



Technical Memorandum (*cont'd*)

Sewer Replacement AV205 to AV305

FRN-21013786-A0

October 26, 2021

Appendix C – 1995 Iqaluit Geotechnical Report

February 7, 1995
YX00409

UMA Engineering Ltd.
17007 - 107 Avenue
Edmonton, Alberta
T5S 1G3

Attention: Mr. K.R. Johnson, P.Eng.

Dear Sir:

RE: Geotechnical Evaluation - Iqaluit Trunk Sewer

1.0 INTRODUCTION

This letter report provides a geotechnical evaluation and associated recommendations with respect to the replacement of existing sewer lines and the installation of new sewer lines in Iqaluit, N.W.T. The scope of work for this study was given in a proposal to UMA Engineering Ltd (UMA), by AGRA Earth & Environmental Limited (AEE), dated November 30, 1994. Authorization to proceed with the study was received on January 4, 1995.

The scope of work of the study was to include:

- review subsurface conditions along the sewer main routes, with particular emphasis to those areas containing new construction;
- provide geotechnical recommendations with respect to sewer installation, backfilling and related issues;
- provide consultation during construction regarding site specific issues.

This letter report addresses the first two items of the scope of work.

2.0 SITE LOCATIONS

There are two areas within the Town of Iqaluit in which sewer construction will take place, as shown on Figure 1. The new construction of sewers is to be performed along Apex Road, near and to the east of the intersection of Ring Road. Approximately 150 m of new sewer trunk is to be installed.

The second area, consisting of removal of old sewer lines and replacement, is along Apex Road in the Lower Base area, between Access Vaults (AVs) 205 and 206, between AVs 207 and 208, and between AVs 209 and 211. Approximately 170 m of sewer line is to be replaced.

3.0 GEOTECHNICAL CONDITIONS

AEE undertook a review of existing geotechnical information available in our files for the Iqaluit area. Borehole logs were obtained from five AEE projects. A site plan (Figure 1), showing the borehole locations is attached, and the borehole logs relevant to the present project are provided in Appendix A. Borehole logs for project YX00377 have not been provided, as this work was undertaken for a private client.

3.1 APEX ROAD - NEW CONSTRUCTION

In the area of new sewer line construction, 11 boreholes were reviewed to evaluate the subsurface conditions. Most of these boreholes were drilled for the purpose of roadway evaluation, and may not be on the sewer line alignment. Therefore, some variation in subsurface should be expected.

The borehole logs for the construction east of Ring Road varied in depth from 1.85 m to 5.7 m. All the boreholes indicated a gravelly, brown sand with little to no silt, and the occasional cobble and boulder. In one borehole, bedrock was indicated at a depth of 1.85 m, although it was not proven by drilling.

The boreholes logs available for the new construction west of Ring Road provided geotechnical information from depths of 2.4 m to 5.1 m. All the boreholes indicated a gravelly, brown sand with little or no silt and the occasional cobble and boulder. In one borehole, bedrock was encountered at a depth of approximately 2.9 m. In this location, the rock was penetrated to a depth of 2.2 m before termination. Boreholes drilled on either side of this borehole did not encounter bedrock, but they were only drilled to depths of 2.4 m and 2.6 m respectively, and may not have been deep enough to encounter bedrock.

3.2 APEX ROAD - LOWER BASE: SEWER REPLACEMENT

In the area of the sewer line replacement, 11 boreholes were available for review of subsurface conditions. It should be noted that most of the boreholes were restricted to the north end of the alignment, with only two of the boreholes located at the south end. The middle area had no available borehole data. The available boreholes were drilled to depths ranging from 1.7 m to 11.6 m.

The subsurface conditions in those areas previously investigated, consisted of a mixture of sand, silt and gravel. The silt content increased along the south westerly portion of the site. Bedrock was not reported in any available borehole logs, although it is known that the bedrock surface is very uneven and it is possible that bedrock may be present near the ground surface at locations between the existing boreholes.

4.0 RECOMMENDATIONS

The performance of buried sewer lines in cold climates, such as Iqaluit has been problematic in the past number of years. The main issue is one of pipe collapse, rendering the sewer pipe ineffective and necessitating replacement. AEE in consultation with others have studied the phenomenon of sewer pipe collapse and prepared draft guidelines (ref: Draft Guidelines for the Remediation of Collapsed HDPE Sewer Pipes in Iqaluit, prepared for Municipal and Community Affairs, Government of the Northwest Territories) for the installation and construction of these services. The recommendations provided below have been extracted from those guidelines, with reference to the requirements of this project.

It should be noted that all causes of HDPE pipe collapse have not been identified. In many cases the problems are still being investigated and final "fail-safe" design and construction techniques have yet to be developed. The recommendations contained herein represent the present level of understanding of the problems and potential solutions.

4.1 PIPE SPECIFICATION

The recent study on sewer pipe failures has shown that HDPE Series 45 and 60 are readily susceptible to collapse. It is believed that stronger pipes, such as Series 80 and 100 will perform better. However, it should be noted that even Series 100 sewer pipe has been reported to have collapsed after about 10 years of service.

At this time, and in consideration of the other recommendations provided, it is suggested that where suitable conditions permit, Series 80 HDPE pipe may be used, and in all other cases,

Series 100 HDPE pipe should be used. For the purposes of this decision, suitable conditions may be taken as the following:

- depth of burial of greater than 3.5 m, or board insulation provided
- trench construction in accordance with recommendations provided herein,
- backfill specifications and placement in accordance with recommendations provided herein,
- unrestricted access for future repairs, if necessary.

4.2 BURIAL DEPTH

It is recommended that the minimum depth of burial for sewer pipes be greater than 3 m. This is intended to reduce the influence of seasonal thawing processes acting on the pipe and pipe-zone backfill.

Where the depth of burial can not be maintained greater than 3 m, rigid board insulation should be provided over the pipe-zone to inhibit seasonal thaw around the pipe. Details of insulation are discussed below.

4.3 PIPE ZONE AND GENERAL BACKFILL

Where ice-rich or silty soils are encountered within 0.5 m below the specified pipe base, it is recommended that the trench be over-excavated to at least 450 mm below the base of the pipe, and laterally from the sides of the pipe, as shown on Figure 2. At transition zones between non ice-rich or non silty soil (stable) and ice-rich or silty soil, the over-excavation should be graded into the stable material at a slope of 3H:1V. The over-excavated material should be replaced with pipe zone fill, as described below.

The placement of select material in the pipe zone beneath, around, and above the pipe is shown in Figure 2. It is recommended that the pipe zone material extend at least 350 mm on each side of the pipe and to at least 300 mm over the pipe.

The pipe zone material for dry trench conditions should consist of well-graded, natural sand and/or fine gravel with a maximum size of 10 mm and less than 10 percent by weight passing the 75 μ m sieve. Suitable gradation limits are provided below:

<u>Sieve Size (mm)</u>	<u>Percent Passing</u>
10	100
4.75	55 - 100
2.00	30 - 100
0.425	10 - 50
0.075	0 - 10

For very wet trench conditions, a coarser material may be preferable. It should consist of well-graded, rounded to sub-rounded, natural gravel with a maximum size of 50 mm, and less than 8 percent by weight passing the 75 μ m sieve. Suitable gradation limits are provided below:

<u>Sieve Size (mm)</u>	<u>Percent Passing</u>
50	100
40	85 - 100
20	50 - 70
10	25 - 50
4.75	15 - 40
2.0	10 - 25
0.425	3 - 12
0.075	0 - 8

Other gradations may be suitable, but should be subject to approval by the geotechnical engineer. The pipe zone material should not be a crushed rock.

Backfill placed under and around the pipe should be placed in 150 mm lifts and compacted to about 90 percent of Standard Proctor maximum dry density. Extreme care should be used in compaction of fill within the pipe zone. Heavy compactive effort within the pipe zone may induce unacceptable stresses in the pipe.

4.4 INSULATION

Where less than 3 m burial depth is available as recommended above, insulation may be used to restrict the influence of seasonal thaw on the pipe zone fill and pipe.

Where insulation is required, it is recommended that it consist of Styrofoam HI40, or equivalent. It should be at least 50 mm thick, and placed at least 1 m below final grade. It

should be at least 2440 mm in width and centred of the pipe. The insulation should be bedded on at least 150 mm of fine sand (as defined above for pipe bedding), and covered with a similar amount to provide protection from sharp objects and projections.

4.5 ACCESS VAULTS

There have been numerous problems with the AVs in Iqaluit, including some problems that have occurred subsequent to the preparation of the Draft Guidelines, that the consultant should obtain details should be aware of.

Access vaults (AVs) are typically prefabricated, insulated metal units, installed at least 0.5 m below the base of the pipes. It is expected that most of the AVs will be founded on permafrost, consisting of granular soils. The typical temperature of the AVs will be in the order of 5 to 10°C, which is controlled by the sewer temperature.

Although the base of the AVs typically contain insulation, due to the above freezing ambient temperature, some long-term thaw will likely develop. Therefore consideration of the soils underlying the AVs is required.

Where ice-rich or silty soils are encountered at the base of the AV excavation, the subgrade should be over-excavated to the base of these soils, or to at least 450 mm, and at least 300 mm radially from the edge of the vault. Pipe zone backfill, as defined above, should be compacted in the over-excavated area. Compaction of this material should be to at least 95 percent Standard Proctor maximum dry density.

Where the underlying soils are noted to be non ice-rich and non silty, a minimum of 150 mm layer of compacted bedding, as previously defined, should be placed to provide a stable foundation for the AVs.

The remainder of the vault excavation should be backfilled with bedding sand, compacted to at least 95 percent Standard Proctor maximum dry density.

4.6 OTHER ISSUES

The following issues should be considered with respect to design and construction:

- The sewer pipes should be provided with as high a gradient as possible to reduce the risk of back-grading in the event of local settlement, and to reduce the "residence time" of water within the pipe.

- Although the review of the available geotechnical information did not identify any large areas where bedrock or large boulders are present, the terrain of the Iqaluit area is highly variable and such occurrence should be expected. Particularly in the new construction area, blasting may be required to achieve the specified depth for the pipe or AVs.
- The recommendations contained in this report are the result of the referenced study, but have as yet not been verified by field trials. It is recommended that the sewer installations be instrumented to assess the effectiveness of the design and construction techniques. Further recommendations with respect to instrumentation may be provided on request.
- The geotechnical aspects of the final design drawings and specifications should be submitted to a geotechnical engineer for review and comment. This is to ensure that the design and proposed construction details are consistent with the recommendations contained in this report. Construction review, and quality control and quality assurance should be performed by suitably qualified personnel.

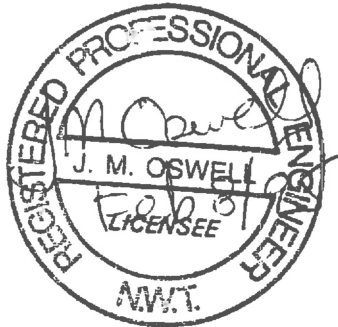
5.0 CLOSURE

We trust this information is sufficient for your present needs. If you have any questions, or if AEE may provide review or testing services during other phases of this project, please contact our office.

UMA Engineering Ltd.
Mr. K.R. Johnson, P.Eng.
February 7, 1995
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Yours truly,

AGRA Earth & Environmental Limited

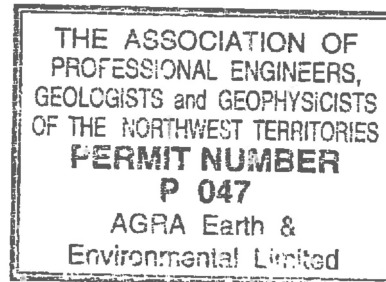


James M. Oswell, Ph.D., P.Eng.
Senior Geotechnical Engineer

Reviewed by

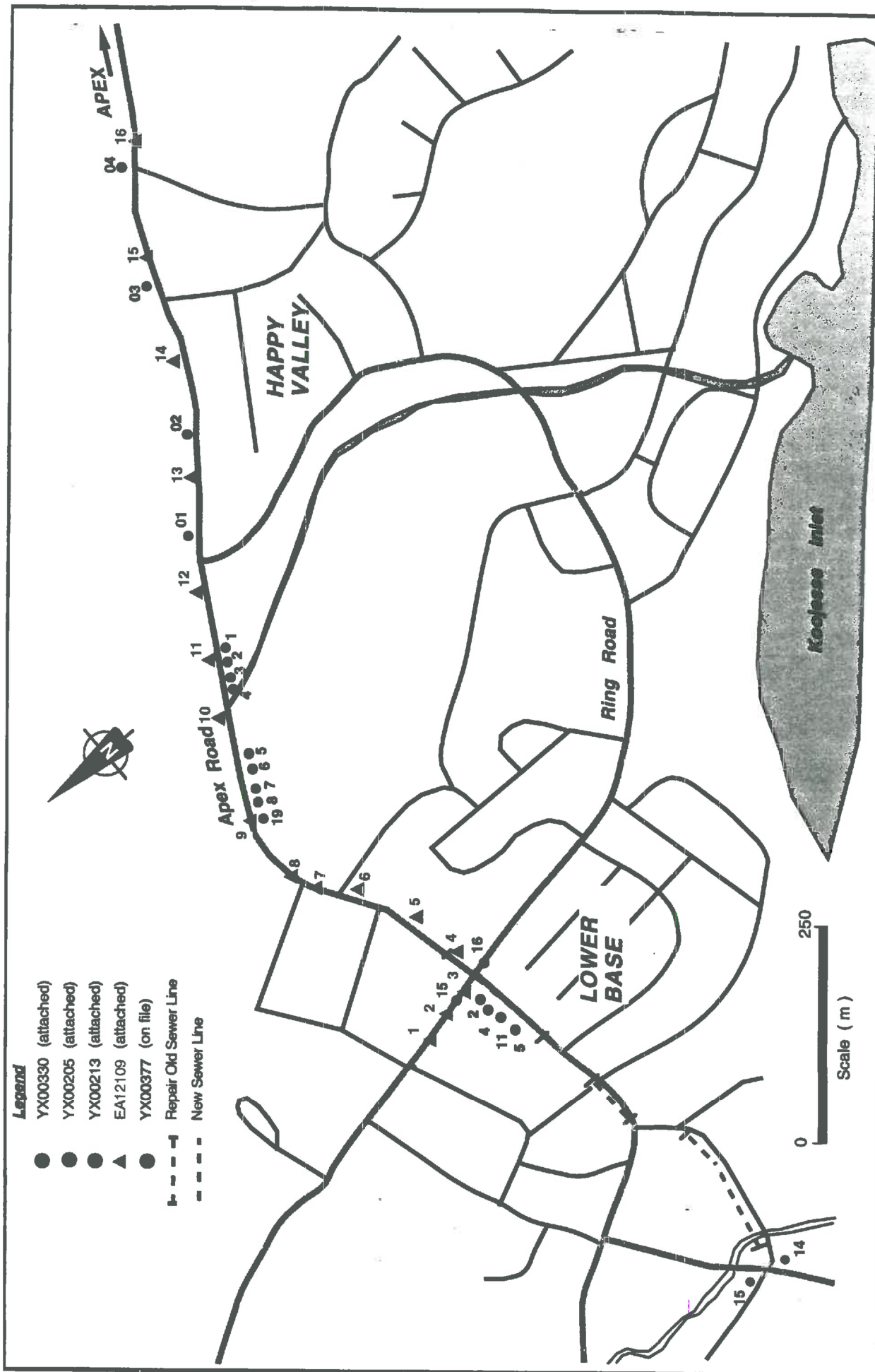
A handwritten signature in dark ink, appearing to read "A. Hanna", written over a horizontal line.

Alan J. Hanna, M.A.Sc., P.Eng.
Manager, Northern Operations



attachments

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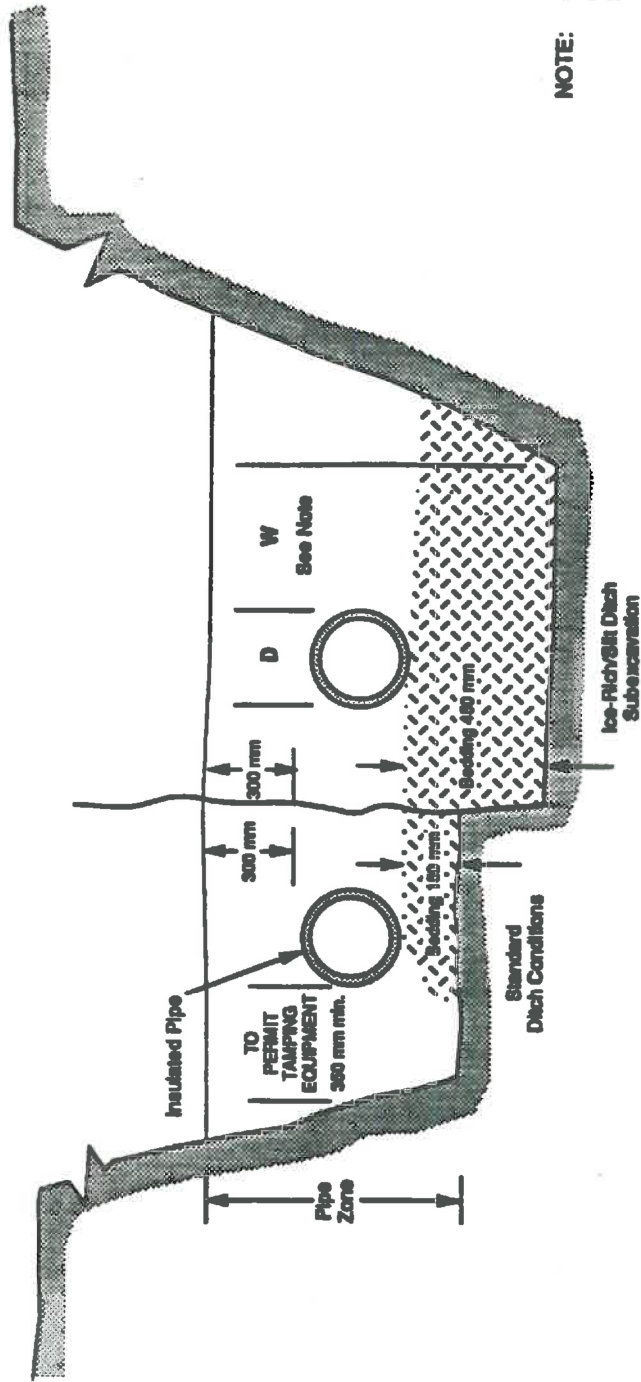
IQUALUIT SEWER PROGRAM SITE PLAN

AGRA
Earth & Environmental
 Engineering & Environmental Services

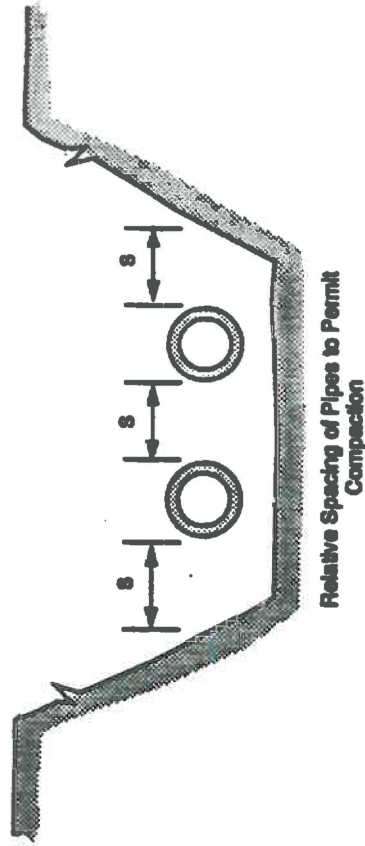
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Figure 1



NOTE: For Water Pipe at Higher Level
Minimum Space Between Pipes
Should be 350 mm
 $S = 350 \text{ mm}$



NOTE: Detail Shows Only Lower Pipe. For Any Configuration
of Pipes in Ditch the Width, W , is Defined as Follows:

$$W = 1/2 \text{ Bedding Thickness}^* + 3/4D$$

* For Upper Pipe, Bedding Equals Total Dimension
From Base of Upper Pipe to Base of Excavation

SHELL PIPELINE - IQALUIT, N.W.T.		DRILLING METHOD: AIR TRACK 150 mm		BOREHOLE No. 330-14	
IQALUIT, N.W.T.		CONTRACTOR: CANADRILL LIMITED		Project No: YX00330	
LOCATION: PIPELINE-NORTH SIDE OF AIRPORT				ELEVATION 0.00 (m)	
SAMPLE TYPE ☒ DISTURBED		☒ SHELBY TUBE		☒ SPT SAMPLE	
		☐ A-CASING		☐ NO RECOVERY	
				☐ CORE	

DEPTH (m)	PLASTIC M.C. LIQUID 10 20 30 40	USC	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO	OTHER TEST COMMENTS	DEPTH (m)
0.0			GRAVEL and SAND				0.0
-1.0		GP	SAND and SILT - brown, damp - frozen at 1.5 m	☒	1		-1.0
-2.0			- grey at 2 m - moist	☒	2		-2.0
-3.0				☒	3		-3.0
-4.0				☒	4		-4.0
-5.0		SP-SM	- trace gravel at 5 m	☒	5	WP#200 3-3.5 m = 43% Salinity 3-3.5 m = 11 ppt	-5.0
-6.0				☒	6		-6.0
-7.0				☒	7		-7.0
-8.0				☒			-8.0
-9.0			End of Hole at 9 m below grade in silt and sand. Hole dry on completion.				-9.0
10.0							10.0

HBT AGRA Limited Calgary, Alberta		COMPLETION DEPTH 9.0 m		COMPLETE 92/11/18	
		LOGGED BY JLA	DWG NO.12	Page 1 of 1	

SHELL PIPELINE - IQALUIT, N.W.T.		DRILLING METHOD: AIR TRACK 150 mm		BOREHOLE No. 330-15	
IQALUIT, N.W.T.		CONTRACTOR: CANADRILL LIMITED		Project No: YX00330	
LOCATION: ADJACENT TO BULK STORAGE YARD				ELEVATION 0.00 (m)	
SAMPLE TYPE ☒ DISTURBED		☒ SHELBY TUBE		☒ SPT SAMPLE	
		☒ A-CASING		☐ NO RECOVERY	
				☐ CORE	

DEPTH (m)	USC	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO	OTHER TEST COMMENTS	DEPTH (m)
0.0		FILL - sandy, gravelly, silty				0.0
1.0	GP			1		1.0
2.0		SAND and SILT - fine to medium grained - brown - frozen at 1.2 - grey, dry to damp - gravel and cobble sizes at 1.3 m		2		2.0
3.0				3		3.0
4.0				4		4.0
5.0	SP-SM			5	WP#200 3-3.5 m = 41%	5.0
6.0				6	WP#200 4-4.5 m = 44%	6.0
7.0				7	Salinity 4-4.5 m = 8 ppt	7.0
8.0				8		8.0
9.0		End of Hole at 9 m below grade in sand and silt. Hole dry on completion.			Salinity 8-9 m = 14 ppt	9.0
10.0						10.0

HBT AGRA Limited Calgary, Alberta		COMPLETION DEPTH 9.0 m	COMPLETE 92/11/18
		LOGGED BY JLA	DWG NO.13
		Page 1 of 1	

REINDERS NORTHERN LIMITED		ROAD IMPROVEMENTS		BOREHOLE No: 1	
		MUNICIPALITY OF IQALUIT		Project No: EA12109	
TRUCK MOUNTED PILING RIG (500 mm Dia.)		NORTHWEST TERRITORIES		ELEVATION: 19.50 (m)	
SAMPLE TYPE ☒ Shelby Tube		☐ No Recovery		☒ SPT Test (N)	
		☐ Grab Sample		☐ Split-Pen	
				☐ Core	

DEPTH (m)	■ STANDARD PEN (N) ■ 20 40 60 80 PLASTIC M.C. LIQUID 20 40 60 80	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO	SPT(N)	OTHER TESTS COMMENTS	DEPTH (m)
0.0		[Cross-hatch symbol]	FILL, SAND, gravelly, silty, medium grained, poorly graded, light brown moist, medium dense					0.0
		[Horizontal line symbol]	SAND, gravelly, silty, medium grained poorly graded, light brown, wet, loose	[Horizontal line symbol]	G1			
		[Horizontal line symbol]	seepage and sloughing	[Horizontal line symbol]				
1.0		[Horizontal line symbol]	slight organic smell at 1.0 m	[Horizontal line symbol]				1.0
		[Horizontal line symbol]		[Horizontal line symbol]	G2			
2.0		[Horizontal line symbol]	End of Hole at 2.0 m Frozen below 2.0 m W.L. at 1.7 m at drilling completion					2.0
3.0								3.0
4.0								4.0
5.0								5.0

HBT AGRA Limited Edmonton, Alberta		LOGGED BY: JA	COMPLETION DEPTH: 2.0 m
		REVIEWED BY:	COMPLETE: 13/09/91
		Fig. No: 1	Page 1 of 1

REINDERS NORTHERN LIMITED		ROAD IMPROVEMENTS		BOREHOLE No: 2	
		MUNICIPALITY OF IQALUIT		Project No: EA12109	
TRUCK MOUNTED PILING RIG (500 mm Dia.)		NORTHWEST TERRITORIES		ELEVATION: 19.60 (m)	
SAMPLE TYPE ☒ Shelby Tube		☐ No Recovery		☒ SPT Test (N)	
		☐ Grab Sample		☐ Split-Pen	
				☐ Core	

DEPTH (m)	STANDARD PEN (N) 20 40 60 80 PLASTIC M.C. LIQUID 20 40 60 80	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO	SPT(N)	OTHER TESTS COMMENTS	DEPTH (m)
0.0			SAND, gravelly, silty, medium grained well graded, brown, moist, medium dense		G1			0.0
1.0			clayey, wet, loose		G2			1.0
1.7		End of Hole at 1.7 m (Frozen beyond 1.7 m) W.L. at 1.0 m at drilling completion						1.7
2.0								2.0
3.0								3.0
4.0								4.0
5.0								5.0

HBT AGRA Limited Edmonton, Alberta		LOGGED BY: JA	COMPLETION DEPTH: 1.7 m
		REVIEWED BY:	COMPLETE: 13/09/91
		Fig. No: 2	Page 1 of 1

REINDERS NORTHERN LIMITED		ROAD IMPROVEMENTS		BOREHOLE No: 3	
		MUNICIPALITY OF IQALUIT		Project No: EA12109	
CANADRILL AIR TRAC (165 mm Dia.)		NORTHWEST TERRITORIES		ELEVATION: 19.70 (m)	
SAMPLE TYPE ☒ Shelby Tube		☒ No Recovery		☒ SPT Test (N)	
		☐ Grab Sample		☐ Split-Pen	
				☐ Core	

DEPTH (m)	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO	SPT(N)	OTHER TESTS COMMENTS	DEPTH (m)
0.0		ASPHALT CONCRETE (25 mm)					0.0
		FILL, SAND, gravelly, well graded, brown, damp, medium dense					
			G1			18% Gravel 80% Sand 2% Fines	
-1.0		SAND & GRAVEL, silty, fine grained, brown damp, medium dense					-1.0
			G2				
			G3				
-2.0		sand seam 200 to 400 mm thick					-2.0
		wet					
		frozen below 2.4 m					
-3.0		End of Hole at 2.80 m					-3.0
		Trace of water at drilling completion					
			G4				
-4.0							-4.0
-5.0							-5.0

HBT AGRA Limited Edmonton, Alberta		LOGGED BY: JA	COMPLETION DEPTH: 2.4 m
		REVIEWED BY:	COMPLETE: 16/09/91
		Fig. No: 3	Page 1 of 1

REINDERS NORTHERN LIMITED		ROAD IMPROVEMENTS		BOREHOLE No: 4	
		MUNICIPALITY OF IQALUIT		Project No: EA12109	
CANADRILL AIR TRAC (165 mm Dia.)		NORTHWEST TERRITORIES		ELEVATION: 19.60 (m)	
SAMPLE TYPE ☒ Shelby Tube		☒ No Recovery		☒ SPT Test (N)	
		☐ Grab Sample		☐ Split-Pen	
				☐ Core	

DEPTH (m)	■ STANDARD PEN (N) ■ 20 40 60 80 PLASTIC M.C. LIQUID 20 40 60 80	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO	SPT(N)	OTHER TESTS COMMENTS	DEPTH (m)
0.0		[Cross-hatched]	ASPHALT CONCRETE (50 mm)					0.0
		[Dotted]	FILL, SAND, gravelly, silty, medium grained poorly graded, brown, moist, dense					
		[Horizontal dashes]	SAND, gravelly, medium grained, well graded, brown, moist, medium dense	G1				
-1.0		[Vertical dashes]	wet					-1.0
		[Vertical dashes]	freewater, cobbles	G2				
		[Vertical dashes]		G3				
-2.0		[Vertical dashes]	frozen at 2.4 m					-2.0
			End of Hole at 2.4 m Trace of water at drilling completion					
-3.0								-3.0
-4.0								-4.0
-5.0								-5.0

HBT AGRA Limited Edmonton, Alberta		LOGGED BY: JA	COMPLETION DEPTH: 2.4 m
		REVIEWED BY:	COMPLETE: 16/09/91
		Fig. No: 4	Page 1 of 1

REINDERS NORTHERN LIMITED		ROAD IMPROVEMENTS		BOREHOLE No: 5	
		MUNICIPALITY OF IQALUIT		Project No: EA12109	
CANADRILL AIR TRAC (165 mm Dia.)		NORTHWEST TERRITORIES		ELEVATION: 20.20 (m)	
SAMPLE TYPE ☒ Shelby Tube		☒ No Recovery		☒ SPT Test (N)	
		☐ Grab Sample		☐ Split-Pen	
				☐ Core	

DEPTH (m)	STANDARD PEN (N) 20 40 60 80 PLASTIC M.C. LIQUID 20 40 60 80	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO	SPT(N)	OTHER TESTS COMMENTS	DEPTH (m)
0.0			ASPHALT CONCRETE (25 mm)					0.0
			FILL, SAND, gravelly, well graded, medium grained, dark brown, damp, loose to medium dense		G1			
			SAND & GRAVEL, poorly graded, medium grained, brown, moist, loose					
-1.0			wet		G2		18% Gravel 80% Sand 2% Fines	-1.0
			freewater		G3			
-2.0			frozen at 2.1 m		G4			-2.0
-3.0			End of Hole at 2.7 m Trace of water at drilling completion					-3.0
-4.0								-4.0
-5.0								-5.0

HBT AGRA Limited Edmonton, Alberta		LOGGED BY: JA	COMPLETION DEPTH: 2.7 m
		REVIEWED BY:	COMPLETE: 16/09/91
		Fig. No: 5	Page 1 of 1

REINDERS NORTHERN LIMITED		ROAD IMPROVEMENTS		BOREHOLE No: 10	
		MUNICIPALITY OF IQUALUIT		Project No: EA12109	
CANADRILL AIR TRAC (165 mm Dia.)		NORTHWEST TERRITORIES		ELEVATION: 37.90 (m)	
SAMPLE TYPE ☒ Shelby Tube		☒ No Recovery		☒ SPT Test (N)	
		☐ Grab Sample		☐ Split-Pen	
				☐ Core	

DEPTH (m)	STANDARD PEN (N) 20 40 60 80 PLASTIC M.C. LIQUID 20 40 60 80	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO	SPT(N)	OTHER TESTS COMMENTS	DEPTH (m)
0.0		[Cross-hatch symbol]	ASPHALT CONCRETE (50 mm)					0.0
		[Dotted symbol]	FILL, SAND, gravelly, silty, well graded, brown, damp, medium dense					
		[Horizontal lines symbol]	SAND, gravelly, silty, well graded, medium grained, brown, damp, loose		G1		22% gravel 70% sand 8% fines	
-1.0		[Horizontal lines symbol]			G2			-1.0
		[Horizontal lines symbol]						
-2.0		[Horizontal lines symbol]	SAND, silty, poorly graded, fine to medium grained, brown, damp, loose		G3			-2.0
		[Horizontal lines symbol]						
		[Horizontal lines symbol]	End of Hole at 2.4 m, Due to No Recovery of cuttings beyond 2.4 m (due to sloughing sand)					
-3.0		[Horizontal lines symbol]						-3.0
		[Horizontal lines symbol]						
-4.0		[Horizontal lines symbol]						-4.0
		[Horizontal lines symbol]						
-5.0		[Horizontal lines symbol]						-5.0

HBT AGRA Limited Edmonton, Alberta		LOGGED BY: JA	COMPLETION DEPTH: 2.4 m
		REVIEWED BY:	COMPLETE: 16/09/91
		Fig. No: 10	Page 1 of 1

REINDERS NORTHERN LIMITED		ROAD IMPROVEMENTS		BOREHOLE No: 11	
		MUNICIPALITY OF IQALUIT		Project No: EA12109	
CANADRILL AIR TRAC (165 mm Dia.)		NORTHWEST TERRITORIES		ELEVATION: 39.60 (m)	
SAMPLE TYPE ☒ Shelby Tube ☐ No Recovery ☒ SPT Test (N) ☐ Grab Sample ☐ Split-Pen ☐ Core					

DEPTH (m)	■ STANDARD PEN (N) ■ 20 40 60 80 PLASTIC M.C. LIQUID 20 40 60 80	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO	SPT(N)	OTHER TESTS COMMENTS	DEPTH (m)
0.0		XXXX	ASPHALT CONCRETE (50 mm)					0.0
			FILL, GRAVEL, sandy, well graded, medium grained, brown, damp, medium dense					
			SAND AND GRAVEL, silty, well graded, medium grained, brown, damp, loose		G1			
-1.0					G2			-1.0
					G3			
-2.0			BEDROCK					-2.0
			End of Hole at 1.85 m No accumulation of freewater or slough material at drilling completion					
-3.0								-3.0
-4.0								-4.0
-5.0								-5.0

HBT AGRA Limited Edmonton, Alberta		LOGGED BY: JA	COMPLETION DEPTH: 1.9 m
		REVIEWED BY:	COMPLETE: 16/09/91
		Fig. No: 11	Page 1 of 1

REINDERS NORTHERN LIMITED		ROAD IMPROVEMENTS		BOREHOLE No: 12	
		MUNICIPALITY OF IQALUIT		Project No: EA12109	
CANADRILL AIR TRAC (165 mm Dia.)		NORTHWEST TERRITORIES		ELEVATION: 43.90 (m)	
SAMPLE TYPE ☒ Shelby Tube		☒ No Recovery		☒ SPT Test (N)	
		☐ Grab Sample		☐ Split-Pen	
				☐ Core	

DEPTH (m)	STANDARD PEN (N) 20 40 60 80 PLASTIC M.C. LIQUID 20 40 60 80	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO	SPT(N)	OTHER TESTS COMMENTS	DEPTH (m)
0.0		[Pattern]	ASPHALT MODIFIED GRAVEL (12.5 mm)					0.0
		[Pattern]	FILL, GRAVEL, sandy, silty, well graded medium grained, brown, medium dense, damp		G1			
		[Pattern]	SAND, gravelly, silty, well graded, medium grained, brown, damp, loose, organic inclusions					
-1.0		[Pattern]	organic inclusions					-1.0
		[Pattern]	clayey, wet					
-2.0		[Pattern]						-2.0
		[Pattern]						
-3.0		[Pattern]	End of Hole at 2.7 m No Recovery of cuttings beyond 2.7 m due to sloughing sands					-3.0
		[Pattern]						
-4.0		[Pattern]						-4.0
		[Pattern]						
-5.0		[Pattern]						-5.0

HBT AGRA Limited		LOGGED BY: JA		COMPLETION DEPTH: 2.7 m	
Edmonton, Alberta		REVIEWED BY:		COMPLETE: 16/09/91	
		Fig. No: 12		Page 1 of 1	

REINDERS NORTHERN LIMITED		ROAD IMPROVEMENTS		BOREHOLE No: 15	
		MUNICIPALITY OF IQALUIT		Project No: EA12109	
CANADRILL AIR TRAC (165 mm Dia.)		NORTHWEST TERRITORIES		ELEVATION: 62.50 (m)	
SAMPLE TYPE ☒ Shelby Tube		☐ No Recovery		☒ SPT Test (N)	
		☐ Grab Sample		☐ Split-Pen	
				☐ Core	

DEPTH (m)	☒ STANDARD PEN (N) ☒ 20 40 60 80 PLASTIC M.C. LIQUID 20 40 60 80	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO	SPT(N)	OTHER TESTS COMMENTS	DEPTH (m)
0.0			SAND, gravelly, silty, medium grained, light brown, damp, medium dense					0.0
				G1				
-1.0			moist	G2				-1.0
				G3				
-2.0			clayey, wet, frozen beyond 2.0 m	G4				-2.0
-3.0			End of Hole at 2.4 m No Recovery of cuttings beyond 2.4 m due to sloughing sands					-3.0
-4.0								-4.0
-5.0								-5.0

HBT AGRA Limited Edmonton, Alberta		LOGGED BY: JA REVIEWED BY: Fig. No: 15	COMPLETION DEPTH: 2.4 m COMPLETE: 16/09/91
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Page 1 of 1

REINDERS NORTHERN LIMITED		ROAD IMPROVEMENTS		BOREHOLE No: 16	
		MUNICIPALITY OF IQALUIT		Project No: EA12109	
CANADRILL AIR TRAC (165 mm Dia.)		NORTHWEST TERRITORIES		ELEVATION: 67.10 (m)	
SAMPLE TYPE ☒ Shelby Tube		☒ No Recovery		☒ SPT Test (N)	
		☐ Grab Sample		☐ Split-Pen	
				☐ Core	

DEPTH (m)	■ STANDARD PEN (N) ■ 20 40 60 80 PLASTIC M.C. LIQUID 20 40 60 80	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE NO	SPT(N)	OTHER TESTS COMMENTS	DEPTH (m)
0.0			SAND, gravelly, silty, medium grained, dark brown, damp, loose		G1		32% gravel 54% sand 14% fines	0.0
1.0					G2			1.0
			clayey, wet					
2.0			frozen at 1.8 m		G3			2.0
					G4			
3.0			End of Hole at 2.6 m No Recovery of cuttings beyond 2.6 m due to sloughing sands					3.0
4.0								4.0
5.0								5.0

HBT AGRA Limited Edmonton, Alberta		LOGGED BY: JA	COMPLETION DEPTH: 2.6 m
		REVIEWED BY:	COMPLETE: 16/09/91
		Fig. No: 16	Page 1 of 1



Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

LOG OF BOREHOLE No. 1,2

IQ'LUIT SERVICES INVESTIGATION

LOGGED/DWN. BF/RM

CKD. BF

DATE OF INVEST. SEPT 13 1988

JOB NO. YX00205

DRILL TYPE AIRTRACK

SOIL DESCRIPTION

DATUM

SURFACE ELEVATION

OTHER TESTS

SAMPLE TYPE

N

WATER CONTENT%

Wp-□ W-O W_L-△

DEPTH
(m)

SOIL SYMBOL

SAND - gravelly, brown, damp,
(fill for Apex Rd.)

- becoming dry, frozen

END OF HOLE @ 3.0m

Borehole sloughed in above
1.8m causing loss of air
circulation and difficulty
in pulling rod.

BOREHOLE 1

- Sieve
analysis.
See Plate 1
Appendix B

SAND - gravelly, brown, moist
(fill for Apex Rd.)

- Frozen
- loss of air circulation, no
samples below 2.2m

END OF HOLE @ 3.0m

BOREHOLE 2

- pore water
salt content
5.0 ppt



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LOG OF BOREHOLE No. 3,4

IQALUIT SERVICES INVESTIGATION

LOGGED/DWN. BF/RM		CKD. BF	DATE OF INVEST. SEPT 13 1988		JOB NO. YX00205	
			DRILL TYPE AIRTRACK	SAMPLE TYPE	OTHER TESTS	
			SOIL DESCRIPTION		N	
WATER CONTENT% 10 20 30 40 50 60 Wp-□ W.O. W _L -Δ			DEPTH (m)	SOIL SYMBOL	DATUM SURFACE ELEVATION	
			0.0	SAND - gravelly, brown, damp (fill for Apex Rd.) -becoming frozen, dry to damp		BOREHOLE 3 - pore water salt content 3.2 ppt - Sieve analysis. See Plate 1 Appendix B
			1.0			
			2.0			
			3.0	SAND - gravelly, silty, damp wet, possibly frozen		
			4.0			
			END OF HOLE @ 4.6m			
			0.0	SAND - gravelly, brown, moist (fill for Apex Rd.) -dry/frozen no cuttings returned to surface below 2.1m		BOREHOLE 4 - Sieve analysis. See Plate 1 Appendix B
			1.0			
			2.0			
			3.0	END OF HOLE @ 4.6m		PLATE 3
			4.0			

**Hardy BBT Limited**

CONSULTING ENGINEERING & PROFESSIONAL SERVICES

LOG OF BOREHOLE No. 15, 16

Iqaluit Services Investigation

LOGGED/DWN. RM/BF

CKD. BF

DATE OF INVEST. Sept. 13, 1988

JOB NO. YX00205

DRILL TYPE Air track

SOIL DESCRIPTION

DATUM

SURFACE ELEVATION

OTHER TESTS

SAMPLE TYPE

N

WATER CONTENT%

W_p □ W_o ○ W_L △

10 20 30 40 50 60

DEPTH
(m)

SOIL SYMBOL

1.0

2.0

3.0

1.0

2.0

3.0

4.0

SAND - gravelly, brown, moist
to damp

—becoming frozen

SAND - gravelly, silty, clayey,
grey, moist to damp

End of hole @ 4.6m

Borehole 15

— pore water
salt content
14.7 ppt

SAND - gravelly, brown, moist to damp

—little sample return

SAND - gravelly, dark grey,
wet

End of hole @ 4.6m

Borehole 16

— pore water
salt content
12.2 ppt

Plate 9



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LOG OF BOREHOLE NO. 1

APEX ROAD EXPANSION AREA

LOGGED/DWN. RSP/TE

CKD. AH

DATE OF INVEST. March 8, 1989

JOB NO. YX00213

WATER CONTENT %		W _p □	W _o ○	W _L △	DEPTH (m)	SOIL SYMBOL	DRILL TYPE	SOIL DESCRIPTION	DATUM	CONDITION	SAMPLE TYPE	OTHER TESTS
10	20	30	40	50	60				SURFACE ELEVATION			N
					1		Air Track - Rotary	SAND - some gravel, trace fines			A1	MA
					2						A2	
					3						A3	
					4						A4	
					5						A5	
					6						A6	
					7						A7	
					6			- few chunks of silty, clayey sand - too small to sample frequent boulders below 3.2m				
					7							
								End of hole at 5.7m 7.5m offset from center line of road				

PLATE 2



Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

LOG OF BOREHOLE NO. 2

APEX ROAD EXPANSION AREA

LOGGED/DWN. RSP/TE

CKD. AH

DATE OF INVEST. March 8, 1989

JOB NO. YX00213

WATER CONTENT %				DEPTH (m)	SOIL SYMBOL	DRILL TYPE Air Track - Rotary	SOIL DESCRIPTION	CONDITION	SAMPLE TYPE	OTHER TESTS	
10	20	30	40							50	60
Wp-□ W-O W _L -Δ											
10 20 30 40 50 60											
1							SAND and GRAVEL - trace to little fines boulder at 0.4m to 0.6m	A1			
2								A2			
3							--- silty, sand at 2.5m (little ice)	A4			
4							--- silty, clayey, sandy layer at 3.3m less gravel with depth from 3.5m to 5.0m boulder at 3.9 to 4.0m --- silty layer at 4.3m to 4.4m	A5 A6 A7			
5							End of hole at 5.0m 10m offset from center line of road				
6											

PLATE 3



APEX ROAD EXPANSION AREA

JOB NO. YX00213

OTHER TESTS

N

MA

SAND - some to little gravel

A1

A2

A3

A4

A5

A6

A7

-- frequent boulders from 2.8m
boulder at 2.8m to 3.2m

boulder at 3.3m to 3.6m

boulder at 4.0m to 4.7m

End of hole at 4.8m
4.5m offset from center line of
road

PLATE 4



Hardy BBT Limited
CONSULTING ENGINEERING & PROFESSIONAL SERVICES

LOG OF BOREHOLE NO. 4

APEX ROAD EXPANSION AREA

LOGGED/DWN. RSP/TE

CKD. AH

DATE OF INVEST. March 8, 1989

JOB NO. YX00213

DRILL TYPE Air Track - Rotary

SOIL DESCRIPTION

DATUM

SURFACE ELEVATION

CONDITION

SAMPLE TYPE

OTHER TESTS

N

WATER CONTENT%

W_p □

W_o ○

W_u △

11

20

30

40

50

60

DEPTH
(m)

SOIL SYMBOL

1

2

3

4

5

6

SAND - some gravel, trace fines

A1

A2

SAND AND GRAVEL

A3

BEDROCK - granite

A4

A5

End of hole at 5.1m
4m offset from center line of
road

PLATE 5