	SOIL DESCRIPTION	Geodetic m	Depth	Standard Penetration Test N Value 20 40 60 80 / Shear Strength kPa 50 100 150 200	Combustible Vapour Reading (ppm) 250 500 750 / Natural Moisture Content % Atterberg Limits (% Dry Weight) 20 40 60	SAMPLES	Natural Unit Wt. kN/m³
			21.1	0				
	⁘	**SAND AND GRAVEL** Organics, some cobbles	20.7				○	
	▨	**BEDROCK** Dolomite, calcite partings, occasional vertical joints, grey (excellent quality)		1				
				2				
			18.7					
		Borehole Terminated at 2.4 m depth						

NOTES:
1. Borehole/Test Pit data requires interpretation by exp. before use by others
2. Borehole backfilled upon completion.
3. Field work was supervised by an exp representative.
4. See Notes on Sample Descriptions
5. This Figure is to read with exp. Services Inc. report OTT-00201369-A0

WATER LEVEL RECORDS

Elapsed Time	Water Level (m)	Hole Open To (m)
On Completion	No water	No Cave

CORE DRILLING RECORD

Run No.	Depth (m)	% Rec.	RQD %
1	0.38 - 1.17	100	100
2	1.17 - 2.36	100	100

LOG OF BOREHOLE BOREHOLE LOGS 201369 WHALE COVE.GPJ TROW OTTAWA.GDT 9/2/12

Log of Borehole 5

exp.

Project No: OTT-00201369-A0

Project: Geotechnical Investigation - Proposed Existing Sewage Lagoon

Location: Hamlet of Whale Cove, Nunavut

Figure No. 7

Page. 1 of 1

Date Drilled: 'September 19, 2011

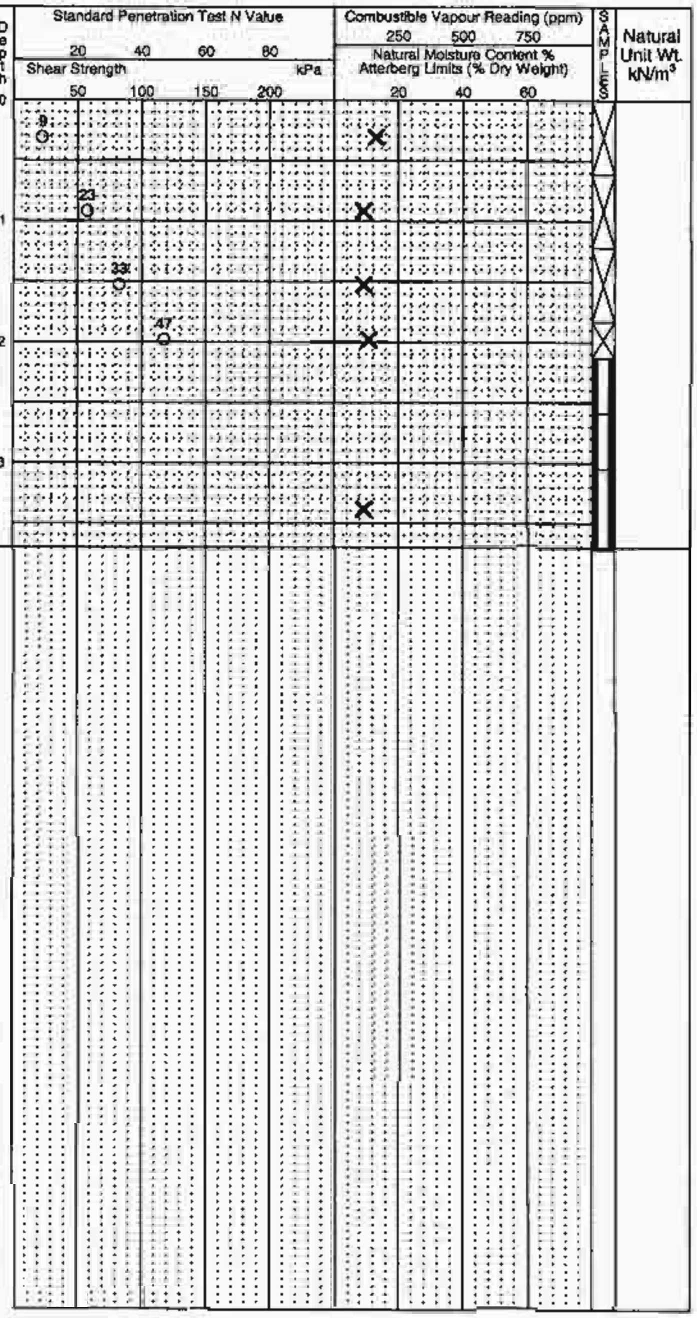
Drill Type:

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	$\overset{+}{S}$		

GWL	SYMBOL	SOIL DESCRIPTION	Geodetic m	Depth
	▨	**SILTY SAND** Some gravel, shells, black organic staining, grey, very moist to wet	16.2	0
	●	**SANDY GRAVEL TILL** Fine to coarse, slightly cohesive, grey, wet	14.7	1 2 3
		Borehole Terminated at 3.7 m depth	12.5	



NOTES:

1. Borehole/Test Pit data requires interpretation by exp. before use by others
2. Borehole backfilled upon completion.
3. Field work was supervised by an exp representative.
4. See Notes on Sample Descriptions
5. This Figure is to read with exp. Services Inc. report OTT-00201369-A0

WATER LEVEL RECORDS

Elapsed Time	Water Level (m)	Hole Open To (m)
On Completion	No water	Cave at 2.13 m

CORE DRILLING RECORD

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

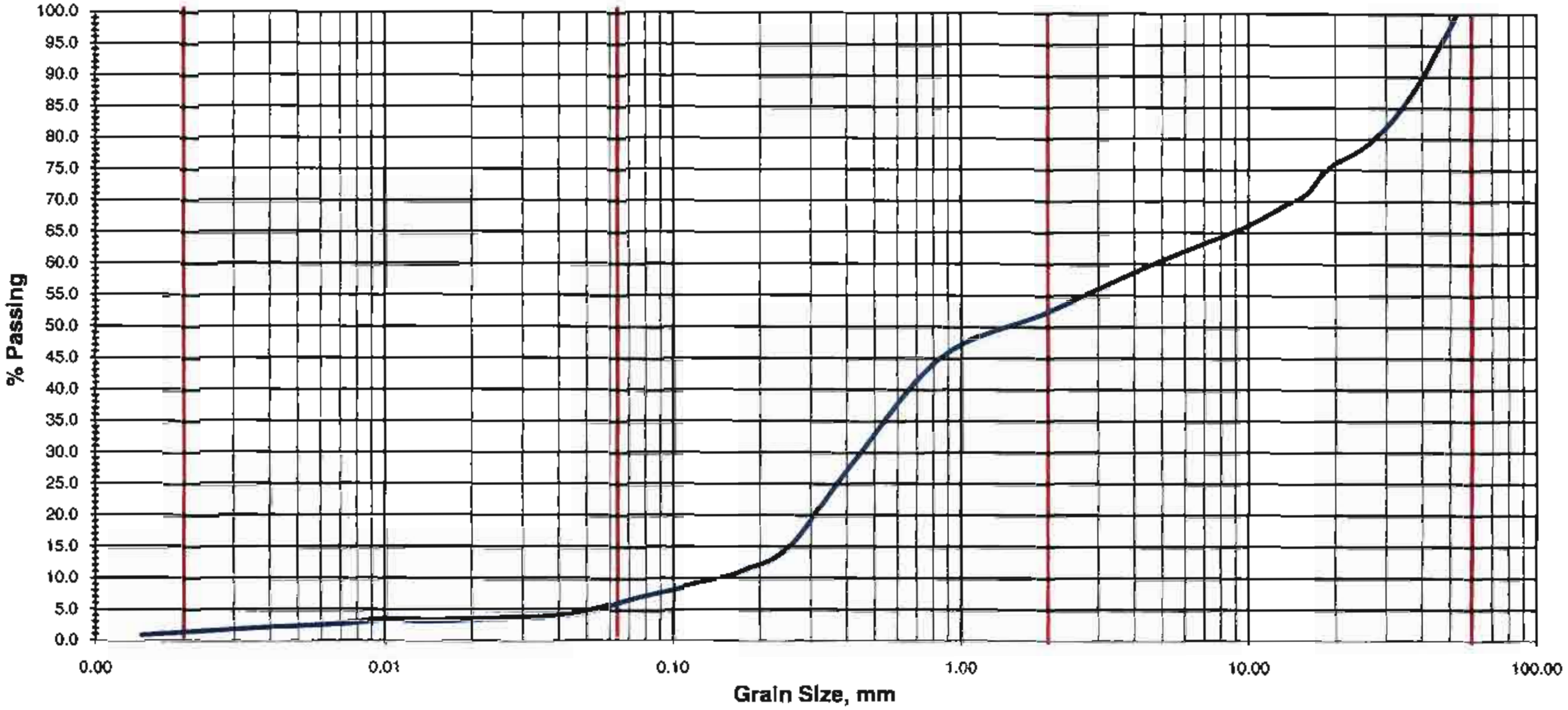
LOG OF BOREHOLE BOREHOLE LOGS 201369 WHALE COVE.GPJ TROW OTTAWA.GDT 9/2/12

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

Method of Test for Particle Size Analysis of Soil

ASTM D-422

Grain Size Distribution Curve



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

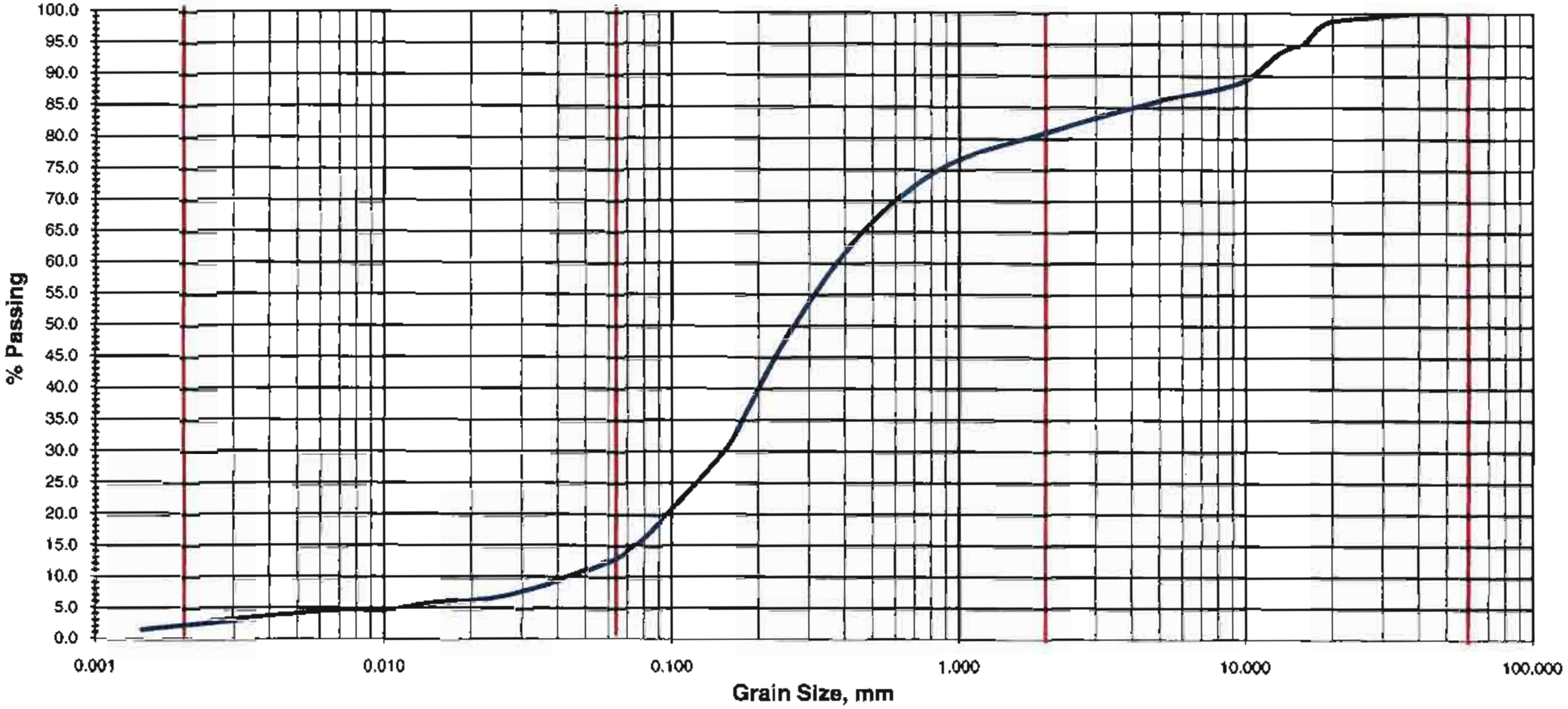
Trow Project No.:	OTT-00201369-A0	Project Name :	Geotechnical Investigation - Proposed Water Reservoir				
Client :	Government of Nunavut	Project Location :	Whale Cove - Government of Nunavut				
Date Sampled :	September 19, 2011	Bore Hole No.:	1	Sample No.:	SS2	Depth (m) :	0.6 to 1.2
Sample Description :		Sand and Gravel				Figure :	8

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

Method of Test for Particle Size Analysis of Soil

ASTM D-422

Grain Size Distribution Curve



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

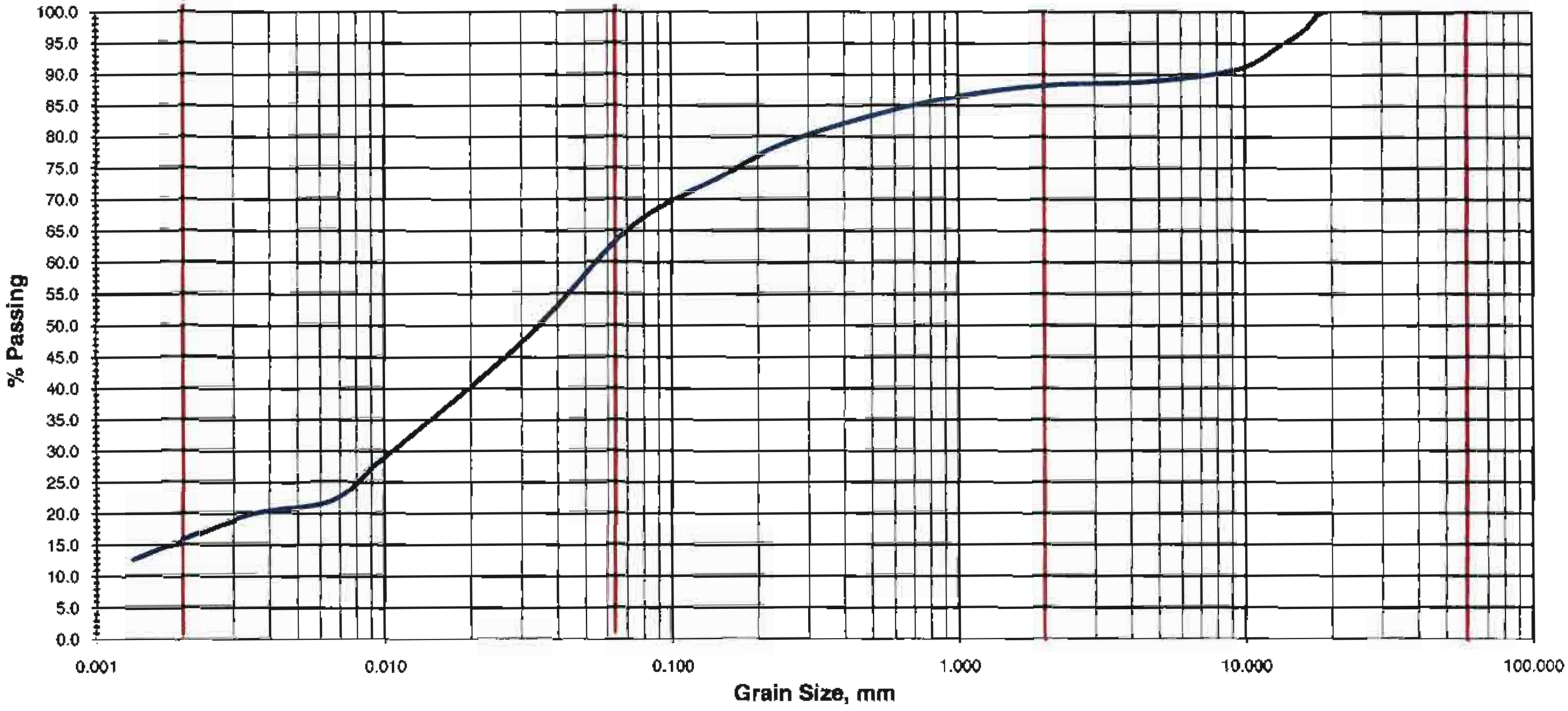
Trow Project No.:	OTT-00201369-A0	Project Name :	Geotechnical Investigation - Proposed Water Reservoir				
Client :	Government of Nunavut	Project Location :	Whale Cove - Government of Nunavut				
Date Sampled :	September 18, 2011	Bore Hole No.:	1	Sample No.:	SS8	Depth (m) :	2.7 to 3.1
Sample Description :		Sand - Some Gravel and Silt				Figure :	9

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

Method of Test for Particle Size Analysis of Soil

ASTM D-422

Grain Size Distribution Curve



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

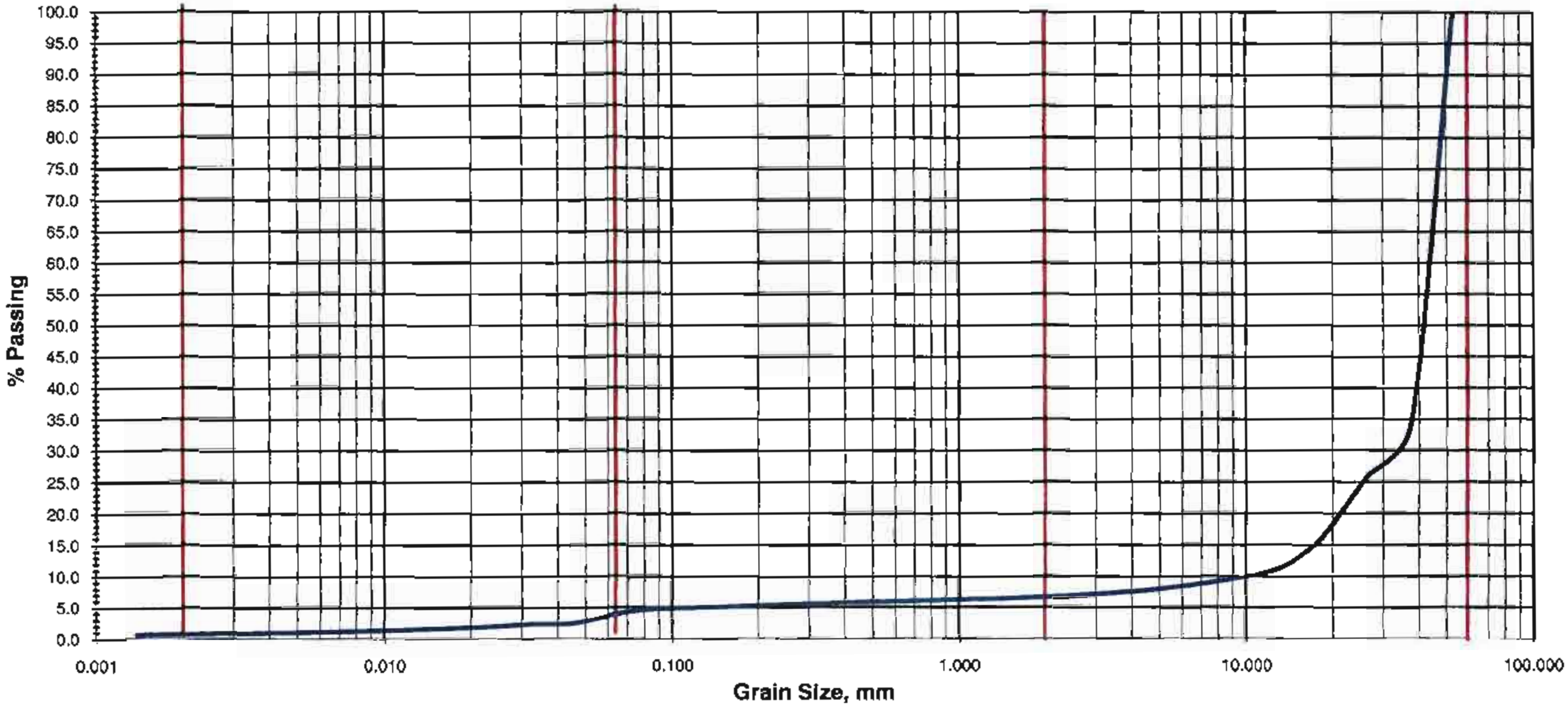
Trow Project No.:	OTT-00201369-A0	Project Name :	Geotechnical Investigation - Proposed Water Reservoir		
Client :	Government of Nunavut	Project Location :	Whale Cove - Government of Nunavut		
Date Sampled :	September 16, 2011	Bore Hole No.:	1	Sample No.: Core 12	Depth (m) : 4.6 to 5.2
Sample Description :	Sandy Silt , Some Clay				Figure : 10

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

Method of Test for Particle Size Analysis of Soil

ASTM D-422

Grain Size Distribution Curve



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

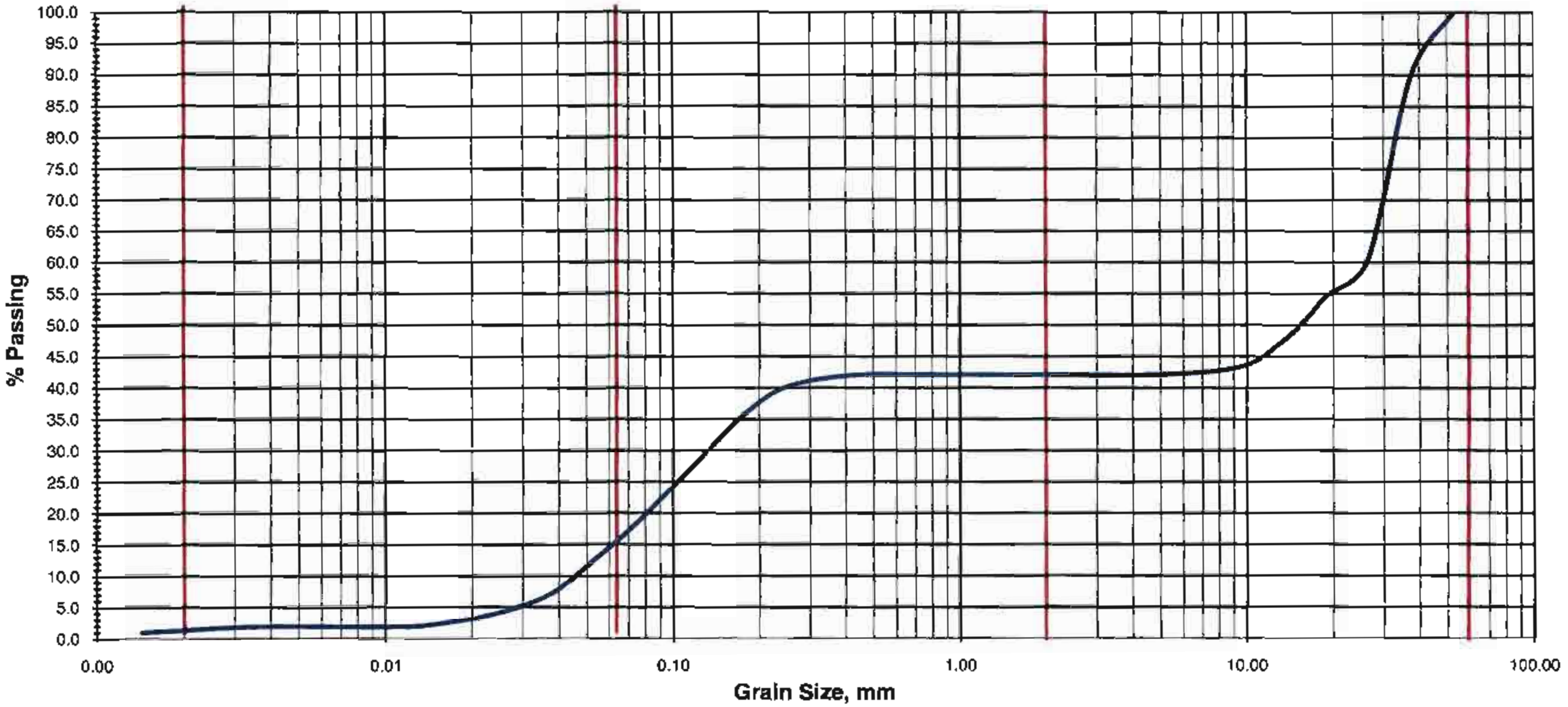
Trow Project No.:	OTT-00201369-A0	Project Name :	Geotechnical Investigation - Proposed Water Reservoir				
Client :	Government of Nunavut	Project Location :	Whale Cove - Government of Nunavut				
Date Sampled :	September 16, 2011	Bore Hole No.:	2	Sample No.:	SS5	Depth (m) :	2.1 to 2.8
Sample Description :		Gravel, Trace Sand				Figure :	11

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

Method of Test for Particle Size Analysis of Soil

ASTM D-422

Grain Size Distribution Curve



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

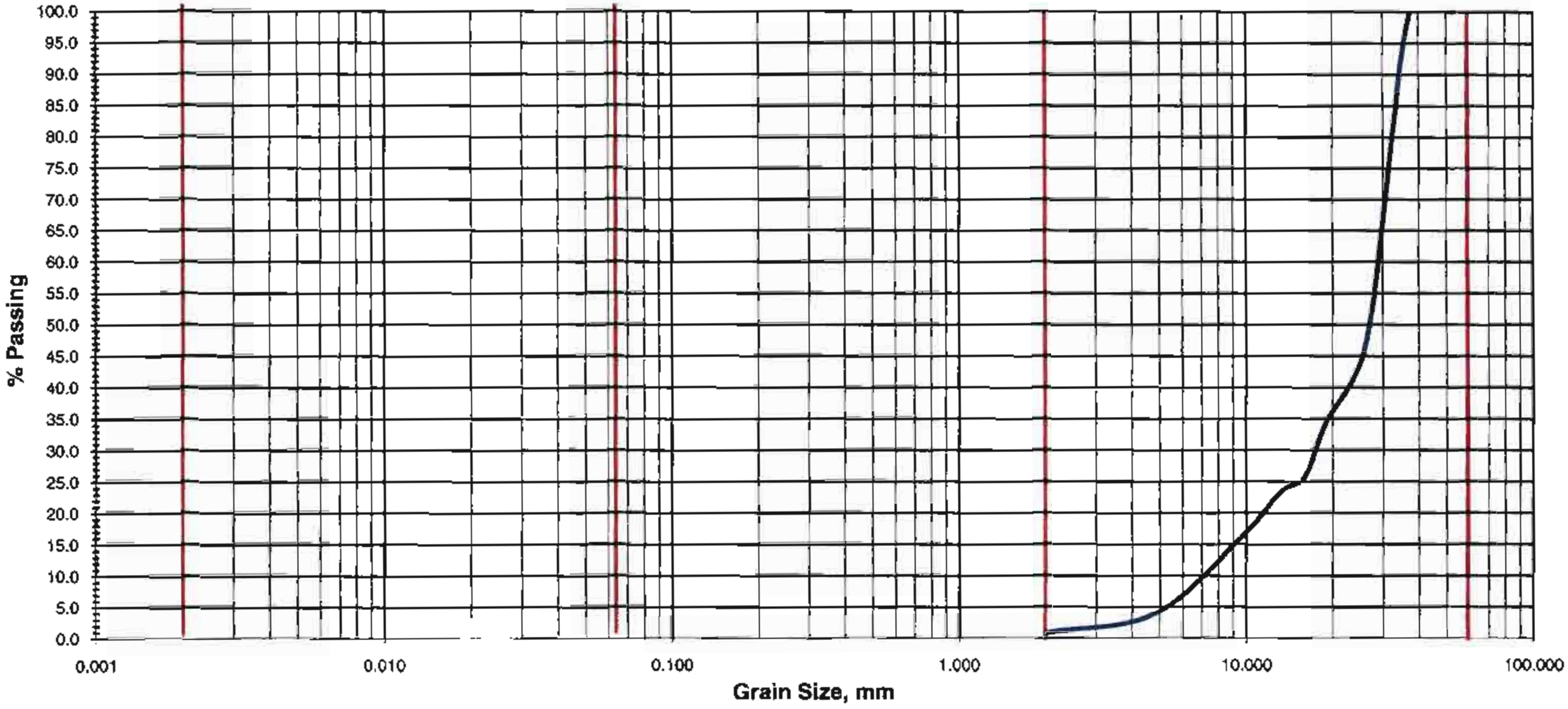
Trow Project No.:	OTT-00201369-A0	Project Name :	Geotechnical Investigation - Proposed Water Reservoir				
Client :	Government of Nunavut	Project Location :	Whale Cove - Government of Nunavut				
Date Sampled :	September 18, 2011	Bore Hole No.:	1	Sample No.:	SS15	Depth (m) :	6.1 to 6.7
Sample Description :	Sandy Gravel, Some Silt					Figure :	12

exp Services Inc.
100-2650 Queensview Drive
Ottawa, ON K28 8H6

Method of Test for Particle Size Analysis of Soil

ASTM D-422

Grain Size Distribution Curve



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

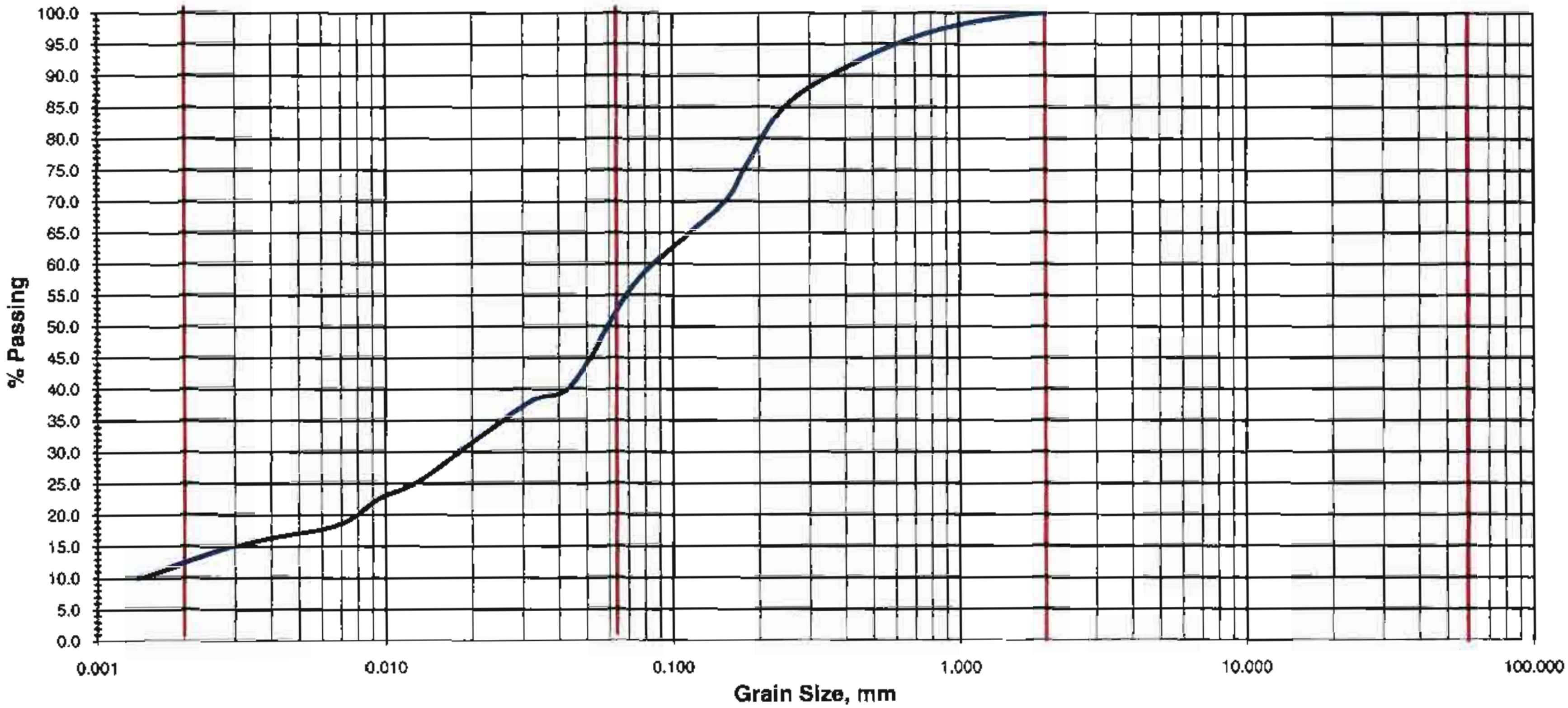
Trow Project No.:	OTT-00201369-A0	Project Name :	Geotechnical Investigation - Proposed Water Reservoir				
Client :	Government of Nunavut	Project Location :	Whale Cove - Government of Nunavut				
Date Sampled :	September 19, 2011	Bore Hole No.:	2	Sample No.:	SS9	Depth (m) :	4.6 to 5.2
Sample Description :	Fine to Coarse Gravel					Figure :	13

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

Method of Test for Particle Size Analysis of Soil

ASTM D-422

Grain Size Distribution Curve



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

Trow Project No.:	OTT-00201369-A0	Project Name :	Geotechnical Investigation - Proposed Water Reservoir			
Client :	Government of Nunavut	Project Location :	Whale Cove - Government of Nunavut			
Date Sampled :	September 16, 2011	Bore Hole No.:	2	Sample No.: SS15	Depth (m) :	8.2 to 8.8
Sample Description :		Silt and Sand , Some Clay			Figure :	14

Slope Stability Analysis - Section A-A
Upstream Slope (Rapid Drawdown)
Topsoil Not Removed
Existing Sewage Lagoon Modifications
Hamlet of Whale Cove

Figure 15
OTT-00201369-A0

Soil: 1
Description: Proposed Fill
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 38

Soil: 2
Description: Existing Fill
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 32

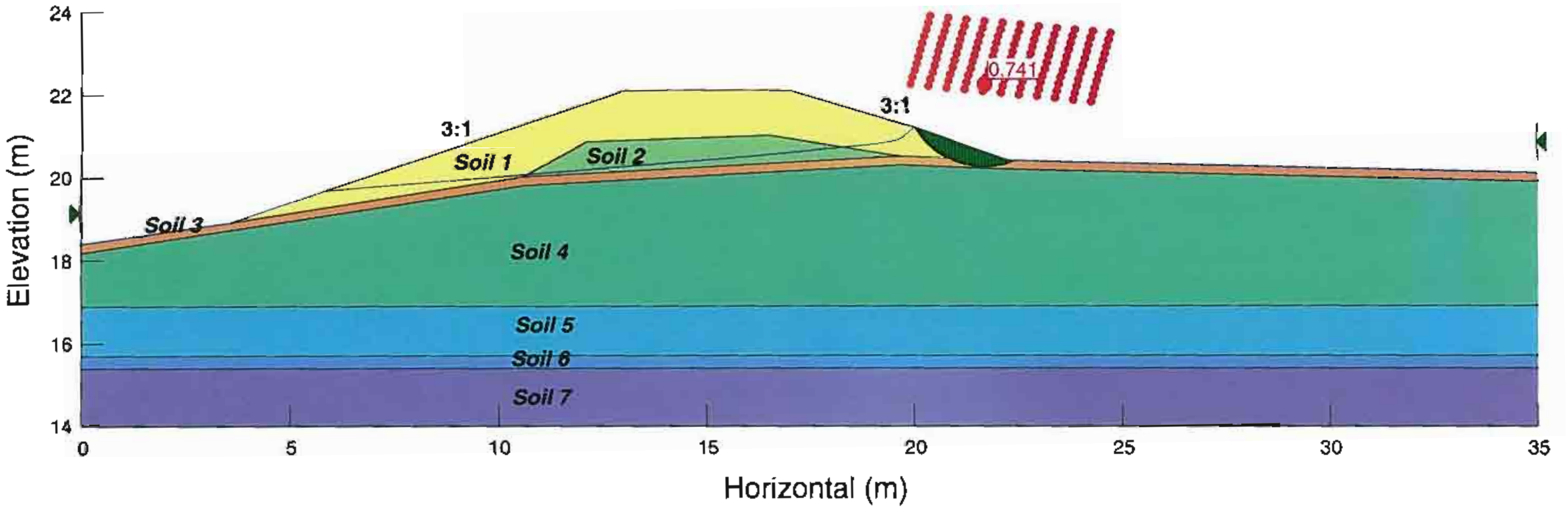
Soil: 3
Description: Organic Silt
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 20

Soil: 4
Description: Sand
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 32

Soil: 5
Description: Sandy Silt
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 25

Soil: 6
Description: Sandy Gravel
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 35

Soil: 7
Description: Permafrost (Sandy Gravel)



Slope Stability Analysis - Section A-A
Upstream Slope (Rapid Drawdown)
Topsoil Removed
Existing Sewage Lagoon Modifications
Hamlet of Whale Cove

Figure 16
OTT-00201369-A0

Soil: 1
Description: Proposed Fill
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 38

Soil: 2
Description: Existing Fill
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 32

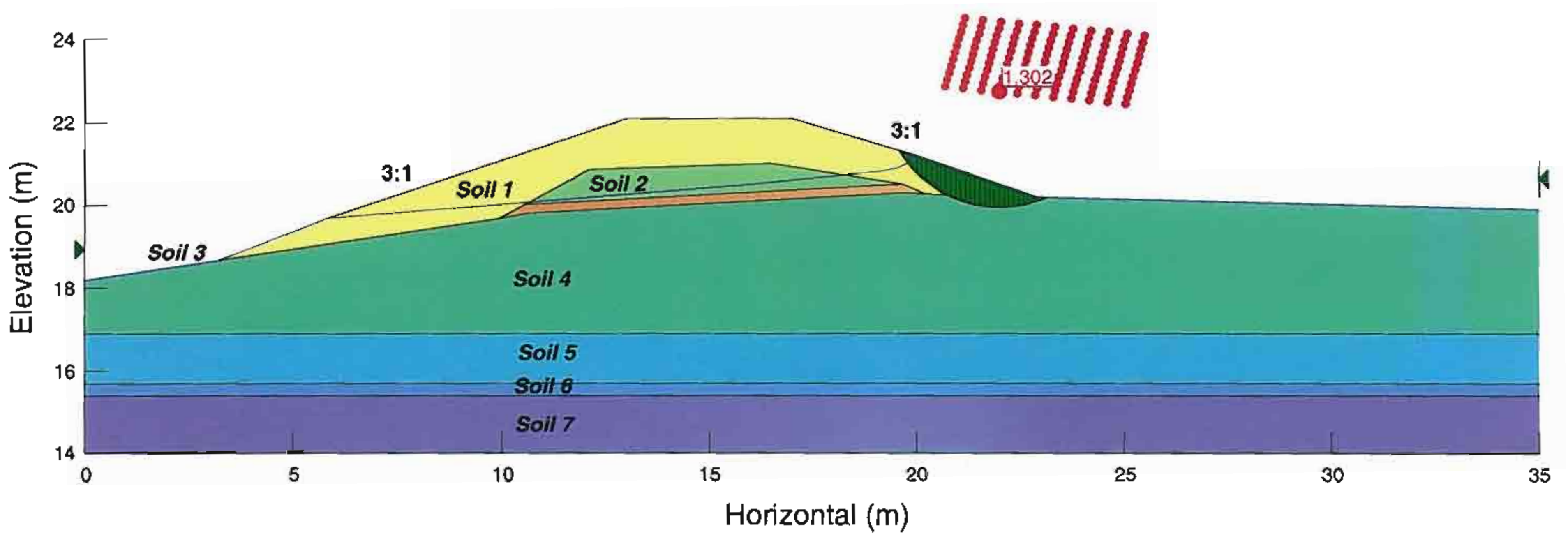
Soil: 3
Description: Organic Silt
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 20

Soil: 4
Description: Sand
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 32

Soil: 5
Description: Sandy Silt
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 25

Soil: 6
Description: Sandy Gravel
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 35

Soil: 7
Description: Permafrost (Sandy Gravel)



Slope Stability Analysis - Section A-A
Upstream Slope (Rapid Drawdown + Seismic Loading)
Topsoil Removed
Existing Sewage Lagoon Modifications
Hamlet of Whale Cove

Figure 17
OTT-00201369-A0

Soil: 1
Description: Proposed Fill
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 38

Soil: 2
Description: Existing Fill
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 32

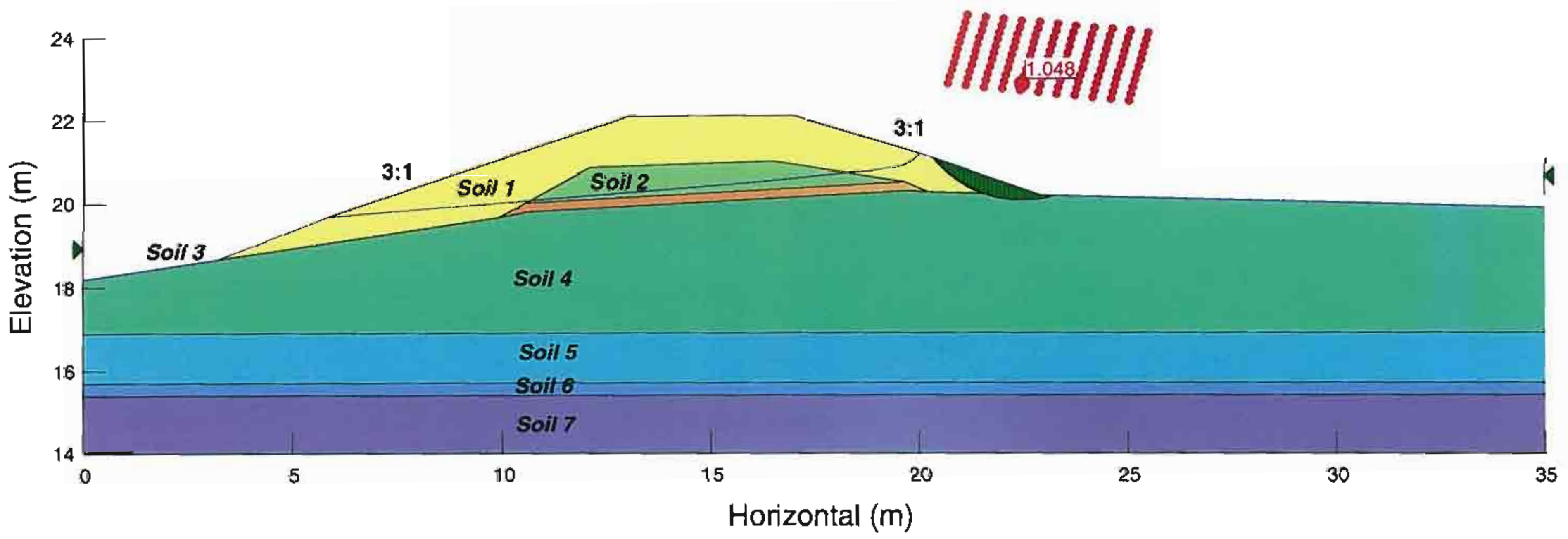
Soil: 3
Description: Organic Silt
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 20

Soil: 4
Description: Sand
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 32

Soil: 5
Description: Sandy Silt
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 25

Soil: 6
Description: Sandy Gravel
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 35

Soil: 7
Description: Permafrost (Sandy Gravel)



Slope Stability Analysis - Section A-A
Upstream Slope (Submerged Slope)
Topsoil Removed
Existing Sewage Lagoon Modifications
Hamlet of Whale Cove

Figure 18
OTT-00201369-A0

Soil: 1
Description: Proposed Fill
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 38

Soil: 2
Description: Existing Fill
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 32

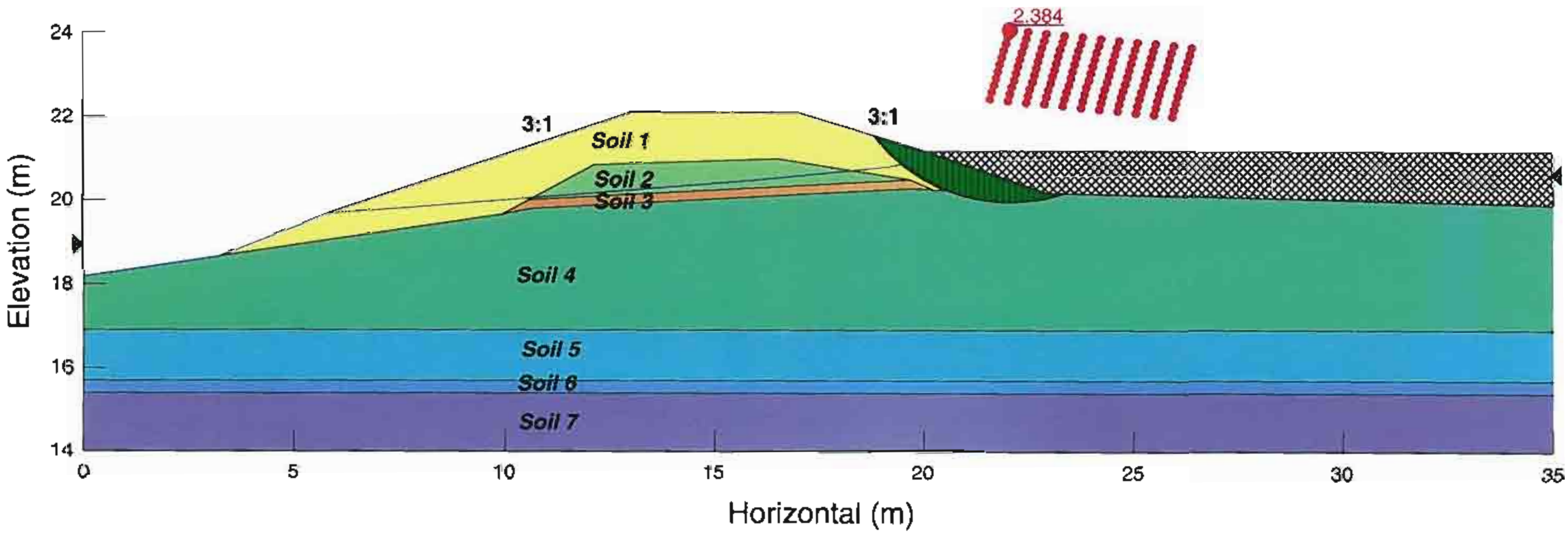
Soil: 3
Description: Organic Silt
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 20

Soil: 4
Description: Sand
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 32

Soil: 5
Description: Sandy Silt
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 25

Soil: 6
Description: Sandy Gravel
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 35

Soil: 7
Description: Permafrost (Sandy Gravel)



Slope Stability Analysis - Section A-A
Upstream Slope (Submerged Slope + Seismic Loading)
Topsoil Removed
Existing Sewage Lagoon Modifications
Hamlet of Whale Cove

Figure 19
OTT-00201369-A0

Soil: 1
Description: Proposed Fill
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 38

Soil: 2
Description: Existing Fill
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 32

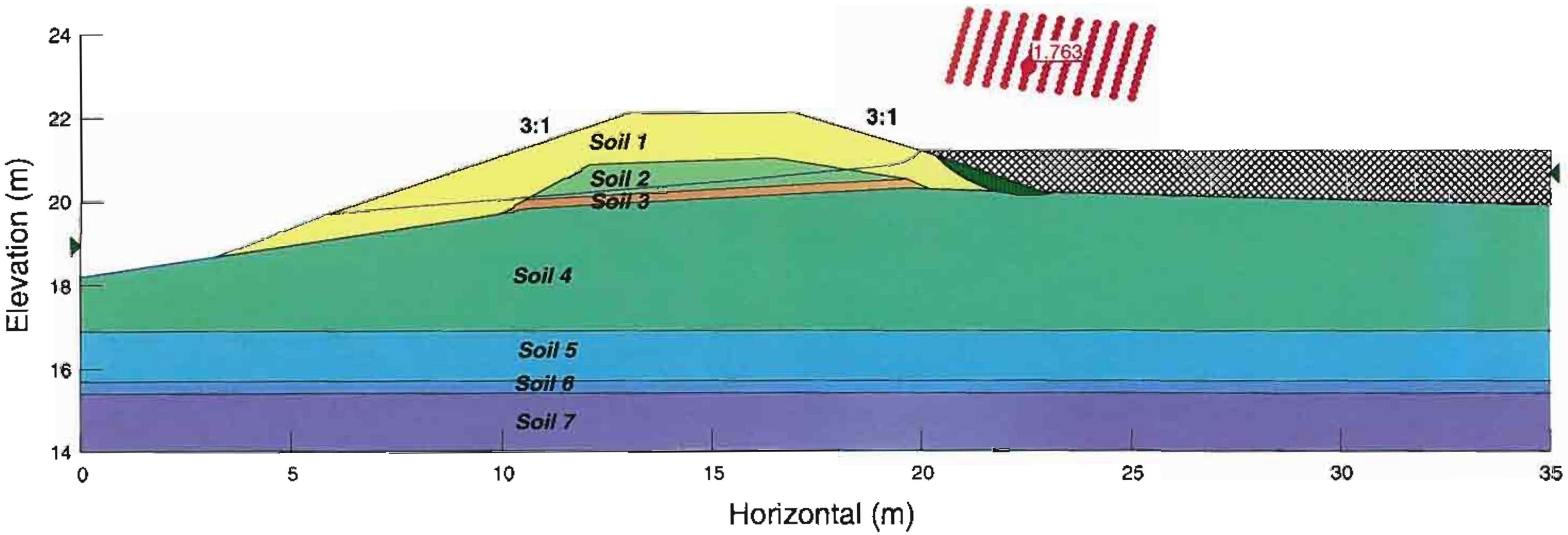
Soil: 3
Description: Organic Silt
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 20

Soil: 4
Description: Sand
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 32

Soil: 5
Description: Sandy Silt
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 25

Soil: 6
Description: Sandy Gravel
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 35

Soil: 7
Description: Permafrost (Sandy Gravel)



Slope Stability Analysis - Section A-A
Upstream Slope (Rapid Drawdown)
Topsoil Removed
Existing Sewage Lagoon Modifications
Hamlet of Whale Cove

Figure 20
OTT-00201369-A0

Soil: 1
Description: Proposed Fill
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 38

Soil: 2
Description: Existing Fill
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 32

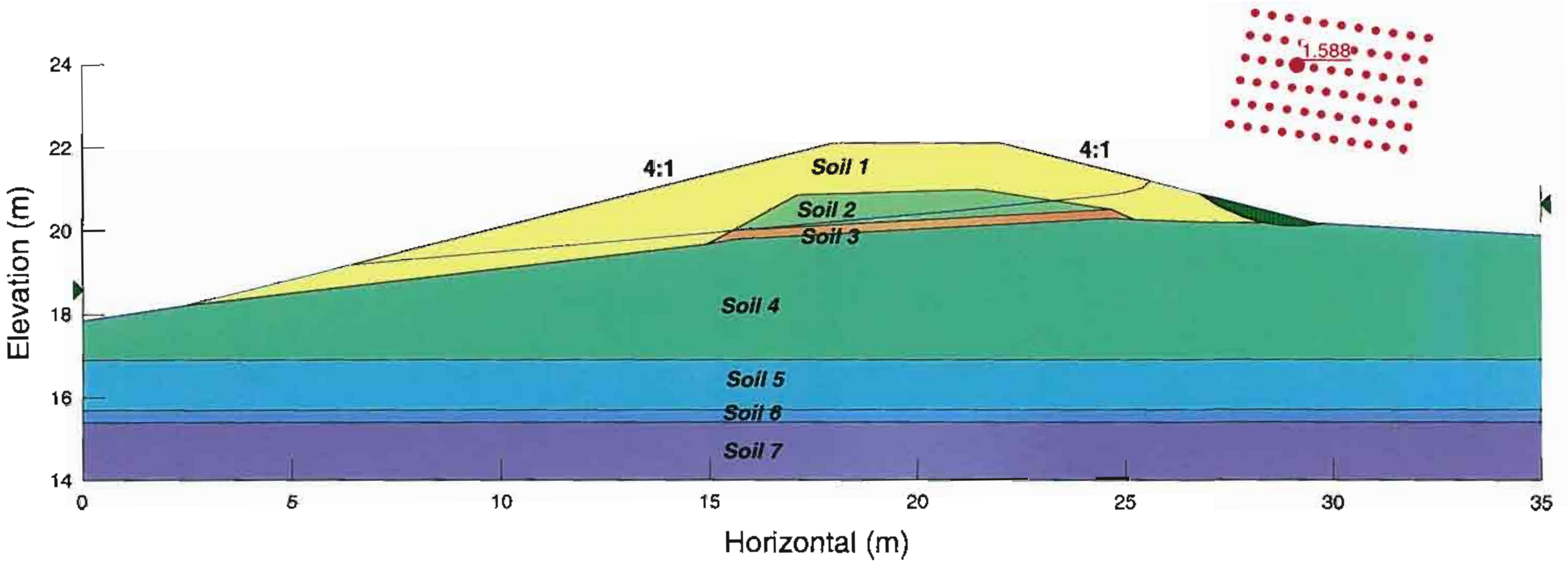
Soil: 3
Description: Organic Silt
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 20

Soil: 4
Description: Sand
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 32

Soil: 5
Description: Sandy Silt
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 25

Soil: 6
Description: Sandy Gravel
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 35

Soil: 7
Description: Permafrost (Sandy Gravel)



Slope Stability Analysis - Section A-A
Upstream Slope (Rapid Drawdown + Seismic Loading)
Topsoil Removed
Existing Sewage Lagoon Modifications
Hamlet of Whale Cove

Figure 21
OTT-00201369-A0

Soil: 1
Description: Proposed Fill
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 38

Soil: 2
Description: Existing Fill
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 32

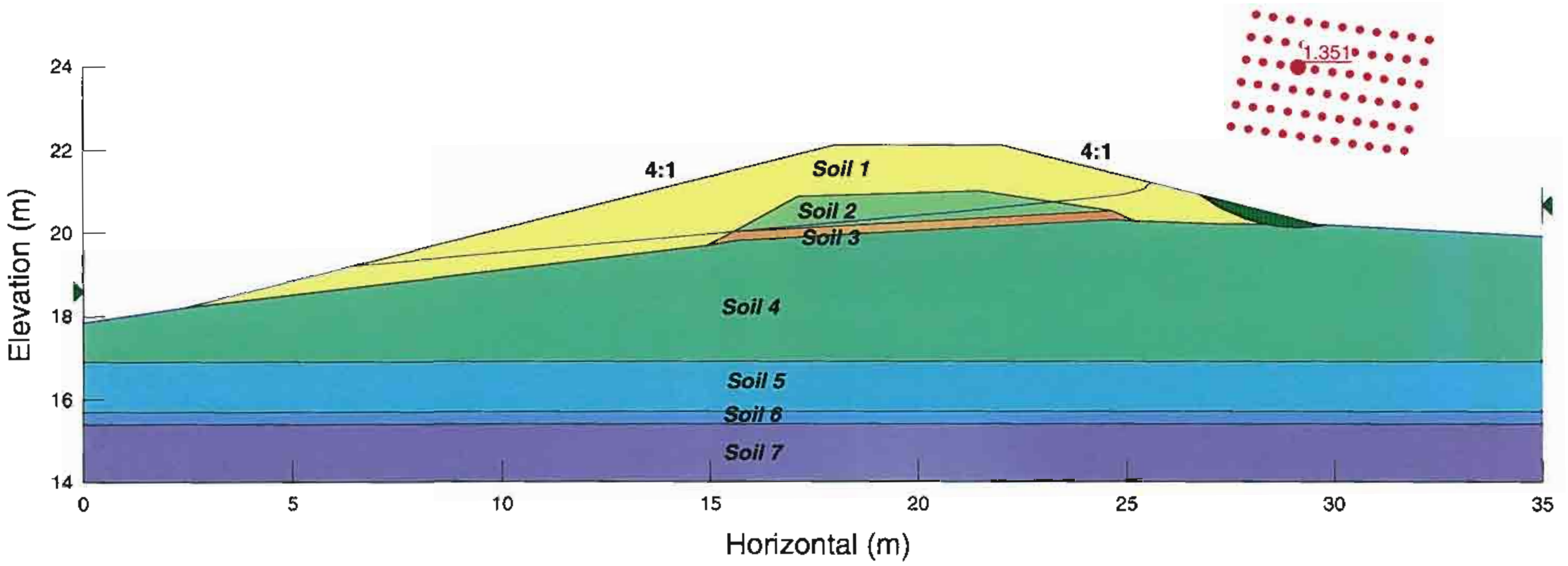
Soil: 3
Description: Organic Silt
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 20

Soil: 4
Description: Sand
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 32

Soil: 5
Description: Sandy Silt
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 25

Soil: 6
Description: Sandy Gravel
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 35

Soil: 7
Description: Permafrost (Sandy Gravel)



Slope Stability Analysis - Section A-A
Upstream Slope (Submerged Slope)
Topsoil Removed
Existing Sewage Lagoon Modifications
Hamlet of Whale Cove

Figure 22
OTT-00201369-A0

Soil: 1
Description: Proposed Fill
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 38

Soil: 2
Description: Existing Fill
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 32

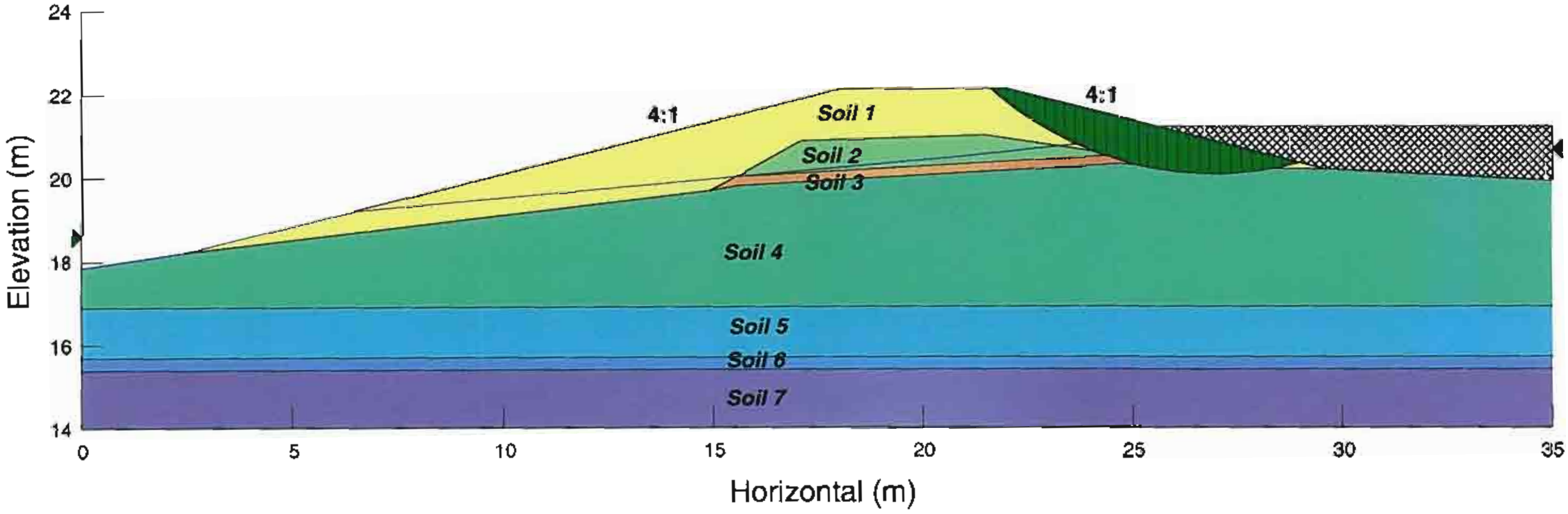
Soil: 3
Description: Organic Silt
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 20

Soil: 4
Description: Sand
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 32

Soil: 5
Description: Sandy Silt
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 25

Soil: 6
Description: Sandy Gravel
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 35

Soil: 7
Description: Permafrost (Sandy Gravel)



Slope Stability Analysis - Section A-A
Upstream Slope (Submerged Slope + Seismic Loading)
Topsoil Removed
Existing Sewage Lagoon Modifications
Hamlet of Whale Cove

Figure 23
OTT-00201369-A0

Soil: 1
Description: Proposed Fill
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 38

Soil: 2
Description: Existing Fill
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 32

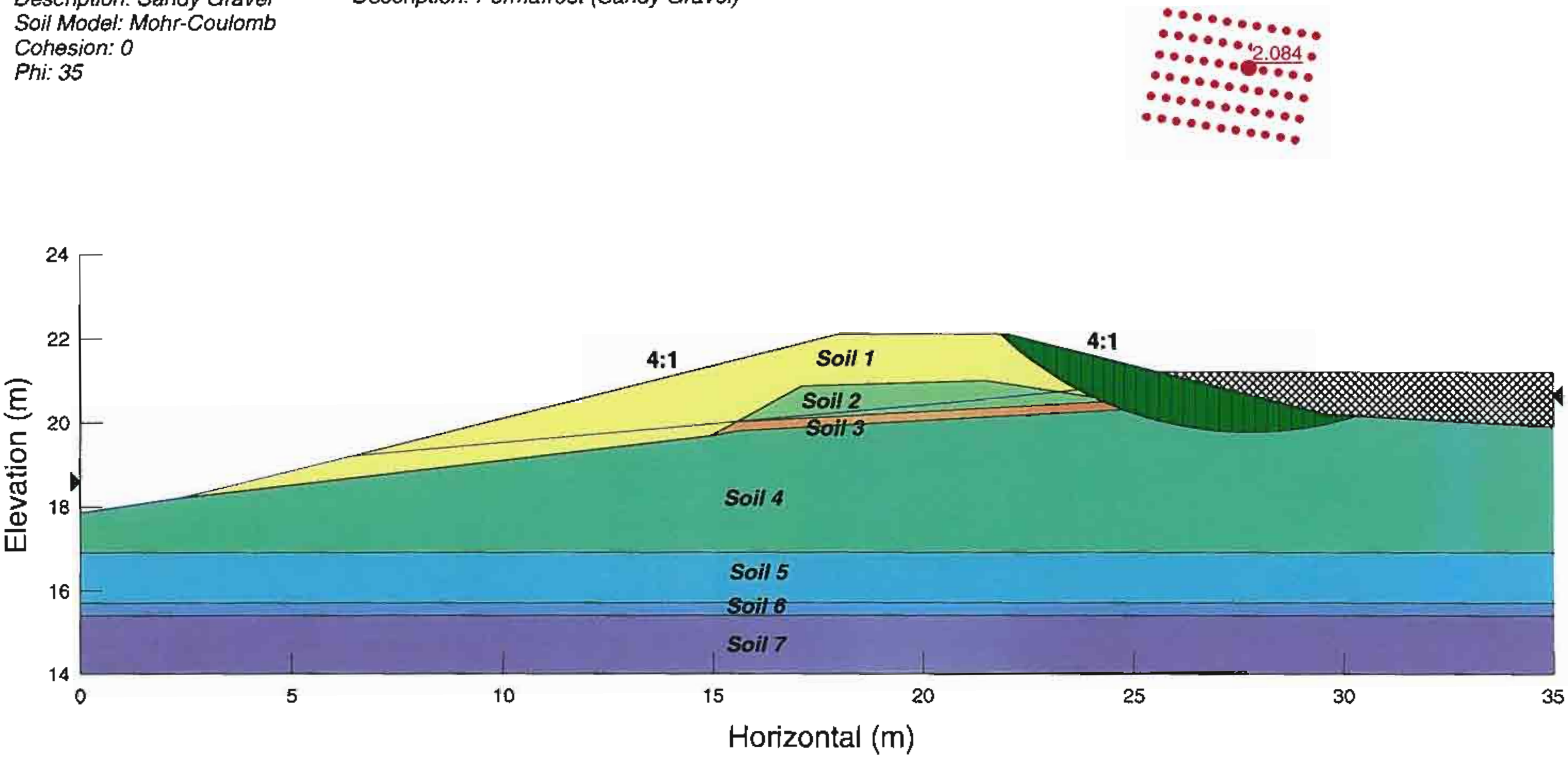
Soil: 3
Description: Organic Silt
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 20

Soil: 4
Description: Sand
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 32

Soil: 5
Description: Sandy Silt
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 25

Soil: 6
Description: Sandy Gravel
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 35

Soil: 7
Description: Permafrost (Sandy Gravel)



Slope Stability Analysis - Section A-A
Downstream (Steady State Seepage)
Topsoil Removed
Existing Sewage Lagoon Modifications
Hamlet of Whale Cove

Figure 24
OTT-00201369-A0

Soil: 1
Description: Proposed Fill
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 38

Soil: 2
Description: Existing Fill
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 32

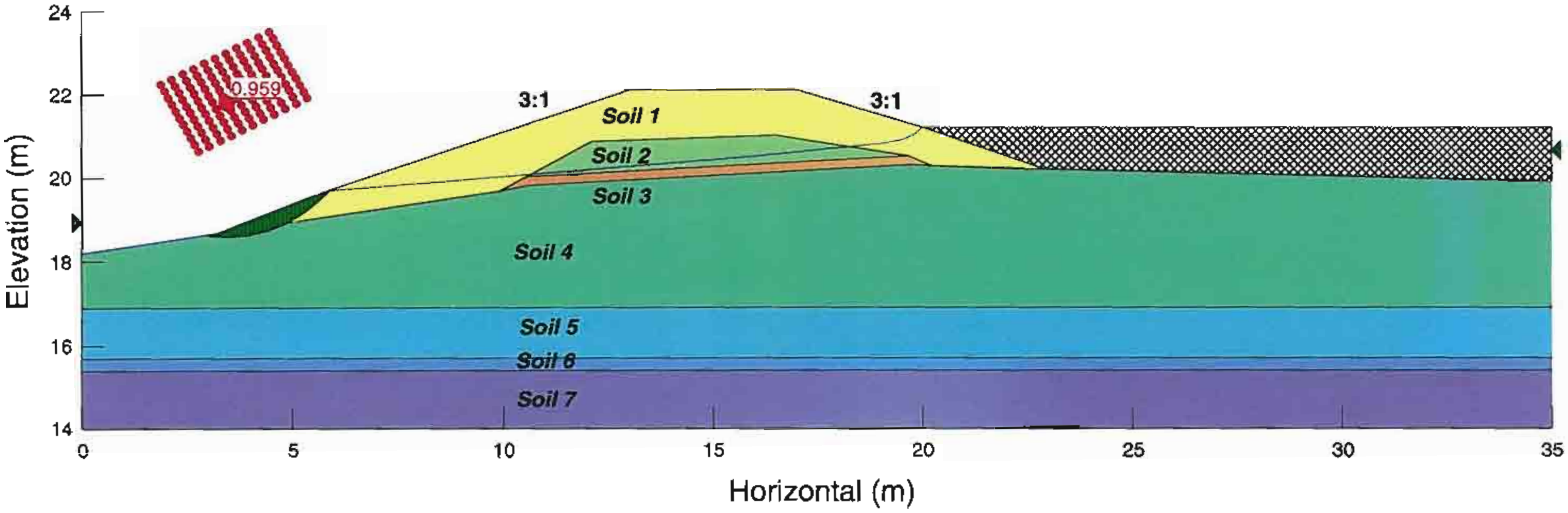
Soil: 3
Description: Organic Silt
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 20

Soil: 4
Description: Sand
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 32

Soil: 5
Description: Sandy Silt
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 25

Soil: 6
Description: Sandy Gravel
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 35

Soil: 7
Description: Permafrost (Sandy Gravel)



Slope Stability Analysis - Section A-A
Downstream (Steady State Seepage + Seismic Loading)
Topsoil Removed
Existing Sewage Lagoon Modifications
Hamlet of Whale Cove

Figure 25
OTT-00201369-A0

Soil: 1
Description: Proposed Fill
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 38

Soil: 2
Description: Existing Fill
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 32

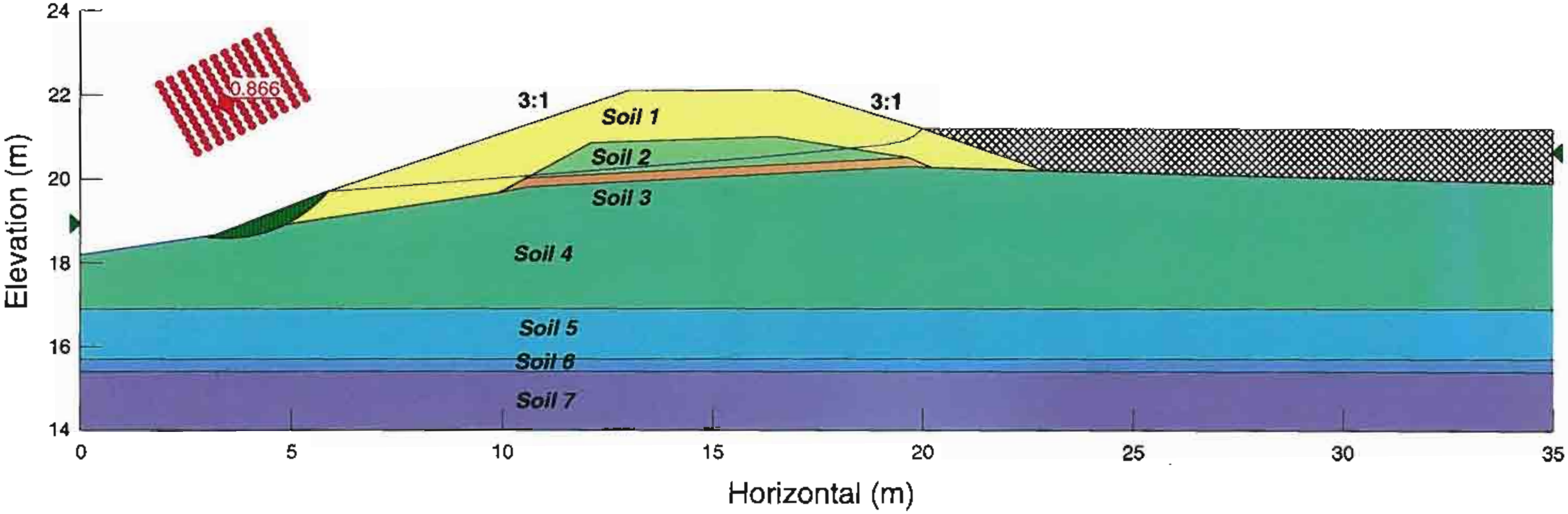
Soil: 3
Description: Organic Silt
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 20

Soil: 4
Description: Sand
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 32

Soil: 5
Description: Sandy Silt
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 25

Soil: 6
Description: Sandy Gravel
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 35

Soil: 7
Description: Permafrost (Sandy Gravel)



Slope Stability Analysis - Section A-A
Downstream Slope (Steady State Seepage)
Topsoil Removed
Existing Sewage Lagoon Modifications
Hamlet of Whale Cove

Figure 26
OTT-00201369-A0

Soil: 1
Description: Proposed Fill
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 38

Soil: 2
Description: Existing Fill
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 32

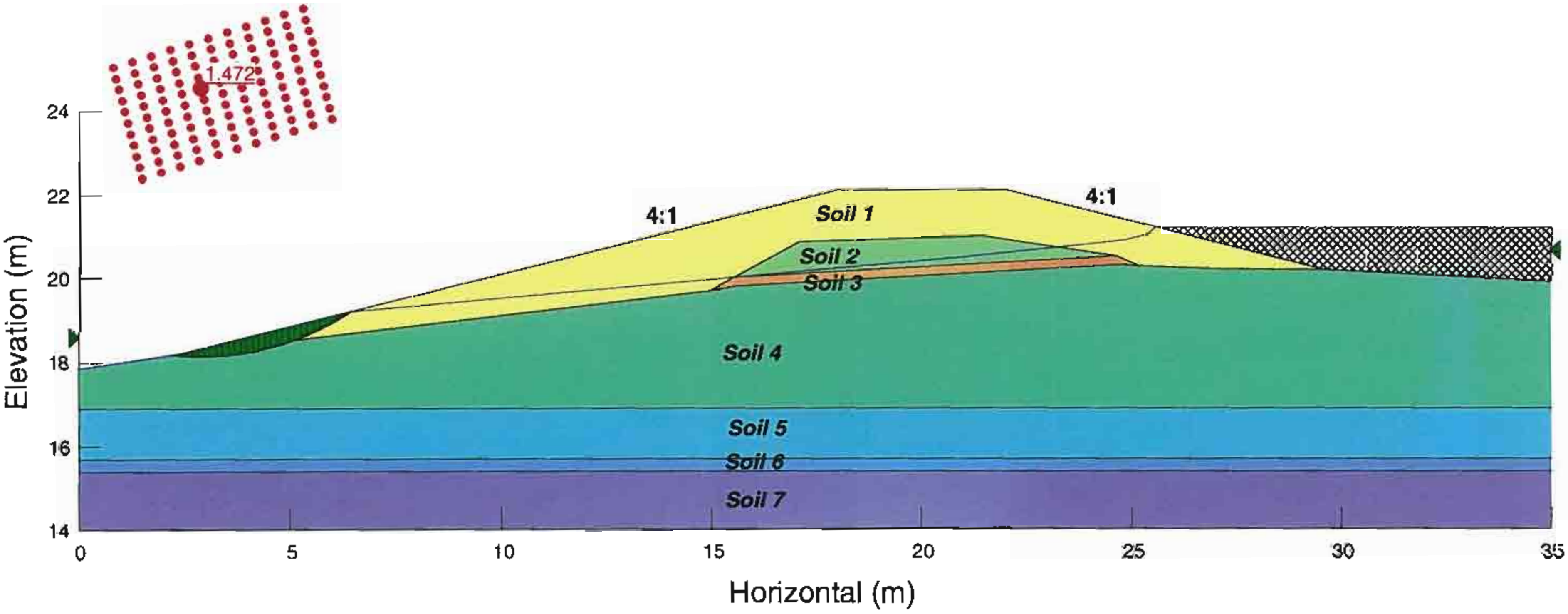
Soil: 3
Description: Organic Silt
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 20

Soil: 4
Description: Sand
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 32

Soil: 5
Description: Sandy Silt
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 25

Soil: 6
Description: Sandy Gravel
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 35

Soil: 7
Description: Permafrost (Sandy Gravel)



Slope Stability Analysis - Section A-A
Downstream Slope (Steady State Seepage + Seismic Loading)
Topsoil Removed
Existing Sewage Lagoon Modifications
Hamlet of Whale Cove

Figure 27
OTT-00201369-A0

Soil: 1
Description: Proposed Fill
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 38

Soil: 2
Description: Existing Fill
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 32

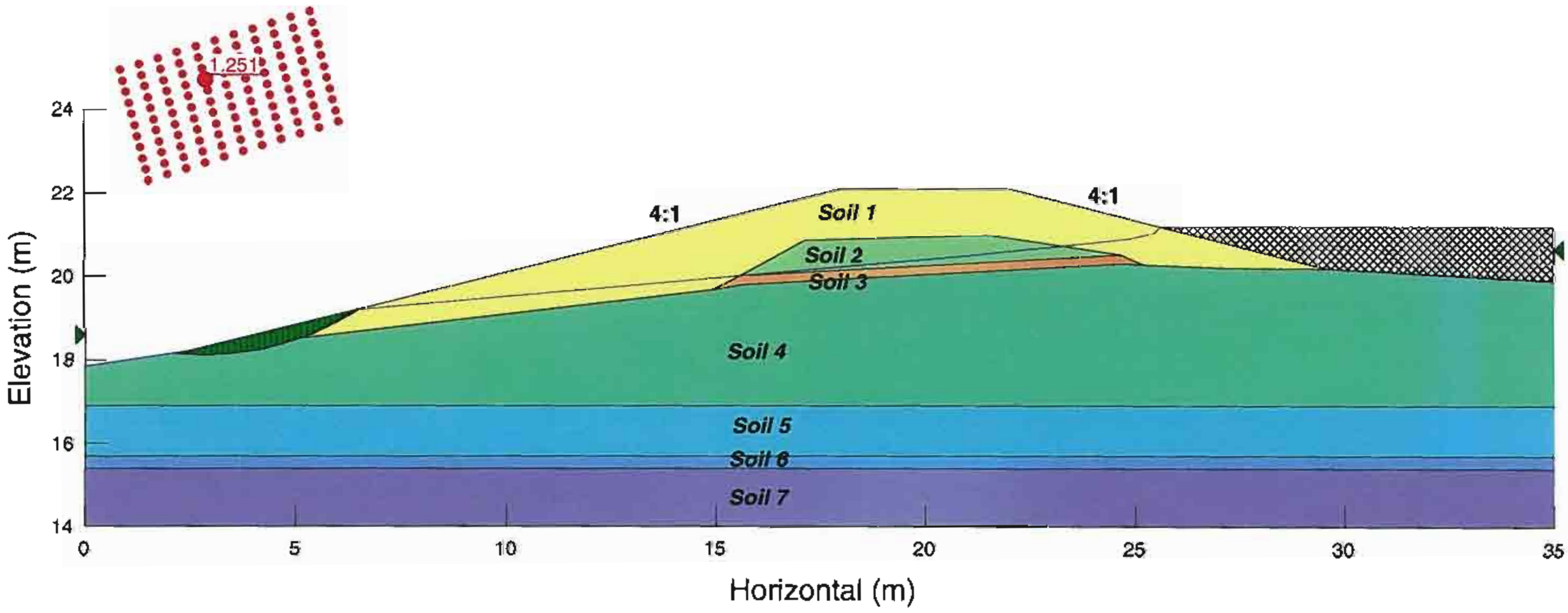
Soil: 3
Description: Organic Silt
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 20

Soil: 4
Description: Sand
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 32

Soil: 5
Description: Sandy Silt
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 25

Soil: 6
Description: Sandy Gravel
Soil Model: Mohr-Coulomb
Cohesion: 0
Phi: 35

Soil: 7
Description: Permafrost (Sandy Gravel)



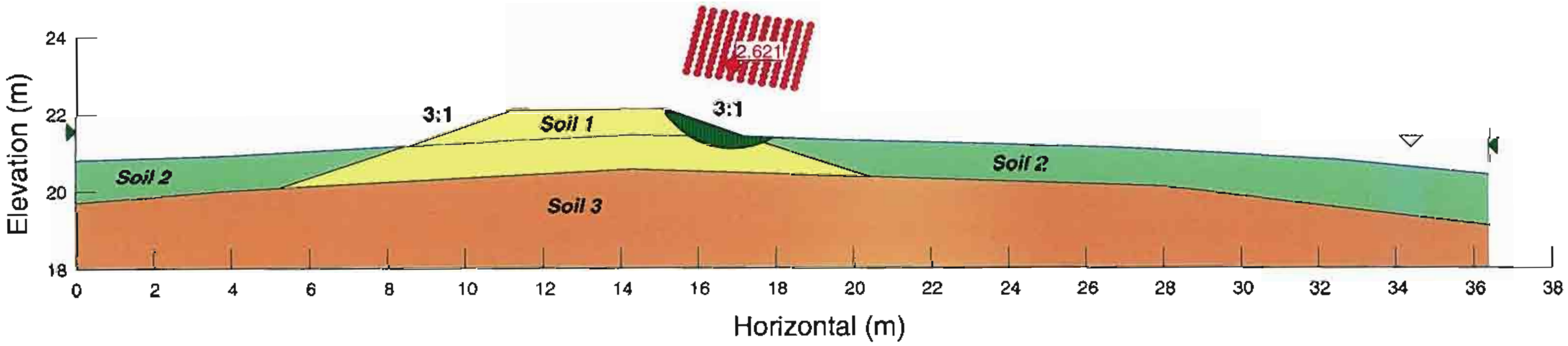
Slope Stability Analysis - Section B-B
Upstream Slope (Rapid Drawdown)
Topsoil Removed
Existing Sewage Lagoon Modifications
Hamlet of Whale Cove

Figure 28
OTT-00201369-A0

Soil: 1
Description: Proposed Fill
Unit Weight: 22
Cohesion: 0
Phi: 38

Soil: 2
Description: Topsoil
Unit Weight: 20
Cohesion: 0
Phi: 22

Soil: 3
Description: Bedrock
Unit Weight: 26
Cohesion: 5000
Phi: 0



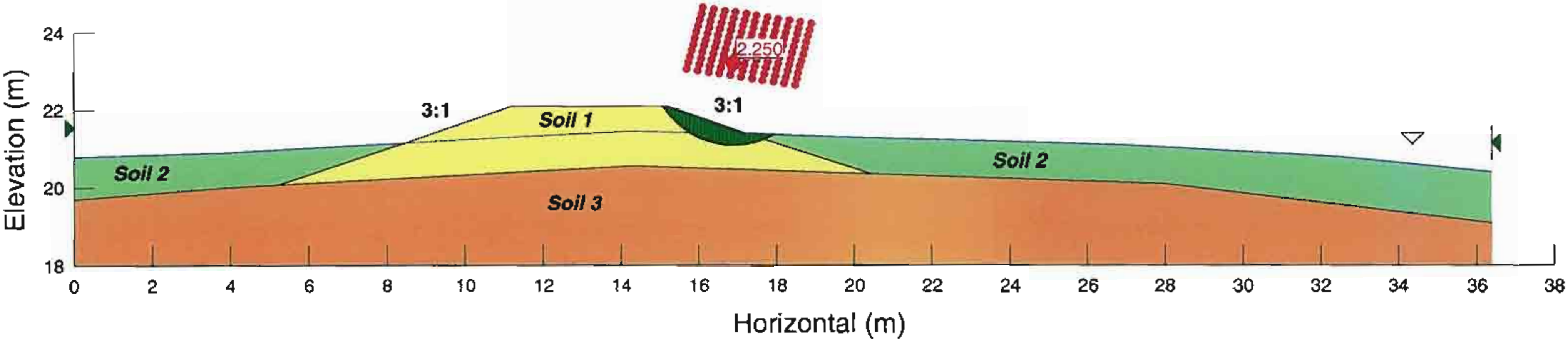
Slope Stability Analysis - Section B-B
Upstream Slope (Rapid Drawdown + Seismic Loading)
Topsoil Removed
Existing Sewage Lagoon Modifications
Hamlet of Whale Cove

Figure 29
OTT-00201369-A0

Soil: 1
Description: Proposed Fill
Unit Weight: 22
Cohesion: 0
Phi: 38

Soil: 2
Description: Topsoil
Unit Weight: 20
Cohesion: 0
Phi: 22

Soil: 3
Description: Bedrock
Unit Weight: 26
Cohesion: 5000
Phi: 0



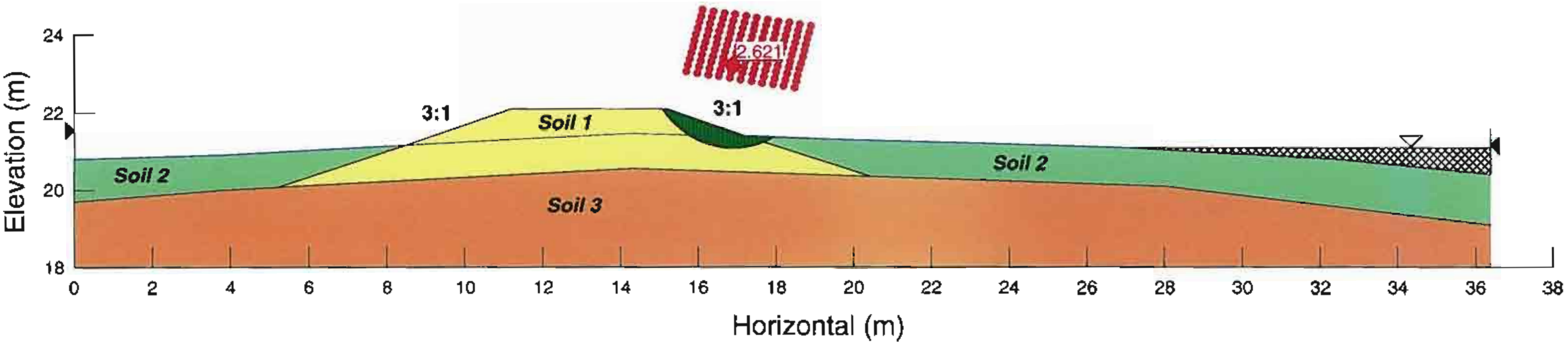
Slope Stability Analysis - Section B-B
Upstream Slope (Submerged Slope)
Topsoil Removed
Existing Sewage Lagoon Modifications
Hamlet of Whale Cove

Figure 30
OTT-00201369-A0

Soil: 1
Description: Proposed Fill
Unit Weight: 22
Cohesion: 0
Phi: 38

Soil: 2
Description: Topsoil
Unit Weight: 20
Cohesion: 0
Phi: 22

Soil: 3
Description: Bedrock
Unit Weight: 26
Cohesion: 5000
Phi: 0



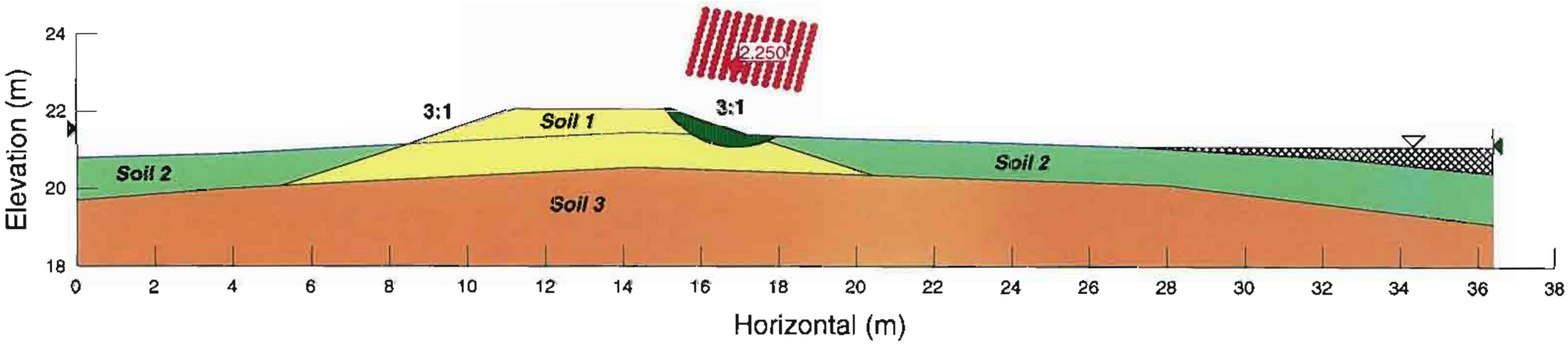
Slope Stability Analysis - Section B-B
Upstream Slope (Submerged Slope + Seismic Loading)
Topsoil Removed
Existing Sewage Lagoon Modifications
Hamlet of Whale Cove

Figure 31
OTT-00201369-A0

Soil: 1
Description: Proposed Fill
Unit Weight: 22
Cohesion: 0
Phi: 38

Soil: 2
Description: Topsoil
Unit Weight: 20
Cohesion: 0
Phi: 22

Soil: 3
Description: Bedrock
Unit Weight: 26
Cohesion: 5000
Phi: 0



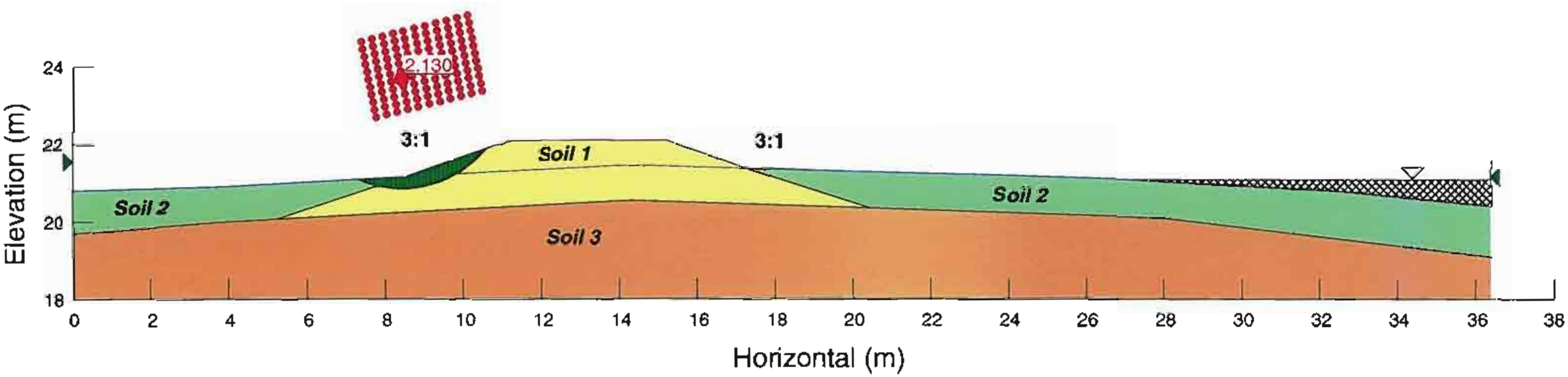
Slope Stability Analysis - Section B-B
Downstream Slope (Steady State Seepage)
Topsoil Removed
Existing Sewage Lagoon Modifications
Hamlet of Whale Cove

Figure 32
OTT-00201369-A0

Soil: 1
Description: Proposed Fill
Unit Weight: 22
Cohesion: 0
Phi: 38

Soil: 2
Description: Topsoil
Unit Weight: 20
Cohesion: 0
Phi: 22

Soil: 3
Description: Bedrock
Unit Weight: 26
Cohesion: 5000
Phi: 0



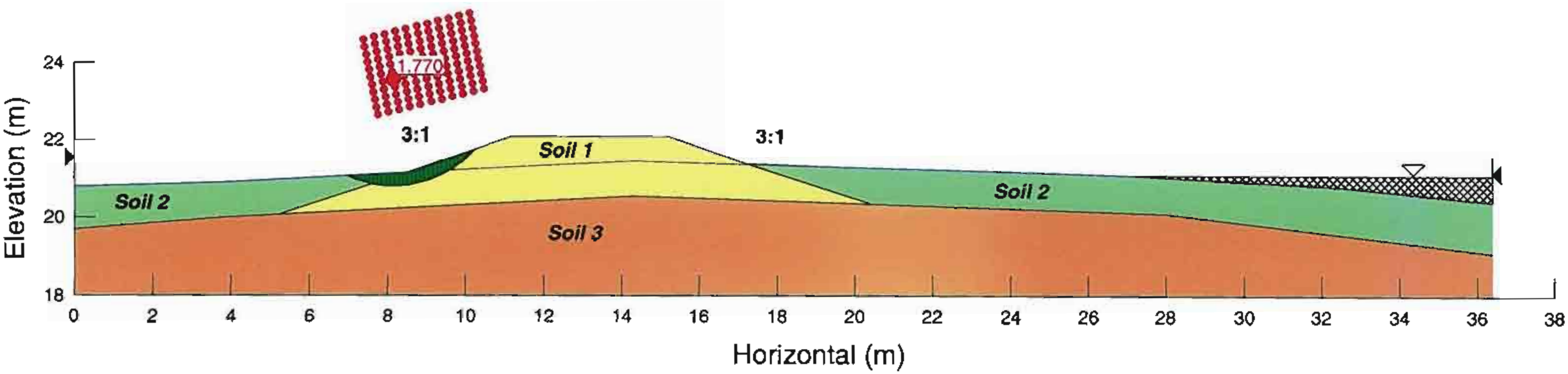
Slope Stability Analysis - Section B-B
Downstream Slope (Steady State Seepage + Seismic Loading)
Topsoil Removed
Existing Sewage Lagoon Modifications
Hamlet of Whale Cove

Figure 33
OTT-00201369-A0

Soil: 1
Description: Proposed Fill
Unit Weight: 22
Cohesion: 0
Phi: 38

Soil: 2
Description: Topsoil
Unit Weight: 20
Cohesion: 0
Phi: 22

Soil: 3
Description: Bedrock
Unit Weight: 26
Cohesion: 5000
Phi: 0



Slope Stability Analysis - Section C-C
Upstream Slope (Rapid Drawdown)
Topsoil Removed
Existing Sewage Lagoon Modifications
Hamlet of Whale Cove

Figure 34
OTT-00201369-A0

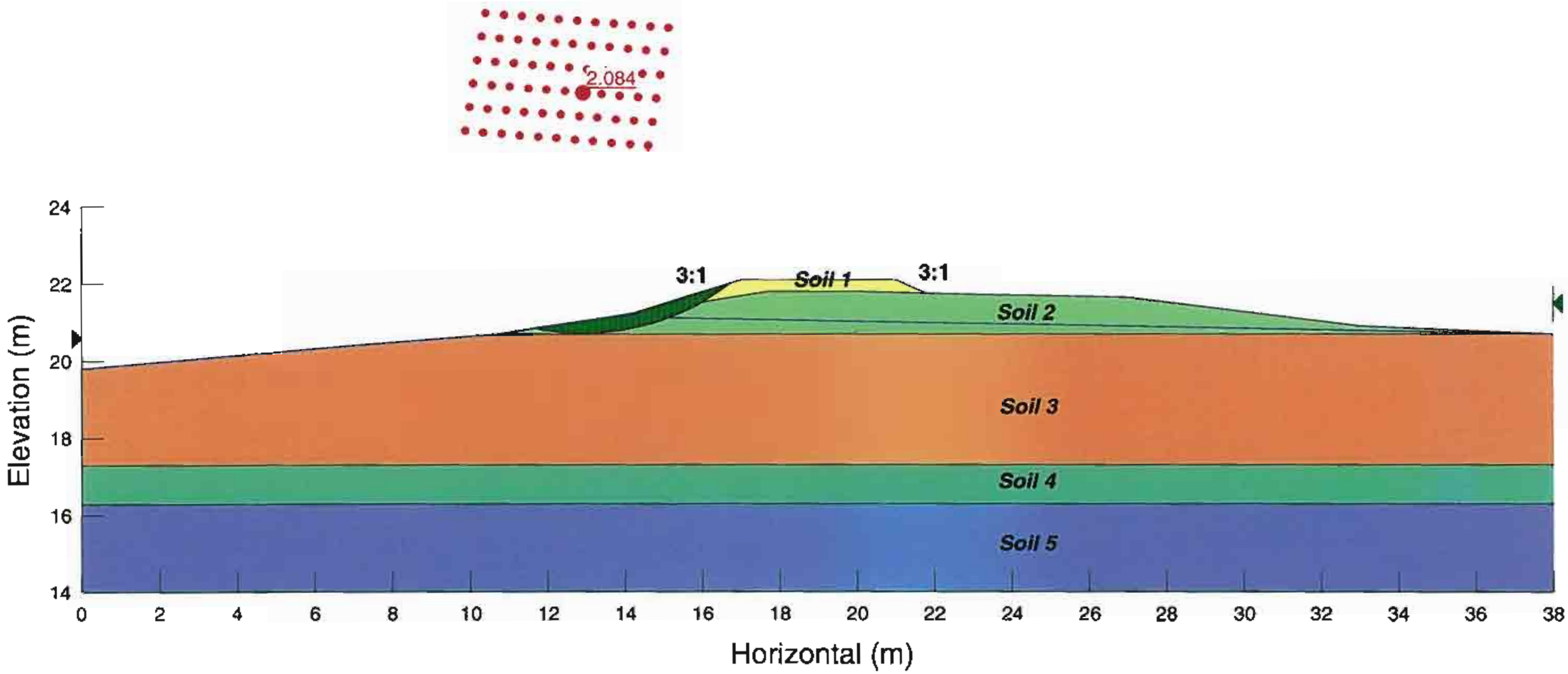
Soil: 1
Description: Proposed Fill
Unit Weight: 22
Cohesion: 0
Phi: 38

Soil: 2
Description: Existing Fill
Unit Weight: 20
Cohesion: 0
Phi: 32

Soil: 3
Description: Sand and Gravel
Unit Weight: 22
Cohesion: 0
Phi: 33

Soil: 4
Description: Sandy Gravel
Unit Weight: 22
Cohesion: 0
Phi: 35

Soil: 5
Description: Permafrost (Silt and Sand)



Slope Stability Analysis - Section C-C
Upstream Slope (Rapid Drawdown + Seismic Loading)
Topsoil Removed
Proposed/Existing Sewage Lagoon
Hamlet of Whale Cove

Figure 35
OTT-00201369-A0

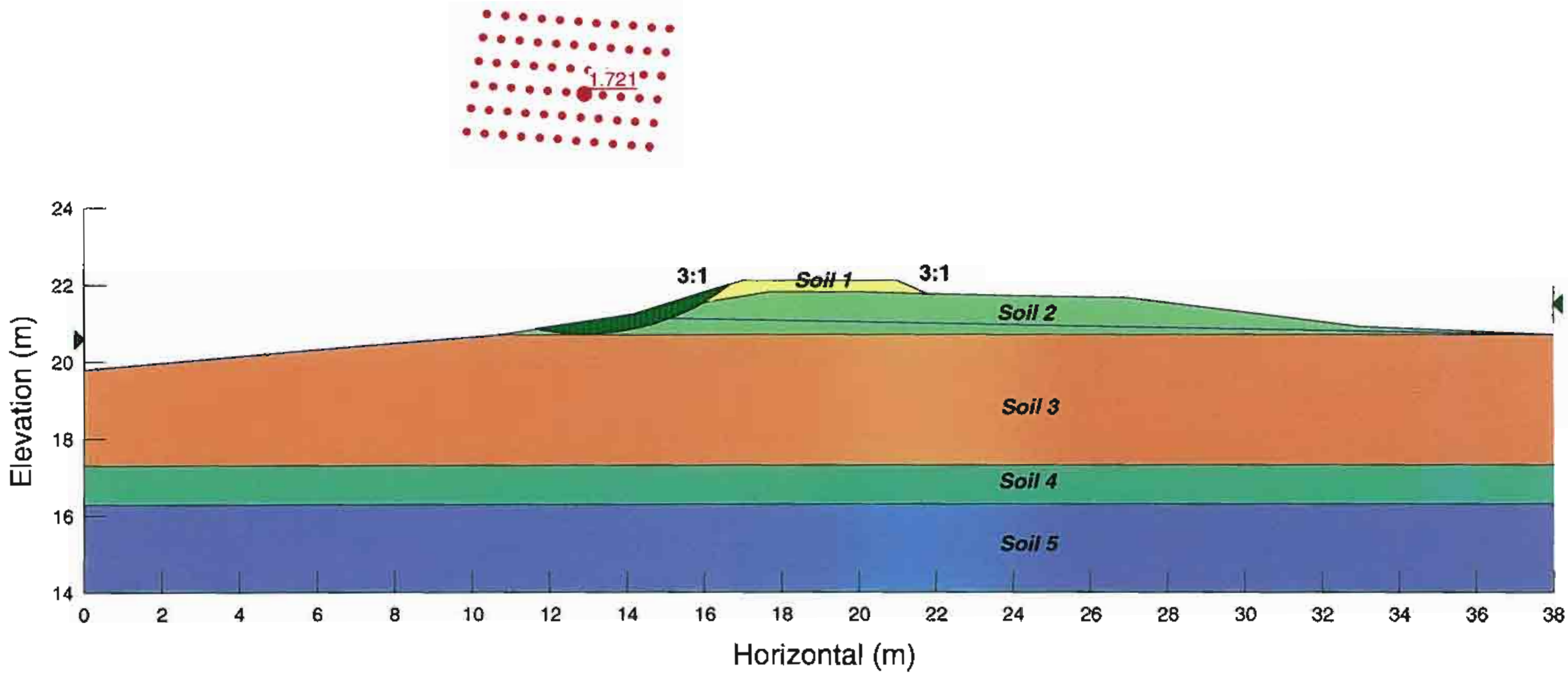
Soil: 1
Description: Proposed Fill
Unit Weight: 22
Cohesion: 0
Phi: 38

Soil: 2
Description: Existing Fill
Unit Weight: 20
Cohesion: 0
Phi: 32

Soil: 3
Description: Sand and Gravel
Unit Weight: 22
Cohesion: 0
Phi: 33

Soil: 4
Description: Sandy Gravel
Unit Weight: 22
Cohesion: 0
Phi: 35

Soil: 5
Description: Permafrost (Silt and Sand)



Slope Stability Analysis - Section C-C
Upstream Slope (Submerged Slope)
Topsoil Removed
Existing Sewage Lagoon Modifications
Hamlet of Whale Cove

Figure 36
OTT-00201369-A0

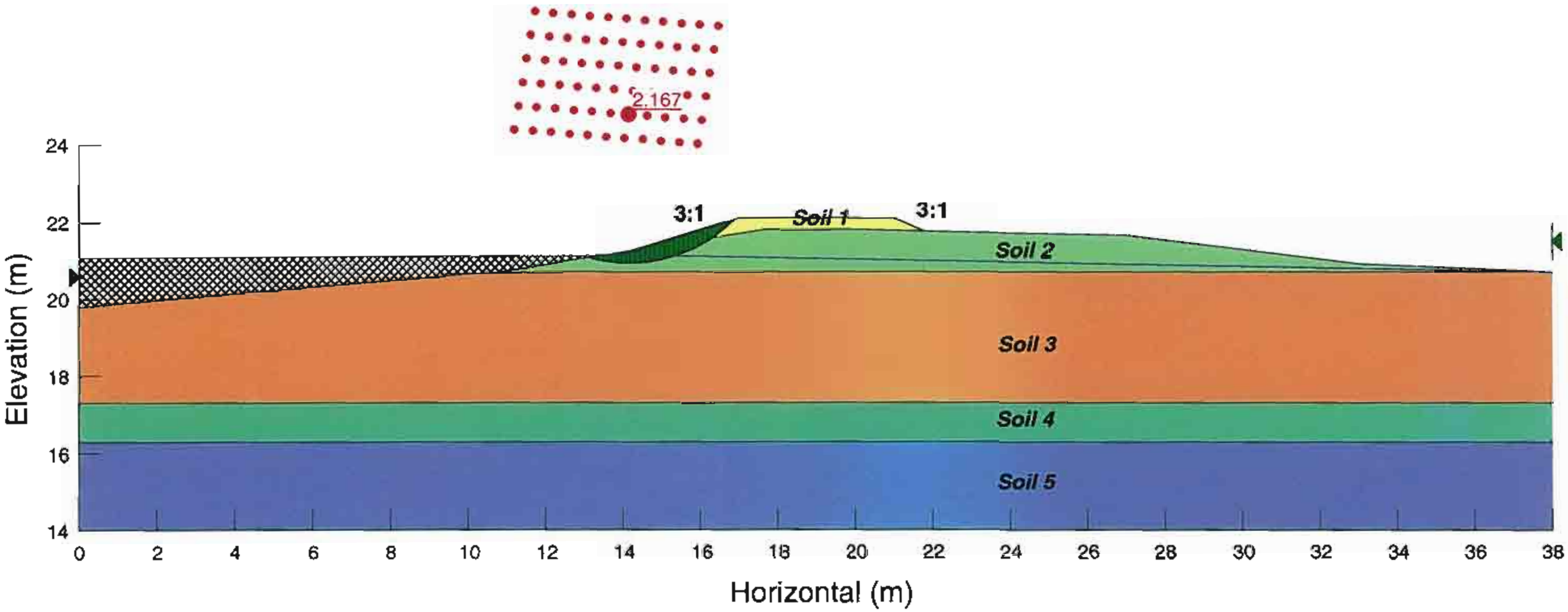
Soil: 1
Description: Proposed Fill
Unit Weight: 22
Cohesion: 0
Phi: 38

Soil: 2
Description: Existing Fill
Unit Weight: 20
Cohesion: 0
Phi: 32

Soil: 3
Description: Sand and Gravel
Unit Weight: 22
Cohesion: 0
Phi: 33

Soil: 4
Description: Sandy Gravel
Unit Weight: 22
Cohesion: 0
Phi: 35

Soil: 5
Description: Permafrost (Silt and Sand)



Slope Stability Analysis - Section C-C
Upstream Slope (Submerged Slope + Seismic Loading)
Topsoil Removed
Existing Sewage Lagoon Modifications
Hamlet of Whale Cove

Figure 37
OTT-00201369-A0

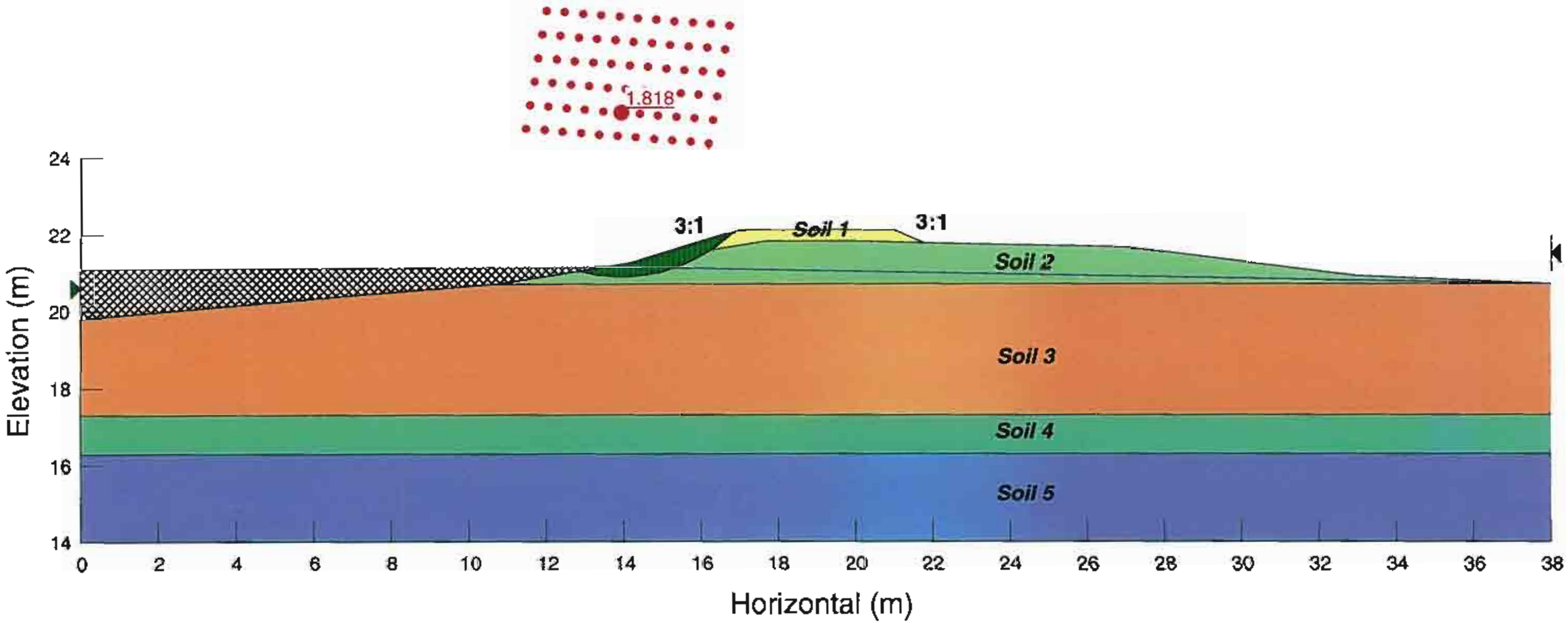
Soil: 1
Description: Proposed Fill
Unit Weight: 22
Cohesion: 0
Phi: 38

Soil: 2
Description: Existing Fill
Unit Weight: 20
Cohesion: 0
Phi: 32

Soil: 3
Description: Sand and Gravel
Unit Weight: 22
Cohesion: 0
Phi: 33

Soil: 4
Description: Sandy Gravel
Unit Weight: 22
Cohesion: 0
Phi: 35

Soil: 5
Description: Permafrost (Silt and Sand)



Slope Stability Analysis - Section C-C
Downstream Slope (Steady State Seepage)
Topsoil Removed
Existing Sewage Lagoon Modifications
Hamlet of Whale Cove

Figure 38
OTT-00201369-A0

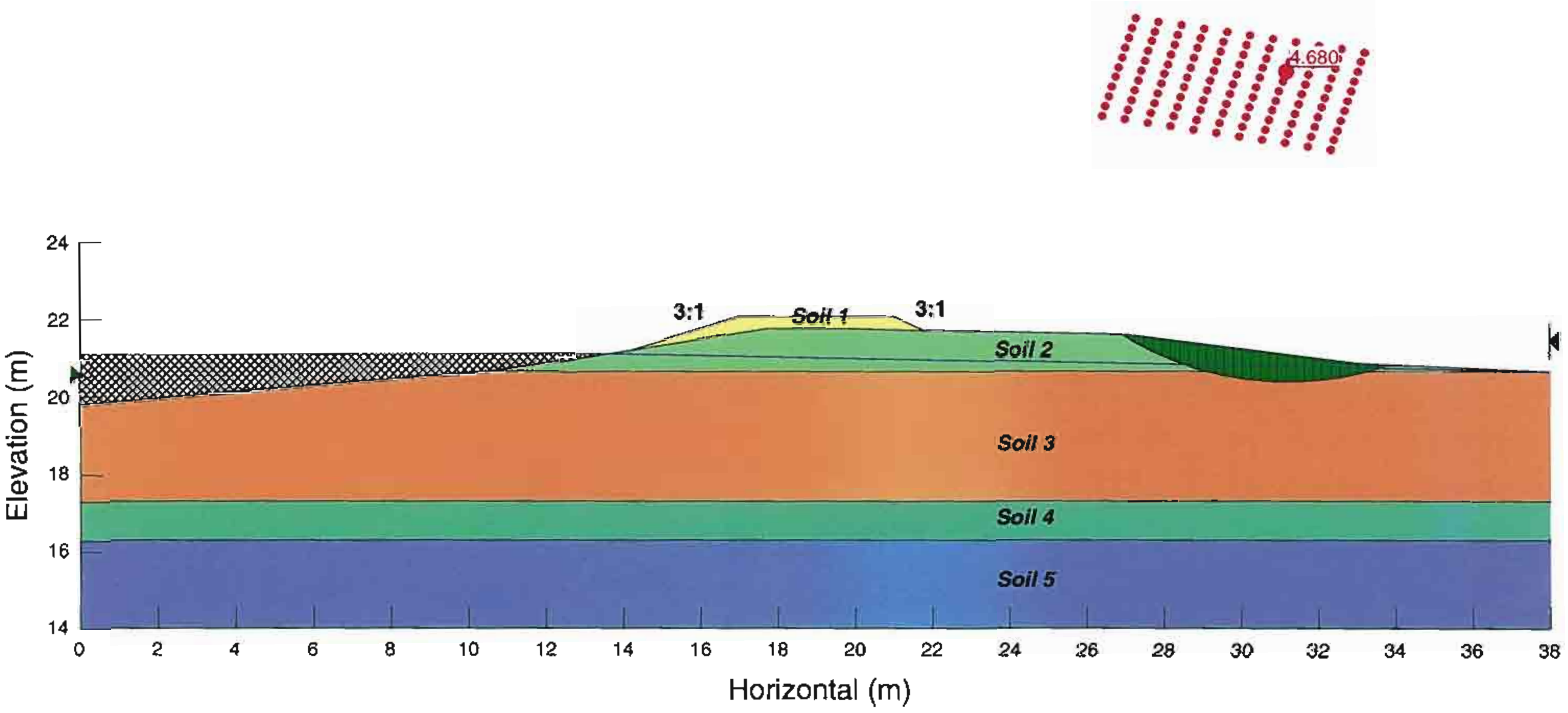
Soil: 1
Description: Proposed Fill
Unit Weight: 22
Cohesion: 0
Phi: 38

Soil: 2
Description: Existing Fill
Unit Weight: 20
Cohesion: 0
Phi: 32

Soil: 3
Description: Sand and Gravel
Unit Weight: 22
Cohesion: 0
Phi: 33

Soil: 4
Description: Sandy Gravel
Unit Weight: 22
Cohesion: 0
Phi: 35

Soil: 5
Description: Permafrost (Silt and Sand)



Slope Stability Analysis - Section C-C
Downstream Slope (Steady State Seepage + Seismic Loading)
Topsoil Removed
Existing Sewage Lagoon Modifications
Hamlet of Whale Cove

Figure 39
OTT-00201369-A0

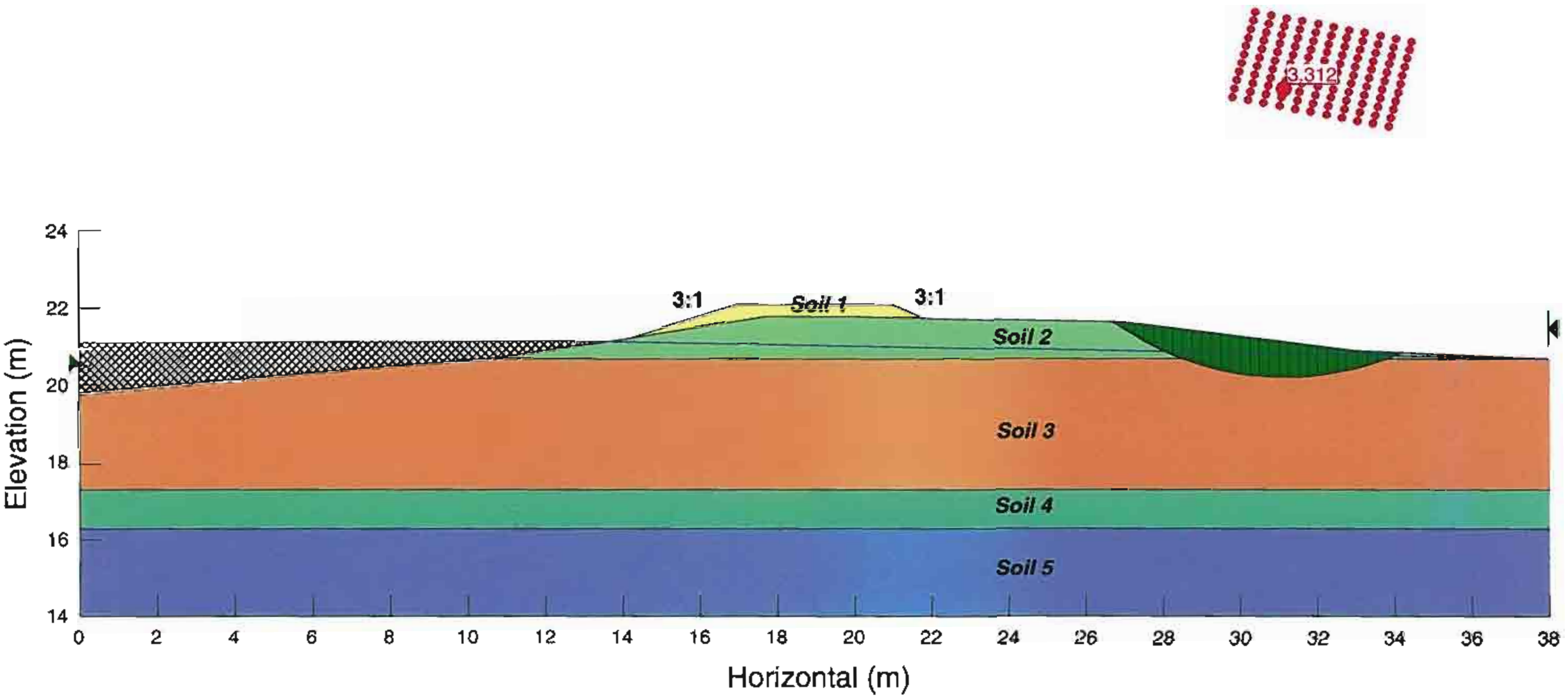
Soil: 1
Description: Proposed Fill
Unit Weight: 22
Cohesion: 0
Phi: 38

Soil: 2
Description: Existing Fill
Unit Weight: 20
Cohesion: 0
Phi: 32

Soil: 3
Description: Sand and Gravel
Unit Weight: 22
Cohesion: 0
Phi: 33

Soil: 4
Description: Sandy Gravel
Unit Weight: 22
Cohesion: 0
Phi: 35

Soil: 5
Description: Permafrost (Silt and Sand)



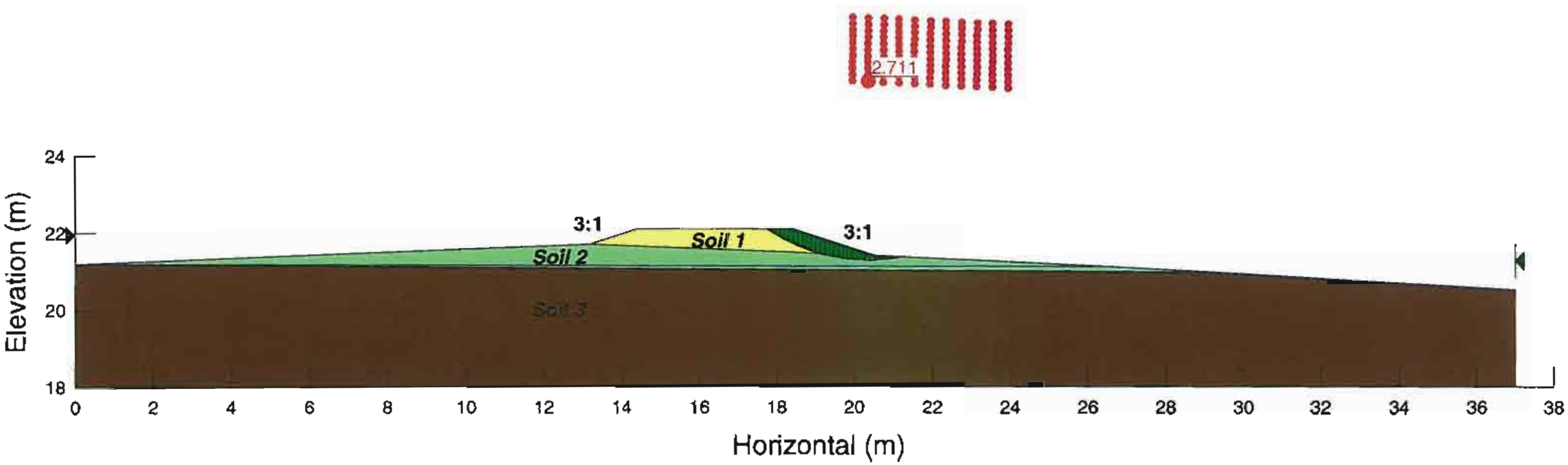
Slope Stability Analysis - Section E-E
Upstream Slope (Rapid Drawdown)
Topsoil Removed
Existing Sewage Lagoon Modifications
Hamlet of Whale Cove

Figure 40
OTT-00201369-A0

Soil: 1
Description: Proposed Fill
Unit Weight: 22
Cohesion: 0
Phi: 38

Soil: 2
Description: Existing Fill
Unit Weight: 20
Cohesion: 0
Phi: 32

Soil: 3
Description: Bedrock
Unit Weight: 26
Cohesion: 5000
Phi: 0



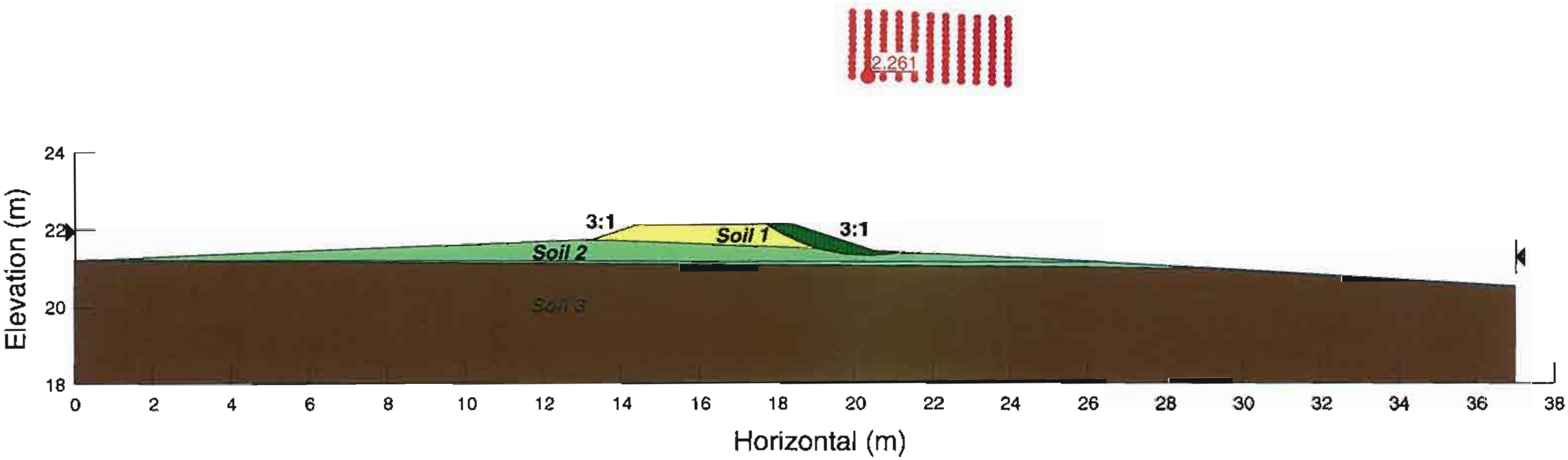
Slope Stability Analysis - Section E-E
Upstream Slope (Rapid Drawdown + Seismic Loading)
Topsoil Removed
Existing Sewage Lagoon Modifications
Hamlet of Whale Cove

Figure 41
OTT-00201369-A0

Soil: 1
Description: Proposed Fill
Unit Weight: 22
Cohesion: 0
Phi: 38

Soil: 2
Description: Existing Fill
Unit Weight: 20
Cohesion: 0
Phi: 32

Soil: 3
Description: Bedrock
Unit Weight: 26
Cohesion: 5000
Phi: 0



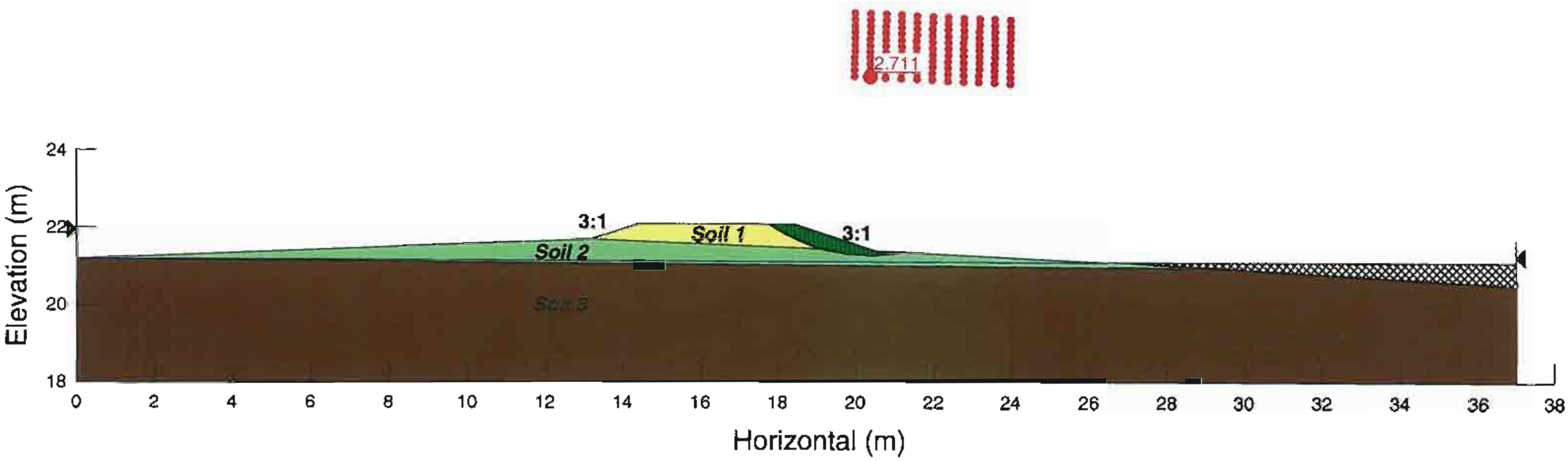
Slope Stability Analysis - Section E-E
Upstream Slope (Submerged Slope)
Topsoil Removed
Existing Sewage Lagoon Modifications
Hamlet of Whale Cove

Figure 42
OTT-00201369-A0

Soil: 1
Description: Proposed Fill
Unit Weight: 22
Cohesion: 0
Phi: 38

Soil: 2
Description: Existing Fill
Unit Weight: 20
Cohesion: 0
Phi: 32

Soil: 3
Description: Bedrock
Unit Weight: 26
Cohesion: 5000
Phi: 0



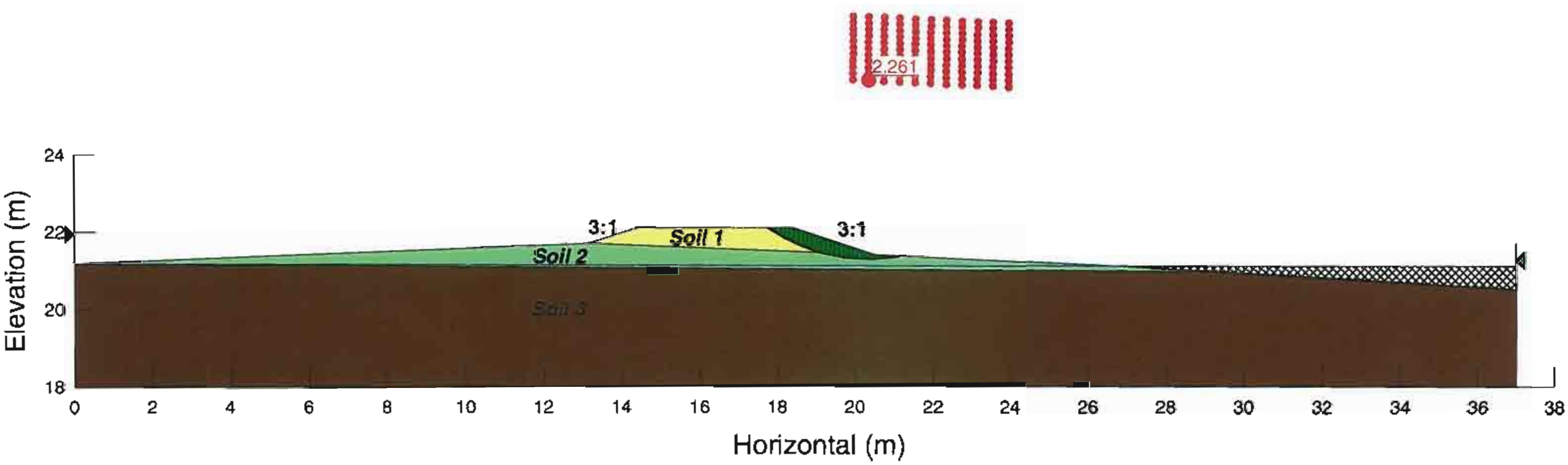
Slope Stability Analysis - Section E-E
Upstream Slope (Submerged Slope + Seismic Loading)
Topsoil Removed
Existing Sewage Lagoon Modifications
Hamlet of Whale Cove

Figure 43
OTT-00201369-A0

Soil: 1
Description: Proposed Fill
Unit Weight: 22
Cohesion: 0
Phi: 38

Soil: 2
Description: Existing Fill
Unit Weight: 20
Cohesion: 0
Phi: 32

Soil: 3
Description: Bedrock
Unit Weight: 26
Cohesion: 5000
Phi: 0



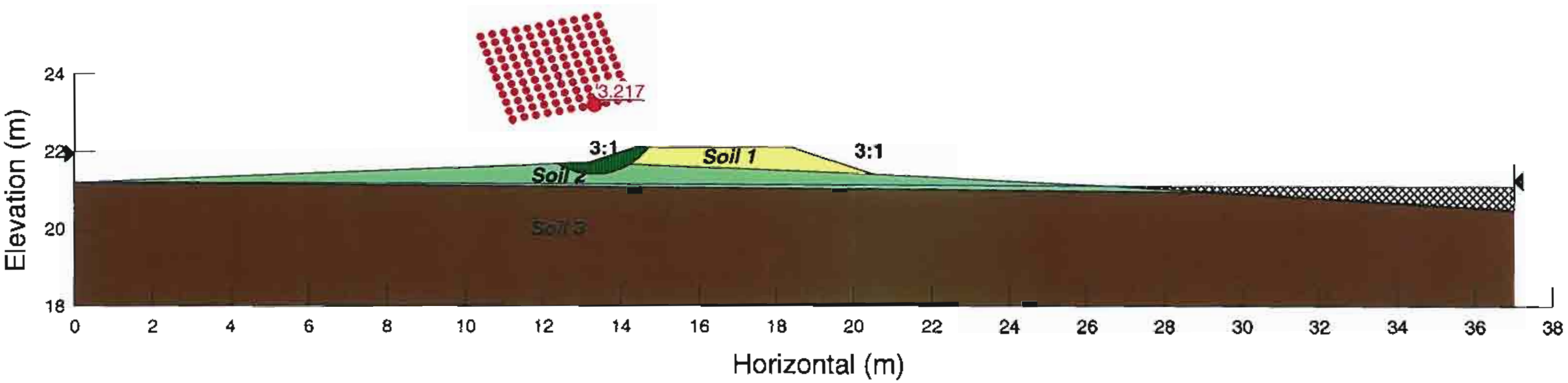
Slope Stability Analysis - Section E-E
Downstream Slope (Steady State Seepage)
Topsoil Removed
Existing Sewage Lagoon Modifications
Hamlet of Whale Cove

Figure 44
OTT-00201369-A0

Soil: 1
Description: Proposed Fill
Unit Weight: 22
Cohesion: 0
Phi: 38

Soil: 2
Description: Existing Fill
Unit Weight: 20
Cohesion: 0
Phi: 32

Soil: 3
Description: Bedrock
Unit Weight: 26
Cohesion: 5000
Phi: 0



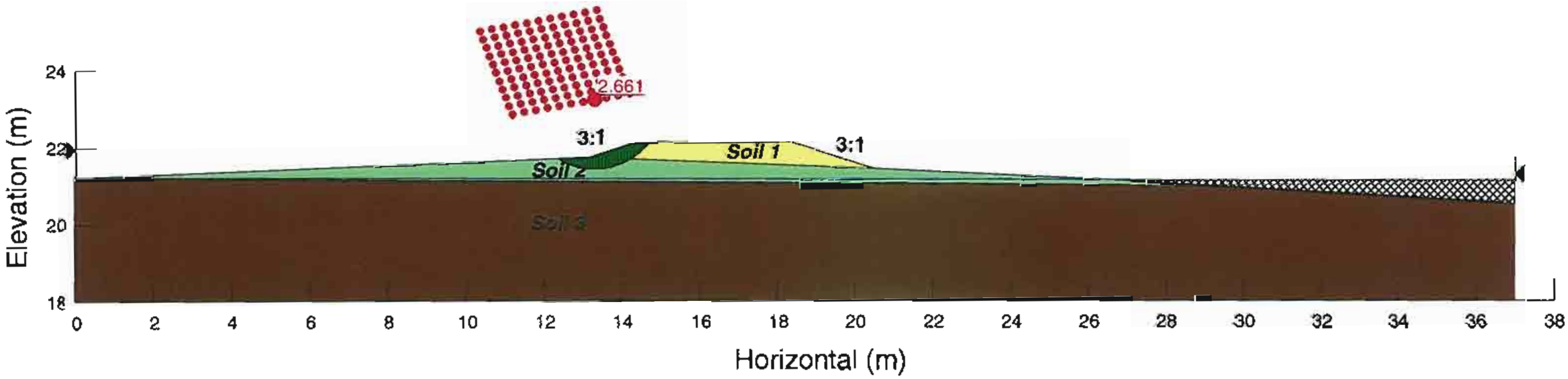
Slope Stability Analysis - Section E-E
Downstream Slope (Steady State Seepage + Seismic Loading)
Topsoil Removed
Existing Sewage Lagoon Modifications
Hamlet of Whale Cove

Figure 45
OTT-00201369-A0

Soil: 1
Description: Proposed Fill
Unit Weight: 22
Cohesion: 0
Phi: 38

Soil: 2
Description: Existing Fill
Unit Weight: 20
Cohesion: 0
Phi: 32

Soil: 3
Description: Bedrock
Unit Weight: 26
Cohesion: 5000
Phi: 0



List of Distribution

Report Distributed To:

Government of Nunavut – Wayne Thistle (1 PDF + 3 Copies)
exp Services Inc. (Infrastructure) – Steve Burden (1 PDF)