Appendix A

SRK Technical Memorandum re: Doris North Project Tailings Properties

SRK Consulting
Engineers and Scientists

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Technical Memorandum

To:	Brian Labadie	**Date:**	July 15, 2005
cc:	Project File	**From:**	Maritz Rykaart
Subject:	Doris North Project Tailings Properties	**Project #:**	1CM014.006

The tailings physical characteristics are documented in the following two reports;

SRK Consulting (Canada) Inc. (2003). *Tailings Impoundment Preliminary Design, Doris North Project, Nunavut, Canada – Volume I, Report*. Technical Report prepared for Miramar Hope Bay Limited. Project No. 1CM014.01, October 2003.

SRK Consulting (Canada) Inc. (2003). *Tailings Impoundment Preliminary Design, Doris North Project, Nunavut, Canada – Volume II, Appendixes*. Technical Report prepared for Miramar Hope Bay Limited. Project No. 1CM014.01, October 2003.

This technical memorandum contains an extract of the relevant sections of the above two reports relating to tailings properties. Please note that we have retained the original report numbering of the source report.

6.3 Tailings Properties

A sample of total combined mill tailings from a pilot metallurgical tests conducted by Bateman Engineering was sent to AMEC Earth Engineering Pty Limited in Perth Australia (AMEC 2003). Representative samples of the tailings were extracted for determination of the tests listed in Table 6.1. The Australian Standards listed in Table 6.1 all have similar or equivalent ASTM procedures. The complete laboratory data sheets for all these tests are presented in Appendixes 6A through 6F.

Table 6.1: Laboratory Tests Conducted on Final Combined Mill Tailings

Test	Test Method (Australian Standards)	Number of Tests
Grain Size Distribution	Sieve and Hydrometer (AS 1289.3.6.2)	1
Plastic Properties	Casagrande Method (AS 1289.3.1.1,.3.2.1,.3.3.1,.3.4.1,.2.1.1)	1
Particle Density	AS 1289.3.5.1	1
Triaxial Test	Consolidated Undrained Triaxial Test with Pore Pressure Measurement (AS 1289.6.4.2)	1
Consolidation Test	One-Dimensional Consolidation (AS 1289.6.6.1)	1
Undrained Settling Test	SRC-WI-4.8.3	1
Drained Settling Test	SRC-WI-4.8.2	1

6.3.1 Index Properties

The total tailings are composed of sandy fine to coarse silt with 56% passing the No. 200 sieve (75 micron). The percent by weight of clay sized particles (less than 2 microns) in the tailings sample was approximately 11%. The tailings were found to be non-plastic and the measured tailings particle density was 2.74 g/cm^3.

6.3.2 Deposited Tailings Densities

The deposited tailings density is dependent on both the specific gravity of the particles and the void ratio of the resulting deposited material. Representative tailings densities deposited by different methods are given in Table 6.2. Void ratios for each method are conservatively estimated from SRK's experience at other mines. The measured dry density for the Doris North Project is summarized in Table 6.3.

Table 6.2: Typical In-Place Dry Densities for Tailings

Deposition Method	Void Ratio e	Dry Density (tonnes/m^3)
Tailings hydraulically deposited above water	1.0	1.50
Tailings hydraulically deposited underwater	1.2	1.36

Table 6.3: Measured Void Ratio & Dry-Density for the Doris North Project Tailings

Data Source	Void Ratio e	Dry Density (tonnes/m^3)
Triaxial Test	0.839	1.49
Consolidation Test - Initial	0.839	1.49
Consolidation Test – Final	0.797	1.54
Undrained Settling Test @ 33.8% solids	-	1.19
Drained Settling Test @ 33.8% solids	-	1.43

The most realistic design value to use for the subaqueous tailings deposition in Tail Lake is 1.19 tonnes/m^3, based on the measured properties. For the preliminary design presented in this report, we have assumed a tailings solids specific gravity of 2.7 and an in-place void ratio of 1.2, which results in an in-situ dry density of 1.23 tonnes/m^3.

6.3.3 Permeability and Strength Parameters

The permeability of the total tailings was measured in the laboratory by using one triaxial and one consolidation test. The results of these tests are summarized in Tables 6.4 and 6.5 respectively.

Table 6.4: Summary of Triaxial Compression Test Data

Stage - Confining Stress, σ_3 (kPa)	Coefficient of Consolidation, C_v (m^2/year)	Coeff. of Volume Compressibility, M_v, (m^2/kN)	Hydraulic Conductivity, K (cm/sec)	Cohesion, c (kPa)
1 (250 kPa)	113,890	0.153	5.4×10^{-5}	0.825
2 (300 kPa)	3,388	0.108	1.1×10^{-5}	0.010
3 (400 kPa)	1,822	0.040	2.2×10^{-6}	0.007

Table 6.5: Summary of One-Dimensional Consolidation Properties of Tailings

Pressure (kPa)	Void Ratio e	Coefficient of Consolidation, C_v (m^2/year)	Coeff. of Volume Compressibility, M_v, (m^2/kN)	Hydraulic Conductivity, K (cm/sec)
0	0.839	-	-	-
20	0.836	0.648	8.170×10^{-5}	1.69×10^{-9}
40	0.830	0.529	8.183×10^{-5}	1.37×10^{-9}
100	0.833	0.488	2.732×10^{-5}	0.42×10^{-9}
200	0.824	0.455	3.289×10^{-5}	0.47×10^{-9}
300	0.811	0.439	7.178×10^{-5}	9.98×10^{-10}
400	0.797	0.441	7.791×10^{-5}	1.11×10^{-10}
200	0.798	-	-	-
40	0.803	-	-	-

Following the measurement of the hydraulic conductivity at 400 kPa confining stress, the tailings sample in the triaxial cell was axially loaded to failure under undrained conditions to measure the frictional strength. The results of this test are summarized in Table 6.6. A value of 43.2° was obtained for the angle of internal friction, which is considered high for tailings. This value may have to be confirmed with further testing if it is required for the final design.

Table 6.6: Summary of Shear Strength Properties for Tailings

Parameter	Stage 1	Stage 2	Stage 3
Confining Stress, σ_3 (kPa)	250	300	400
Porewater Pressure, U (kPa)	222	137	134
Effective Confining Stress, (σ_3 – U) (kPa)	28	163	266
Deviator Stress, (σ_1 - σ_3) (kPa)	128	706	1,163
Shear Stress (σ_1 - σ_3)/2 (kPa)	64	353	582
Internal Friction, Φ (degrees)	43.2		
Cohesion, c (kPa)	1		

6.3.4 Tailings Settling Properties

The tailings settling tests results are summarized in Table 6.7. These results confirm that due to the coarse nature of the tailings they settle out quickly and the recovery of clarified water should, therefore, be relatively simple. The bench scale tests suggest that under undrained conditions, similar to subaqueous deposition in Tail Lake, the maximum settling time is in the order of 2 hours.

Table 6.7: Tailings Settlement Time

Test	Supernatant Suspension (%)	Dry Density (tonnes/m^3)	Elapsed Time (minutes)
Undrained	74.44	1.112 (1.190 maximum)	120 (2,880 minutes to reach maximum dry density)
Drained	84.16	1.412 (1.430 maximum)	75 (150 minutes to reach maximum dry density)

The Appendixes referred to in the text above are appended.

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TEST CERTIFICATE

Client: MIRAMAR HOPE BAY LIMITED
Project: DORIS NORTH COMBINED FINAL MILL TAILING

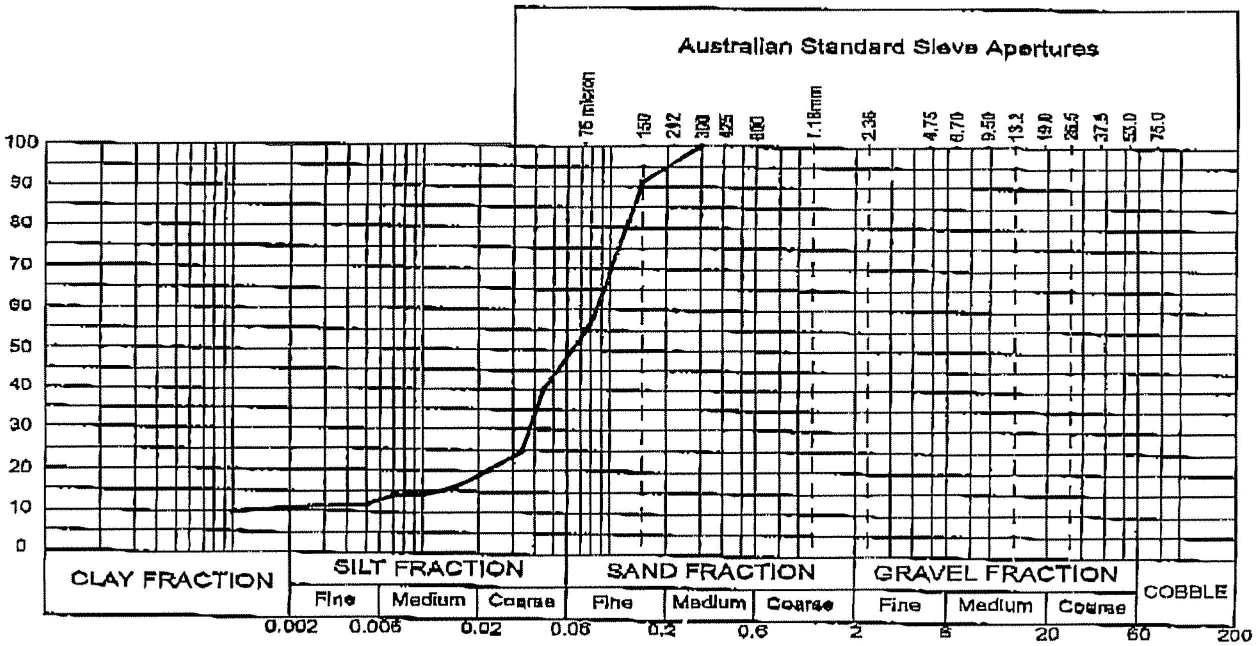
Sheet No.: 2 OF 10
Job No.: S9645
Date Tested: 25.08.03

Sample ID: TAILS

Particle Size Distribution of a Soil

AS 1289.3.6.2: Sieving with Hydrometer

Sieving				Hydrometer			
Sieve Size	% Passing	Sieve Size	% Passing	Diameter	% Passing	Diameter	% Passing
75.0mm		1.18 mm		67 micron	49	10 micron	14
37.5 mm		600 micron		49 micron	40	7 micron	14
19.0 mm		425 micron		35 micron	34	5 micron	12
9.50 mm		300 micron	100	26 micron	25	1 micron	10
4.75 mm		150 micron	92	18 micron	21		
2.36mm		75 micron	56	13 micron	18		



Remarks: Sampling Method/s - Submitted by Client.

This laboratory is accredited by the National Association of Testing Authorities, Australia. The test(s) reported herein have been performed in accordance with its terms of accreditation. This document shall not be reproduced except in full.

Approved: W Rozmianiec

Date: 17.09.03

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TEST CERTIFICATE

Client: MIRAMAR HOPE BAY LIMITED
Project: DORIS NORTH COMBINED FINAL MILL TAILING

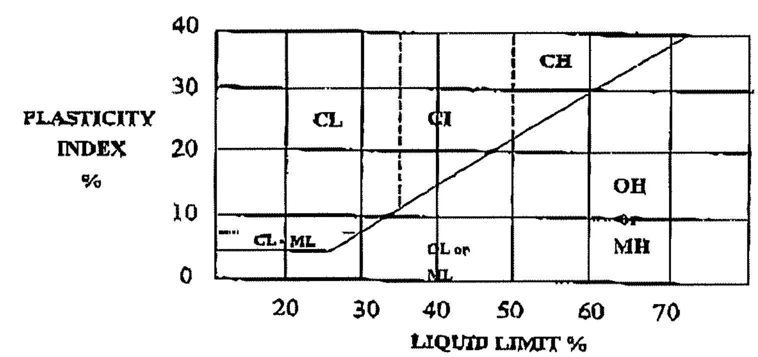
Sheet No.: 3 OF 10
Job No.: S9645
Date Tested: 11.09.03

Plastic Properties - Casagrande Method

AS 1289.3.1.1, .3.2.1, .3.3.1, .3.4.1, .2.1.1

Test No.		1	2	3	4
Sample ID		TAILS			
Liquid Limit	%	Not Obtainable			
Plastic Limit	%	Non Plastic			
Plasticity Index	%	Non Plastic			
Linear Shrinkage	%	0.5			

PLASTICITY CHART: AS 1726



History of Sample: Cool Oven Dried
Method of Preparation: Dry Sieved
Remarks: Sampling Method/s - Submitted by client.

Length of Linear Shrinkage Mould: 250 mm
Nature of Shrinkage: Normal

NATA

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Approved: W Rozmianiec

Date: 17.09.03

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TEST CERTIFICATE

Client: MIRAMAR HOPE BAY LIMITED
Project: DORIS NORTH COMBINED FINAL MILL TAILING

Sheet No.: 4 OF 10
Job No.: S9645
Date Tested: 28.08.03

Determination of the Soil Particle Density of a Soil

AS 1289.3.5.1

Sample ID	Temperature of Test	Average Soil Particle Density (-2.36mm)	Average Soil Particle Density (+2.36mm)	Soil Particle Density Total Soil Sample
	°C	g/cm^3	g/cm^3	g/cm^3
TAILS	20.5	2.74	N/A	2.74

Remarks: Sampling Method/s - Submited by client

NATA

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Approved: W Rozmianiec

Date: 17.09.03

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TEST CERTIFICATE

Client: MIRAMAR HOPE BAY LIMITED
Project: DORIS NORTH COMBINED FINAL MILL TAILING
Sample ID: TAILS

Sheet No.: 2 OF 11
Job No.: S 9645
Testing period: 07.09.03 16.09.03

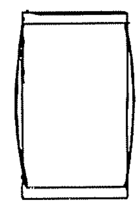
Triaxial Compression Test

AS 1289.6.4.2

Triaxial Test Conditions: Consolidated Undrained Multistage with Pore Pressure Measurement

Specimen Data		Initial
Diameter	mm	50.0
Length	mm	99.9
Volume	mm^3	196153.2
Moisture Content	%	22.5
Dry Density	t/m^3	1.49
Soil Particle Density	t/m^3	2.74
Volume of Solids	m^3	1.067E-04
Volume of Voids	m^3	8.949E-05
Void Ratio		0.839
Volume of Water	m^3	6.566E-05
Saturation	%	73

MODE OF FAILURE



Stage	Cv (m^2/year)	Mvl (m^2/MN)	k (m/sec)	c	Drainage
1	11389	0.153	5.4E-07	0.825	One End only
2	3388	0.108	1.1E-07	0.010	One End only
3	1822	0.040	2.2E-08	0.007	One End only

Remarks: A 200kPa back pressure was applied during the saturation/consolidation phases

Authorised: R . Deznan

Date: 16.09.03

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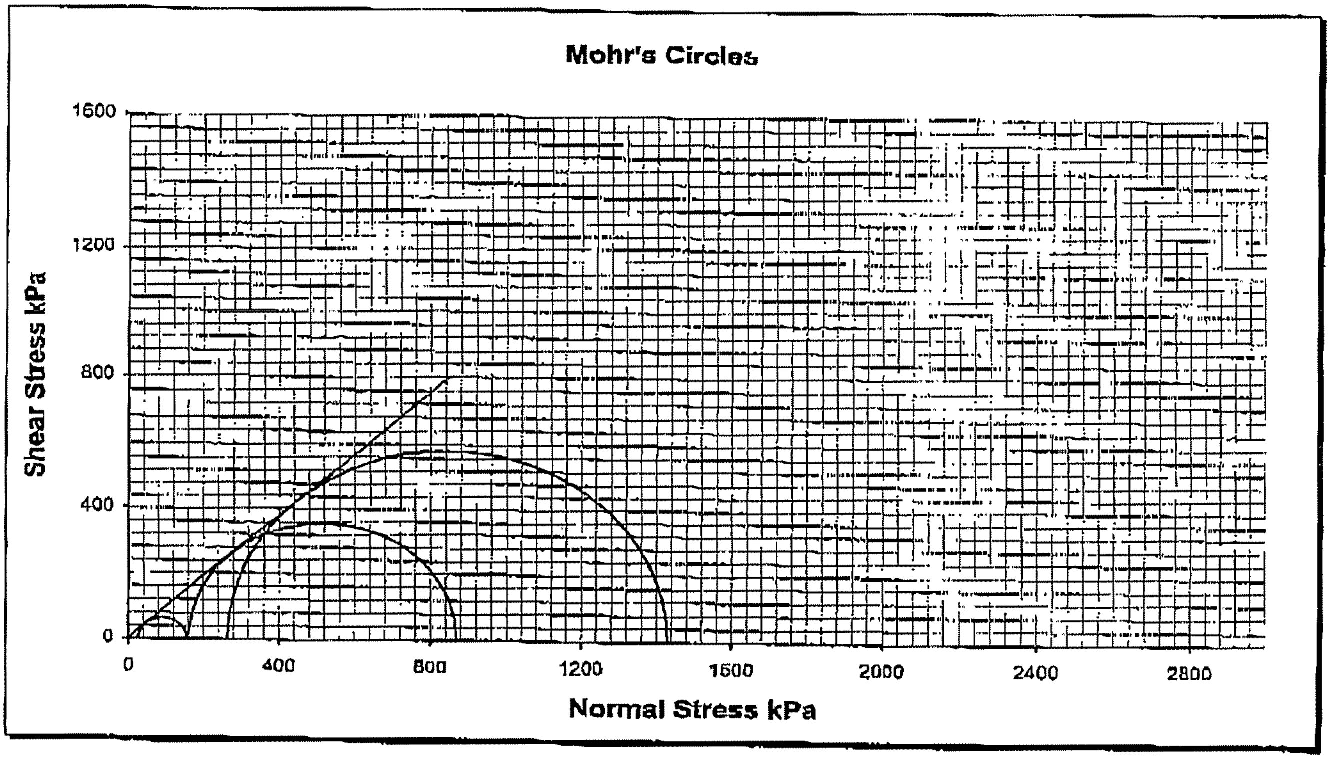
TEST CERTIFICATE

Client: MIRAMAR HOPE BAY LIMITTED
Project: DORIS NORTH COMBINED FINAL MILL TAILING
Sample ID: TAILS

Sheet No.: 3 OF 11
Job No.: S 9645
Testing Period: 07.09.03 16.09.03

Triaxial Compression Test

Confining Stress (σ_3)	kPa	250	300	400
Porewater Pressure (U)	kPa	222	137	134
Effective Confining Stress (σ_3-U)	kPa	28	163	266
Deviator Stress ($\sigma_1-\sigma_3$)	kPa	128	706	1163
Shear Stress ($\sigma_1-\sigma_3$) /2	kPa	64	353	582
Internal Friction (Φ)	Degrees	43.2		
Cohesion (c)	kPa	1		



Remarks: A 200kPa back pressure was applied during the saturation/consolidation phases

Authorised By: R, Deznan

Date : 16.09.03

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TEST CERTIFICATE

Client: MIRAMAR HOPE BAY LIMITTED
Project: DORIS NORTH COMBINED FINAL MILL TAILING
Sample ID: TAILS

Sheet No.: 4 OF 11
Job No.: S 9645
Date Tested: 07.09.03
16.09.03

One Dimensional Consolidation Properties of a Soil

AS 1289.6.6.1

Data:		Initial	Final	Pressure (kPa)	T_{50} minutes
Sample Preparation:	Insitu				
Initial Dry Density:	t/m^3	1.49	1.54	20	13.667
Initial Moisture Content:	%	22.6	13.4	40	16.667
Soil Particle Density (AS 1289.3.5.1):	t/m^3	2.74	2.74	100	18.000
Initial % Saturation:	%	73.8	47.3	200	19.167
Test Condition:	Inundated			300	19.667
Cycle :	24 Hours			400	19.167

PRESSURE kPa	VOID RATIO	COEFFICIENT OF CONSOLIDATION Cv (m^2/year)	COEFFICIENT OF VOLUME COMPRESSIBILITY Mv (m^2/kN)	COEFFICIENT OF PERMEABILITY k (m/sec)
0	0.839	-	-	-
20	0.836	0.648	8.170×10^{-5}	1.69×10^{-11}
40	0.833	0.529	8.183×10^{-5}	1.37×10^{-11}
100	0.830	0.488	2.732×10^{-5}	0.42×10^{-11}
200	0.824	0.455	3.289×10^{-5}	0.47×10^{-11}
300	0.811	0.439	7.178×10^{-5}	9.98×10^{-12}
400	0.797	0.441	7.791×10^{-5}	1.11×10^{-12}
200	0.798	-	-	-
40	0.803	-	-	-

Remarks: Sampling Method/s - Submitted by client. Soil Particle Density value was assume.

Approved: R Deznan

Date: 16.09.03

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TEST CERTIFICATE

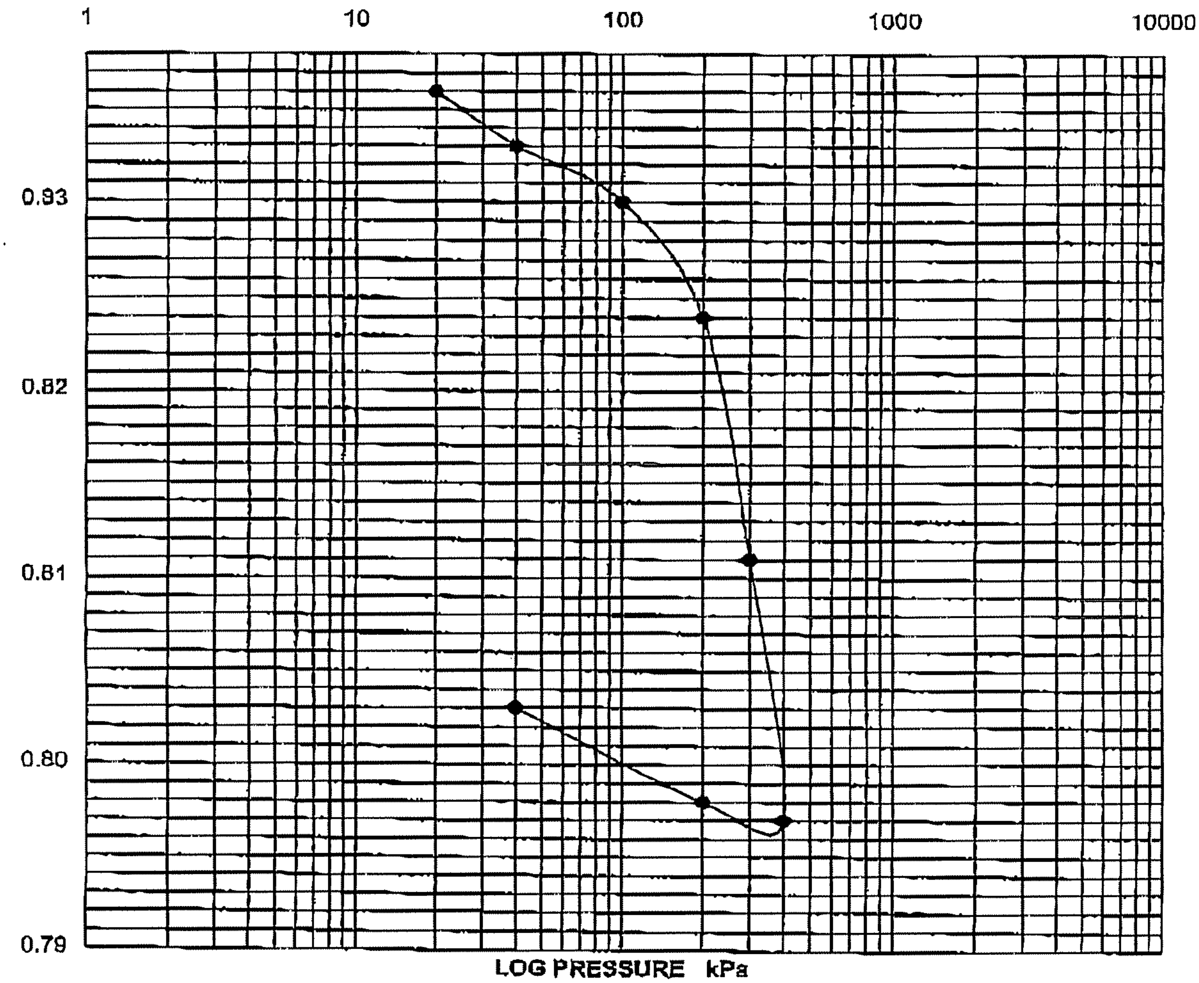
Client: MIRAMAR HOPE BAY LIMITTED
Project: DORIS NORTH COMBINED FINAL MILL TAILING

Sheet No.: 5 OF 11
Job No.: S 9645
Date Tested: 07.09.03
16.09.03

Sample ID: TAILS

One Dimensional Consolidation Properties of a Soil

AS 1289.6.6.1



Remarks: Sampling Method/s- Submitted by client.

Approved: R Dezman

Date: 16.09.03

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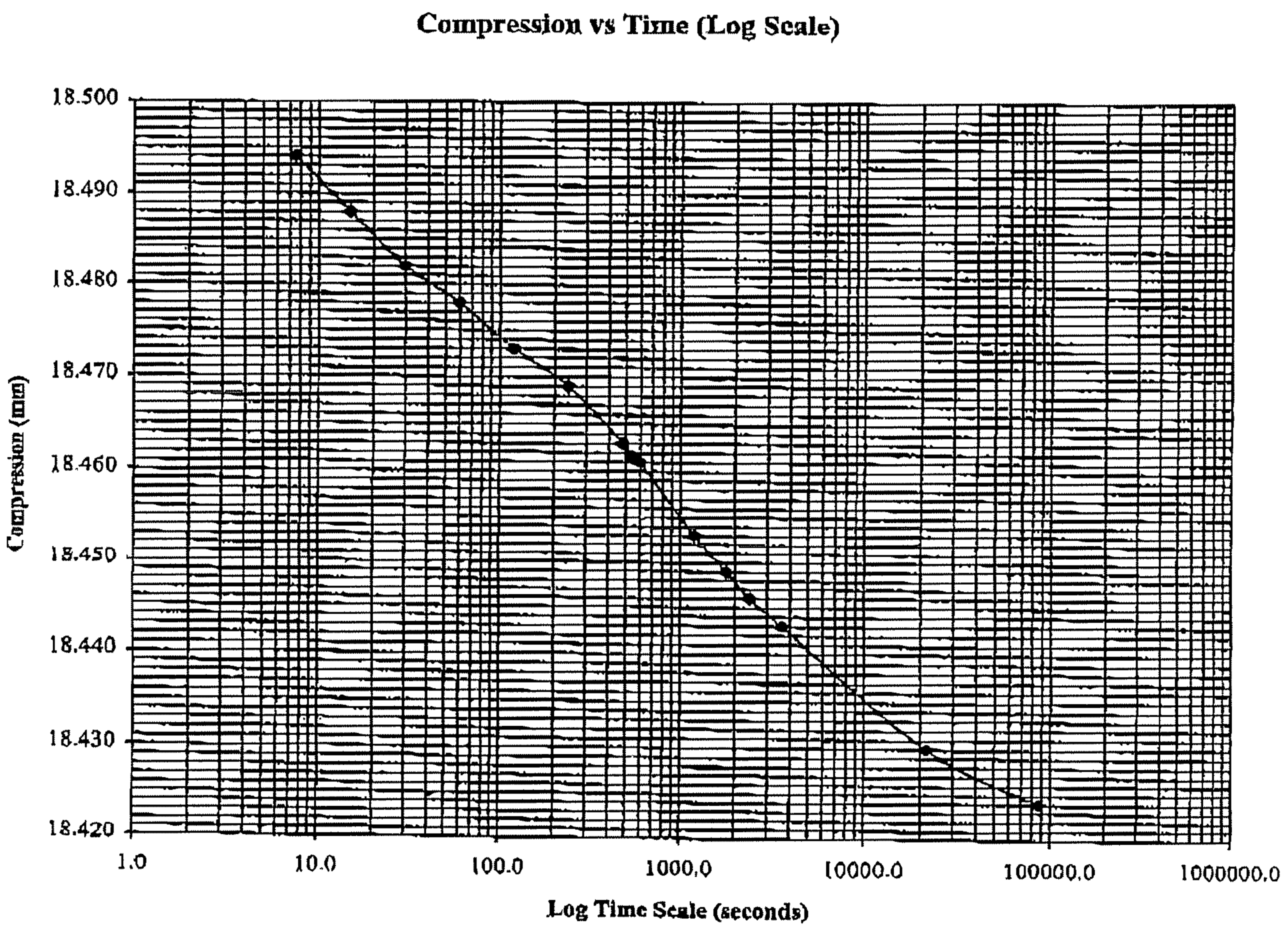
TEST CERTIFICATE

Client: MIRAMAR HOPE BAY LIMITTED
Project: DORIS NORTH COMBINED FINAL MILL TAILING
Sample ID: TAILS

Sheet No.: 6 OF 11
Job No.: S 9645
Date Tested: 07.09.03
19.09.03

CONSOLIDATION TEST
AS 1289.6.6.1

LOAD:	20	kPa	0 %	Consolidation :	18.485 mm
INITIAL HEIGHT:	18.500	mm	50 %	Consolidation :	18.455 mm
FINAL HEIGHT:	18.424	mm	100 %	Consolidation :	18.424 mm
Cα:		m²/yr	t 50 :	16.667 min	



Remarks: Sampling Method/s - Submitted by client

Approved: R. Deznan

Date: 16.09.03

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TEST CERTIFICATE

Client: MIRAMAR HOPE BAY LIMITTED
Project: DORIS NORTH COMBINED FINAL MILL TAILING
Sample ID: TAILS

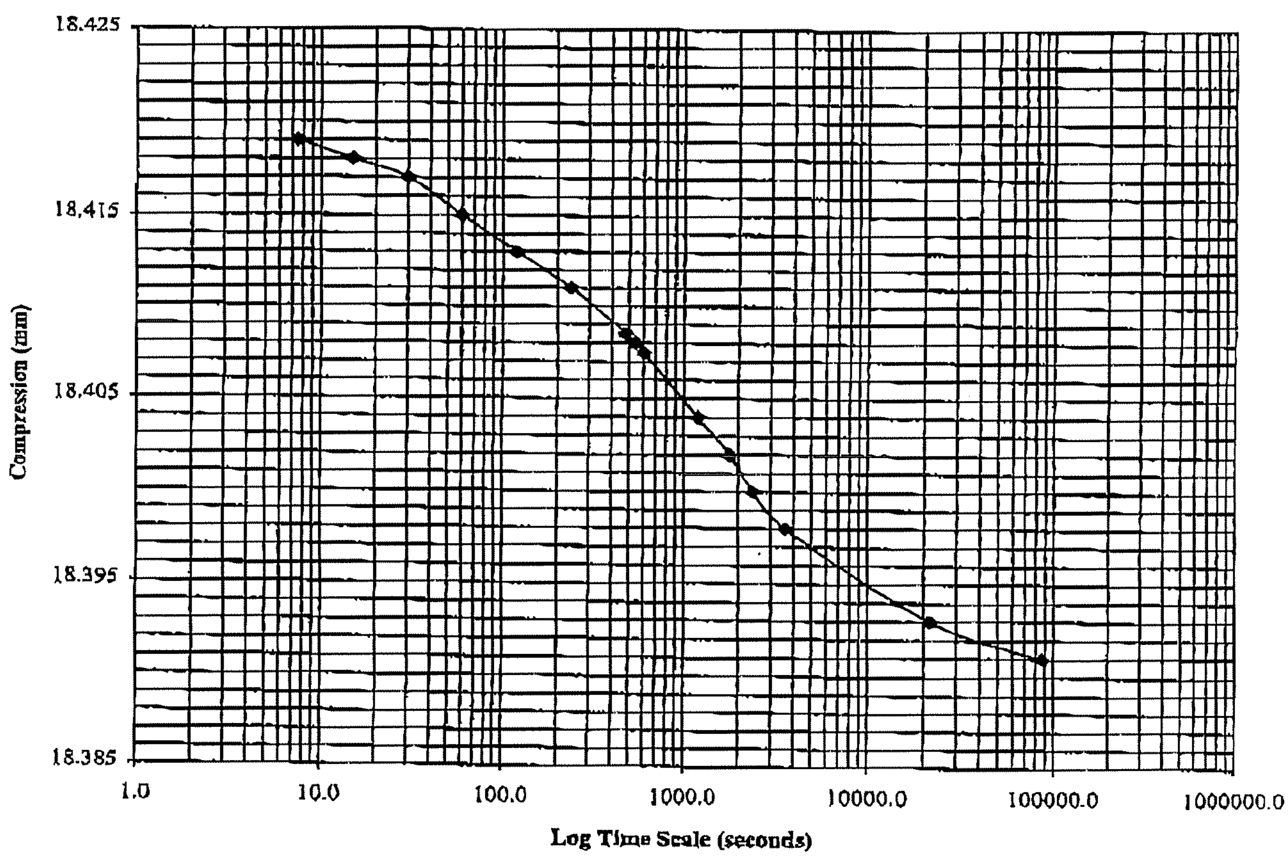
Sheet No.: 7 OF 11
Job No.: S 9645
Date Tested: 07.09.03
19.09.03

CONSOLIDATION TEST

AS 1289.6.6.1

LOAD:	40	kPa	0 % Consolidation :	18.421 mm
INITIAL HEIGHT:	18.424	mm	50 % Consolidation :	18.406 mm
FINAL HEIGHT:	18.391	mm	100 % Consolidation :	18.391 mm
Cα:		m^2/yr	t 50 :	13.667 min

Compression vs Time (Log Scale)



Remarks: Sampling Method/s - Submitted by client

Approved: R. Dezman

Date: 16.09.03

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TEST CERTIFICATE

Client: MIRAMAR HOPE BAY LIMITED
Project: DORIS NORTH COMBINED FINAL MILL TAILING
Sample ID: TAILS

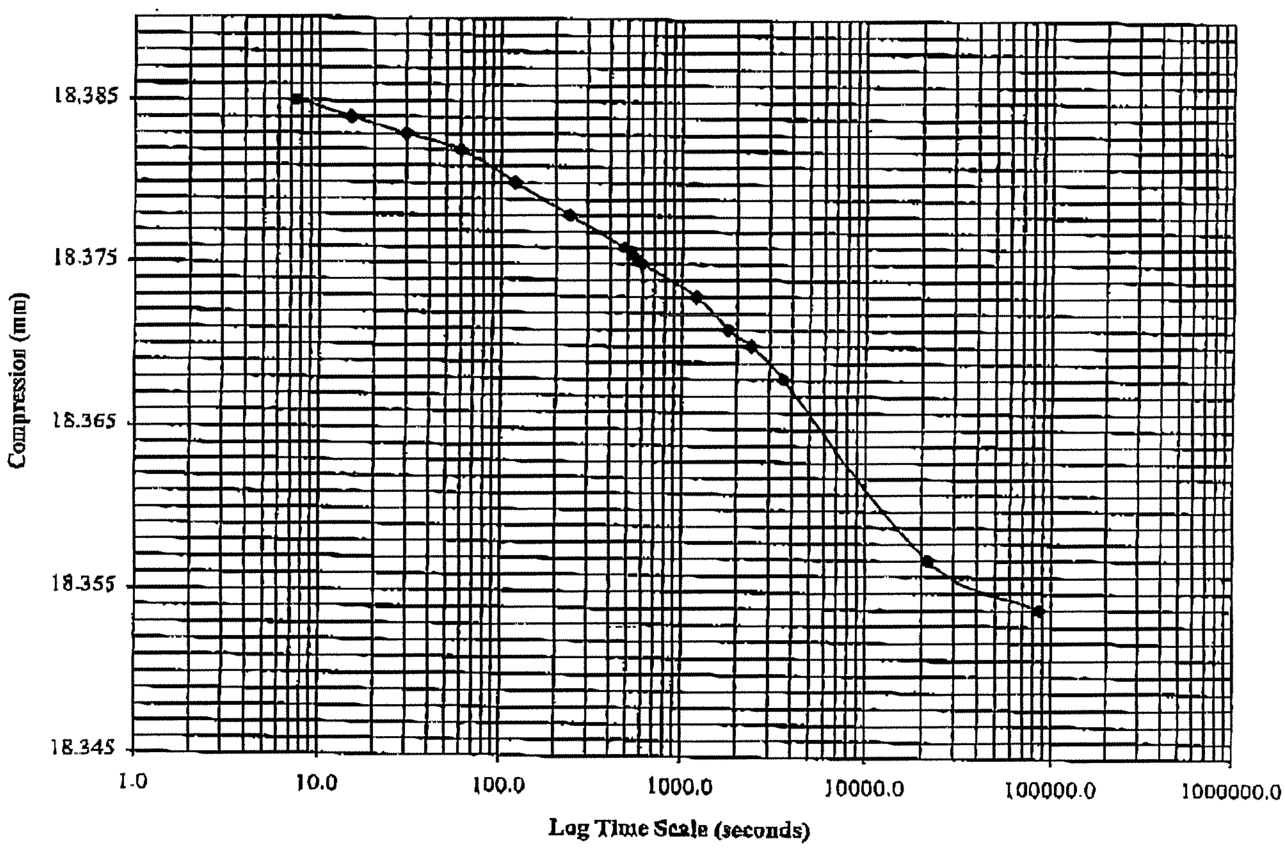
Sheet No.: 8 OF 11
Job No.: S 9645
Date Tested: 07.09.03
19.09.03

CONSOLIDATION TEST

AS 1289.6.6.1

LOAD:	100	kPa	0 %	Consolidation :	18.387 mm
INITIAL HEIGHT:	18.391	mm	50 %	Consolidation :	18.371 mm
FINAL HEIGHT:	18.354	mm	100 %	Consolidation :	18.354 mm
Cα:		m²/yr	t 50 :	18.00 min	

Compression vs Time (Log Scale)



Remarks: Sampling Method/s - Submitted by client

Approved: R. Deznan

Date: 16.09.03

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TEST CERTIFICATE

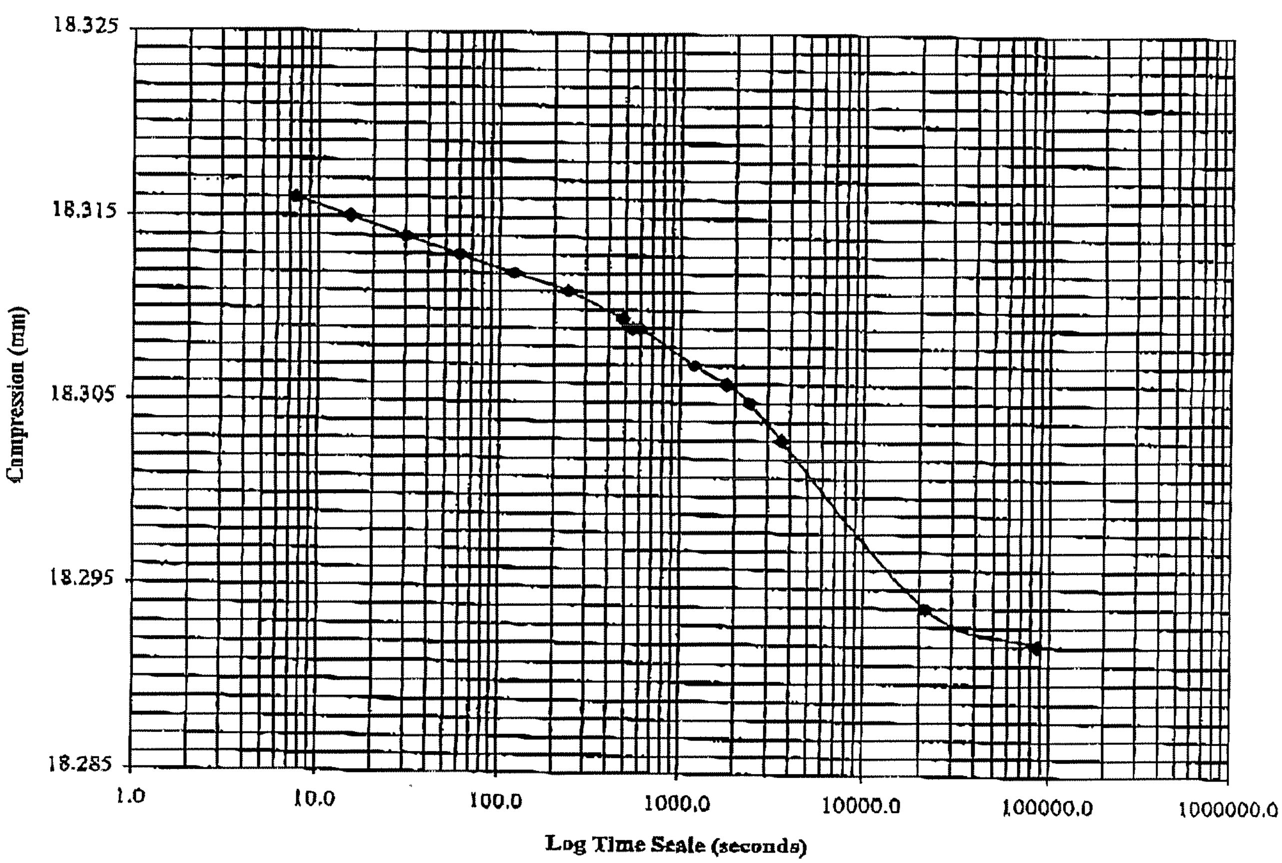
Client: MIRAMAR HOPE BAY LIMITTED
Project: DORIS NORTH COMBINED FINAL MILL TAILING
Sample ID: TAILS

Sheet No.: 9 OF 11
Job No.: S 9645
Date Tested: 07.09.03
19.09.03

CONSOLIDATION TEST

AS 1289.6.6.1

LOAD:	200	kPa	0 %	Consolidation :	18.318 mm
INITIAL HEIGHT:	18.354	mm	50 %	Consolidation :	18.305 mm
FINAL HEIGHT:	18.292	mm	100 %	Consolidation :	18.292 mm
Cα:		m²/yr	t 50 :	19.167 min	



Remarks: Sampling Method/s - Submitted by client

Approved: R. Dezman

Date: 16.09.03

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TEST CERTIFICATE

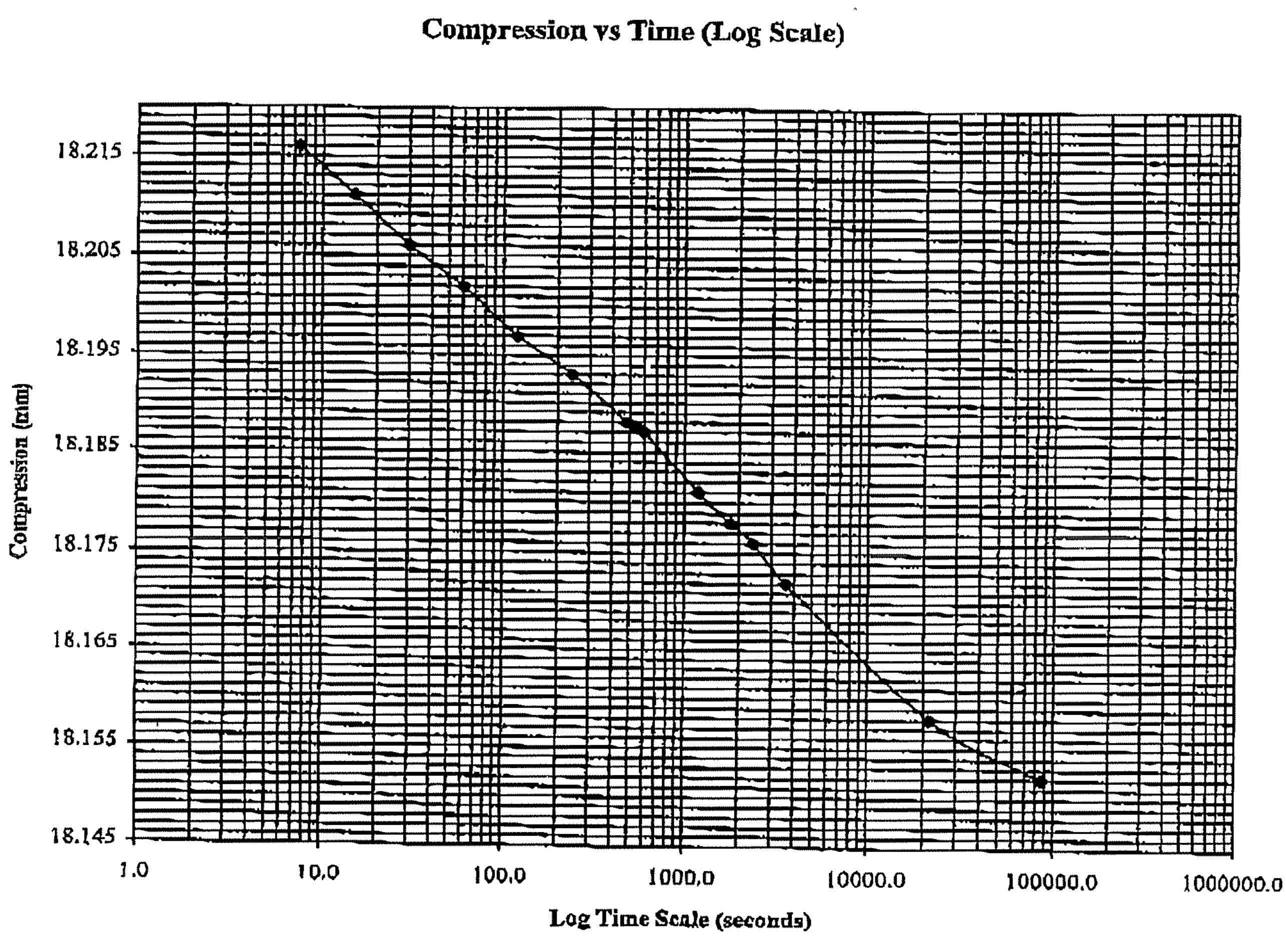
Client: MIRAMAR HOPE BAY LIMITTED
Project: DORIS NORTH COMBINED FINAL MILL TAILING
Sample ID: TAILS

Sheet No.: 10 OF 11
Job No.: S 9645
Date Tested: 07.09.03
19.09.03

CONSOLIDATION TEST

AS 1289.6.6.1

LOAD:	300	kPa	0 % Consolidation :	18.198 mm
INITIAL HEIGHT:	18.292	mm	50 % Consolidation :	18.175 mm
FINAL HEIGHT:	18.152	mm	100 % Consolidation :	18.152 mm
Cα:		m^2/yr	t 50 :	19.667 min



Remarks: Sampling Method/s - Submitted by client

Approved: R. Dezhah

Date: 16.09.03

SRC
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TEST CERTIFICATE

Client: MIRAMAR HOPE BAY LIMITTED
Project: DORIS NORTH COMBINED FINAL MILL TAILING
Sample ID: TAILS

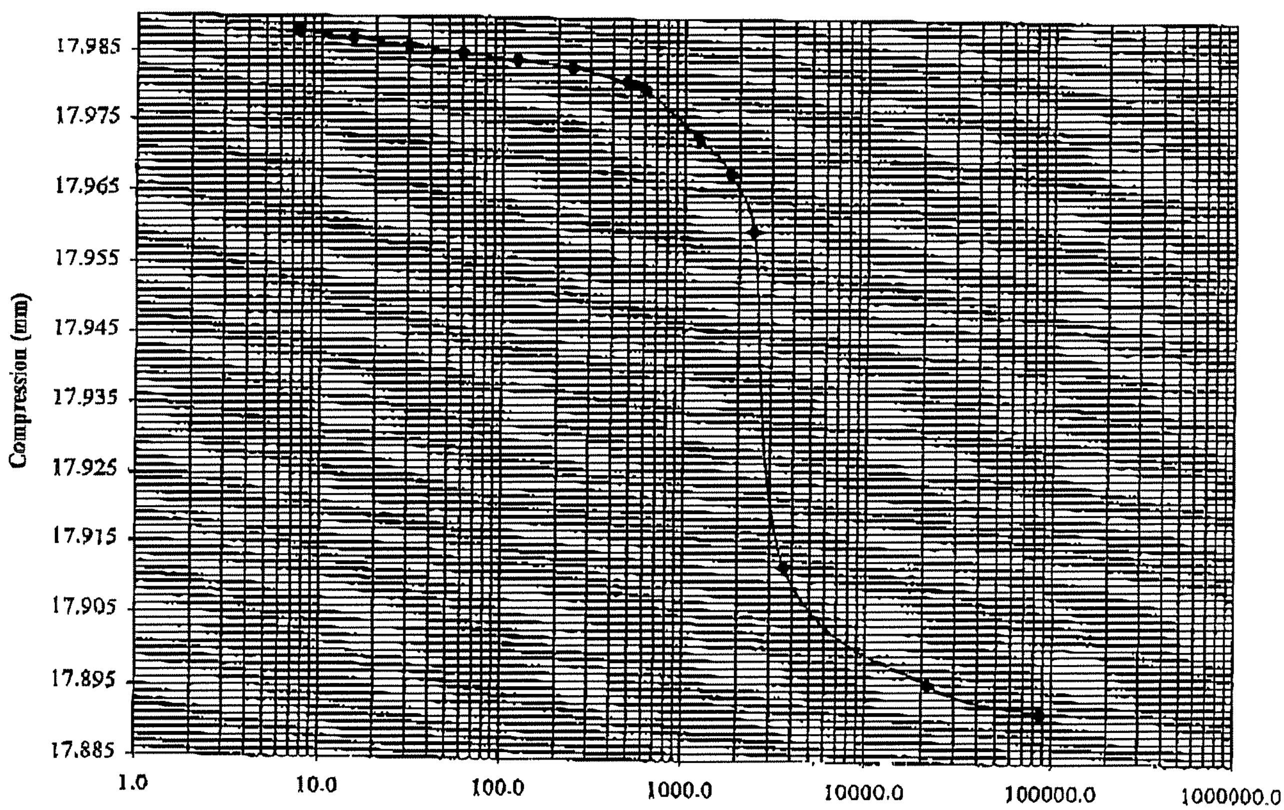
Sheet No.: 11 OF 11
Job No.: S 9645
Date Tested: 07.09.03
19.09.03

CONSOLIDATION TEST

AS 1289.6.6.1

LOAD:	400	kPa	0 %	Consolidation :	18.012 mm
INITIAL HEIGHT:	18.152	mm	50 %	Consolidation :	17.952 mm
FINAL HEIGHT:	17.892	mm	100 %	Consolidation :	17.892 mm
Cα:		m²/yr	t 50 :	19.167 min	

Compression vs Time (Log Scale)



Remarks: Sampling Method/s - Submitted by client

Approved: R. Dekman

Date: 16.09.03

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TEST CERTIFICATE

Client: MIRAMAR HOPE BAY LIMITED
Project: DORIS NORTH COMBINED FINAL MILL TAILINGS

Sheet No.: 5 OF 10
Job No.: S9645
Date Tested: 25.08.03-28.08.03

Sample ID: TAILS

Undrained Settling Test
SRC-WI-4.8.3

% SOLIDS: 33.8

TEST CYLINDER

Diameter of Cylinder	60.9	mm
Area of Cylinder	2913.3	mm^2
Mass of Cylinder	833.42	g
Mass Cylinder & Tailings	1714.67	g
Mass of Tailings Wet	881.25	g
Mass of Tailings Dry	298.10	g

MOISTURE CONTENT CHECK

Container No.	6	
Mass Cont. & Tailings Wet	257.48	g
Mass Cont. & Tailings Dry	153.29	g
Mass Container	100.03	g
Moisture Content	**195.63**	%

Amount of Water in Sample 200.17 mm

Date & Time Test Commenced: 25.08.03 @ 0930HRS

Elapsed Time min	Height of Water mm			Height of Tailings mm	With Respect to Initial Volume of Water: Cumulative Supernatan %				Dry Density t/m3
0	0			239	0.00				0.428
15	37			202	18.48				0.507
30	75			166	37.47				0.616
45	106			133	52.95				0.769
60	129			111	64.44				0.922
75	142			96	70.94				1.066
90	146			94	72.94				1.089
120	149			92	74.44				1.112
150	149			89	74.44				1.150
180	149			89	74.44				1.150
240	150			88	74.94				1.163
1440	151			87	75.44				1.176
2880	152			86	75.93				1.190
4320	152			86	75.93				1.190

Remarks: Sampling method/s - Submitted by client

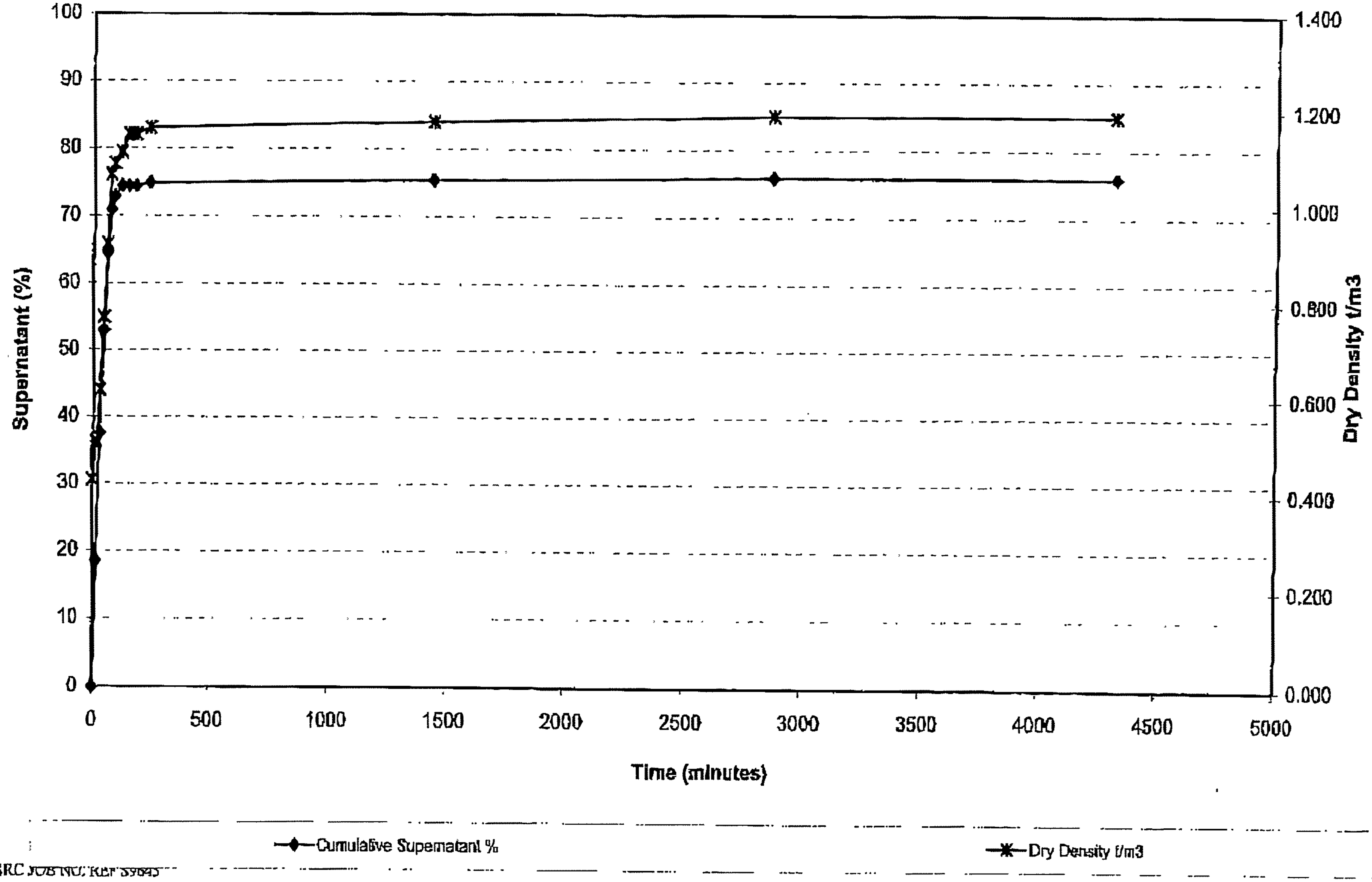
Approved: [signature]
W Rozmianiec

Date: 17.09.03

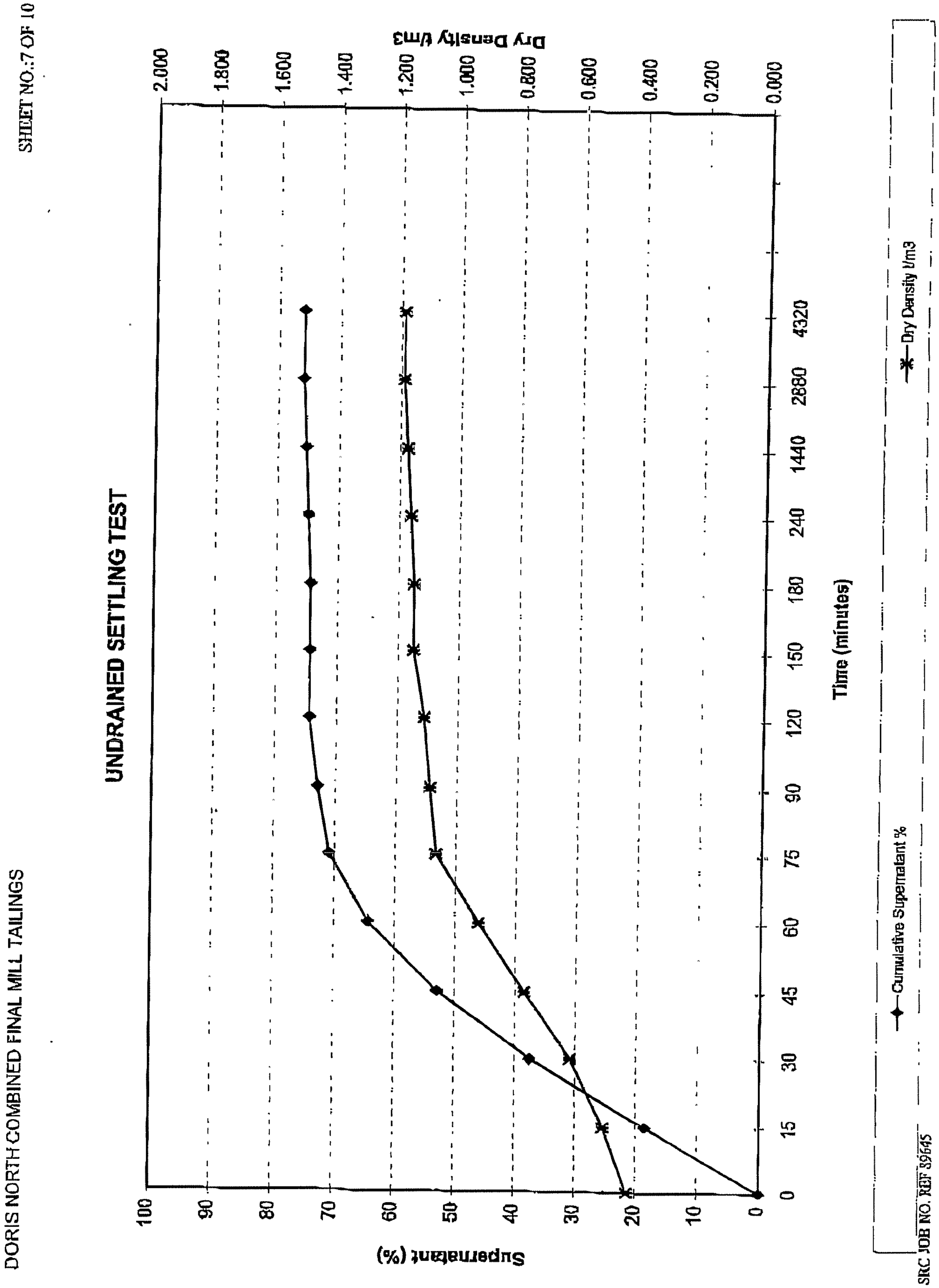
DORIS NORTH COMBINED FINAL MILL TAILINGS

SHEET NO.:6 OF 10

UNDRAINED SETTLING TEST



SRC JOB NO. REF 59845


DORIS NORTH COMBINED FINAL MILL TAILINGS
SHEET NO.:7 OF 10
UNDRAINED SETTLING TEST
Supernatant (%)
100
90
80
70
60
50
40
30
20
10
0
Dry Density t/m3
2.000
1.800
1.600
1.400
1.200
1.000
0.800
0.600
0.400
0.200
0.000
0
15
30
45
60
75
90
120
150
180
240
1440
2880
4320
Time (minutes)
Cumulative Supernatant %
Dry Density t/m3
SRC JOB NO. REF 39645

amec

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TEST CERTIFICATE

Client: MIRAMAR HOPE BAY LIMITED
Project: DORIS NORTH COMBINED FINAL MILL TAILINGS

Sheet No.: 8 OF 10
Job No.: S9645
Date Tested: 25.08.03-28.08.03

Sample ID: TAILS

Drained Settling Test
SRC-WI-4.8.2

% SOLIDS:	**33.8**	
TEST CYLINDER		
Diameter of Cylinder	57.3	mm
Area of Cylinder	2579.0	mm^2
Mass of Cylinder	1064	g
Mass Cylinder & Tailings	1914.30	g
Mass of Tailings Wet	850.30	g
Mass of Tailings Dry	287.63	g
AFTER TEST		
Mass Cylinder & Tailings	1433.42	g
Mass of Tailings Wet	369.42	g
Mass of Tailings Dry	287.63	g
Amount of Water in Sample	**218.17**	mm
Amount of Water Drained	**88.79**	mm
Amount of Water Removed	**0.00**	mm
Remaining Water in Sample	**129.38**	mm

MOISTURE CONTENT CHECK

Container No.	6	
Mass Cont. & Tailings Wet	257.48	g
Mass Cont. & Tailings Dry	153.29	g
Mass Container	100.03	g
Moisture Content	**195.63**	%
AFTER TEST		
Final Moisture Content	**28.44**	%

Date & Time Test Commenced: 25.08.03 @ 1000HRS

check: **120.51** 97.66

Elapsed Time min	Height of Water mm	Water Drained ml	Water Drained mm	Height of Tailings mm	With Respect to Initial Volume of Water: Supernatan %	Drainage %	Cumulative Underdrain %	Total Recovery %	Dry Density t/m3	Moisture Content of Slurry %
0	0	0	0	251	0.00	0.00	0.00	0.00	0.444	195.63
15	39	100	39	187	17.88	17.77	17.77	35.65	0.596	125.89
30	75	20	8	149	34.38	3.55	21.33	55.70	0.748	86.66
45	105	10	4	108	48.13	1.78	23.10	71.23	1.033	56.28
60	123	8	3	86	56.38	1.42	24.53	80.90	1.297	37.36
75	127	8	3	79	58.21	1.42	25.95	84.16	1.412	30.99
90	124	6	2	79	56.84	1.07	27.01	83.85	1.412	31.59
120	120	10	4	79	55.00	1.78	28.79	83.79	1.412	31.70
150	115	10	4	78	52.71	1.78	30.57	83.28	1.430	32.71
180	111	12	5	78	50.88	2.13	32.70	83.58	1.430	32.13
240	10	20	8	78	4.58	3.55	36.26	40.84	1.430	115.73
1440	0	25	10	78	0.00	4.44	40.70	40.70	1.430	116.01
2880	0	0	0	78	0.00	0.00	40.70	40.70	1.430	116.01
4320	0	0	0	78	0.00	0.00	40.70	40.70	1.430	116.01

Remarks: Sampling method/s - Submitted by client

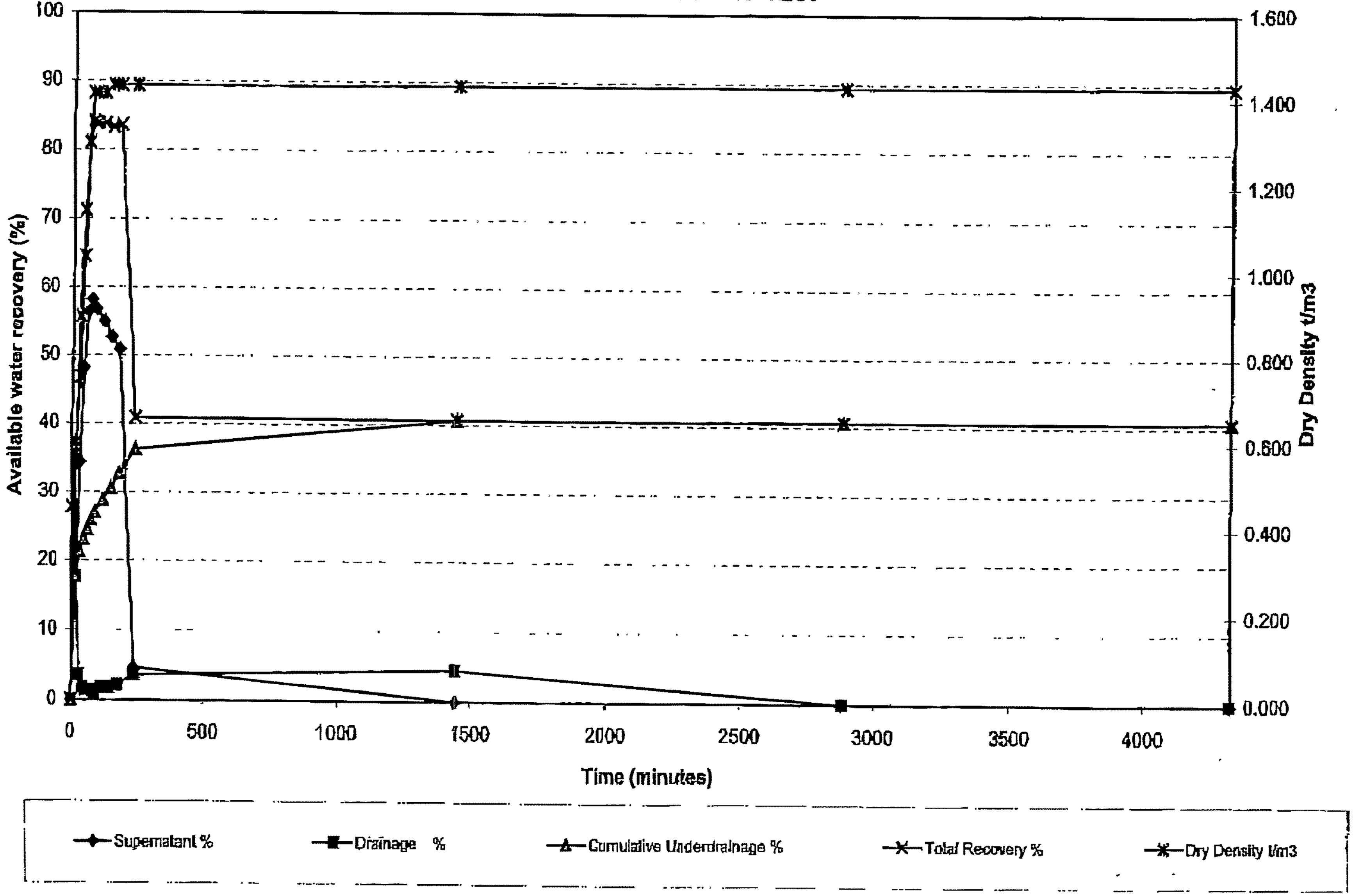
Approved: [signature]
W Rozmianiec

Date: 17.09.03

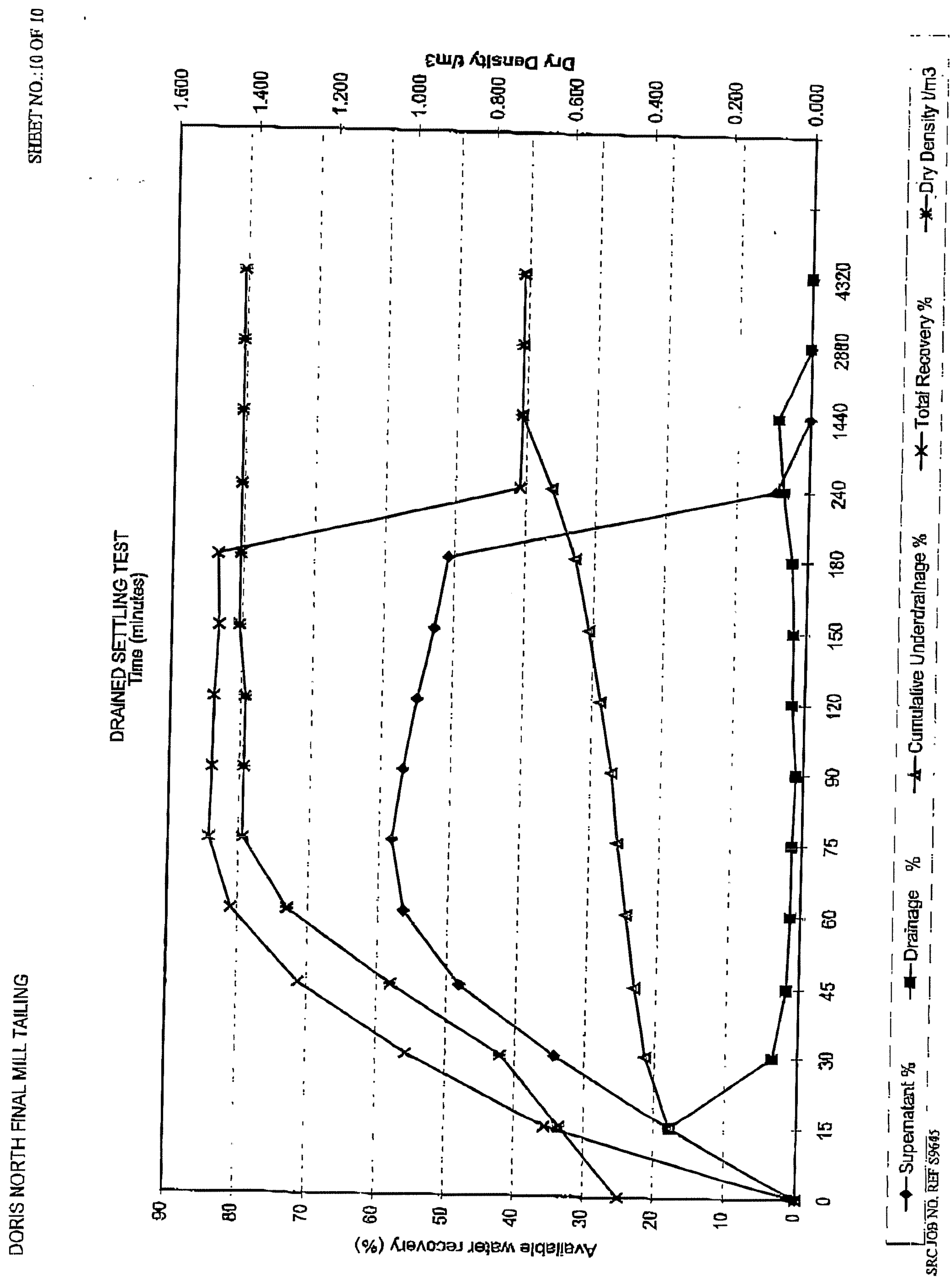
DORIS NORTH COMBINED FINAL MILL TAILINGS

SHEET NO. 9 OF 10

DRAINED SETTLING TEST



SRC JOB NO. REF S9645


SHEET NO. 10 OF 10
DORIS NORTH FINAL MILL TAILING
DRAINED SETTLING TEST
Time (minutes)
Dry Density t/m3
1.600
1.400
1.200
1.000
0.800
0.600
0.400
0.200
0.000
Available water recovery (%)
90
80
70
60
50
40
30
20
10
0
0
15
30
45
60
75
90
120
150
180
240
1440
2880
4320
Supernatant %
Drainage %
Cumulative Underdrainage %
Total Recovery %
Dry Density t/m3
SRC JOB NO. REF S9645

Appendix B

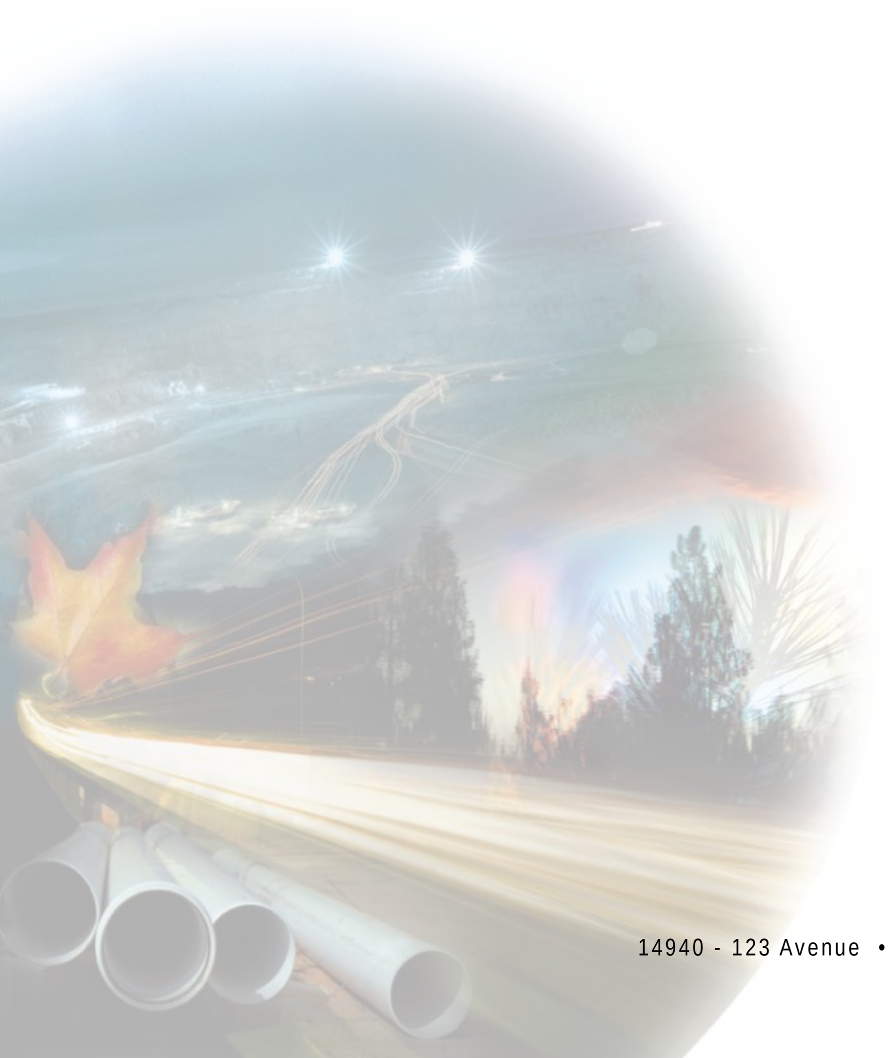
Thermal Design of Tailings Dams (EBA 2006)

SRK Consulting (Canada) Inc.

THERMAL DESIGN OF TAILINGS DAMS
DORIS NORTH PROJECT, NU

1100126

September 2006



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EXECUTIVE SUMMARY

The tailings water management plan for the Doris North Project requires the construction of two dams, the North Dam and the South Dam. The two dams have been designed as frozen core dams within an environment where cold permafrost soils persist. The dams are intended to have a 25-year design life. This report summarizes the analyses carried out in support of final dam design.

The North Dam is up to approximately 11.4 m high, has a 190 m crest length and is designed to retain up to 7.4 m of water at the full supply level. The South Dam is up to approximately 7.2 m high, has a 350 m crest length, and is designed to retain up to 2.7 m of water at the full supply level.

The North Dam foundation consists of predominantly ice-poor frozen sand below approximately two-thirds of the dam alignment, with the remaining portion comprising saline, marine clayey silt. The South Dam foundation is predominantly thick saline marine clays and silts overlying gravel. At both dam alignments, bedrock is relatively shallow in the abutment areas.

Each dam consists of a frozen core of nearly-saturated crushed quarry rock with a well-graded sand and gravel texture. The core is surrounded by a transition zone of processed 200 mm minus material. A geosynthetic clay liner (GCL) will be placed upstream of the core to provide seepage control if cracks were ever to develop in the frozen core. A series of horizontal thermosyphon loops will be installed within the key trench to ensure that the core and foundation soils beneath the core are sufficiently cold to limit creep-induced deformations and to be impervious to seepage. The dam shell will be constructed of run-of-quarry rock. The dam will be constructed during the winter in such a manner that the core and permafrost foundation are frozen as the dam is built and will remain in a permafrost condition throughout the dam's design life. The design has appropriate precedence from 10 years of performance history at the EKATI Diamond Mine where similar structures have been in service.

Finite element thermal analyses were carried out to predict future ground temperature within the dam and foundation. The analyses accommodate potential global warming trends by assuming that future air temperatures will rise at a rate of approximately 0.6°C per decade over the design life of the dams. The results indicate that frozen conditions are maintained with much of the core remaining colder than -2°C and the permafrost foundation soils beneath the core remaining colder than -8°C in order to enhance stability of the saline clay soils. Sensitivity thermal analyses indicated that thermosyphons installed in the key trench were required to sustain the core and underlying permafrost foundation sufficiently cold over the dams' design life. Two consecutive extreme warm years were also evaluated as an upset condition. The results indicate that the core and underlying foundation remain well-frozen even under this upset condition. Overburden soils are predicted to thaw under the upstream shell below the water impoundment. Thaw settlement will occur over time as a result of the thaw in areas where the foundation soils contain excess ground ice. The design has anticipated and accommodated predicted embankment settlement.

The portions of the dam underlain by saline marine clays and silts will undergo creep deformation due to the imposed loading from the dam embankment. Creep-deformation analyses were carried out using a two-dimensional, finite difference stress-deformation model. Relatively flat slopes (4H:1V to 6H:1V) were adopted in dam design to minimize the creep movements. The highest creep strains and stresses are located under the upstream shell. Minimal creep strains and shear stresses are predicted within the dam core and the foundation beneath the core. These strains and associated imposed stresses are viewed to be within tolerable limits and are expected to occur in a ductile manner over the life of the dam.

Total stress limit equilibrium analyses carried out for the design side-slopes indicate that the factor of safety against slope movement is greater than 1.5 and 1.1 for both the upstream and downstream slopes under static and earthquake loading, respectively. This result satisfies dam safety requirements.

The crest elevations of the dam and dam core have been designed to be over-built by 0.5 m and 1.0 m for the North and South Dams, respectively, to accommodate future settlements due to creep deformation. The predicted magnitude and rate of displacements due to permafrost creep and thaw are considered conservative. However, non-uniform displacements are anticipated because of variable soil conditions along each dam alignment. Therefore, it is recommended that a deformation monitoring program be implemented following construction to determine what measures, if any, will be required under the unlikely event that movements are greater than predicted.

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1.0 INTRODUCTION

EBA Engineering Consultants Ltd. (EBA) was subcontracted by SRK Consulting (Canada) Inc. (SRK) on behalf of Miramar Hope Bay Limited (MHBL) to conduct thermal and creep deformation analyses and provide advice for the design of two new tailings dams proposed for the Doris North Project. This report describes the thermal and mechanical behaviour of the local overburden soils and presents the methodology and results of thermal analyses, creep deformation analyses, and slope stability analyses carried out in support of dam design.

2.0 SITE DESCRIPTION

2.1 FOUNDATION CONDITIONS

This section summarizes the interpretation of soil conditions at the North and South Dam alignments (SRK, 2005).

The North Dam alignment is within a relatively narrow valley within which subsurface conditions are characterized by two distinct zones. About two-thirds of the dam longitudinal section is dominated by an ice-saturated sand deposit that is approximately 10 m to 15 m thick. The sand deposit is overlain by a silt and clay layer that is less than 3 m thick. The remaining one-third portion is dominated by marine clayey silt that is up to 15 m thick. The fine-grained materials are also ice-saturated and contain excess ground ice. The overburden soils are up to 20 m thick at the base of the valley and thin out at the dam abutments. Bedrock is generally competent basalt.

The South Dam alignment is along a flat valley section at the watershed boundary that separates Tail Lake and Ogama Lake to the south. Soil conditions along this alignment typically consist of marine silt and clay overlying gravel. The marine deposit, which is up to 20 m thick at the base of the valley, is ice-saturated and contains excess ground ice. The gravel layer is up to 15 m thick. The overburden soils thin out at the dam abutments. Bedrock consists of basalt and argillite and is generally competent.

The Doris North Project site is located within the zone of continuous permafrost. Mean ground surface temperatures typically range from -9°C to -7°C. Permafrost thickness has been estimated to be approximately 550 m deep.

Pore water salinity measured from selected soil samples typically ranged from 30 parts per thousand (ppt) to 50 ppt. As 30 to 35 ppt is the typical salinity for sea water (Nixon and Neukirchner, 1984), the salinity measurements indicate that the marine deposit is highly saline. The pore water salinity of the sand deposit is typically 4 ppt or less and is considered non-saline.

2.2 CLIMATIC DATA FOR THERMAL MODELLING

Thermal modelling of the Doris North Project dams requires the input of climate data, including air temperature, wind speed, snow cover, and solar radiation.

A meteorological station was installed on the northern shore of Doris Lake in May 2003. Longer-term site specific data are not available. The closest meteorological station with a longer monitoring period is the Boston Camp site, located approximately 50 km south of Doris North. Climatic data have been collected at the Boston Camp site since 1993, although there are several gaps in the data set (AMEC, 2003). The closest Environment Canada meteorological stations (and the year when the station began collecting climatic data) with a long-term climatic record are as follows:

- Coppermine/Kugluktuk (operating since 1931), located approximately 320 km west of Doris North;
- Cambridge Bay (operating since 1929), located approximately 180 km northeast of Doris North;
- Contwoyto Lake/Lupin (operating since 1959), located approximately 320 km southwest of Doris North; and
- Lady Franklin Point (operating from 1957 to 1993), located approximately 260 km northwest of Doris North.

Assuming that the climate at Boston Camp is representative of Doris North, AMEC (2003) found that from the available air temperature data, the best correlation was obtained by multiple regression of the Boston data with the data from the Kugluktuk, Cambridge Bay, and Lupin stations as follows:

$$T_{Boston} = 0.3200 \cdot T_{Kugluktuk} + 0.3326 \cdot T_{CambridgeBay} + 0.3512 \cdot T_{Lupin} \qquad [1]$$

where T is the daily air temperature (°C) at the respective stations.

Figure 1 compares the historical air temperature records since 1959 for Kugluktuk, Cambridge Bay, and Lupin/Contwoyto Lake. The Environment Canada stations show remarkably similar long-term trends, which implies that Doris North has likely experienced a similar warming trend. The annual air temperature history since 1998 for Doris North, computed using Equation 1 and the monthly Environment Canada station temperatures over this period, is also shown. The computed annual air temperatures at Doris North are approximately 2°C warmer than Cambridge Bay and 1°C colder than Lupin/Contwoyto Lake and Kugluktuk. The temperature comparison with Cambridge Bay agrees with the available air temperature data from Doris North since 2003 (Golder, 2005). Therefore, Equation [1] is considered reasonable for estimating long-term air temperatures. Long-term monthly air temperatures at Doris North were estimated using Equation [1] and the mean monthly air temperatures at the three Environment Canada stations, based on the

1971-2000 climate normal period. The mean annual air temperature at Doris North is estimated to be -12.1°C.

Long-term monthly mean wind speeds (1971-2000 climate normal period) are available from the Kugluktuk, Cambridge Bay and Lady Franklin Point stations. The average annual wind speed ranges from 16.1 km/h at Kugluktuk to 21.2 km/h at Cambridge Bay. Monthly wind speeds at Doris North were estimated to be the same as at Lady Franklin Point, which has an average annual wind speed of 20.1 km/h.

Long-term snow cover data (1971-2000 climate normal period) are available from Kugluktuk, Lady Franklin Point and Cambridge Bay. On average, Kugluktuk gets approximately 50 percent more snow cover than Lady Franklin Point and Cambridge Bay. The long-term monthly snow cover at Doris North was estimated to be the same as the monthly average of Lady Franklin Point and Cambridge Bay.

Daily solar radiation data are available for only a limited number of sites in the arctic. The closest meteorological station with solar radiation data is Cambridge Bay. Daily solar radiation at Doris North was assumed to be the same as that at Cambridge Bay (based on the climate normal period of 1951-1980, Environment Canada 1982).

Table 1 summarizes the long-term climatic data used in the thermal analyses.

TABLE 1: ESTIMATED MEAN (1971-2000) CLIMATIC CONDITIONS, DORIS NORTH PROJECT

	Air Temperature[a] (°C)	Wind Speed [b] (km/h)	Snow Cover[c] (cm)	Daily Solar Radiation[d] (W/m^2)
January	-31.6	19.5	21	2.2
February	-31.0	20.5	24	21.1
March	-28.0	19.6	28	87.6
April	-18.9	20.0	28	185.5
May	-7.1	20.4	22	251.9
June	3.8	20.0	0	268.1
July	9.5	18.7	0	214.6
August	7.6	19.4	0	138.5
September	1.1	21.4	0	71.8
October	-9.2	22.3	7	33.0
November	-21.5	19.9	14	4.5
December	-27.6	19.3	18	0.0

Notes:
(a) Based on Equation [1] and monthly air temperatures from 1971-2000 climate normal period for Kugluktuk, Contwoyto Lake/Lupin, and Cambridge Bay.
(b) Assumed equal to monthly wind speeds from 1971-2000 climate normal period for Lady Franklin Point.
(c) Averaged from monthly snow cover from 1971-2000 climate normal period for Lady Franklin Point and Cambridge Bay.
(d) Assumed equal to daily solar radiation data from 1951-1980 climate normal period for Cambridge Bay (Environment Canada, 1982).

3.0 DESIGN BASIS

3.1 PHYSICAL CHARACTERISTICS OF SALINE FROZEN SOILS

The marine fine-grained soils beneath the dam alignments are in a permafrost condition and are saline. High pore water salt content increases the freezing point depression (i.e., lowers the temperature at which the pore water freezes) and increases the unfrozen water content (Andersland and Ladanyi, 2004). The lower ice content results in reduced frozen soil strength, increased hydraulic conductivity, and higher creep rate at a given temperature. Furthermore, it increases the potential for the frozen soil to behave as an unfrozen cohesive soil that may compress and consolidate upon loading.

3.1.1 Unfrozen Water in Frozen Soil

The water-ice phase composition in a soil or rock varies with particle mineral composition, specific surface area of the particles, salt content, and temperature (Andersland and Ladanyi, 2004).

According to Anderson and Tice (1972), the percentage of unfrozen moisture content (by dry weight of the soil) at a given temperature is given by:

$$w_{u\theta} = A \cdot \theta^{B} \qquad [2]$$

where: $A = 1.2993\ S_a^{0.5519}$

$B = -1.4495\ S_a^{-0.264}$

θ = temperature in degrees Centigrade below zero

and S_a = specific surface area of soil (m^2/g)

At a given temperature, the percentage of unfrozen moisture is greater for soils with a high specific surface area (typically fine-grained, plastic soils).

The relationship between freezing point and pore water salinity can be calculated using the following equation (Ono, 1966):

$$\theta_f = \frac{-54.11 \cdot S}{(1000 - S)} \qquad [3]$$

where θ_f is the freezing point (°C) and S is the pore water salinity (parts per thousand, or ppt). The effect of salinity is to shift the unfrozen water content curve by an amount equal to the freezing point depression of the pore water.

3.1.2 Hydraulic Conductivity of Frozen Soils

Nixon (1991) reviewed the hydraulic conductivity of frozen, fine-grained soils. Figure 2 summarizes the review of the literature. The reduction in hydraulic conductivity with colder temperatures strongly correlates with the reduction in unfrozen water content (and corresponding decrease in voids available for water percolation). To EBA's knowledge, there are no published data relating hydraulic conductivity with temperature for saline, frozen soils. However, if we assume that the saline fine-grained foundation soils at the Doris North dam alignments are at an average temperature of -8°C and have an average pore water salinity of 50 ppt (corresponding to a freezing point depression of approximately -3°C), and if we apply a temperature adjustment of 3°C as a safety factor, its hydraulic conductivity can be considered equivalent to freshwater clay/silt at a temperature of approximately -2°C. From Figure 2, the hydraulic conductivity of the saline clay and silt foundation is estimated to range from 10^{-12} cm/s to 10^{-10} cm/s, which is equivalent to unfractured rock or unweathered marine clay (Freeze and Cherry, 1979).

3.1.3 Mechanical Behaviour of Frozen Soils

Frozen soils and/or ice behave as visco-plastic materials and, as such, exhibit creep (Weaver and Morgenstern, 1981). Time-dependent deformation (creep) is composed of an instantaneous (elastic) response that is followed by decelerating (primary) creep, constant rate (secondary) creep, and at sufficient stress levels, tertiary creep (Mellor, 1979). Under moderate stress levels, the long-term deformation behaviour of ice or ice-rich soil is controlled by secondary creep, while the deformation behaviour of ice-poor soil is controlled by primary creep (Weaver and Morgenstern, 1981). Figure 3 illustrates a typical creep curve for ice-rich frozen soil or ice.

Power law models are used to model primary and secondary creep behaviour. The model not only depends on the soil characteristics, such as soil type, ice content, and temperature, but also the stress level in the soil. A model to describe the creep behaviour of frozen soils using power law relationships to represent the primary and secondary stages of creep under uniaxial compression was presented by Vyalov (1962). Sayles (1988) reviewed the available creep models and concluded that the Vyalov model provided the best approach to describe the primary phase of the creep curve. The creep law proposed by Vyalov can be expressed in the following form:

$$\varepsilon = \left\lfloor \frac{1}{w \cdot (\theta + 1)^k} \right\rfloor^n \cdot \sigma^n \cdot t^b \qquad [4]$$

where:

ε	=	primary strain;
w	=	a constant with dimensions of temperature;
θ	=	temperature below the freezing point of water, 0°C [C°];
σ	=	applied uniaxial stress [kPa];
t	=	elapsed time after application of the load [hours]; and
k, n, b	=	dimensionless constants that depend on the material properties.

Equation [4] can be expressed in a more generalized form as follows:

$$\varepsilon = B \cdot \sigma^n \cdot t^b \quad [5]$$

Differentiating Equation [5], a generalized expression for the primary strain rate, $\dot{\varepsilon}$, can be found:

$$\dot{\varepsilon} = b \cdot B \cdot \sigma^n \cdot t^{b-1} \quad [6]$$

The following flow law representing secondary creep is commonly used to describe the steady-state creep of polycrystalline ice and ice-rich frozen soils:

$$\dot{\varepsilon} = B \cdot \sigma^n \quad [7]$$

Equation [7] is a simple form of Equation [6], with b = 1. Nixon and Lem (1984) reported that this flow law is also applicable to frozen saline soils. Ladanyi (1972) described how these relationships could be modified to include the influence of confining pressure. In a two- or three-dimensional deformation analysis, the applied effective stresses and resulting effective strains and strain rates can be expressed in deviatoric terms (Odqvist, 1966).

The creep response of frozen soils generally requires specialized testing equipment and a well-controlled temperature environment over an extended period. For the vast majority of permafrost engineering design applications, creep tests are rarely conducted and secondary creep behaviour is typically characterized by data published by Morgenstern et al. (1980) and McRoberts (1988) for ice and freshwater frozen soils, and by Nixon and Lem (1984) for saline frozen soils. Laboratory creep tests of frozen, saline marine clays from Svalbard, Norway, have also been reported (e.g., Berggren, 1983; Gregersen et al., 1983; Furuberg and Berggren, 1988). Figure 4 compares the relationship of creep parameter B with salinity and temperature.

While creep is often considered the main source of deformation of frozen soils, deformations due to consolidation may also be important, particularly for frozen soils with high unfrozen water content (Andersland and Ladanyi, 2004). Currently, very little is known about the laws governing the consolidation of frozen soils under load and their temperature dependence, which makes it difficult to separate settlements due to consolidation from those due to creep (Andersland and Ladanyi, 2004).

As the hydraulic conductivity of the partially frozen marine clay and silt is expected to be relatively low (see Section 3.1.2) and the drainage boundaries for the cold permafrost foundation are expected to be large, deformations due to consolidation are anticipated to be negligible over the design life of the structures, particularly compared with creep-induced deformations. The partially-frozen marine silt and clay is expected to behave similarly to an unfrozen, low-permeability cohesive soil. At the end of construction, the foundation soil will be in a virtually undrained condition and excess pore pressures will be generated.

The physical properties of the Doris North marine clay and silt are very similar to those reported for a Norwegian clay known as Svea Clay (Berggren, 1983). Table 2 below compares some of the physical properties. It is noted that these are typical values, and that there is considerable natural variability in the recorded measurements.

TABLE 2: COMPARISON OF PHYSICAL PROPERTIES, DORIS NORTH CLAY/SILT AND SVEA CLAY

Parameter	Doris North Clay/Silt	Svea Clay (Berggren, 1983)
Natural Moisture Content	50	45
Natural Bulk Density	1.65	1.68
Clay Fraction (%)	45	40
Mineralogy	Illite, mica, chlorite, quartz, plagioclase	Chlorite, illite, albite, kaolin, quartz
Atterberg Limits (plastic limit, liquid limit, plasticity index) (% dry weight)	40, 22, 18	47, 28, 19
Natural Porewater Salinity (ppt)	45	34
Volumetric Fraction of Unfrozen Water at -5°C	0.60	0.33

Berggren (1983) reported a thawed undrained shear strength of 40 kPa for Svea Clay. This value was also considered its long-term frozen creep strength. Based on the similarity of physical properties, the undrained shear strength for the Doris North marine clay and silt has also been estimated to be 40 kPa.

3.2 ROCKFILL EMBANKMENTS CONSTRUCTED ON SALINE PERMAFROST

Rockfill embankments constructed in permafrost environments may alter the thermal regime of the foundation soils/rock and cause the permafrost subgrade to thaw. If the permafrost consists of coarse-grained materials and is ice-poor (i.e., contains less than 5 percent visible excess ground ice), permafrost thaw beneath the embankment will not generate excess pore pressures, thaw strains will be limited, and the embankment will remain stable. However, if the permafrost contains significant quantities of excess ground ice, permafrost thaw below the embankment may generate excess pore pressures, thaw strains may be significant, and the embankment may become unstable and ultimately fail.

As previously described, a large portion of the Doris North dams are founded on permafrost soils that are highly saline and contain excess ground ice. If the permafrost soils are ice-rich and/or highly saline, and the permafrost foundation is maintained in a frozen state, embankment loading may cause the permafrost to deform due to creep, which may lead to ruptures and cracks in the permafrost and embankment.

To EBA's knowledge, there are no reported case histories describing the long-term creep deformations of earthfill or rockfill embankments founded on cold, highly saline permafrost such as found at the Doris North Project site. The closest reported case histories are of road embankments founded on warm, freshwater permafrost in Alaska. Phukan (1983) reported the results from the Bonanza Creek test embankment. The 7.6 m high roadway embankment was founded on ice-rich permafrost soils that were at a temperature of -0.5°C.

Over a five-year period, the embankment crest settled at a rate of approximately 2 cm per year. McHattie and Esch (1988) reported the results from a road section near Fairbanks that was founded on ice-rich permafrost soils with a mean ground temperature of -0.4°C. Embankment settlements averaging 0.3 m per year were reported over a 10 year period for the roadway that was originally 10.5 m high. Embankment side slopes at both test sites ranged from approximately 1.5H:1V to 2H:1V. Based on the results from these case histories, it can be inferred that a large rockfill embankment founded on saline permafrost can be expected to experience similar, if not greater, magnitudes of creep deformation unless measures are taken to reduce levels of shear stress in the permafrost (by using relatively flat dam side slopes) or to thermally protect the frozen core and permafrost foundation (through the use of rockfill cover as a thermal insulator or by incorporating passive refrigeration devices known as thermosyphons), as part of dam design.

3.3 FROZEN CORE DAM CONCEPT

The nature of the foundation conditions beneath the Doris North dams is such that it is desirable to maintain the foundation soils and rock frozen rather than necessitating a massive excavation below the embankment. The frozen core design concept relies on the pores within the core and foundation soils and rock to be nearly ice-saturated to produce a well-bonded and impermeable mass.

Frozen core dams have been constructed in Canada—e.g., at the Lupin Mine (Dufour and Holubec, 1988); at the Polaris Mine (Cathro et al., 1992), at the EKATI Diamond Mine (Hayley et al., 2004), and at the Diavik Diamond Mine (Holubec et al., 2003). Frozen core dams have also been constructed in Alaska, Greenland, and Russia (Johnston and MacPherson, 1981).

Frozen core dams are particularly effective in areas of continuous permafrost, where winters are very cold and ground temperatures are typically several degrees Centigrade below freezing. What is technically challenging about the design of the Doris North dams is that significant portions of the dams are founded over thick layers of saline permafrost soils that not only contain excess ground ice but also have a high unfrozen water content. This creates a high potential for creep-deformation of the dam embankment. Therefore, alternative design concepts, such as a conventional lined dam, would not be practical under such conditions because any movement below the liner could rupture the liner. Furthermore, a frozen core dam is a more robust structure. It is essentially a rockfill structure with an impervious frozen core. A secondary seepage barrier is provided by installing a geosynthetic clay liner (GCL) against the upstream side of the core. Finally, a combination of relatively flat dam side slopes and horizontal thermosyphons installed within the key trench will minimize lateral creep displacements, vertical thaw settlements beneath the dam, and deformation of the frozen core over the design life of these structures. Thermosyphons have been installed in many of the dams at the EKATI Diamond Mine and have performed effectively to date (Hayley et al., 2004).

3.4 DAM LAYOUT AND GEOMETRY

The selected dam geometry and layout have been designed to minimize material costs, protect the integrity of the frozen core, and satisfy thermal, stability, and settlement design criteria.

As described by SRK (2005), the dams have been designed with a minimum 1.0 m freeboard for the full supply water elevation of 33.5 m. As will be discussed in Section 5, the core is predicted to settle over time due to creep deformation of the saline permafrost foundation. Therefore, the design elevations of the crest of the core have been raised by 0.5 m and 1.0 m for the North and South Dams, respectively, to accommodate future settlement of the core while maintaining minimum freeboard requirements for the first several years following dam construction.

Figure 5 shows generalized cross sections of the North and South Dams. The North Dam is approximately190 m long and has a crest width of 13 m. The crest width is required for constructability and thermal protection of the frozen core. The maximum dam height is approximately 11.4 m. The South Dam is approximately 350 m long and also has a crest width of 13 m. The maximum dam height is approximately 7.2 m.

The impervious core of the dams will be constructed of frozen, nearly-saturated well graded gravel prepared by crushing quarried rock (processed 20 mm minus). A key trench will be excavated beneath the core to 2.0 m (typical) below original grade.

Transition material (processed 200 mm minus rockfill) will be placed over the face of the frozen core to provide increased protection of the core from thermal and mechanical degradation. The transition material downstream of the core is designed to act as a filter material in the unlikely event of thaw of the core. The top of the frozen core (defined as the crest of the internal GCL within the zone of processed 20 mm minus material), will be covered with 300 mm of 20 mm minus material and 700 mm of transition material. A 1.0 m thick blanket of transition material is provided over the upstream dam foundation to provide thermal protection of the foundation soils and upstream toe of the core against convective heat transfer within the pores of the submerged shell rockfill.

Shell material has been provided for stability and thermal protection of the frozen core. The shell will consist of run-of-quarry rockfill. The upstream and downstream slopes of the North Dam will be 6H:1V and 4H:1V, respectively. Both the upstream and downstream slopes of the South Dam will be 6H:1V. The slopes are designed to maintain long-term stability by limiting potential creep deformations.

There is 2.5 m thick rockfill cover over the crest of the frozen core to prevent summer thaw of the frozen core. The core is positioned just downstream of the centre of the dam to increase the distance of the core from the impounded water, which acts as a heat source.

3.5 OPERATING INTENT

As detailed in SRK (2005), the tailings impoundment requires the construction of two dams at the north and south ends of Tail Lake. The tailings impoundment is sized to operate as a zero discharge facility during the two years of mine operation. As the water management plan is based on a water quality model, analyses by SRK indicate that Tail Lake would take between 5 and 22 years to reach the design full supply level of 33.5 m. Therefore, the dams have been designed for a minimum operational design life of 25 years.

4.0 THERMAL EVALUATION

4.1 THERMAL MODEL

Thermal analyses were carried out using EBA's proprietary finite element computer program, GEOTHERM. The model simulates transient, two-dimensional heat conduction. The program has been verified by comparison with closed form solutions and numerous field observations. The model has been the design basis for a large number of projects in the arctic and subarctic, including the design of frozen core dams at the Polaris Mine in Resolute, NU (Cathro et al., 1992) and at the EKATI Diamond Mine in Lac de Gras, NT (Hayley et al., 2004).

4.2 THERMAL MODEL CALIBRATION

The thermal model was calibrated against measured temperatures from Boreholes SRK-15 and SRK-51 at the North Dam alignment, and Borehole SRK-33 at the South Dam alignment. These locations were selected because they showed the thickest sections of saline, marine clay and silt at each alignment and were thus considered the most sensitive locations to creep-induced deformations. Ground temperatures have been collected at Boreholes SRK-15 and SRK-33 since April 2003 and at Borehole SRK-51 since April 2005. Data from both Boreholes SRK-15 and SRK-51 were used to calibrate the thermal model at the North Dam alignment because Borehole SRK-51 provided detailed temperatures only up to 5.0 m depth while Borehole SRK-15 provided deep ground temperature data (to 19.5 m depth), but with only one measurement within the top 5 m depth.

Simplified soil profiles were developed for each dam alignment, based on the soil descriptions in the borehole logs. Table 3 summarizes the soil profile and properties used at each dam alignment. The freezing point depression was calculated using Equation [3].

TABLE 3: PHYSICAL PROPERTIES USED IN THERMAL MODEL CALIBRATION ANALYSES					
Material	Depth Interval (m)	Water Content (% dry weight)	Bulk Density (Mg/m^3)	Pore Water Salinity (ppt)	Freezing Point Depression (°C)
North Dam (Borehole SRK-51)					
Peat/Organic Soil	0.0 – 0.4	100	1.00	0	0.0
Icy Silt	0.4 – 1.3	60	1.60	33	-1.9
Silt	1.3 – 2.1	35	1.80	33	-1.9
Silt and Clay	2.1 – 12.9	45	1.77	50	-2.9
Basalt Bedrock	12.9 – 50.0	1	2.63	0	0.0
South Dam (Borehole SRK-33)					
Peat/Organic Soil	0.0 – 0.08	100	1.00	0	0.0
Silt No. 1	0.08 – 5.6	50	1.69	40	-2.3
Clay No. 1	5.6 – 6.2	50	1.71	50	-2.9
Silt No. 2	6.2 –11.0	37	1.85	45	-2.6
Clay No. 2	11.0 – 21.3	60	1.65	45	-2.6
Silt No. 3	21.3 – 23.1	30	1.94	45	-2.6
Gravel	23.1 – 30.0	18	2.11	5	-0.3
Basalt Bedrock	30.0 – 50.0	1	2.63	0	0.0

Thermal properties were determined directly from well-established correlations with soil index properties (Farouki, 1986; Johnston, 1981). Table 4 summarizes the material properties used in the calibration thermal analyses.

TABLE 4: THERMAL PROPERTIES USED IN THERMAL MODEL CALIBRATION ANALYSES					
Material	Thermal Conductivity (W/m°C)		Specific Heat (kJ/kg°C)		Latent Heat (MJ/m^3)
	Frozen	Unfrozen	Frozen	Unfrozen	
Native Foundation Materials (North Dam, Borehole SRK-51)					
Peat/Organic Soil	1.45	0.62	1.41	2.46	167
Icy Silt	2.32	0.98	1.25	2.03	198
Silt	1.52	1.20	1.10	1.63	152
Silt and Clay	1.92	1.35	1.21	1.80	167
Basalt Bedrock	2.20	2.20	0.75	0.77	9
Native Foundation Materials (South Dam, Borehole SRK-33)					
Peat/Organic Soil	1.45	0.62	1.41	2.46	167
Silt No. 1	2.40	1.07	1.20	1.88	186
Clay No. 1	2.25	1.08	1.24	1.88	175
Silt No. 2	2.51	1.25	1.11	1.67	163
Clay No. 2	2.27	1.01	1.30	2.03	193
Silt No. 3	2.54	1.37	1.06	1.53	146
Gravel	2.60	1.64	0.94	1.26	108
Basalt Bedrock	2.20	2.20	0.75	0.77	9

Unfrozen water content curves were estimated for each soil layer based on the methodology described in Section 3.1.1. The estimated unfrozen water content curves were in good agreement with the measured data reported by SRK (2005).

One-dimensional thermal analyses were initially carried out in order to calibrate the model with measured ground temperatures. For simplification, the thermal model was calibrated against only the 2004/2005 measured ground temperatures. By inspection, 2003 ground temperatures were comparatively warmer than the 2004/2005 ground temperatures. This was expected, since 2003 was a relatively warm year.

The mean climatic conditions described in Table 1 were applied to the ground surface of each soil profile for a period of thirty years, by which time ground temperatures were stable from year to year. Then, beginning January 1, 2004, mean monthly air temperatures from January 2004 to September 2005 (estimated from the Kugluktuk, Cambridge Bay, and Lupin data and Equation [1] and listed in Table 5) were used. All other climate parameters were assumed to be the same as for the mean conditions described in Table 1.

TABLE 5: ESTIMATED MONTHLY AIR TEMPERATURES (°C) AT DORIS NORTH (2004-2005)

Month	2004	2005
January	-32.6	-28.8
February	-32.3	-31.8
March	-31.2	-26.7
April	-20.7	-14.5
May	-11.4	-8.1
June	4.3	4.3
July	9.9	8.3
August	6.6	8.4
September	0.7	0.4
October	-10.6	-7.8
November	-22.0	-19.0
December	-29.7	-23.7

Figures 6 and 7 compare the predicted and measured ground temperatures at the North Dam and South Dam alignments, respectively. Both figures show excellent agreement between the measured and predicted ground temperatures below 5 m depth. Within the top 5 m depth, there is very good agreement between the predicted and measured data at the end of summer (August/September) and good agreement during the spring (April-May). Based on EBA's experience, the overall match between the measured and predicted ground temperatures is considered very good. Therefore, the selected input parameters are considered reasonable and the thermal model can be used for thermal design of the tailings dams.

4.3 THERMAL DESIGN CRITERIA

A frozen core dam constructed over a saline permafrost foundation must be designed to ensure that the core and its foundation will be perennially frozen and nearly ice-saturated throughout the life of the structure. It is intended that the frozen core will be nearly saturated with freshwater ice that freezes at 0°C.

The Doris North dams have been designed to maintain "critical sections" of the core and underlying saline permafrost foundation sufficiently cold over a wide enough section to be an impervious barrier to seepage. The critical section of the core is defined as the part of the core that is colder than -2°C during impoundment under normal operating conditions or colder than -1°C during impoundment under upset conditions. A warmer design temperature has been selected for the upset condition because the probability of its occurrence is considered relatively remote. The critical section of the saline permafrost foundation is defined as the portion of the saline permafrost layer that is colder than -8°C under normal or upset operating conditions. A colder design temperature has been selected for the saline permafrost foundation compared to the frozen core because of the unfrozen water content distribution with permafrost temperature. Furthermore, colder foundation temperatures will reduce the rate and magnitude of creep-induced deformations of the frozen core and permafrost foundation.

For design purposes, the Doris North Dams must satisfy the following conditions:

- the elevation of the top of the critical section of the core must remain higher than the maximum operating level (Elevation 33.5 m);
- the width of the critical section within the core must be at least twice the head of water impounded against the dam [e.g., for the North Dam, the maximum head is approximately 7.4 m; therefore, the width of the critical section of the core at its thickest section must be at least 14.8 m]; and
- the critical section in the marine clay/silt layer must extend to the base of this layer and have a minimum width equal to the critical section of the core (e.g., it must be at least 14.8 m wide at the thickest section of the North Dam).

4.4 ANALYSES METHODOLOGY

Thermal analyses were carried out for dam cross sections near the deepest sections for each of the North and South Dam alignments. The generalized foundation profiles at each dam alignment were simplified from those used in the respective thermal model calibrations. The selected soil profiles are considered the worst foundation conditions along each proposed dam alignment from a creep-deformation perspective.

Thermal analyses were carried out to model every step from dam construction through subsequent pond impoundment. It was assumed that both the North and South Dams would be constructed the same season. The thermal analyses conservatively assumed that the water level in Tail Lake will be at Elevations 31.0 m and 33.5 m by the first and second freshets (assumed to be June 1), respectively, following construction of the dam. It was also assumed that the water level would remain at full impoundment (Elevation 33.5 m) level over the remainder of its 25-year design life.

It is understood that the South Dam could be constructed at a later date than the North Dam. This fact is not expected to influence dam design since the dam configuration is governed more by long-term creep deformation than by the thermal influence of water impoundment against the dam. Furthermore, the modeled rate and level of impoundment are very conservative, based on SRK's water balance evaluation (SRK, 2005).

Figure 1 shows that air temperatures from the closest long-term meteorological stations to the Doris North project site have increased at an average rate of approximately 0.5°C per decade since 1959. Varying degrees of warming have also been observed on a national and global scale over this same period. Therefore, the Doris North dams have been designed assuming global warming over their 25-year design life as the normal environmental condition. The effects of two consecutive extreme warm years immediately following dam construction have also been evaluated as an upset condition.

4.5 INPUT PARAMETERS

4.5.1 Climate Parameters

4.5.1.1 Global Warming

According to the International Panel on Climate Change (IPCC), a working group jointly-established by the World Meteorological Organization (WMO) and the United Nations Environment Program (UNEP) to assess scientific information on climate change, the observed recent global warming is attributed to increasing concentration of greenhouse gases.

General Circulation Models (GCMs) are mathematical representations of the global climate system that are used to explore the effects on climate behaviour of changes in the composition of the atmosphere, and specifically, human-induced changes. GCMs are highly complex and include global representations of the atmosphere, oceans, and land surface. The globe is modelled on a grid with grid sizes ranging from 41,000 km^2 to 168,000 km^2, depending on the GCM.

The IPCC's working groups use several GCMs but there are five models that are highly regarded and well-reported:

- CGCM2 – Canadian Centre for Climate Modelling and Analysis – Canada;
- ECHAM – Max-Planck Institute of Meteorology – Germany;
- GFDL-R30 – Geophysical Fluid Dynamics Laboratory – United States; and
- HadCM3 – Hadley Centre for Climate Prediction and Research – United Kingdom.

The magnitude of climate change projected by GCMs depends on the amount of change in concentration of atmospheric gases, which depends, in turn, on the emissions of radiatively-active gases into the atmosphere, from both natural and anthropogenic sources. The IPCC has developed emission scenarios based on assumptions of "storylines" of the global socio-economic conditions. These are known as the SRES emissions scenarios after the IPCC's Special Report on Emissions Scenarios (IPCC, 2000). The SRES scenarios are divided into four main "families": A1, A2, B1 and B2. The A1 and A2 families have a more economic focus than the B1 and B2 families, which are more environmentally based. The A1 and B1 families are based on storylines that assume a high degree of global coordination and uniformity, whereas A2 and B2 maintain considerable regional diversity.

GCM output for Canada is available from the Canadian Institute for Climate Studies' Canadian Climate Impacts Scenarios (CCIS) Project website: http://www.cics.uvic.ca/scenarios. The CCIS web site provides GCM output for a baseline period (1961-1990) and three future intervals (2019-2039; 2040-2069; and 2070-2099). Different GCMs and SRES scenarios result in various temperature projections, with some GCM output predicting greater temperature changes during certain seasons (e.g., during the winter) than others.

For the grid cell encompassing the Doris North site, seasonal air temperature changes from a total of 20 GCM output, derived mainly from the A2 and B2 families, were obtained for the future interval 2019-2039. These values are considered equivalent to the change in temperature over a 30-year period. According to these models, annual air temperatures at Doris North are predicted to rise by between 1.3°C and 2.5°C (median value of 1.9°C) over a 30-year period. Seasonal changes in temperature over a thirty-year period corresponding to the median GCM output are estimated to be 1.9°C (December to February), 2.1°C (March to May), 1.7°C (June to August), and 2.3°C (September to November). The median annual projection (approximately 0.6°C per decade) is greater than the observed historical trends (0.5°C per decade) in the area and is thus considered conservative for long-term thermal design of the Doris North dams.

4.5.1.2 Extreme Warm Year

There is insufficient historical air temperature data at the Doris North site to carry out a probabilistic analysis of site air temperatures. Therefore, for design purposes, the monthly air temperatures at Doris North from 1998, the warmest year on record at the Kugluktuk, Cambridge Bay and Lupin stations, were estimated from the latter stations and taken to represent the design warm-year air temperatures.

4.5.1.3 Design Climatic Conditions

Assuming that air temperatures have been linearly increasing since 1971, the mean monthly air temperatures listed in Table 1 correspond to the mid-point of the 1971-2000 period, or year 1986. Future air temperatures at Doris North were projected by increasing the mean (1986) monthly air temperatures by the corresponding rate of seasonal temperature change multiplied by the number of years since 1986. For example, the December to February monthly air temperatures are predicted to rise at a rate of 1.9°C over thirty years. December 2007 monthly air temperatures were estimated by adding the rate of seasonal temperature change (1.9°C/30 years) multiplied by the number of years since 1986 (2007 – 1986 = 21 years) to the mean (1986) monthly air temperature listed in Table 1. The design monthly air temperatures used in the thermal analyses are listed in Table 6. The other climate parameters (wind speed, snow cover and solar radiation) were assumed to be the same as the mean conditions listed in Table 1.

TABLE 6: DESIGN AIR TEMPERATURES USED IN THERMAL ANALYSES

	Global Warming		Warm-Year
	2007	2032	
January	-29.1	-27.5	-31.4
February	-28.4	-26.8	-28.5
March	-25.2	-23.4	-23.5
April	-16.6	-14.9	-15.3
May	-5.2	-3.5	-3.9
June	6.0	7.4	6.3
July	11.5	12.9	13.5
August	9.3	10.7	10.2
September	3.1	5.0	3.3
October	-7.5	-5.5	-6.2
November	-19.5	-17.6	-15.3
December	-26.0	-24.4	-14.3
Mean Annual	-10.6	-9.0	-8.8

4.5.2 Soil Profile and Properties

The design foundation soil profile and parameters are listed in Table 7. The physical properties of the embankment materials were based on past experience with similar materials. The profile and physical properties of the foundation materials were simplified from the soil layers used in the thermal model calibration analyses for each dam alignment.

TABLE 7: PHYSICAL PROPERTIES USED IN DAM THERMAL ANALYSES					
Material	Depth Interval (m)	Water Content (% dry weight)	Bulk Density (Mg/m³)	Pore Water Salinity (ppt)	Freezing Point Depression (°C)
Dam Rockfill					
20 mm Core	–	11	2.28	0	0.0
Saturated 200 mm Transition	–	10	2.31	0	0.0
Unsaturated 200 mm Transition	–	4	2.18	0	0.0
Saturated Shell	–	13	2.37	0	0.0
Unsaturated Shell	–	3	2.16	0	0.0
Native Foundation Materials (North Dam 2-D)					
Silt and Clay	0.0 –13.0	45	1.77	50	-2.9
Basalt Bedrock	13.0 – 75.0	1	2.63	1	0
Native Foundation Materials (South Dam 2-D)					
Silt	0.0 – 11.0	45	1.71	40	-2.3
Clay	11.0 – 23.0	50	1.65	45	-2.6
Gravel	23.0 – 30.0	18	2.11	5	-0.3
Basalt Bedrock	30.0 – 75.0	1	2.63	0	0.0

Table 8 lists the thermal properties used in the thermal analyses. These values were determined directly from well-established correlations with soil index properties (Farouki, 1986 ; Johnston, 1981).

TABLE 8: THERMAL PROPERTIES USED IN DAM THERMAL ANALYSES					
Material	Thermal Conductivity (W/m°C)		Specific Heat (kJ/kg°C)		Latent Heat(MJ/m³)
	Frozen	Unfrozen	Frozen	Unfrozen	
Dam Rockfill					
20 mm Core	2.64	1.97	0.87	1.07	75
Saturated 200 mm Transition	2.70	2.05	0.86	1.05	70
Unsaturated 200 mm Transition	1.72	1.77	0.79	0.87	28
Saturated Shell	2.80	10.00/2.06[a]	0.89	1.13	91
Unsaturated Shell	1.56	1.68	0.77	0.83	21
Native Foundation Materials (North Dam)					
Silt and Clay	1.92	1.35	1.21	1.80	167
Basalt Bedrock	2.20	2.20	0.75	0.77	9
Native Foundation Materials (South Dam)					
Silt	2.34	1.09	1.17	1.80	174
Clay	2.27	1.01	1.30	2.03	193
Gravel	2.60	1.64	0.94	1.26	108
Basalt Bedrock	2.20	2.20	0.75	0.77	9

Note: (a) The thermal conductivity of the saturated shell was assumed to be 2.06 W/m-°C in the vertical direction and 10.0 W/m-°C in the horizontal direction. The larger horizontal thermal conductivity was used to account for potential heat transfer by convection through the open voids of the saturated shell material.

The unfrozen water content curves estimated for the permafrost foundation soils are shown on Figure 8. These curves compare well against the measured data reported by SRK (2005).

4.6 INITIAL CONDITIONS

It was assumed that construction of each dam would be carried out in the winter of 2007/08 and completed by April 2008.

Initial temperatures of the embankment and foundation were estimated based on monitoring records of similar dam height sections during construction of frozen core dams at EKATI, and from thermal calibration of measured ground temperatures from Boreholes SRK-51 and SRK-15 for the North Dam, and Borehole SRK-33 for the South Dam.

4.7 BOUNDARY CONDITIONS APPLIED IN THERMAL ANALYSES

Climatic conditions were applied at the surface of the dam and ground exposed to air. Mean snow cover was applied to the natural ground surface and over the slope face of the dam, except for the case of the downstream slope of the North Dam where, because of the relatively steep slope (4H:1V), snow drifting was assumed at the downstream toe. In this case, the snow cover was assumed to vary linearly from mean at a distance of 7 m on either side of the slope toe to three times the mean at the slope toe. Snow cover at the crest of both dams was reduced to 10 percent of the mean snow depth to account for wind-blown snow cover that is typical around topographic highs in the area.

Water from the initial impoundment will infiltrate the upstream dam shell as water rises against the dam. Prior to impoundment, the upstream shell and transition are generally frozen and unsaturated. It has been assumed that impounded water will seep through the shell and into the transition zone, thereby raising the temperature of the upstream shell and transition. Upon initial impoundment, the elements representing the saturated upstream shell and transition were assigned a temperature of 0.01°C.

There are limited published temperature measurements in northern lakes. Temperature data from two lakes, one located in northern Manitoba (P&N Lake) (Welch and Bergmann, 1986) and another located in the Mackenzie Delta, NT (Todd Lake) (Burn, 2002) are shown in Figure 9. Based on these two data sets, the temperature history of Tail Lake was estimated, as shown in Figure 9. The thermal influence of the water impounded against the dam was modeled as a temperature boundary for all nodal points along the dam slope and natural ground surface at and below the water level.

The thermosyphons were modelled as a convective boundary. The U.S. Army Cold Regions Research and Engineering Laboratory conducted laboratory tests of full-scale, two-phase thermosyphons to relate heat transfer to wind speed and evaporator slope angle (Haynes and Zarling, 1988). For a thermosyphon with a 6.5 m^2 radiator and a horizontal evaporator, heat transfer conductance, $\left[\frac{Q}{\Delta T}\right]_{6.5}$ (W/°C), is expressed by the following equation:

$$\left[\frac{Q}{\Delta T}\right]_{6.5} = 8.70 + 12.29 \cdot V_w^{0.83} \qquad [8]$$

where V_w is the wind velocity (m/s). The heat transfer conductance is a measure of the ability of a thermosyphon system to extract heat from the evaporator section and release it to the atmosphere. For different size radiators, Jardine et al. (1992) indicate that the heat transfer conductance, $\left[\frac{Q}{\Delta T}\right]_{area}$, can be determined by multiplying $\left[\frac{Q}{\Delta T}\right]_{6.5}$ by the ratio of the radiator area (m^2) to the reference radiator area (6.5 m^2).

The heat transfer coefficient, H_c (W/m^2), can then be computed from the following equation:

$$H_c = \frac{\left[\frac{Q}{\Delta T}\right]_{area}}{2\pi r \ell} \qquad [9]$$

where: r = evaporator pipe radius (m) and

ℓ = effective length of buried evaporator pipe (m).

Convective heat transfer, Q_h (W), is calculated by the following:

$$Q_h = H_c \cdot (T_s - T_a) \qquad [10]$$

where T_s is the temperature of soil around the thermosyphon evaporator and T_a is the ambient air temperature.

As a safety factor, thermosyphon heat transfer conductance was calculated assuming a low wind speed -- 13 km/h, or approximately two-thirds of the mean winter wind speed. The thermosyphons provide cooling only when ambient air temperatures are colder than the ground temperatures surrounding the evaporator pipes.

4.8 RESULTS OF THERMAL ANALYSES

4.8.1 North Dam

Figures 10 to 14 show the ground temperature distribution during the month of December in Years 1, 2, 5, 10 and 25, respectively following dam construction. December is the time of year when temperatures below the frozen core are warmest. The results show that upstream of the frozen core, the permafrost foundation is progressively getting warmer over the years in response to the continued warming influence of the lake impoundment. If we assume that the marine clay and silt layer fully thaws at -3°C, much of the marine clay and silt upstream of the core is predicted to thaw after 25 years of full impoundment. Downstream of the frozen core, the permafrost foundation is predicted to progressively warm due to the long-term effects of snow drifting and the modelled climate warming trend. The degree of permafrost warming below the downstream shell is not expected to be as great as below the upstream shell. Permafrost thaw will result in settlement as excess ground ice melts and dissipates under loading.

Beneath the frozen core, permafrost temperatures are predicted to progressively cool with time over the first ten years or so due to the thermal influence of the thermosyphons but then become warmer because of long-term climate warming. The results show that the frozen core is well frozen (temperatures mainly colder than -5°C), as is the permafrost foundation beneath the core (temperatures colder than -8°C).

An upset condition was evaluated by assuming extreme warm years for the first two years following initial impoundment. The short-term, extreme warm year has a greater influence on dam embankment temperatures (e.g., active layer penetration) than on the permafrost foundation temperatures, which are largely controlled by long-term temperature trends. Figure 15 shows the predicted early-October temperature distribution the year following initial impoundment. October is the time of year when temperatures near the top of the frozen core are warmest. Figure 15 shows that the frozen core is colder than -1°C. This indicates that the 2.5 m rockfill cover over the core crest provides sufficient thermal insulation to maintain the core perennially frozen even under extreme temperatures.

As a sensitivity evaluation, analyses were conducted assuming that there were no thermosyphons installed within the core. Figure 16 presents the predicted December temperatures ten years after construction, assuming the same climate warming scenario adopted for the earlier analyses with thermosyphons. The permafrost foundation beneath the core is predicted to warm to a temperature of between -7°C and -8°C. This compares to the base case (with thermosyphons) in Figure 13, where temperatures in the permafrost foundation beneath the core ten years after construction are predicted to be colder than -9°C.

4.8.2 South Dam

Figures 17 to 21 show the ground temperature distribution during the month of December in Years 1, 2, 5, 10 and 25, respectively following dam construction. The long-term geothermal response of the dam embankment and its permafrost foundation is similar to that described for the North Dam above. Permafrost foundation temperatures beneath the core are predicted to remain colder than -8°C over the 25-year design life.

Figure 22 shows the predicted early-October temperature distribution the year following initial impoundment for the upset condition of two extreme warm years following dam construction. As with the North Dam, the frozen core and permafrost foundation are predicted to be colder than -1°C and -8°C, respectively.

Figure 23 shows the predicted December temperature distribution ten years after dam construction, assuming no thermosyphons were installed within the core. The marine silt and clay layers are predicted to warm to between -7°C and -8°C, compared with temperatures colder than -8°C for the base case (with thermosyphons) shown in Figure 20.

4.8.3 Summary

The results of the thermal analyses demonstrate that the Doris North dams are predicted to maintain the "critical sections" of the frozen core and underlying marine clay and silt permafrost foundation sufficiently cold and over a wide enough section, even under reasonable worst-case upset conditions. Therefore, the Doris North dams satisfy the thermal design criteria described in Section 4.3. The results also show the need for thermosyphons to be included in dam design.

5.0 CREEP DEFORMATION EVALUATION

5.1 CREEP DEFORMATION ANALYSIS METHODOLOGY

Creep deformation analyses were carried out for the same dam section and foundation conditions used in the thermal evaluation. Two-dimensional plane-strain analyses were carried out using FLAC (Fast Lagrangian Analysis of Continua), a commercial, two-dimensional, explicit finite difference stress analysis program developed by HCItasca.

The results of the thermal analyses show that temperatures below and within the dam vary seasonally and from year-to-year in response to variations in surface temperature and thermosyphon cooling. At the base of the frozen core, temperatures are predicted to initially become colder with time because of thermosyphon cooling but then gradually warm over time in response to long-term climate warming. Accurate predictions of creep deformations require a coupled thermal-creep deformation model since the creep behaviour of frozen soils containing excess ground ice is strongly temperature-dependent. There is currently no available commercial software that can implement this efficiently. Long-term creep displacements were therefore estimated from the predicted ground temperature distribution ten years after dam construction (Figures 13 and 20 for the North and South Dams, respectively). The temperature-dependent creep parameters were applied to the model element based on the predicted temperatures. This time interval (ten years) was selected because it is considered the most representative for long-term creep deformation predictions. The procedure used in the analyses is as follows:

- Initialize stresses in the dam embankment and permafrost foundation by assuming elastic parameters and turning gravity on.
- Change the dam shell and transition materials to Mohr-Coulomb parameters and bring the model again to equilibrium.
- Change the frozen core and permafrost soils to creeping materials. Assign creep properties to the model elements based on the predicted ten-year ground temperature distribution.
- Set the model to allow for large-strain deformations (i.e., deforming grid) and compute stresses and deformations for a 25-year period.

Roller boundaries were assigned to the left and right ends of the grid, and a fixed boundary was assigned to the base of the grid.

EBA has found that the FLAC creep model reasonably predicts the observed deformations of the Alder Creek Valley, Alaska road embankment constructed on warm, freshwater permafrost soils (McHattie and Esch, 1988). As described in Section 3.2, there is no documented case history describing the long-term performance of an embankment constructed on a saline permafrost foundation such as that found at the Doris North site. However, pile load tests by Nixon (1988) and Biggar and Kong (2001) in areas of saline permafrost have shown that the power law creep model described in Section 3.1.3 also applies to pile creep behaviour in saline permafrost. Therefore, the viscoelastic power law model used in FLAC is considered a realistic method to predict creep deformations of the dam embankment.

5.2 CREEP DEFORMATION DESIGN CRITERIA

Strains will develop within the dam embankment and underlying permafrost foundation in response to long-term creep deformations. Failure strains in frozen soils decrease with warmer temperatures and lower strain rates (Andersland and Ladanyi, 2004). Bragg and Andersland (1982) conducted laboratory creep tests on frozen sand and observed that at low strain rates (i.e., less than 10^{-5} s^{-1}), the frozen sand deformed elastically in the early stages of deformation followed by an initial yield or rapid change in slope. Beyond the peak stress, the frozen sand deforms in a ductile fashion with no visible cracking or formation of shear planes at strains. Minimum axial strains of approximately 8 percent were required for the frozen sand to fail at these low strain rates. At high strain rates (i.e., greater than 4×10^{-5} s^{-1}), the frozen sand exhibits brittle failure. The frozen core is anticipated to behave similarly to a frozen sand.

Sego and Morgenstern (1983) conducted constant strain rate experiments on polycrystalline ice and observed that at low strain rates (i.e., less than 8.3×10^{-5} s^{-1}), the ice did not collapse in brittle failure or deform to tertiary creep to strains of up to 15 percent. These findings indicate that ice undergoes ductile deformation at low strain rates, even up to 15 percent strain.

Berggren (1983) conducted constant stress tests on Svea clay, a saline marine clay from Svalbard, Norway. Test results indicated that the frozen saline clay undergoes ductile deformation at low strain rates (less than 10^{-5} s^{-1}), even up to 20 to 30 percent strain.

Based on these observations, and using engineering judgment about the risk of brittle rupture, the Doris North dams have been designed to maintain the long-term integrity of the frozen core and permafrost foundation by limiting the long term shear strains in these two areas to less than 2 and 10 percent, respectively. Localized zones of collapse or cracking away from the frozen core are tolerated, as this should not jeopardize the overall stability of the embankment or the ability of the frozen core and permafrost foundation soils to retain water.

5.3 INPUT PARAMETERS

5.3.1 Elastic Parameters

The stress state in the dam and foundation must be generated prior to the onset of creep. An elastic stress-strain analysis was carried out to determine the initial stress state. The material properties used in the stress initialization are given in Table 9. The elastic properties of the dam shell and transition were based on mean values for unfrozen, compact sand and gravel (Bowles, 1982). The elastic moduli for the frozen core and permafrost foundation soils were estimated from empirical equations for freshwater frozen soils (Johnston, 1981) and applying engineering judgment to consider reduced stiffness in saline frozen soils because of unfrozen water content. The values for Poisson's ratio were based on typical mean values for the materials considered (Bowles, 1982, Johnston, 1981).

The initial stress conditions were generated by virtue of a total stress analysis with no water impoundment.

TABLE 9: PHYSICAL PROPERTIES USED TO INITIALIZE STRESSES			
Material	Elastic Modulus (kPa)	Poisson's Ratio ν	Unit Weight (kN/m^3)
Bedrock	1.0×10^8	0.25	26
Shell	1.2×10^5	0.25	22
20 mm Core	1.0×10^5	0.35	22
200 mm Transition	1.0×10^5	0.30	21
North Dam			
Silt and Clay	5.0×10^4	0.35	17
South Dam			
Silt	5.0×10^4	0.35	17
Clay	5.0×10^4	0.35	17
Gravel	1.0×10^5	0.35	22

5.3.2 Shear Strength Parameters

The dam embankment materials were changed from elastic to Mohr-Coulomb materials after the stresses were initialized. The shear strength parameters are listed in Table 10. The shear strength parameters for the dam shell and transition were estimated based on engineering judgment and are believed to be conservative for these materials. The shear strength of the thawed marine clay/silt was based on published values for a similar saline marine clay, Svea Clay (Berggren, 1983), as described in Section 3.1.3

TABLE 10: SHEAR STRENGTH PROPERTIES USED IN THE DEFORMATION ANALYSES		
Material	Cohesion (kPa)	Angle of Internal Friction (°)
Bedrock	1000	-
Shell	-	40
200 mm Transition	-	35
Thawed Marine Clay/Silt	40	-

5.3.3 Creep Parameters

The frozen core can be considered to behave like saturated, frozen sand. Creep properties for the frozen core were based on those for Ottawa Sand (Sayles, 1968).

The marine silt and clay behaves like saline frozen soil. Figure 4 shows the estimated temperature-dependent B parameter curve, extrapolated from published data for freshwater and saline frozen soils by McRoberts (1988) and Nixon and Lem (1984), respectively.

Table 11 summarizes the temperature-dependent creep properties used in the deformation analyses. The temperature-dependent elastic modulus for the marine clay/silt was estimated

Generally, creep deformation is considered to be a non-volume change phenomenon (i.e., Poisson's ration = 0.5).

TABLE 11: CREEP PROPERTIES USED IN DEFORMATION ANALYSES

Material	n	b	B (kPa^{-n} x yr^{-b})	Elastic Modulus (kPa)
Marine Clay/Silt[(a)]				
Thawed (> -3°C)		-	-	5.0 x 10^{3}
-4°C	3	1	4.0 x 10^{-5}	3.0 x 10^{4}
-5°C	3	1	7.0 x 10^{-6}	6.0 x 10^{4}
-6°C	3	1	2.0 x 10^{-6}	9.0 x 10^{4}
-7°C	3	1	7.0 x 10^{-7}	2.0 x 10^{5}
-8°C	3	1	2.0 x 10^{-7}	5.0 x 10^{5}
-9°C	3	1	1.0 x 10^{-7}	8.0 x 10^{5}
20 mm Core[(b)]				
Above Key Trench (-3°C)	1.32	0.26	5.9 x 10^{-7}	1.0 x 10^{5}
Within Key Trench (-5°C)	1.32	0.26	3.2 x 10^{-7}	1.8 x 10^{5}

Source: (a) Extrapolated, as shown in Figure 4
(b) Sayles (1968)

5.4 DEFORMATION ANALYSES RESULTS

Figure 24 presents the predicted vertical settlement histories at the crest of the frozen core for both the North and South Dams. These have been calculated based solely on creep deformation and ignore displacements due to other mechanisms (e.g., thaw settlement, consolidation, and compression). Substantial settlement of the cores of both dams is predicted. In fact, the predicted rates of settlement are such that the crests of the cores will reach the minimum allowable elevation that satisfies freeboard requirements (El. 34.5 m) by approximately 8 to 10 years following dam construction.

It should be noted that the predicted creep deformations are considered very conservative. First, they are based on geothermal predictions of a pessimistic scenario that assumes that Tail Lake will reach full supply level (El. 33.5 m) within two years of dam construction and be maintained at that level for the 25-year design life. A more realistic water level scenario—one in which the water level is well below the full supply level—would result in colder permafrost foundation temperatures, especially at the South Dam, where the water level against the dam will likely be sufficiently low that the water would freeze to the bottom each winter and the foundation soils should remain in a permafrost condition. Secondly, they are based on the predicted ground thermal regime ten years following dam construction. While this approach may best-represent long-term conditions, this approach will over-predict the rate of creep deformations for the first few years or so following dam construction.

The design approach adopted for establishing the minimum freeboard requirements of the Doris North dams has been to initially over-build the crest of the frozen core to accommodate some, but not all, of the predicted settlement over the 25-year design life. This approach is taken in part because the predicted dam deformations are believed to be conservative, and because additional embankment loading associated with raising the height of the dam to satisfy minimum freeboard requirements over the entire 25-year design life would increase the rate of creep deformations. It is intended that the dams will be regularly surveyed following construction. The predicted movements will be slow to develop; therefore, monitoring will provide additional assurance of satisfactory performance. In the unlikely event that movements are greater than predicted, the dam slopes could be flattened, berms constructed, or the foundation could be cooled with additional thermosyphons.

For the reasons described above, the results presented below are for the elapsed time of ten years after dam construction. The creep deformation analyses did not consider any future dam reconstruction activities, such as redistributing rockfill, that would affect the predicted rate or magnitude of deformations.

5.4.1 North Dam

Figures 25 and 26 show the predicted horizontal and vertical displacements, respectively, ten years after construction of the North Dam. The results show that the predicted deformations are largely away from the frozen core. Because the saline permafrost soils are warmer upstream and downstream of the frozen core, embankment loading causes the permafrost foundation soils beneath the core to "squeeze" laterally, causing the core to settle. Greater displacements are predicted upstream of the frozen core because of the predicted warmer foundation temperatures. The core itself is expected to behave rigidly.

Figures 27 and 28 show the predicted maximum shear strain and maximum shear strain rate, respectively, ten years after construction. Figure 27 shows that the most likely mechanisms of slope failure are deep-seated, rotational slips located upstream and downstream of the frozen core. Furthermore, the maximum shear strains within the frozen core and permafrost foundation beneath the core are predicted to be less than 2 percent and 10 percent, respectively. Figure 28 shows that the maximum shear strain rates within and beneath the frozen core are predicted to be less than $0.2 \times 10^{-6}\ yr^{-1}$ or $6.3 \times 10^{-14}\ s^{-1}$. At the given strains and strain rate, the frozen core and permafrost foundation are expected to remain ductile and brittle rupture is not expected.

Figure 29 shows the predicted shear stress distribution ten years after construction. The shear stresses are predicted to be generally less than 20 kPa. The strengths of the frozen core and underlying permafrost foundation soils are expected to well exceed these stress levels.

5.4.2 South Dam

Figures 30 and 31 show the predicted horizontal and vertical displacements, respectively, ten years after construction of the South Dam. Deformation trends at the South Dam are similar to those at the North Dam. Although the dam is thinner and is designed to retain a lower head of water than the North Dam, even greater creep deformations are predicted at the South Dam because the creep-susceptible marine clay and silt foundation is much thicker at this dam alignment than it is at the North Dam alignment.

Figures 32 and 33 show the predicted maximum shear strain and maximum shear strain rate, respectively, ten years after construction. Figure 32 shows that the most likely mechanism of slope failure is a deep-seated rotational slip surface upstream of the frozen core. The maximum shear strains developing within the frozen core and underlying permafrost foundation are predicted to be less than 1 percent and 8 percent, respectively. Furthermore, the maximum shear strain rate is predicted to be less than 1.5 x 10^{-5} yr^{-1} or 4.8 x 10^{-13} s^{-1}. At these strains and strain rates, the frozen core and underlying permafrost foundation are expected to remain ductile and brittle rupture is not expected.

Figure 34 shows the predicted shear stress distribution ten years after construction. The shear stresses are predicted to be generally less than 30 kPa. The strength of the frozen core and underlying permafrost foundation are expected to exceed these stress levels.

5.4.3 Discussion

The results of the creep deformation analyses indicate relatively high movement and strains in the foundation upstream and downstream of the frozen core, and relatively small movements and strains in the dam core and underlying foundation soils.

The strains are predicted to occur very slowly and in a ductile manner. The monitoring program will identify long term displacement and potential stability concerns in time to allow mitigating measures to be undertaken. With these safeguards in place, acceptable dam performance is anticipated.

6.0 STABILITY EVALUATION

6.1 ANALYSIS METHODOLOGY

Limit equilibrium analyses were conducted to determine the factor of safety against slope failure during construction and operation of the dam. All analyses were conducted using the commercially available two-dimensional, limit equilibrium software, SLOPE/W, developed by Geo-Slope International Ltd. The principles underlying the method of limit equilibrium analyses of slope stability are as follows (Morgenstern and Sangrey, 1978):

- A slip mechanism is postulated;
- The shear resistance required to equilibrate the assumed slip mechanism is calculated by means of statics;
- The calculated shear resistance required for equilibrium is compared with the available shear strength in terms of factor of safety; and

- The slip mechanism with the lowest factor of safety is determined through iteration.

Factor of safety is used to account for the uncertainty and variability in the strength and pore water pressure parameters, and to limit deformations.

Earthquake loading was modelled using a pseudo-static peak horizontal ground acceleration. According to SRK (2005), an earthquake with a 2,475 year return period coincides with a peak ground acceleration of 0.06 g; this value was used in the pseudo-static assessment.

Stability analyses were carried out for the dam sections near its maximum thickness. The same dam geometry and soil profile used in the thermal and creep deformation analyses were used in the stability evaluation. Analyses were carried out for two cases: one assuming full impoundment (i.e., water level = 33.5 m), and another assuming no water against the dam. A deep-seated slip surface and failure along the GCL liner were evaluated.

6.2 DESIGN CRITERIA

The slopes of the Doris North Dams were designed so that the dam, foundation and abutments are stable under all stages of construction, reservoir levels, and operating conditions, in accordance with the Dam Safety Guidelines (CDA, 1999). The minimum acceptable factors of safety specified in the Dam Safety Guidelines are 1.5 under static loading conditions and 1.1 under earthquake loading conditions.

6.3 MATERIAL PROPERTIES

The material properties chosen for the embankment and foundation materials in the stability analyses are presented in Table 12.

TABLE 12: MATERIAL PROPERTIES USED IN STABILITY ANALYSES

Material	Angle of Internal Friction (°)	Cohesion (kPa)	Unit Weight (kN/m^3)
Run-of-Quarry (shell)	40	--	20
200 mm Material (transition)	35	--	21
20 mm Material (core)	32	--	21
GCL	15	--	18
Marine Silt/Clay (Undrained)	--	40	17

Derivation of the shear strengths of the shell, transition, and marine silt/clay was previously described in Section 5.3.2.

The long-term strength of the frozen core (20 mm material) was represented by conventional effective stress strength parameters, based on studies by McRoberts and Morgenstern (1974), which showed that the long-term strength of ice-poor soil was frictional.

The friction angle for the GCL (15°) was determined from published residual shear strengths of reinforced GCL as measured in the laboratory (Gilbert et al., 1996; Richardson, 1997).

6.4 RESULTS OF STABILITY ANALYSES

Table 13 summarizes the computed minimum factors of safety for static and earthquake loading conditions. Minimum factors of safety were determined from cases where there was no water impounded against the dam. This is because in total stress analyses, the weight of the water acts as a resisting load against slope failures beneath the upstream slope.

TABLE 13: SUMMARY OF STABILITY ANALYSES RESULTS

Loading Condition	North Dam		South Dam	
	Upstream	**Downstream**	**Upstream**	**Downstream**
Static	1.6	1.5	1.7	1.7
Earthquake	1.1	1.1	1.1	1.1

The minimum factors of safety listed in Table 13 are for deep-seated, circular slip failures from the opposite slope (e.g., from the downstream dam slope for the upstream slip surface), through the marine silt/clay layer and daylighting beyond the slope toe. The calculated factors of safety satisfy dam safety requirements.

6.5 LIQUEFACTION POTENTIAL

The peak horizontal ground acceleration for the area is very low at 0.06 g and, as a consequence, liquefaction of the thawed marine silt and clay due to earthquake loading is not expected to be a concern.

7.0 EMBANKMENT SETTLEMENT EVALUATION

Thaw settlements were estimated based on the predicted thaw penetration into the typical cross section described in the thermal evaluation (Section 4). Large portions of the North and South Dams are founded on thick layers of frozen saline, fine-grained soils. In the extreme condition where the dams continuously retain water at its maximum operating level over a 25-year period, up to 6 m of the frozen saline fine-grained soils is predicted to thaw below the upstream shell; however, below the core, the permafrost is predicted to remain well-frozen. Assuming that the permafrost contains approximately 20 to 40 percent excess ground ice, thaw strains of up to 20 to 40 percent can be expected under the upstream shell and toe. Thaw settlements are not expected to affect the integrity of the frozen core.

Total deformations are predicted to occur due to permafrost creep and thaw and, to a lesser extent, consolidation of the marine clay and silt foundation soils. Given the variability in soil conditions along each dam alignment, there is a high potential for differential movements across the dam embankment. This is particularly true at the North Dam, where most of the dam is sited on non-saline, ice-poor frozen sand and displacements are expected to be relatively small, compared to the remaining portion of the dam, which is sited on saline clays and silts, over which relatively large displacements are predicted.

The predicted deformations are considered conservative and are expected to develop slowly. The dam monitoring data should be regularly reviewed to verify that the dams are behaving as predicted. Remediation measures, such as flattening slopes or installing thermosyphons, should be implemented should differential dam movements be seen to pose a risk of rupture of the frozen core and/or permafrost foundation.

8.0 CLOSURE

The information contained in this report is based on the best available data at the time of its preparation. Engineering judgment has been applied in developing the designs contained in this report.

This report has been prepared for the exclusive use of SRK and the owner, Miramar Hope Bay Limited, for the specific use at the Doris North site.

Respectfully submitted,
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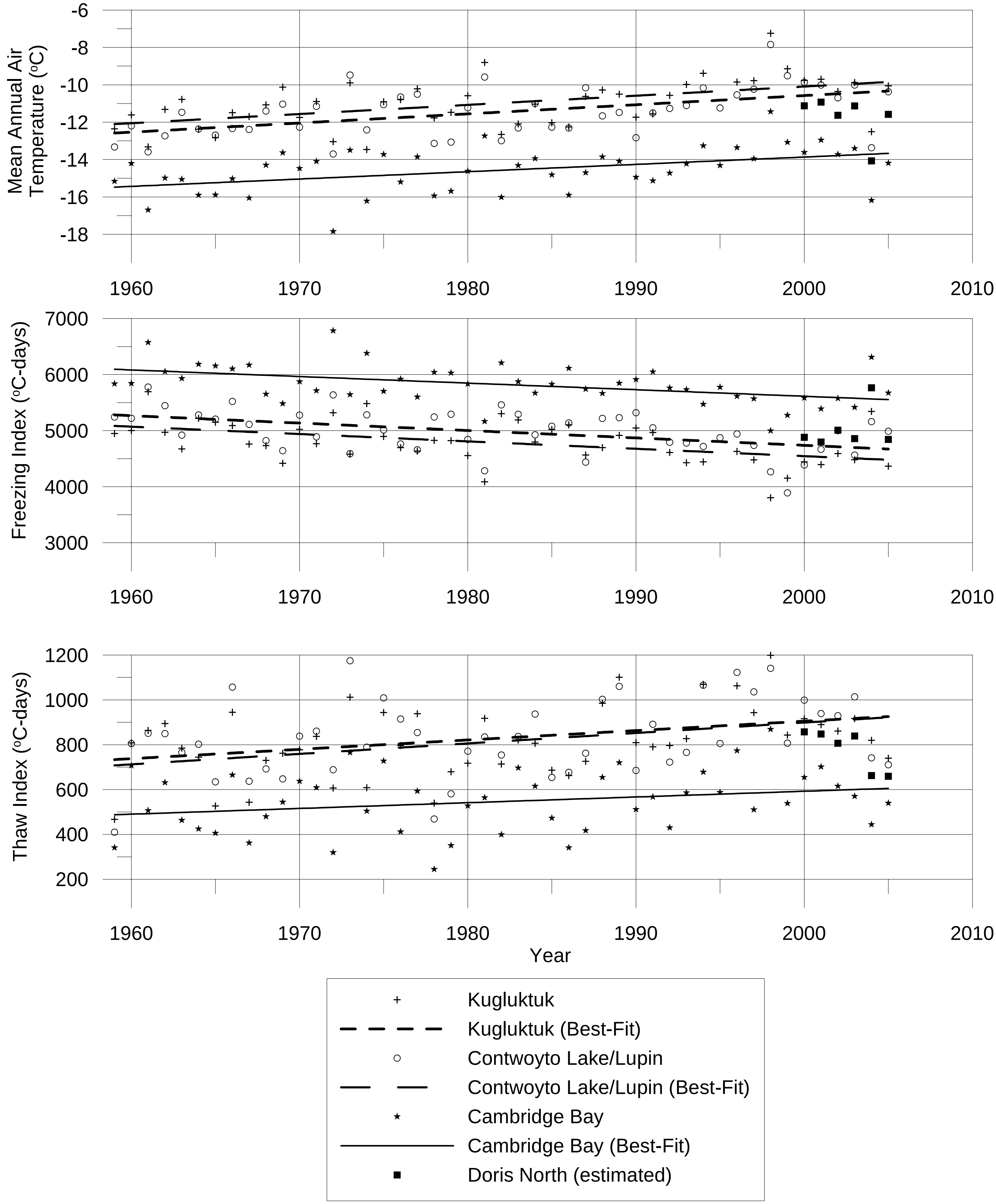
FIGURES

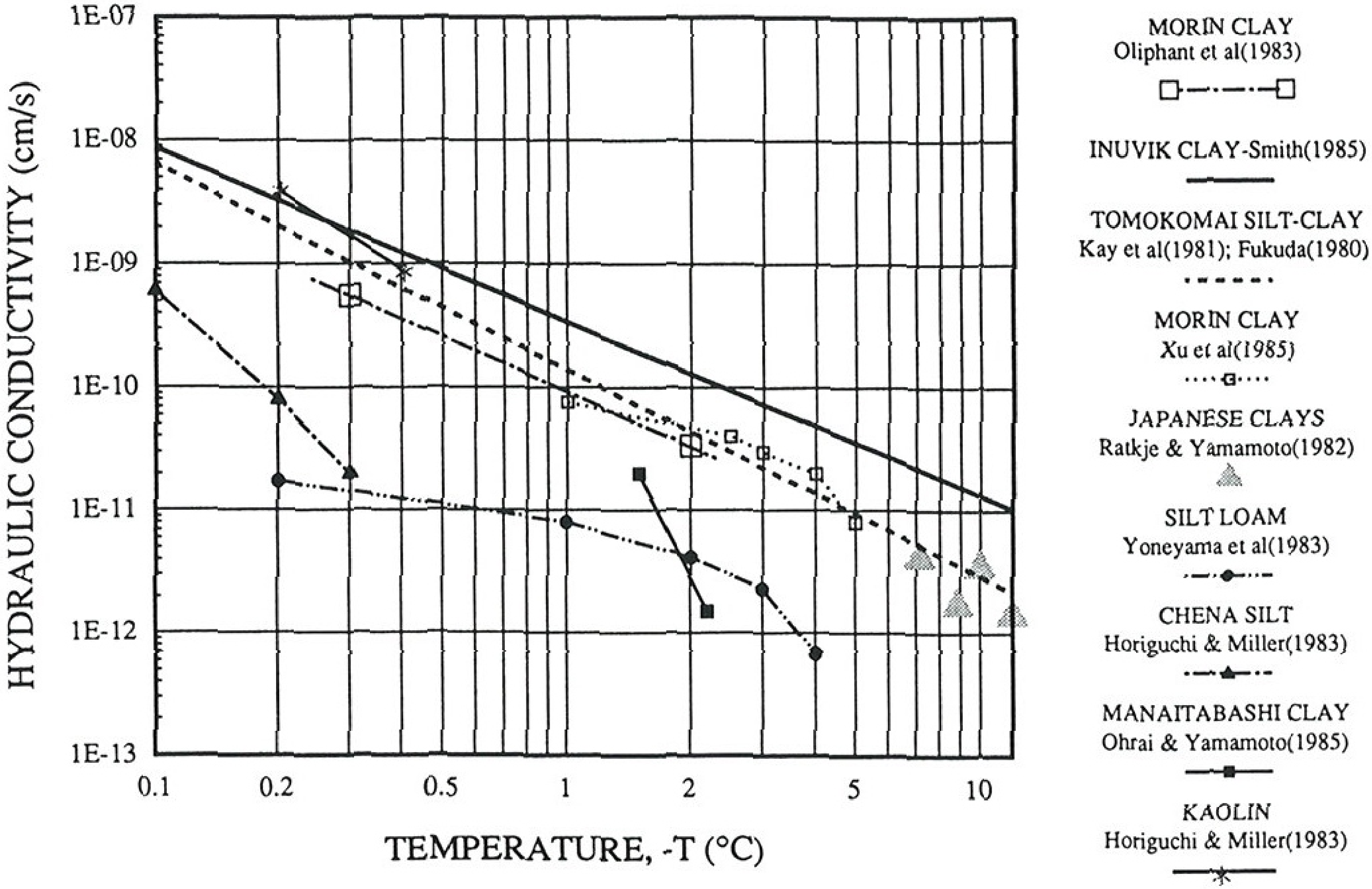


Notes:

1. Kugluktuk, Cambridge Bay, and Contwoyto Lake/Lupin data from Environment Canada's website.
2. Doris North air temperature estimated from above three meteorological stations.

EBA Engineering Consultants Ltd.	CLIENT SRK Consulting Engineers and Scientists	PROJECT	Thermal Design of Tailings Dams Doris North Project, NU
DWN. JTCS	CHKD. JTCS	TITLE	Historical Air Temperature Record for Kugluktuk, Cambridge Bay and Contwoyto Lake/Lupin (1959-2005)
EBA JOB NO. 1100126	FILE: 1100126_AirTemps.grf REVISION NO.:	DATE: September 2006	Figure 1

16:56 09/18/06



CLIENT

SRK Consulting
Engineers and Scientists

Thermal Design of Tailing Dams
Doris North Project, NU

Hydraulic Conductivity of Frozen Fine-Grained Soils (After Nixon, 1991)

EBA Engineering Consultants Ltd.

PROJECT NO./FILE NO.	DWN	CKD	REV
1100126 1100126J01.cdr	JLS	JS	1

OFFICE	DATE
EBA-EDM	September 1, 2006

Figure 2

NOTES

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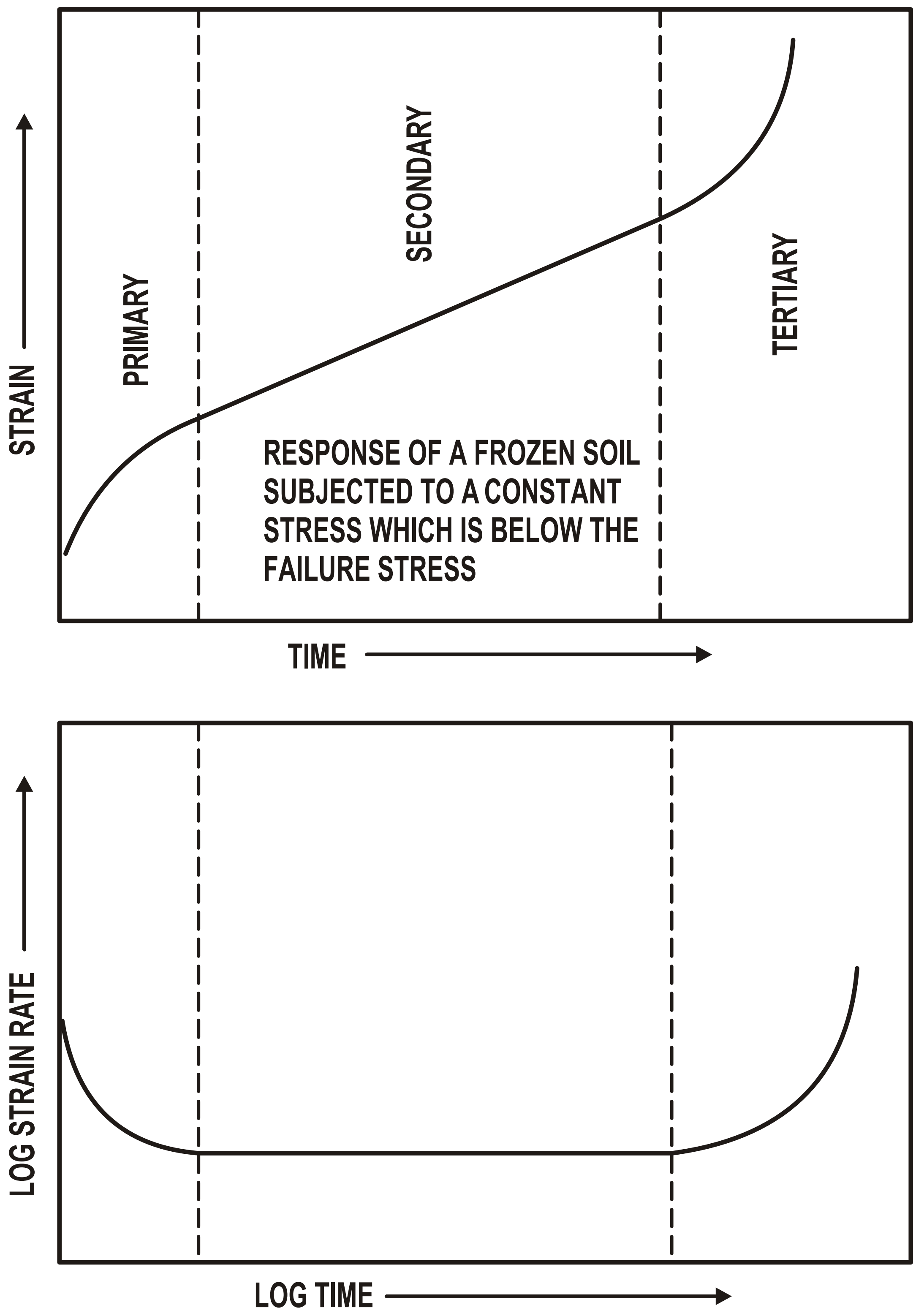

CLIENT

SRK Consulting
Engineers and Scientists

EBA Engineering Consultants Ltd.

Thermal Design of Tailings Dam
Doris North Project, NU

Typical Creep Curve for Frozen Soil

PROJECT NO./FILE NO.	DWN	CKD	REV
1100126 1100126Q01a.cdr	DBD	JTCS	1
OFFICE: EBA-EDM	DATE: September 12, 2006		

Figure 3

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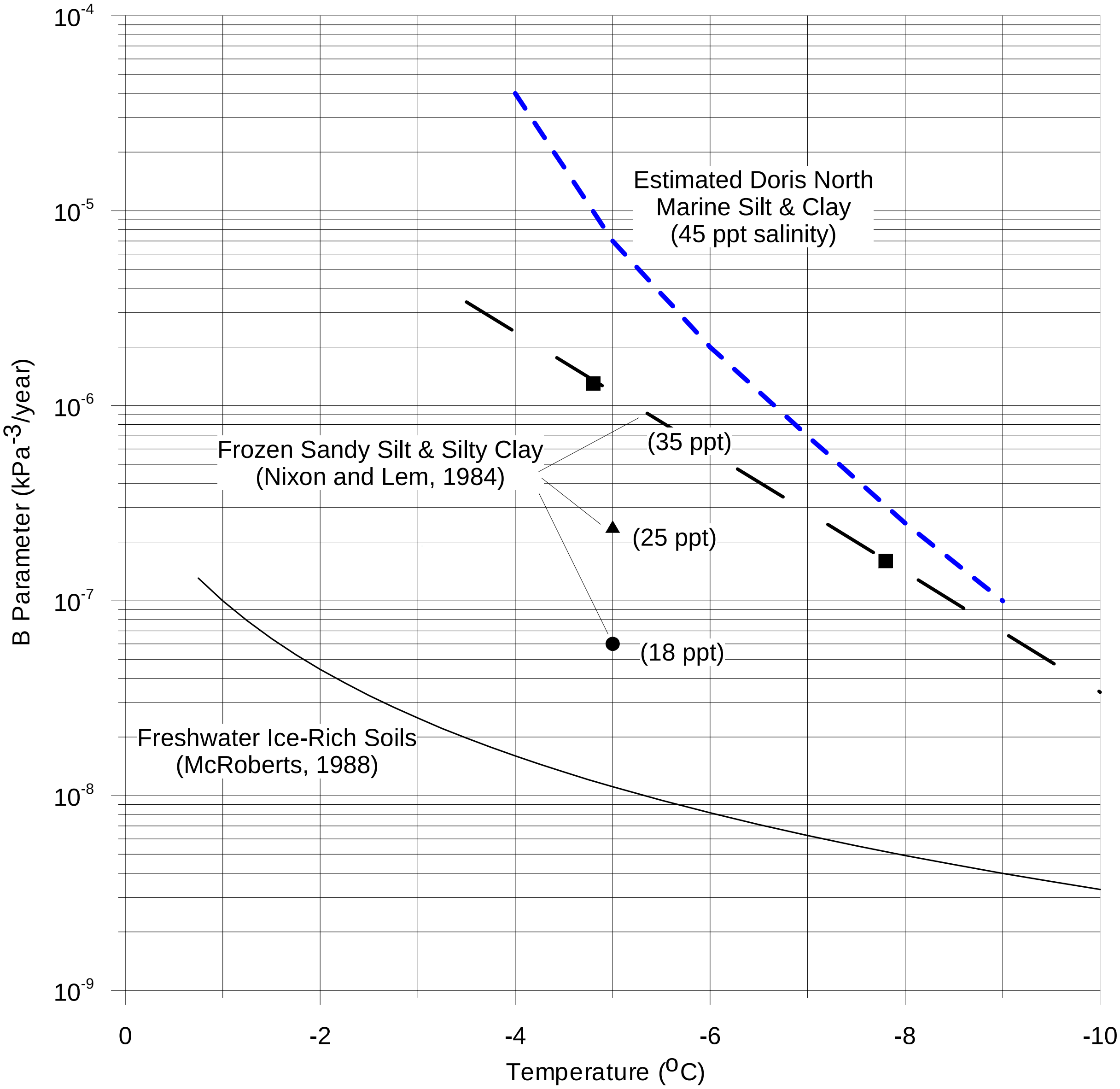
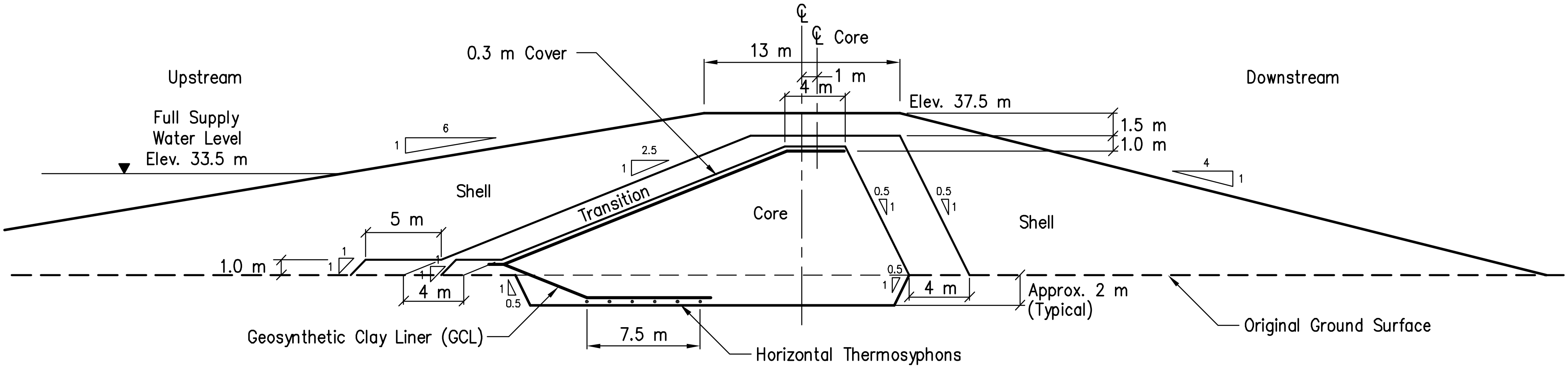


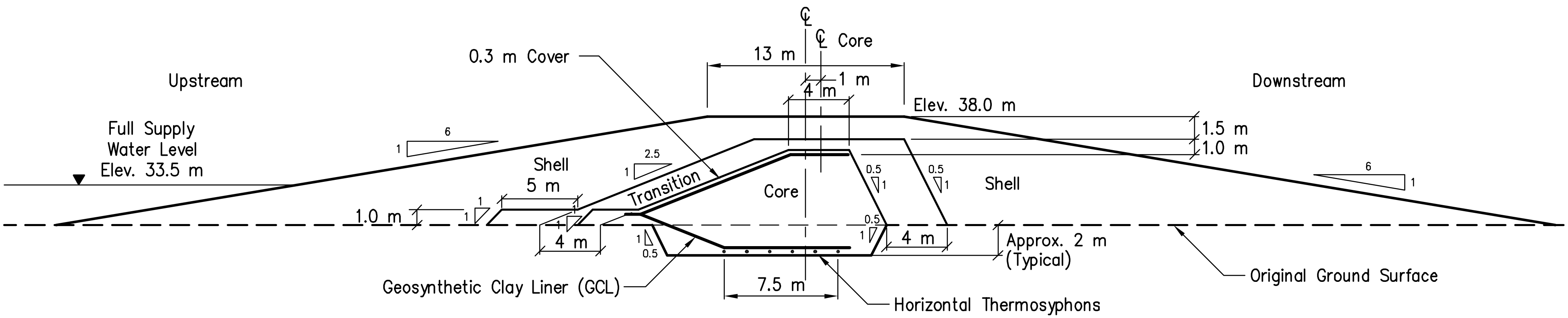
EBA Engineering Consultants Ltd.

DWN. JTCS	CHKD. JTCS	CLIENT: SRK Consulting, Engineers and Scientists	PROJECT	Thermal Design of Tailings Dams Doris North Project, NU
			TITLE	Relationship of the Creep Parameter B with Salinity and Temperature
EBA JOB NO. 1100126		FILE: 1100126_BCalc.grf	REVISION NO.:	DATE: September 2006 — Figure 4

16:52 09/18/06



NORTH DAM



SOUTH DAM

0 — 20

Scale: 1: 400 (metres)

CLIENT

SRK Consulting
Engineers and Scientists

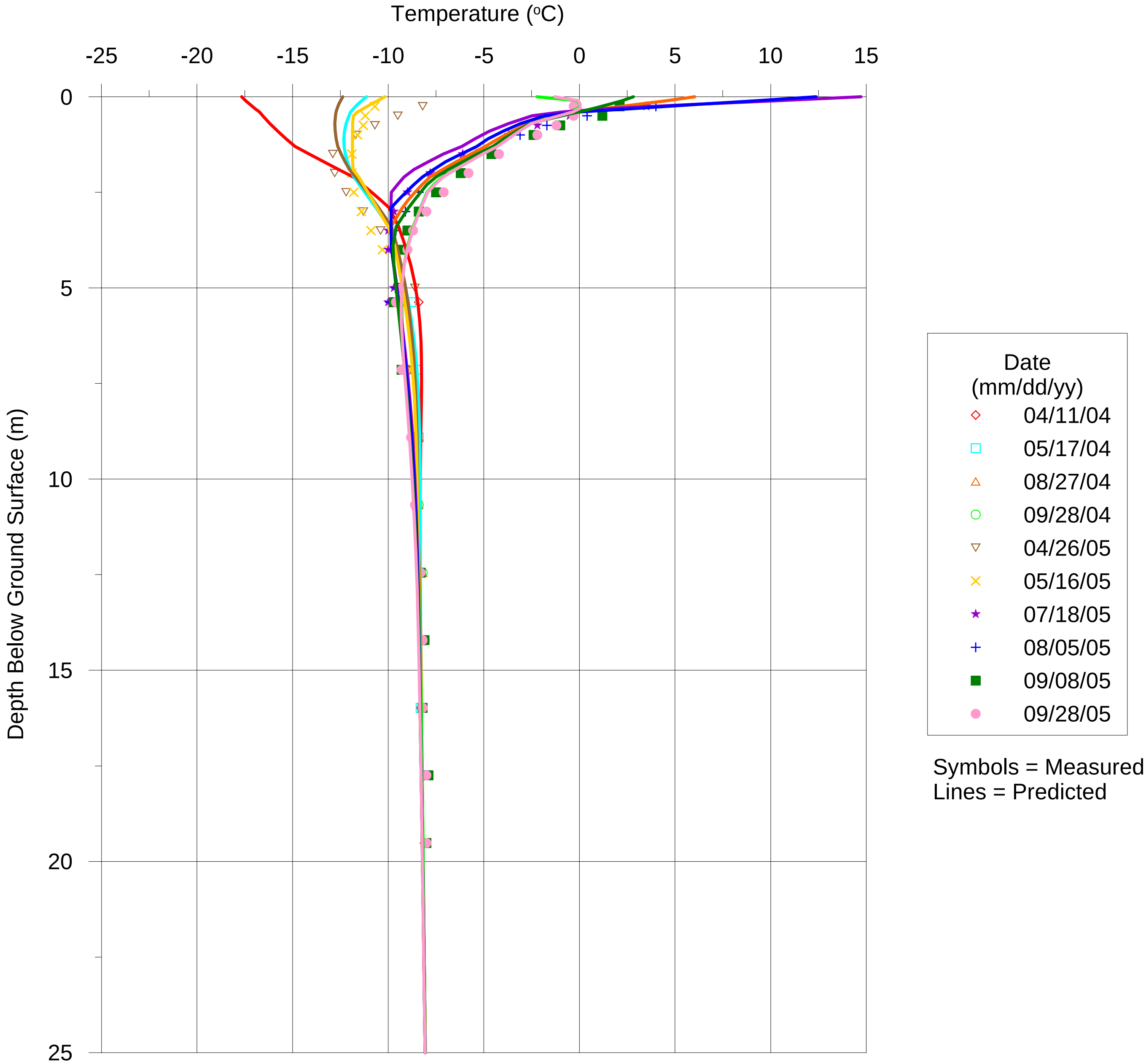
EBA Engineering Consultants Ltd.

THERMAL DESIGN OF TAILING DAMS
DORIS NORTH PROJECT, NU

GENERALIZED DAM CROSS-SECTIONS

PROJECT NO.	DWN	CKD	REV
1100126	BR	JTCS	0
OFFICE	DATE		
EBA-EDMONTON	July 27, 2006		

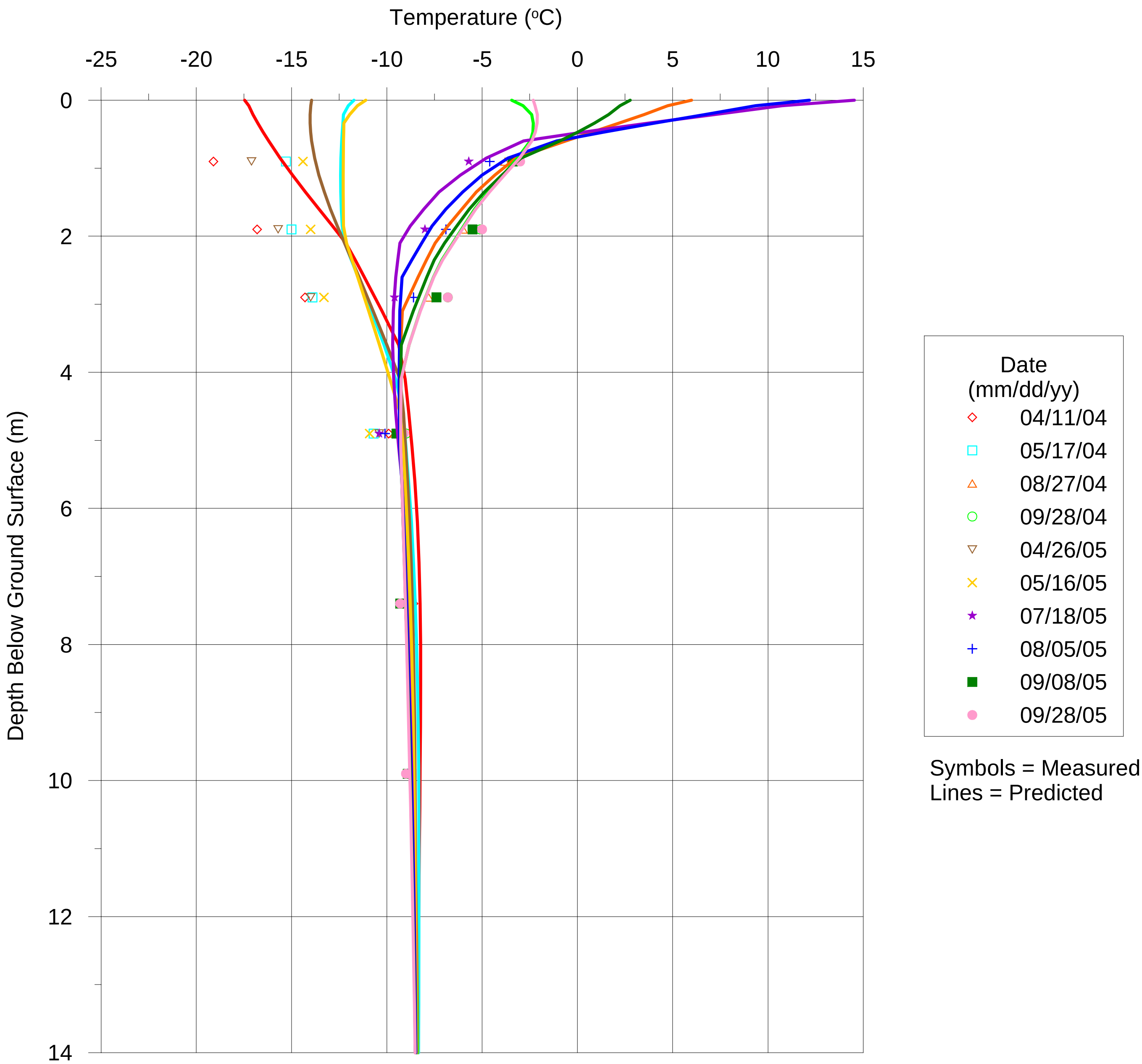
Figure 5



Note: Measured Temperatures: Top 5 m based on BH SRK-51, below 5 m based on BH SRK-15

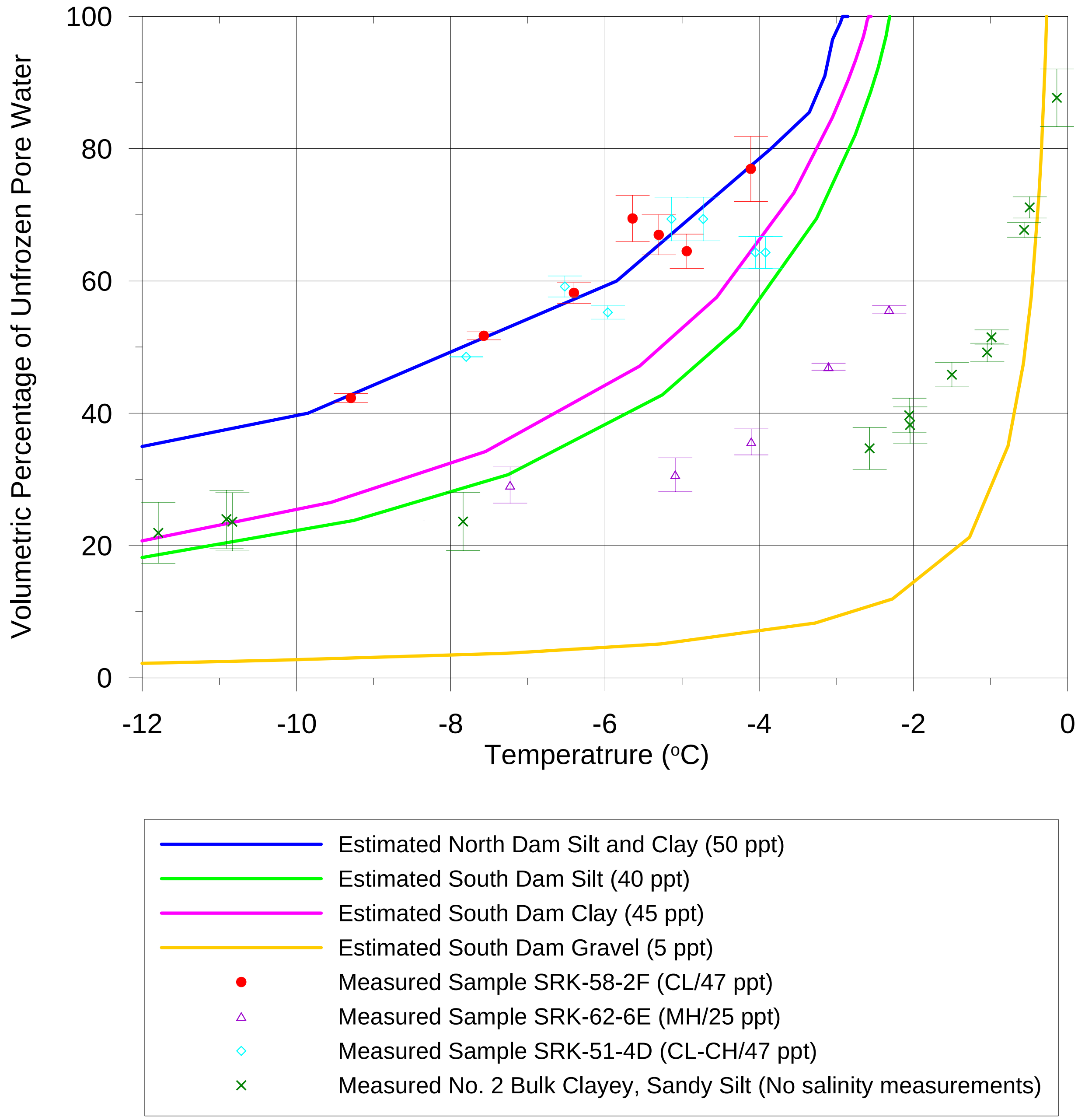
EBA Engineering Consultants Ltd.	CLIENT: SRK Consulting Engineers and Scientists	PROJECT: Thermal Design of Tailings Dams Doris North Project, NU	
DWN. JTCS / CHKD. JTCS		TITLE: Thermal Model Calibration, 2004/2005 North Dam Alignment, Boreholes SRK-15 & SRK-51	
EBA JOB NO. 1100126	FILE: 1100126_SRK15_Cal.grf / REVISION NO.:	DATE: September 2006	Figure 6

16:51 09/18/06



EBA Engineering Consultants Ltd.	CLIENT SRK Consulting Engineers and Scientists	PROJECT Thermal Design of Tailings Dams Doris North Project, NU
DWN. JTCS CHKD. JTCS		TITLE Thermal Model Calibration, 2004/2005 South Dam Alignment, Boreholes SRK-33
EBA JOB NO. 1100126	FILE: 1100126_SRK33_Cal.grf REVISION NO.:	DATE: September 2006 Figure 7

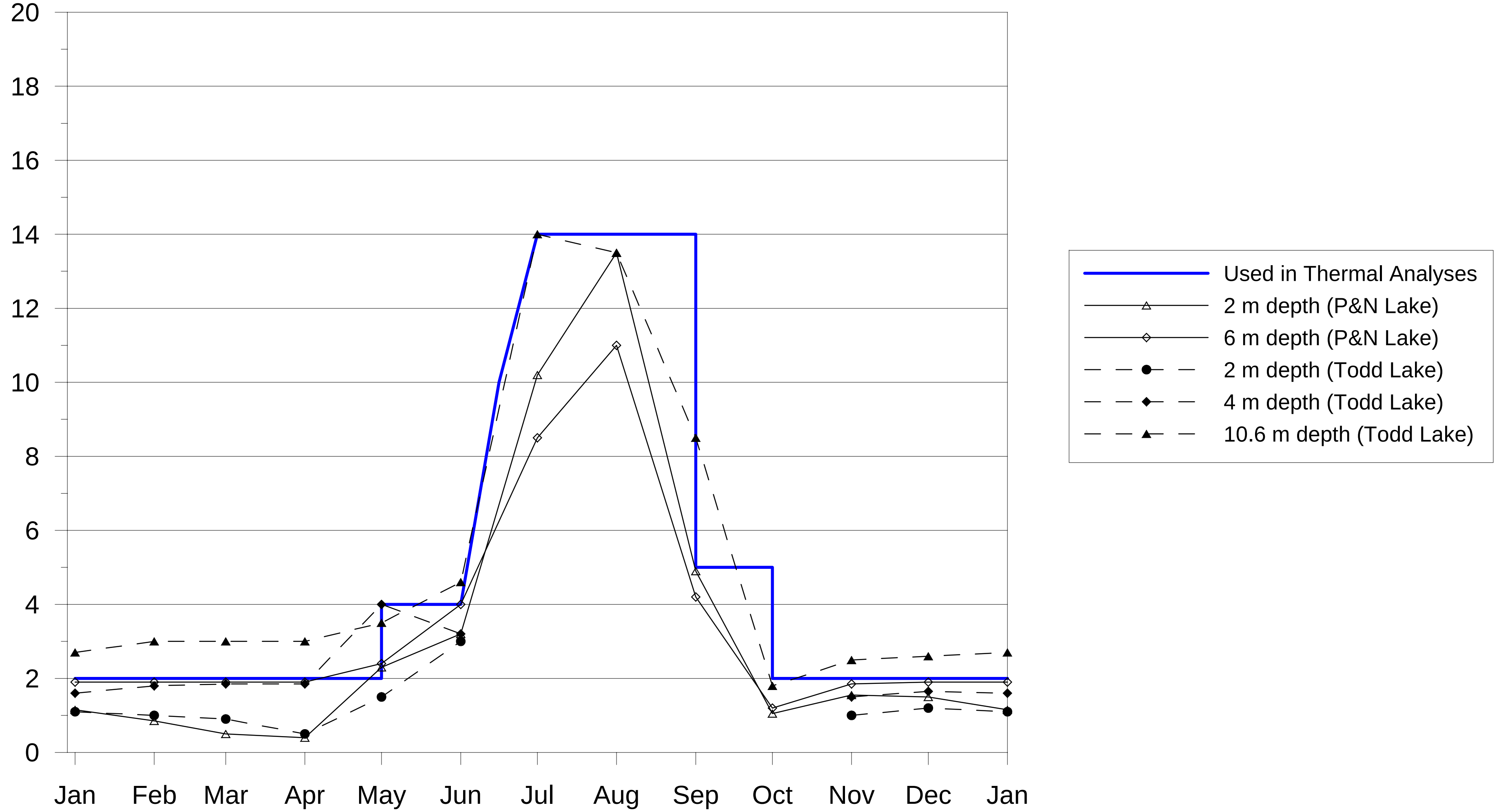
16:53 09/18/06



Note: Measured data reported in SRK's 2004 Summer and 2005 Winter Site Investigation reports.

EBA Engineering Consultants Ltd.	CLIENT SRK Consulting Engineers and Scientists	PROJECT Thermal Design of Tailings Dams Doris North Project, NU
DWN. JTCS / CHKD. JTCS		TITLE Unfrozen Water Content Curves Used in Dam Design Thermal Analyses
EBA JOB NO. 1100126	FILE: 1100126_UWC.grf / REVISION NO.:	DATE: September 2006 / Figure 8

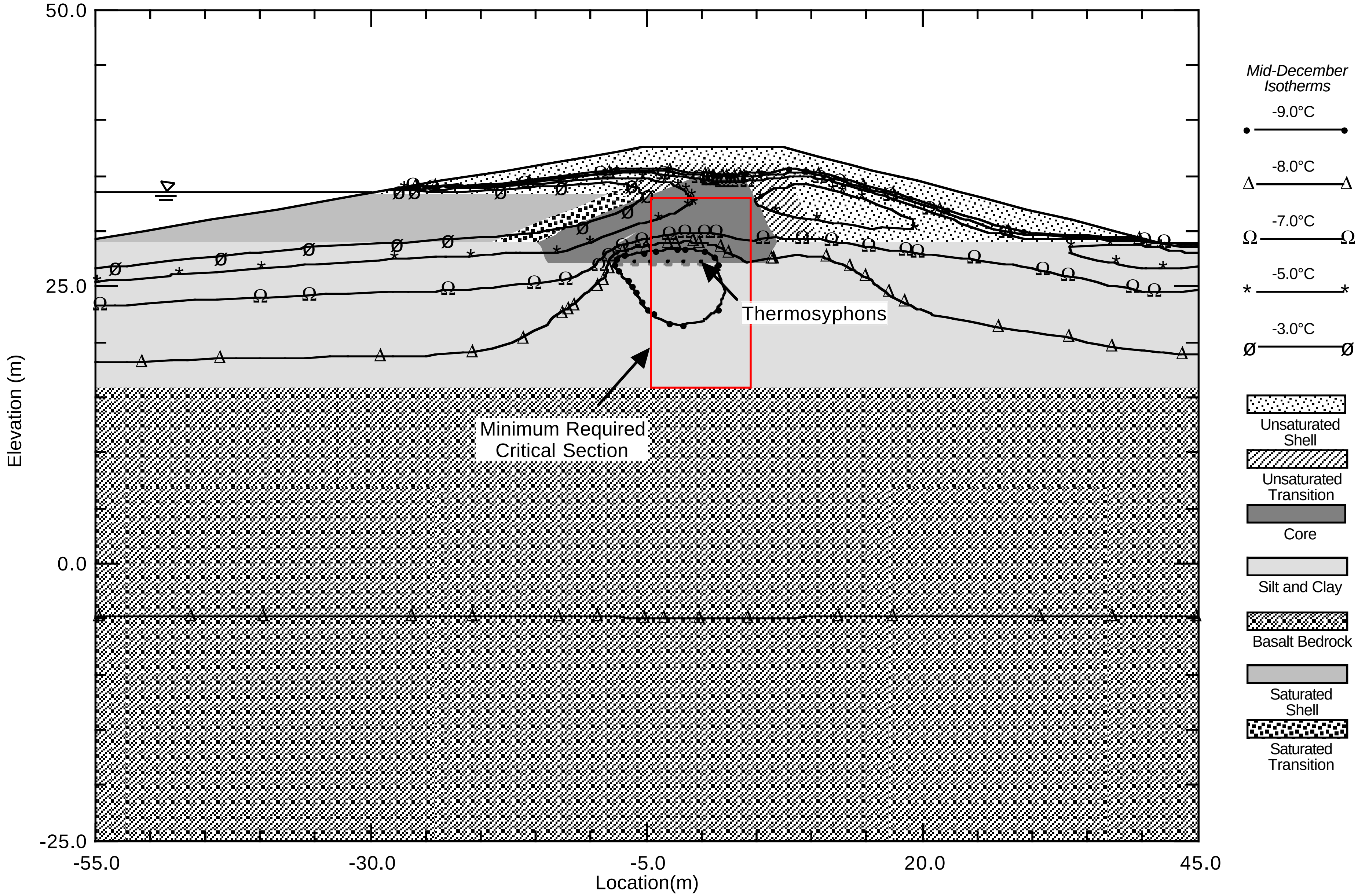
16:29 09/22/06



Notes:
1. P&N Lake data from Welch and Bergmann (1985)
2. Todd Lake data from Burn (2002)

EBA Engineering Consultants Ltd.	CLIENT: SRK Consulting, Engineers and Scientists	PROJECT	Thermal Design of Tailings Dams Doris North Project, NU
DWN. JTCS / CHKD. JTCS		TITLE	Lake Temperature Data Used in Thermal Analyses
EBA JOB NO. 1100126	FILE: 1100126wattemps.grf / REVISION NO.:	DATE: September 2006	Figure 9

16:30 09/22/06



EBA Engineering Consultants Ltd.

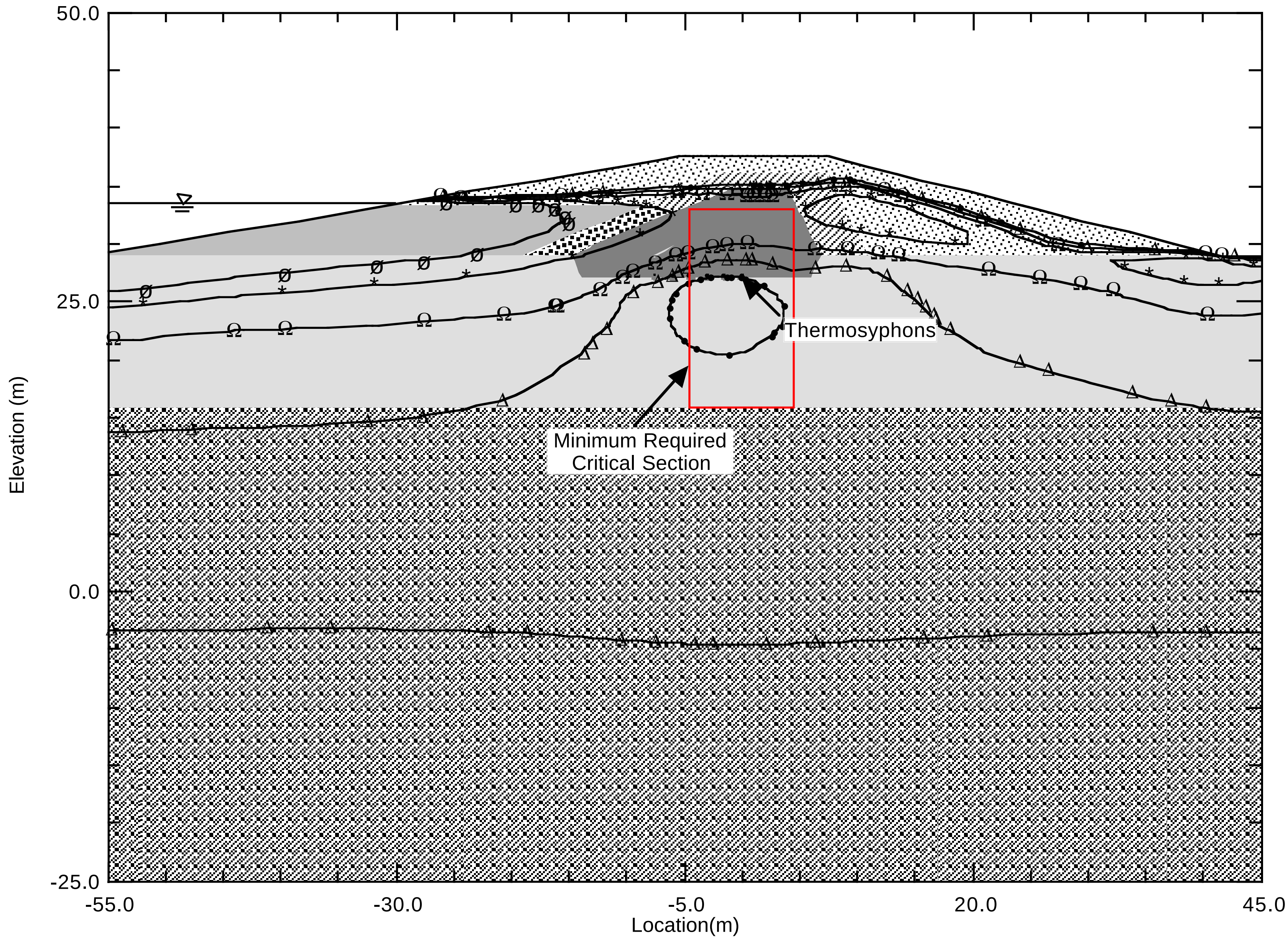
CLIENT: SRK Consulting, Engineers and Scientists

PROJECT: Thermal Design of Tailings Dams, Doris North Project, NU

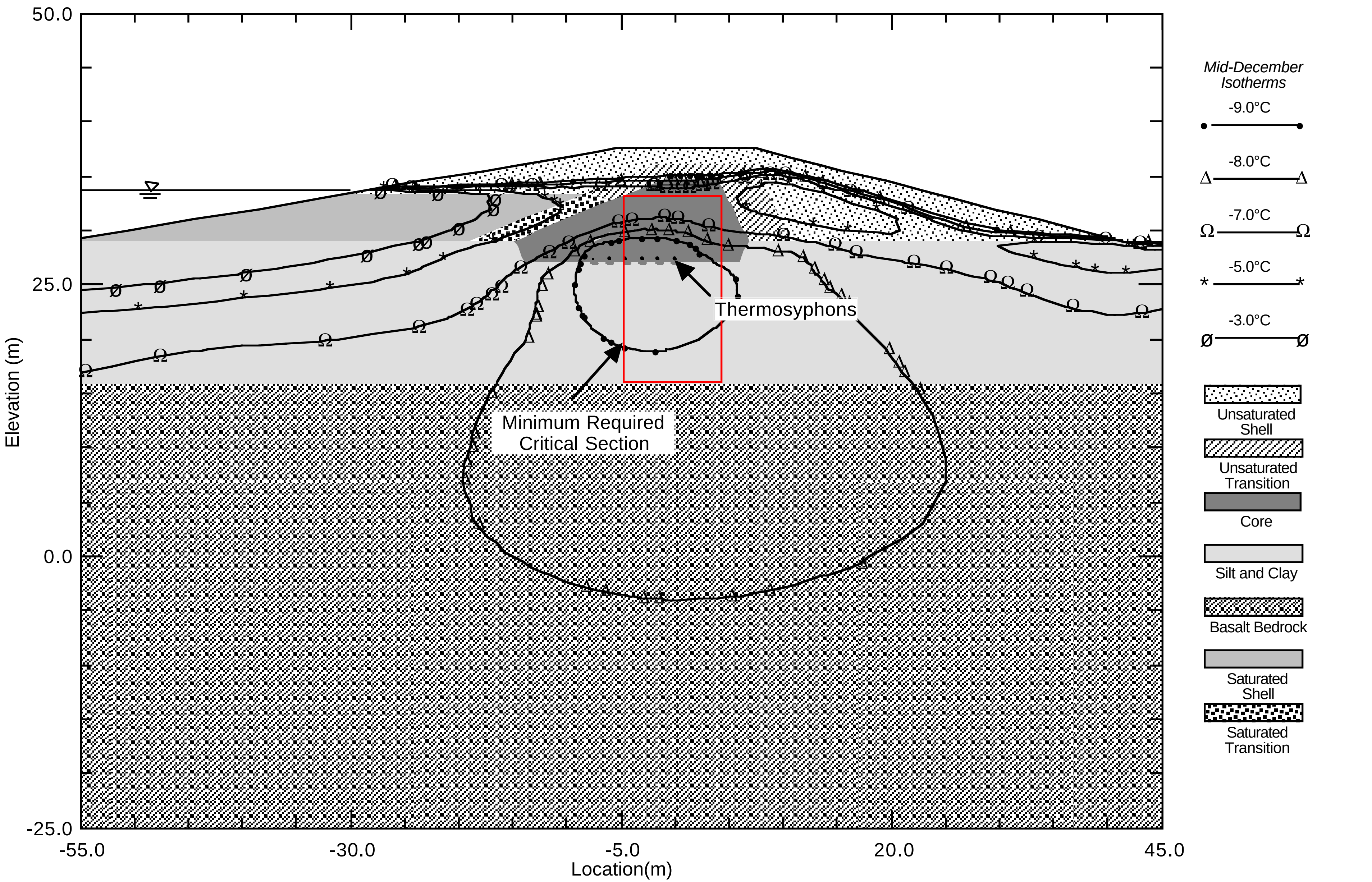
TITLE: Predicted Temperature Distribution One Year After Construction, North Dam

DWN.: JTCS	CHKD.: JTCS		
EBA JOB NO.: 1100126	FILE: 1100126 Fig 10	REVISION NO.:	DATE: September 2006

Figure 10



EBA Engineering Consultants Ltd.	CLIENT: SRK Consulting Engineers and Scientists	PROJECT: Thermal Design of Tailings Dams Doris North Project, NU	
DWN.: JTCS	CHKD.: JTCS	TITLE: Predicted Temperature Distribution Two Years After Construction, North Dam	
EBA JOB NO.: 1100126	FILE: 1100126 Fig 11	REVISION NO.:	DATE: September 2006
			Figure 11



EBA Engineering Consultants Ltd.

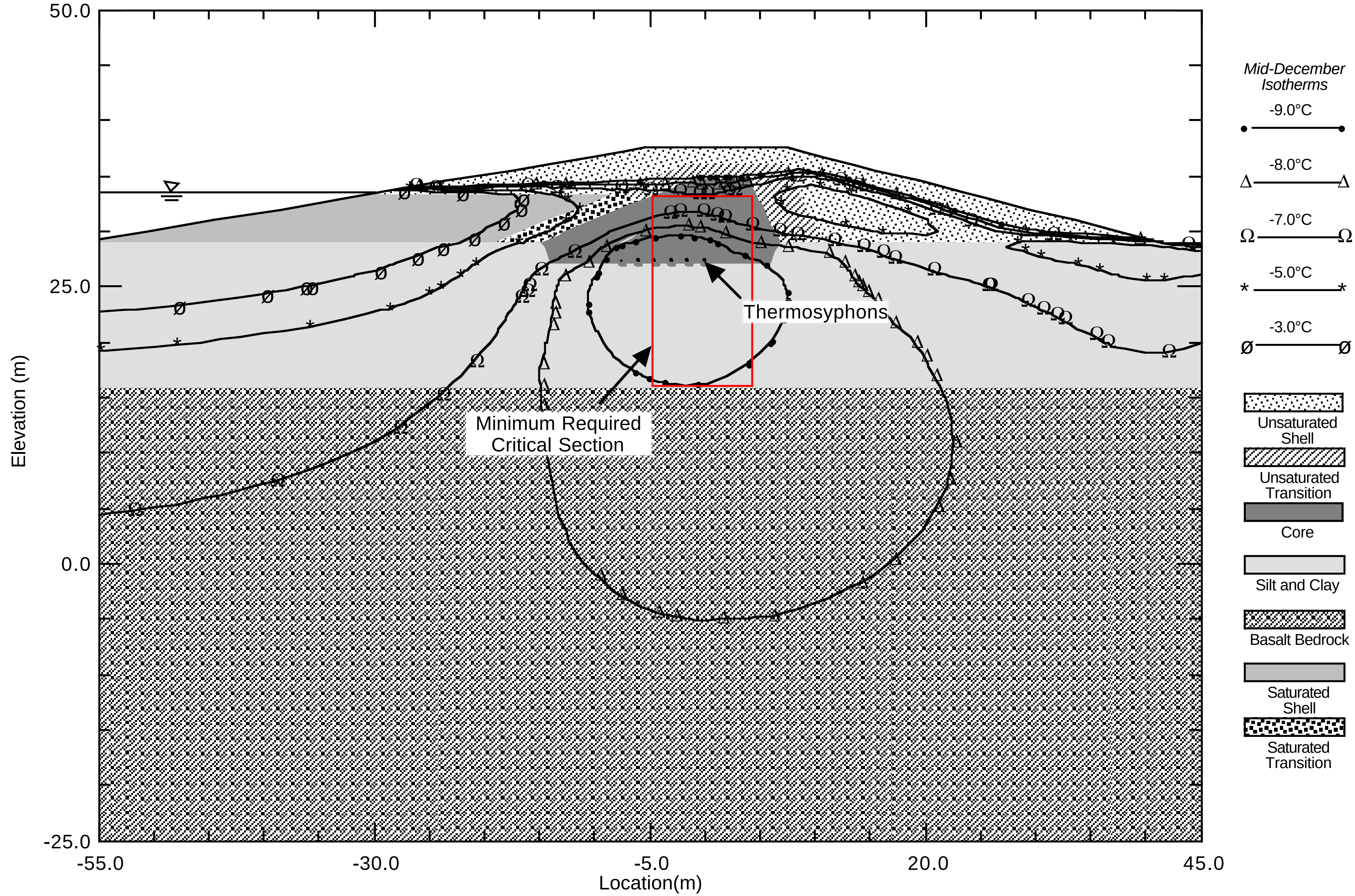
DWN.: JTCS | CHKD.: JTCS

CLIENT: SRK Consulting Engineers and Scientists

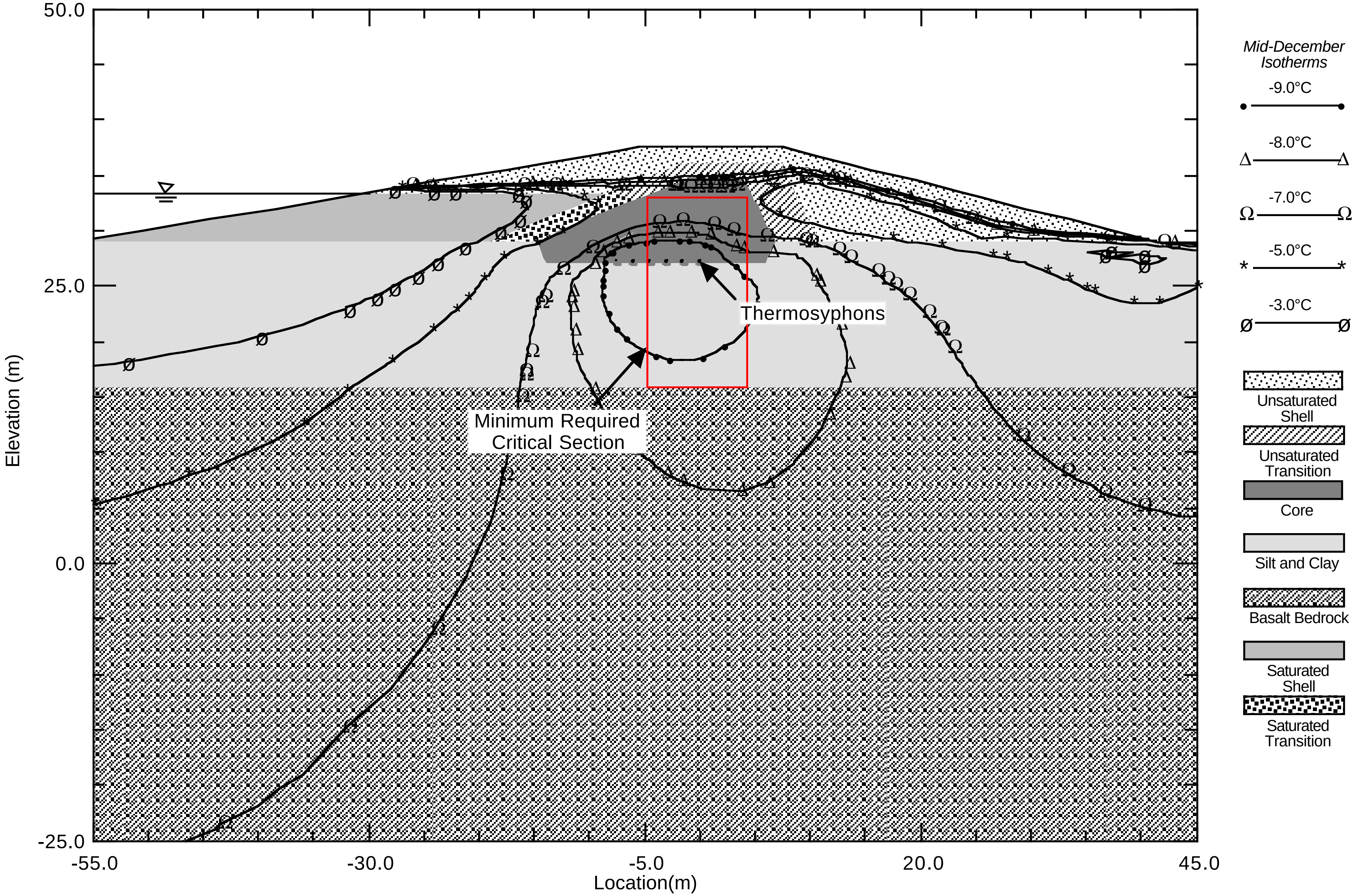
PROJECT: **Thermal Design of Tailings Dams Doris North Project, NU**

TITLE: **Predicted Temperature Distribution Five Years After Construction, North Dam**

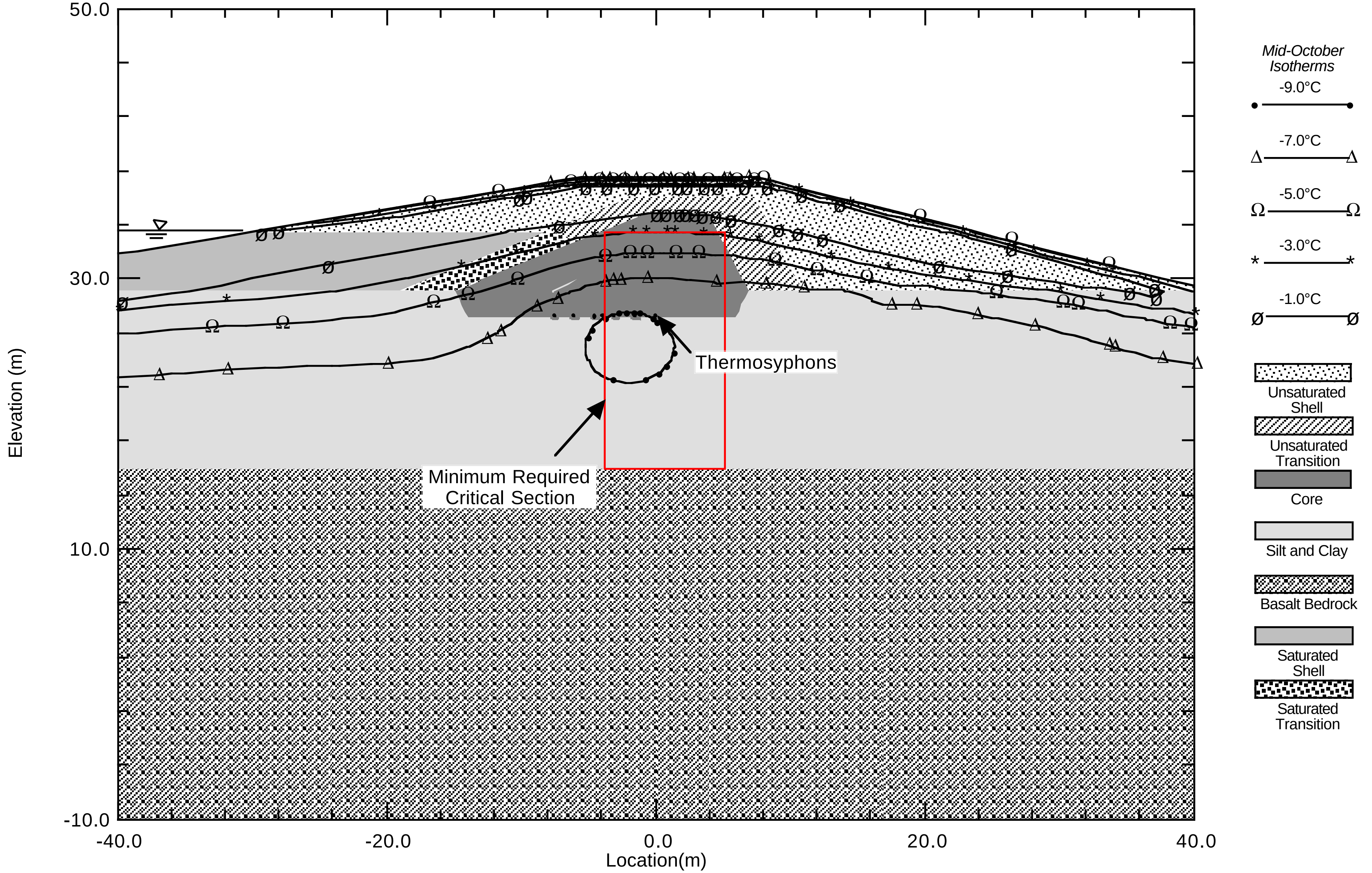
EBA JOB NO.: 1100126 | FILE: 1100126 Fig 12 | REVISION NO.: | DATE: September 2006 | **Figure 12**



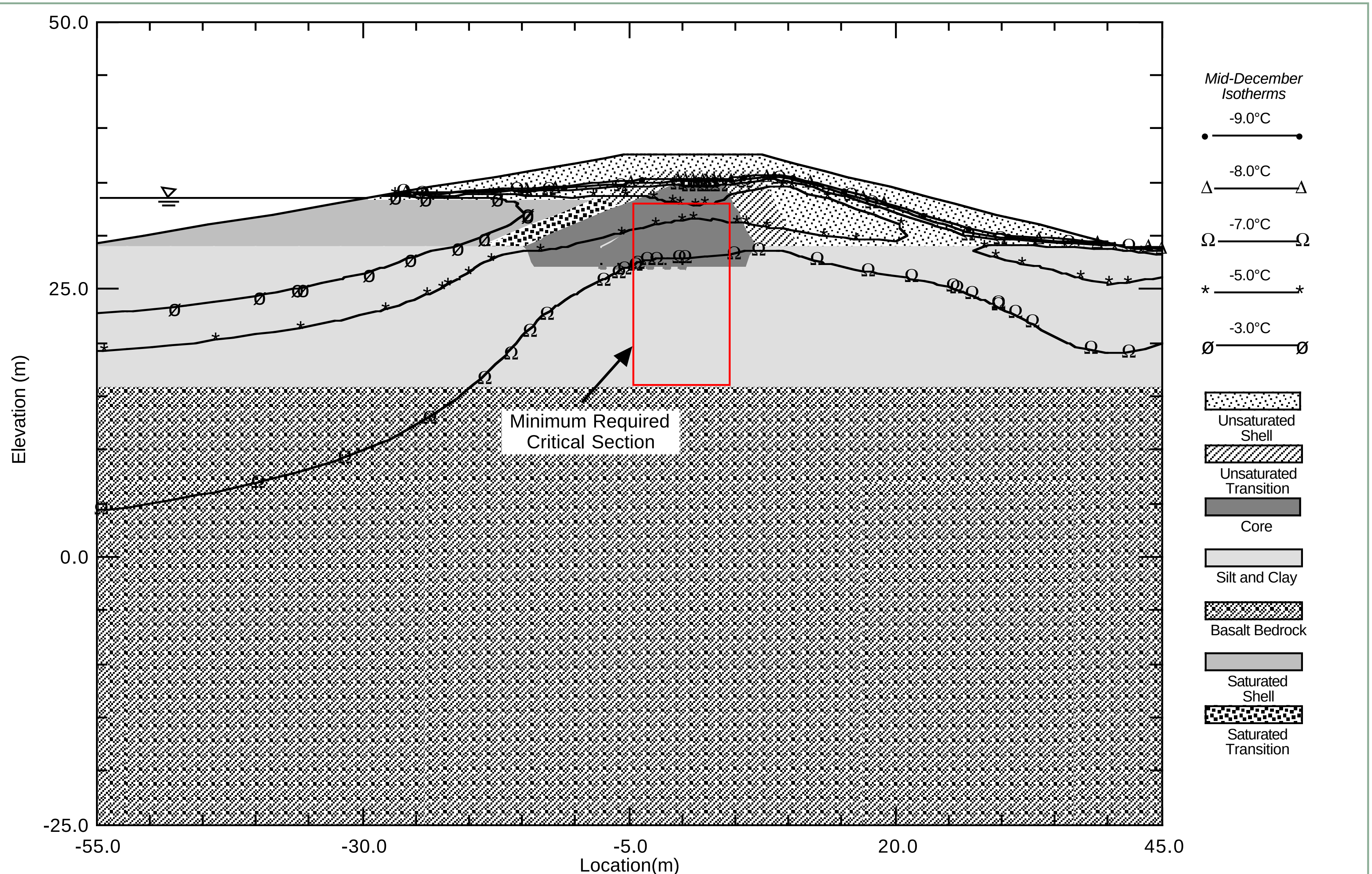
EBA Engineering Consultants Ltd.	CLIENT: SRK Consulting Engineers and Scientists	PROJECT: **Thermal Design of Tailings Dams Doris North Project, NU**
DWN.: **JTCS** CHKD.: **JTCS**		TITLE: **Predicted Temperature Distribution Ten Years After Construction, North Dam**
EBA JOB NO.: **1100126**	FILE: **1100126 Fig 13** REVISION NO.:	DATE: **September 2006** **Figure 13**



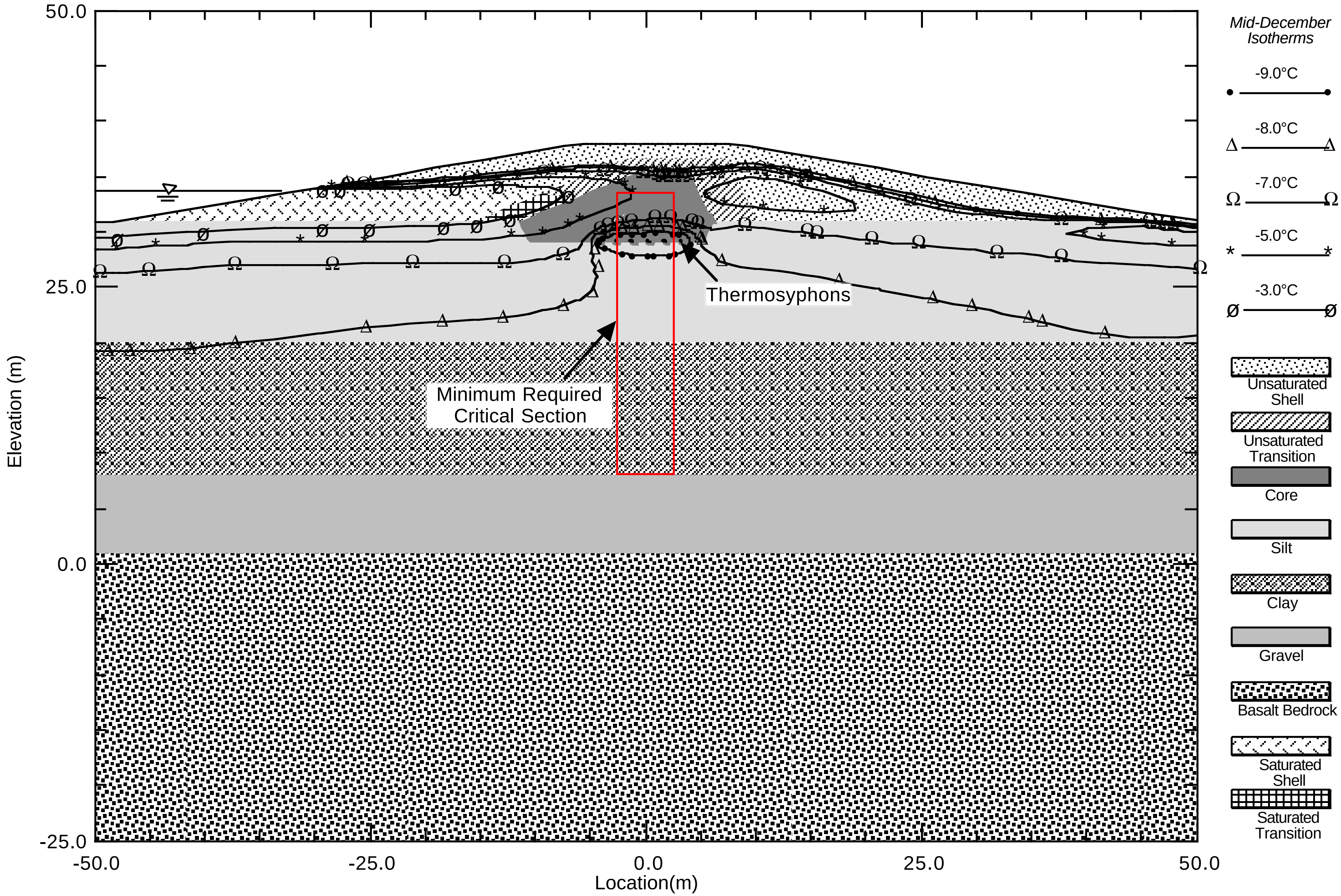
EBA Engineering Consultants Ltd.	CLIENT: SRK Consulting, Engineers and Scientists	PROJECT: Thermal Design of Tailings Dams, Doris North Project, NU
DWN.: JTCS	CHKD.: JTCS	TITLE: Predicted Temperature Distribution Twenty-Five Years After Construction, North Dam
EBA JOB NO.: 1100126	FILE: 1100126 Fig 14	REVISION NO.:
DATE: September 2006	Figure 14	



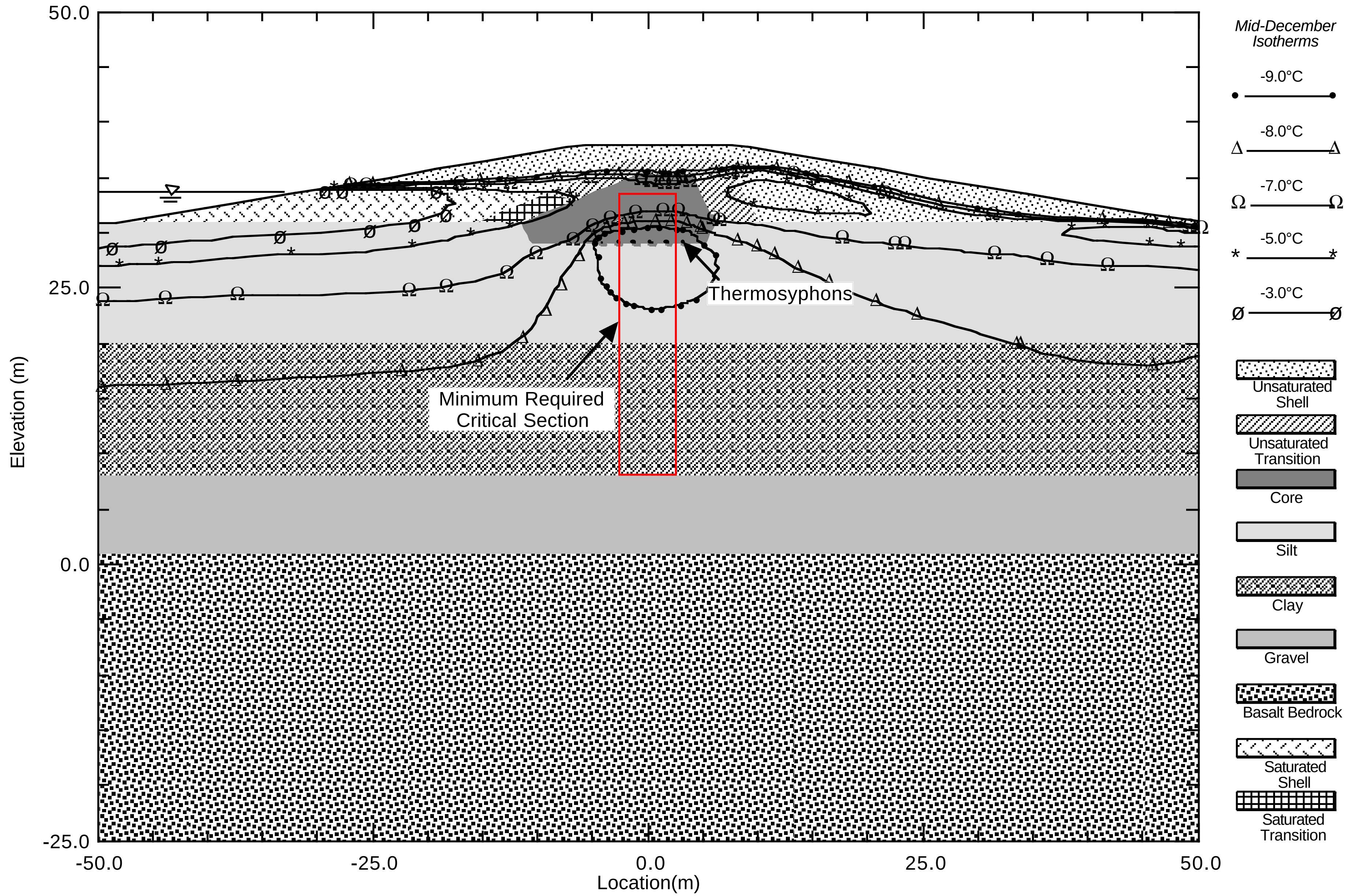
EBA Engineering Consultants Ltd.	CLIENT: SRK Consulting Engineers and Scientists		PROJECT: Thermal Design of Tailings Dams Doris North Project, NU	
DWN.: JTCS	CHKD.: JTCS		TITLE: Predicted Temperature Distribution Two Extreme Warm Years After Construction, North Dam	
EBA JOB NO.: 1100126	FILE: 1100126 Fig 15	REVISION NO.:	DATE: September 2006	Figure 15



EBA Engineering Consultants Ltd.	CLIENT SRK Consulting Engineers and Scientists	PROJECT	Thermal Design of Tailings Dams Doris North Project, NU
DWN.: JTCS	CHKD.: JTCS	TITLE	Predicted Temperature Distribution Ten Years After Construction, No Thermosyphons, North Dam
EBA JOB NO.: 1100126	FILE: 1100126 Fig 16	REVISION NO.:	DATE: September 2006
			Figure 16



EBA Engineering Consultants Ltd.	CLIENT SRK Consulting Engineers and Scientists	PROJECT	Thermal Design of Tailings Dams Doris North Project, NU
DWN.: JTCS	CHKD.: JTCS	TITLE	Predicted Temperature Distribution One Year After Construction, South Dam
EBA JOB NO.: 1100126	FILE: 1100126 Fig 17	REVISION NO.:	DATE: September 2006
			Figure 17



EBA Engineering Consultants Ltd.

DWN.: JTCS CHKD.: JTCS

EBA JOB NO.: 1100126

CLIENT: SRK Consulting Engineers and Scientists

FILE: 1100126 Fig 18

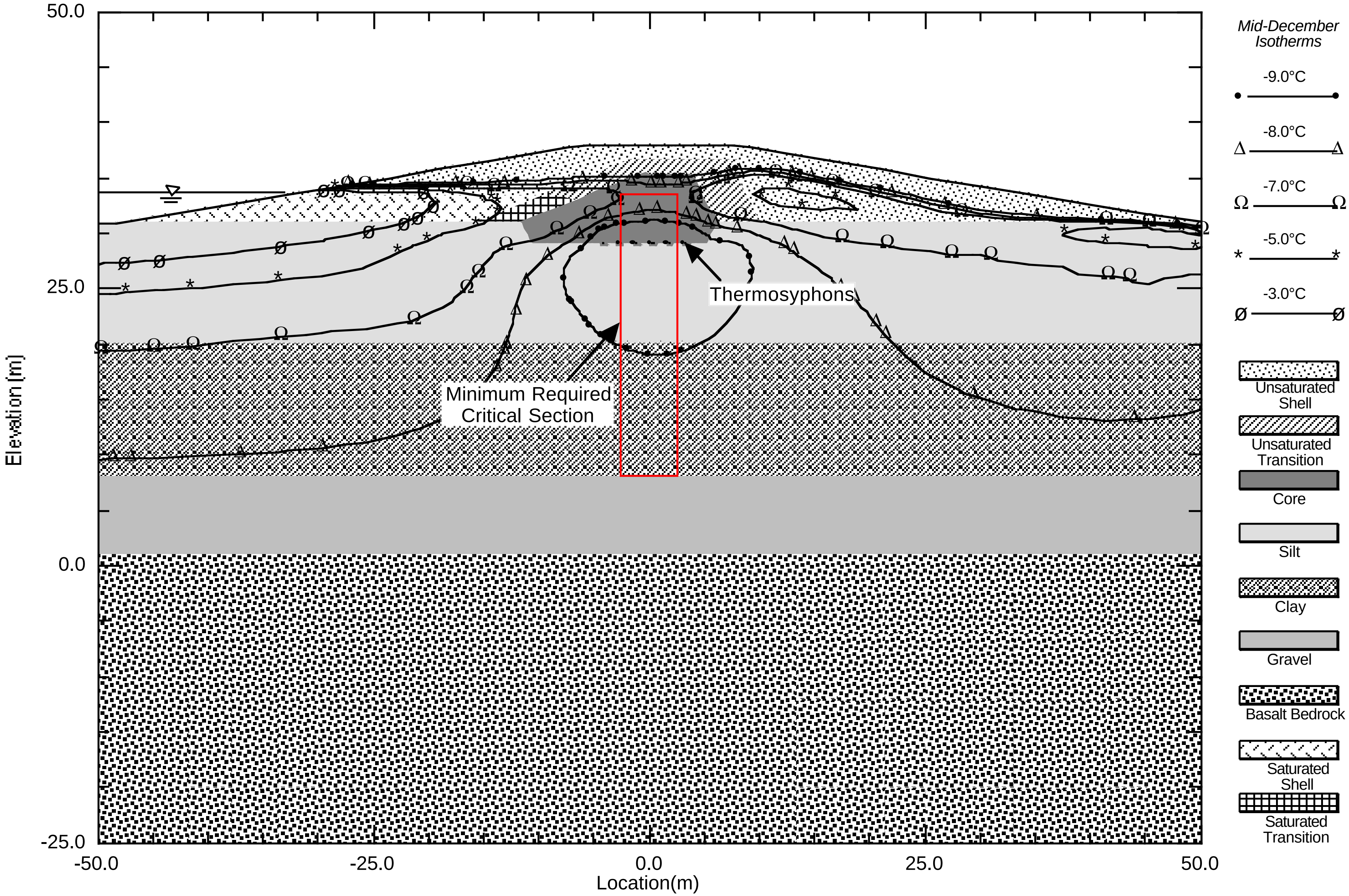
REVISION NO.:

PROJECT: Thermal Design of Tailings Dams Doris North Project, NU

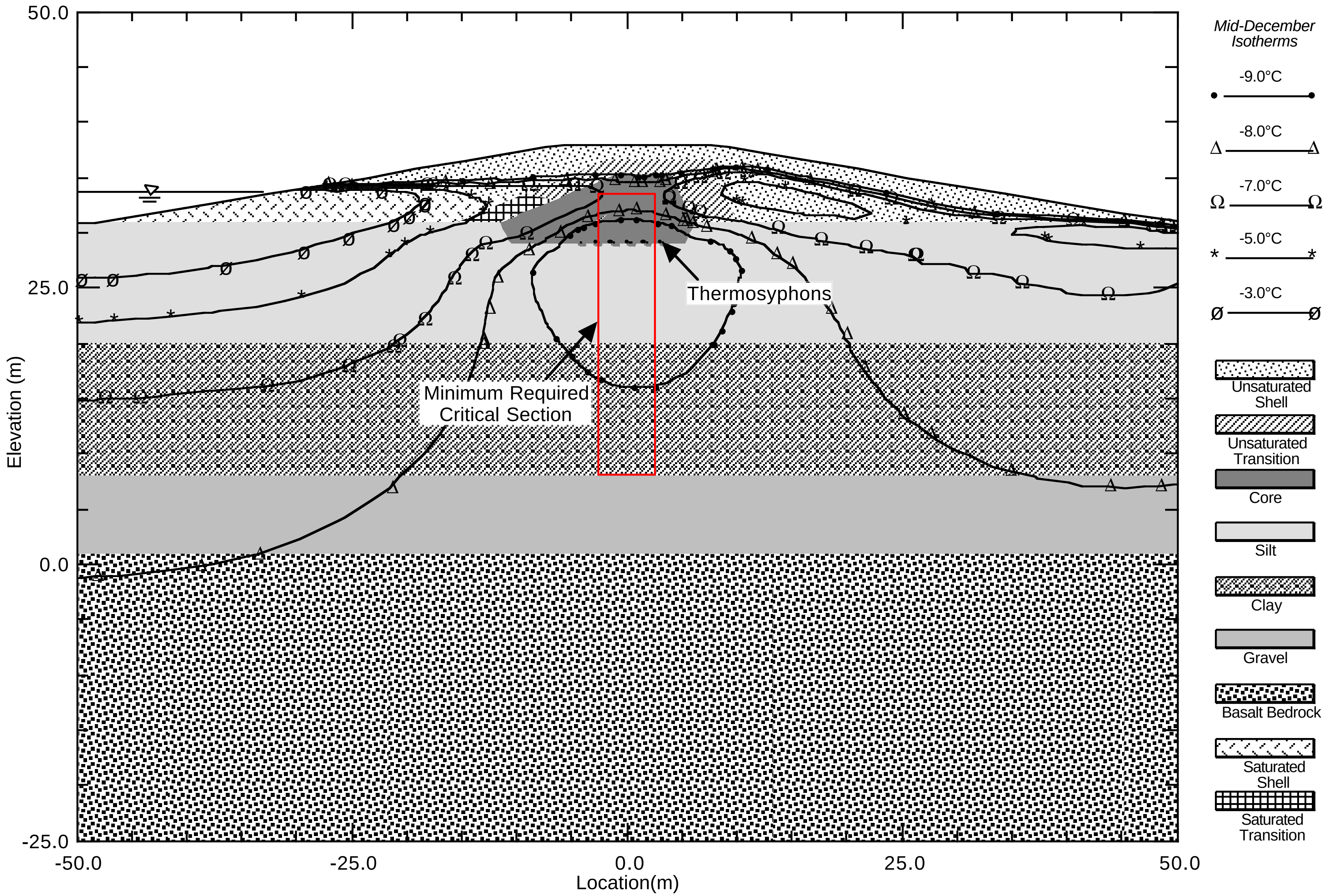
TITLE: Predicted Temperature Distribution Two Years After Construction, South Dam

DATE: September 2006

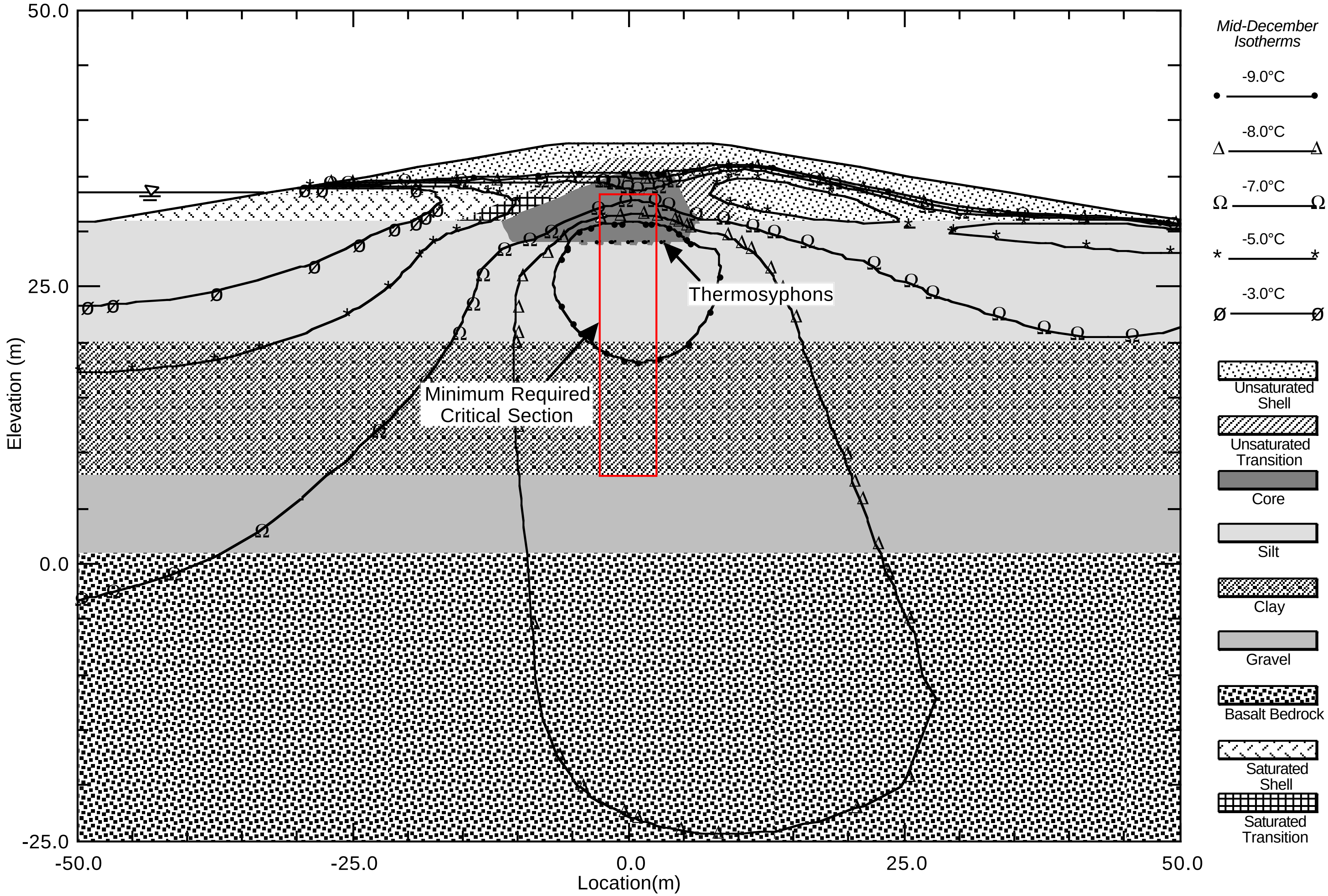
Figure 18



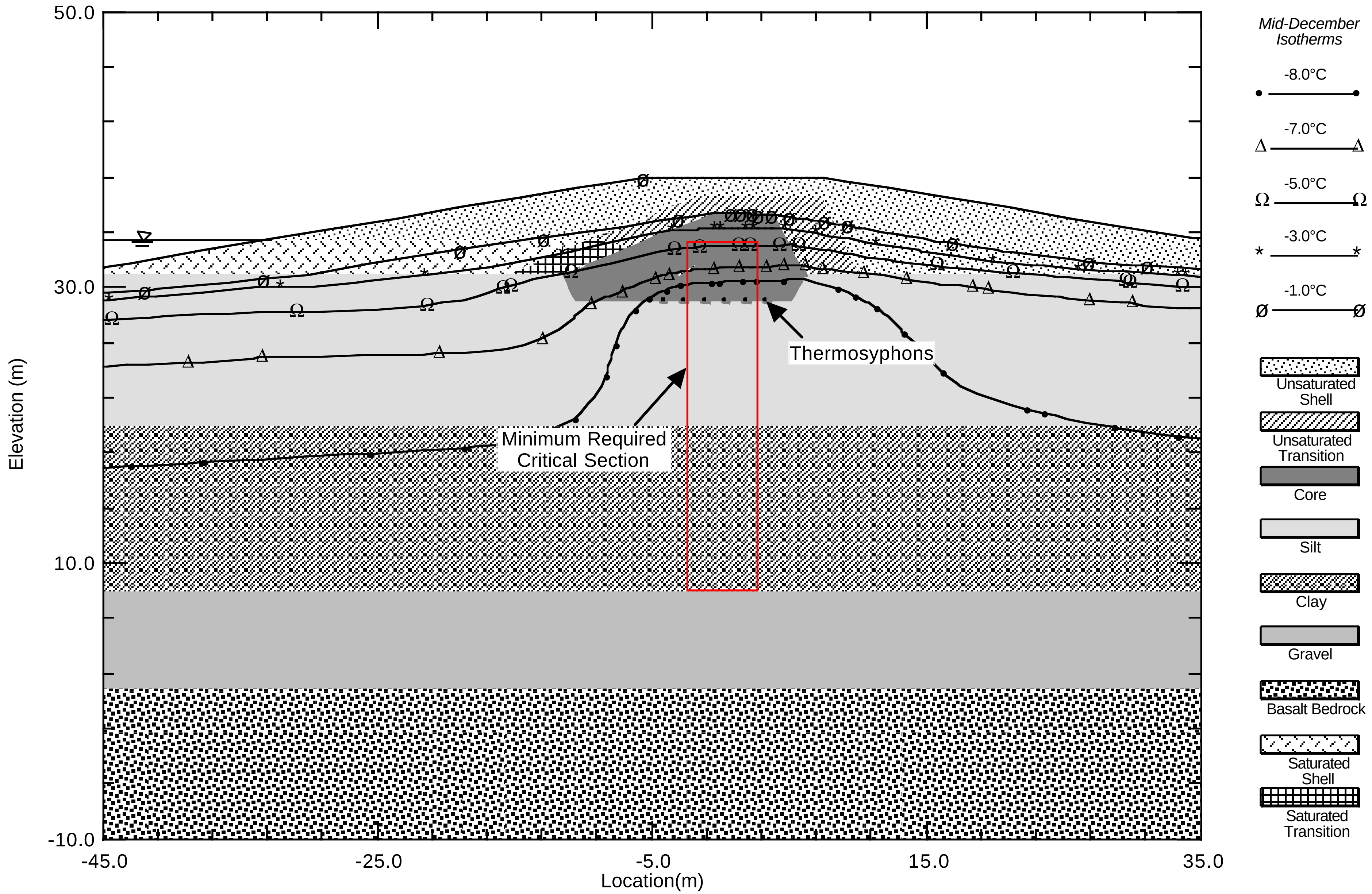
EBA Engineering Consultants Ltd.	CLIENT: SRK Consulting, Engineers and Scientists	PROJECT	Thermal Design of Tailings Dams Doris North Project, NU
DWN.: JTCS	CHKD.: JTCS	TITLE	Predicted Temperature Distribution Five Years After Construction, South Dam
EBA JOB NO.: 1100126	FILE: 1100126 Fig 19	REVISION NO.:	DATE: September 2006
			Figure 19



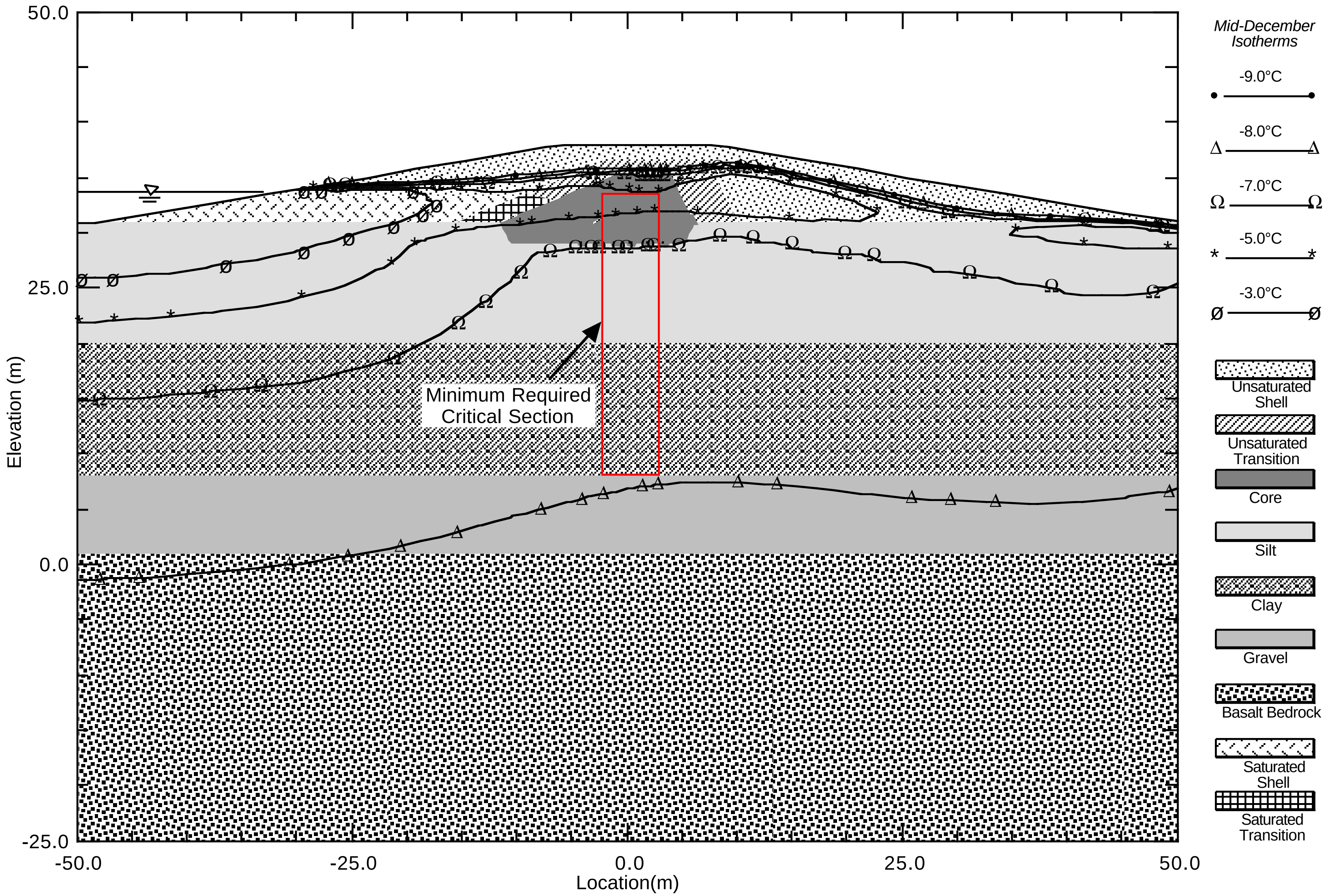
EBA Engineering Consultants Ltd.	CLIENT: SRK Consulting Engineers and Scientists	PROJECT: Thermal Design of Tailings Dams Doris North Project, NU
DWN.: JTCS CHKD.: JTCS		TITLE: Predicted Temperature Distribution Ten Years After Construction, South Dam
EBA JOB NO.: 1100126	FILE: 1100126 Fig 20 REVISION NO.:	DATE: September 2006 Figure 20



EBA Engineering Consultants Ltd.	CLIENT: SRK Consulting, Engineers and Scientists		PROJECT: **Thermal Design of Tailings Dams Doris North Project, NU**	
DWN.: **JTCS** CHKD.: **JTCS**			TITLE: **Predicted Temperature Distribution Twenty-Five Years After Construction, South Dam**	
EBA JOB NO.: **1100126**	FILE: **1100126 Fig 21**	REVISION NO.:	DATE: **September 2006**	**Figure 21**



EBA Engineering Consultants Ltd.	CLIENT SRK Consulting Engineers and Scientists		PROJECT **Thermal Design of Tailings Dams Doris North Project, NU**	
DWN.: **JTCS**	CHKD.: **JTCS**		TITLE **Predicted Temperature Distribution Two Extreme Warm Years After Construction, South Dam**	
EBA JOB NO.: **1100126**	FILE: **1100126 Fig 22**	REVISION NO.:	DATE: **September 2006**	**Figure 22**



EBA Engineering Consultants Ltd.

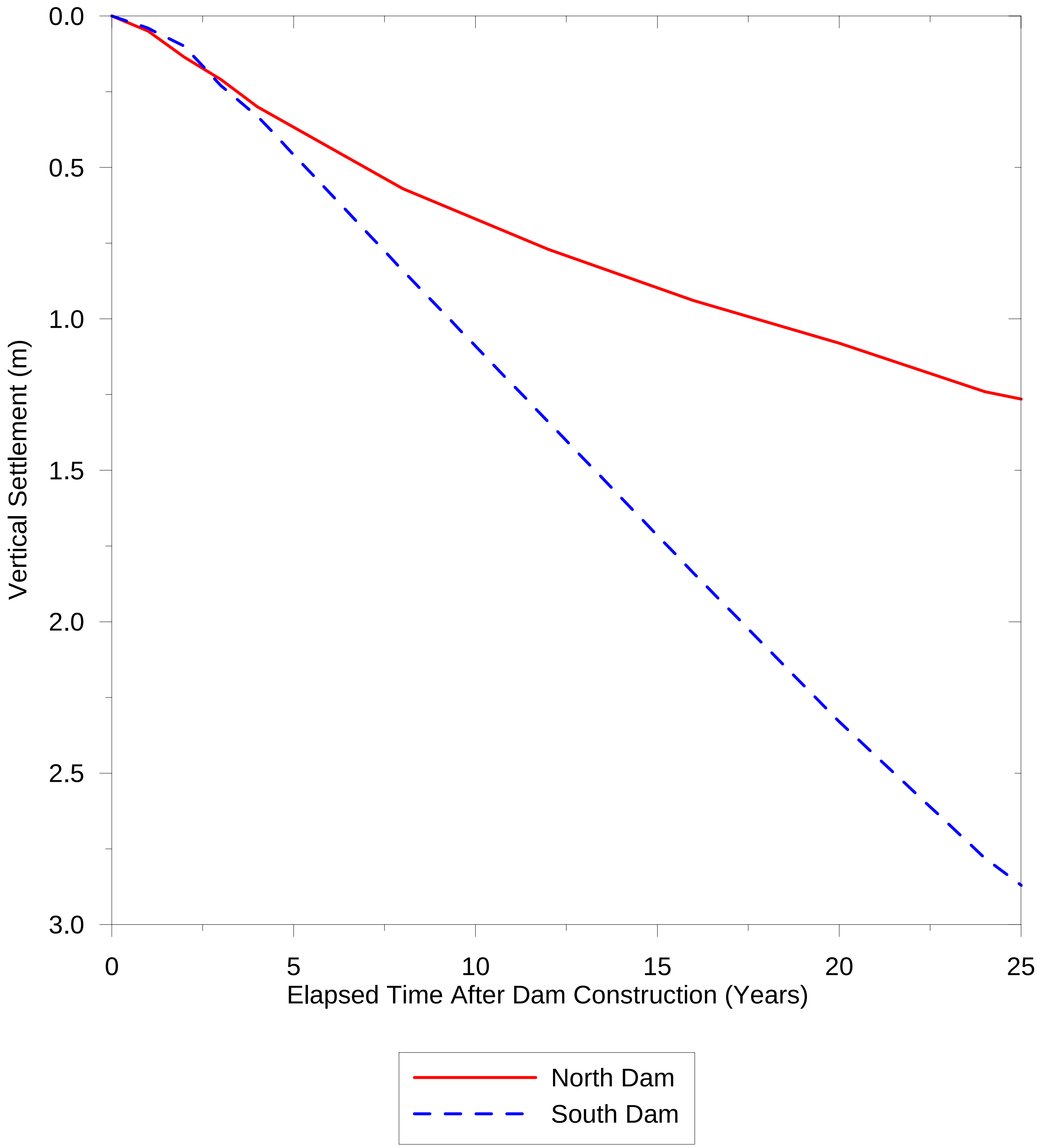
CLIENT: SRK Consulting Engineers and Scientists

PROJECT: **Thermal Design of Tailings Dams Doris North Project, NU**

TITLE: **Predicted Temperature Distribution Ten Years After Construction, No Thermosyphons, South Dam**

DWN.: JTCS | CHKD.: JTCS

EBA JOB NO.: 1100126 | FILE: 1100126 Fig 23 | REVISION NO.: | DATE: September 2006 | **Figure 23**



EBA Engineering Consultants Ltd.	CLIENT SRK Consulting Engineers and Scientists	PROJECT	Thermal Design of Tailings Dams Doris North Project, NU
DWN. JTCS / CHKD. JTCS		TITLE	Predicted Settlement History of Core Crest Doris North Dams
EBA JOB NO. 1100126	FILE: 1100126_fig24.grf / REVISION NO.:	DATE: September 2006	Figure 24

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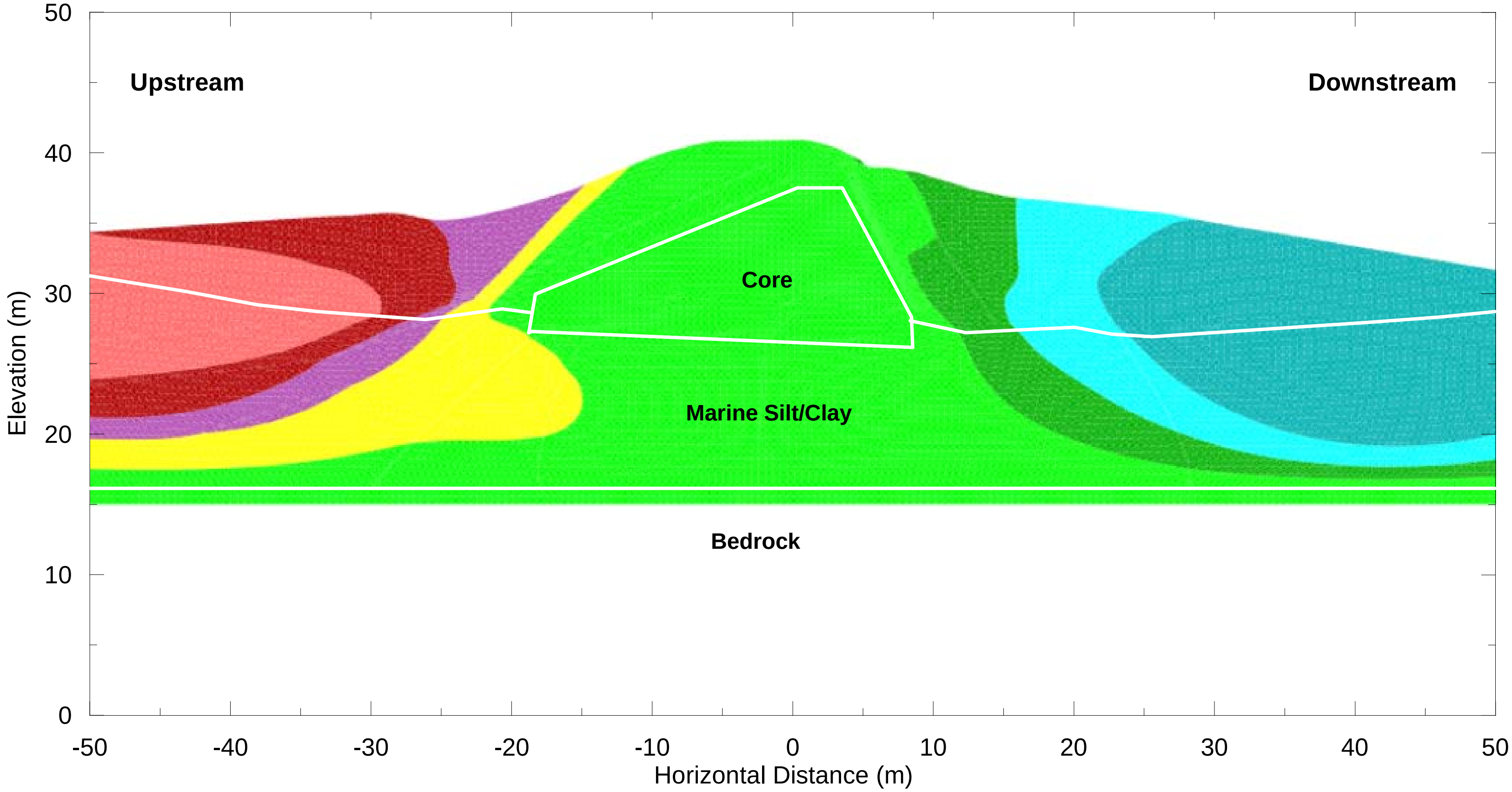
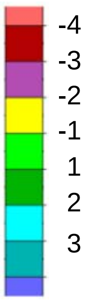


Scale
Lateral Displacement
(m)



(zero contour omitted)

Note: Negative Displacement Upstream; Positive Displacement Downstream

EBA Engineering Consultants Ltd.		CLIENT: SRK Consulting – Engineers and Scientists		PROJECT	Thermal Design of Tailings Dams Doris North Project, NU
DWN. JTCS	CHKD. JTCS			TITLE	Predicted Lateral Creep Deformations Ten Years After Dam Construction, North Dam
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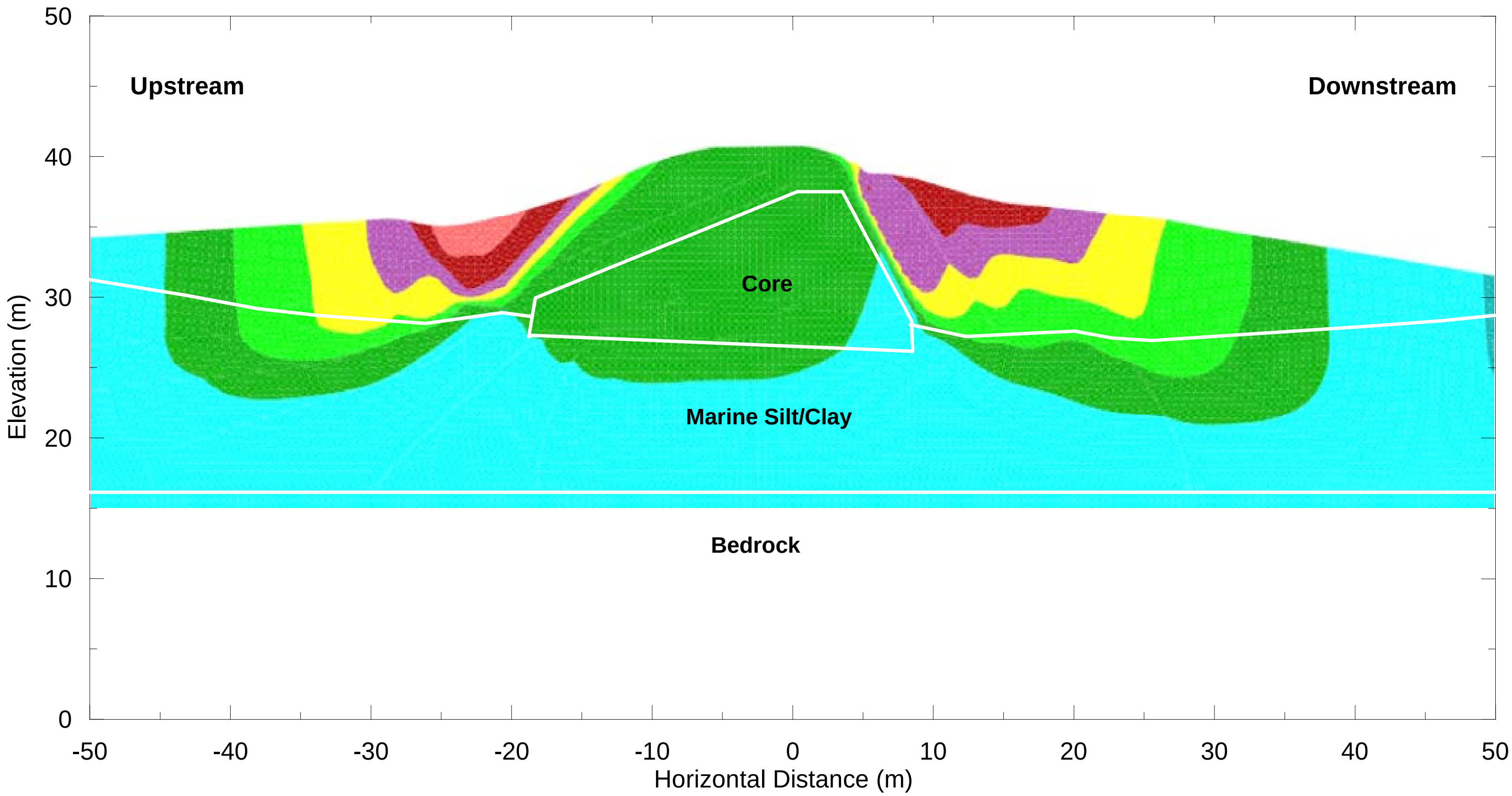
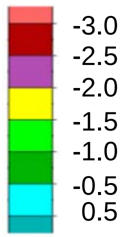


Note: Negative Displacement Downward; Positive Displacement Upward



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EBA JOB NO. 1100126	FILE: 1100126fig26.grf	REVISION NO.:	DATE: September 2006 — Figure 26

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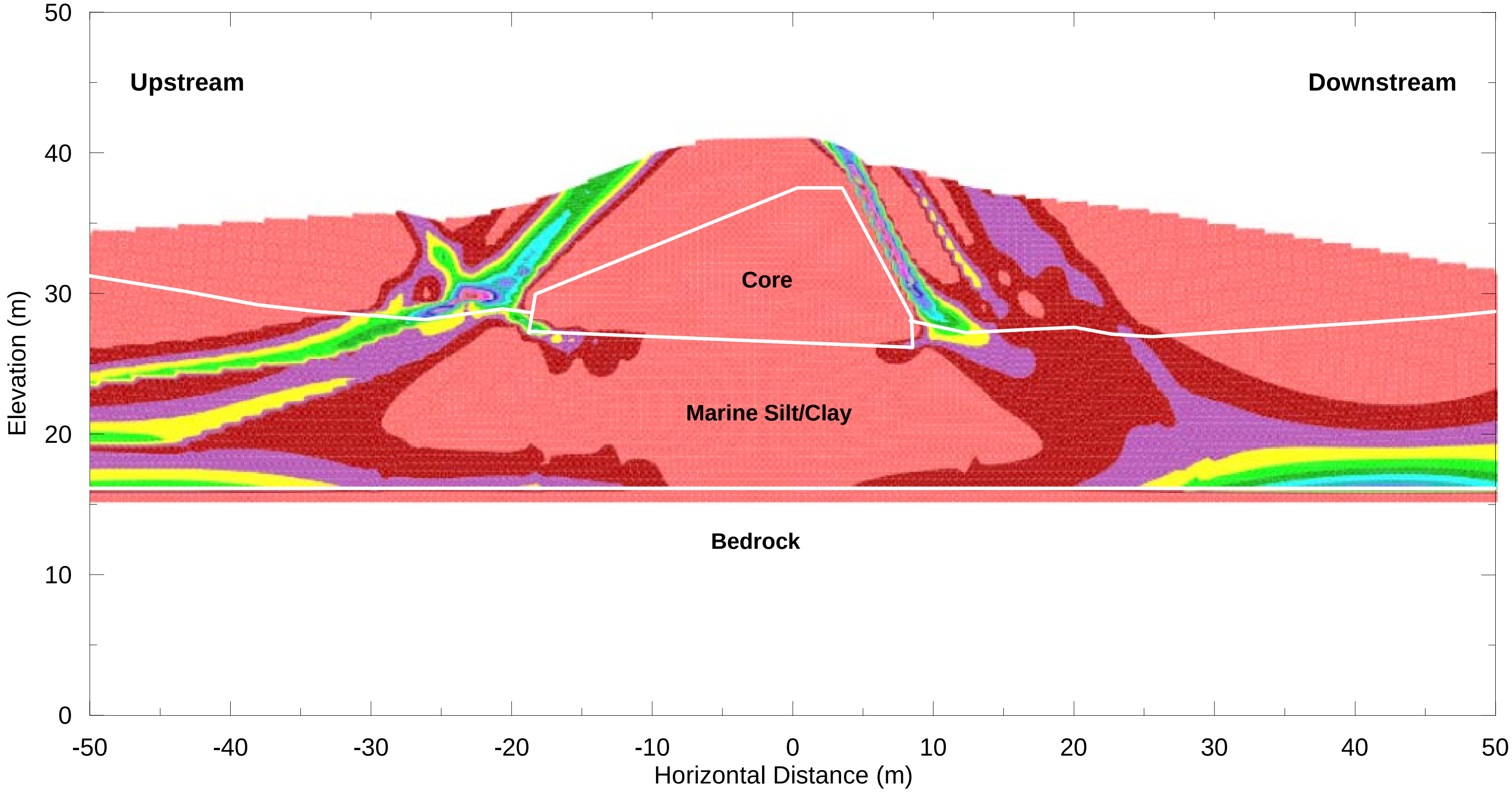

Scale
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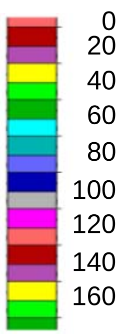

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DWN. JTCS	CHKD. JTCS			TITLE: Predicted Maximum Shear Strain Ten Years After Dam Construction, North Dam
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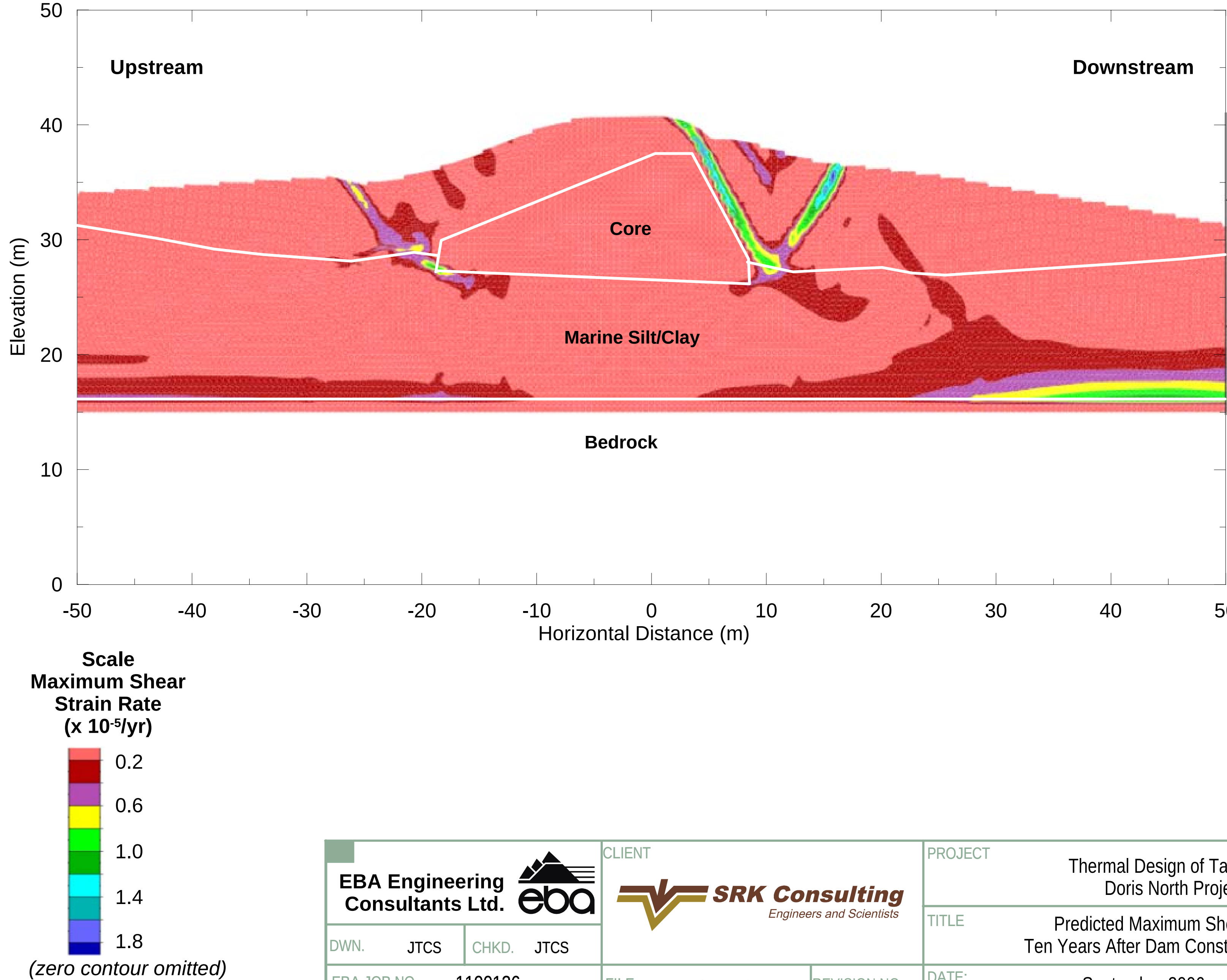

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DWN. JTCS	CHKD. JTCS		TITLE	Predicted Maximum Shear Strain Rate Ten Years After Dam Construction, North Dam
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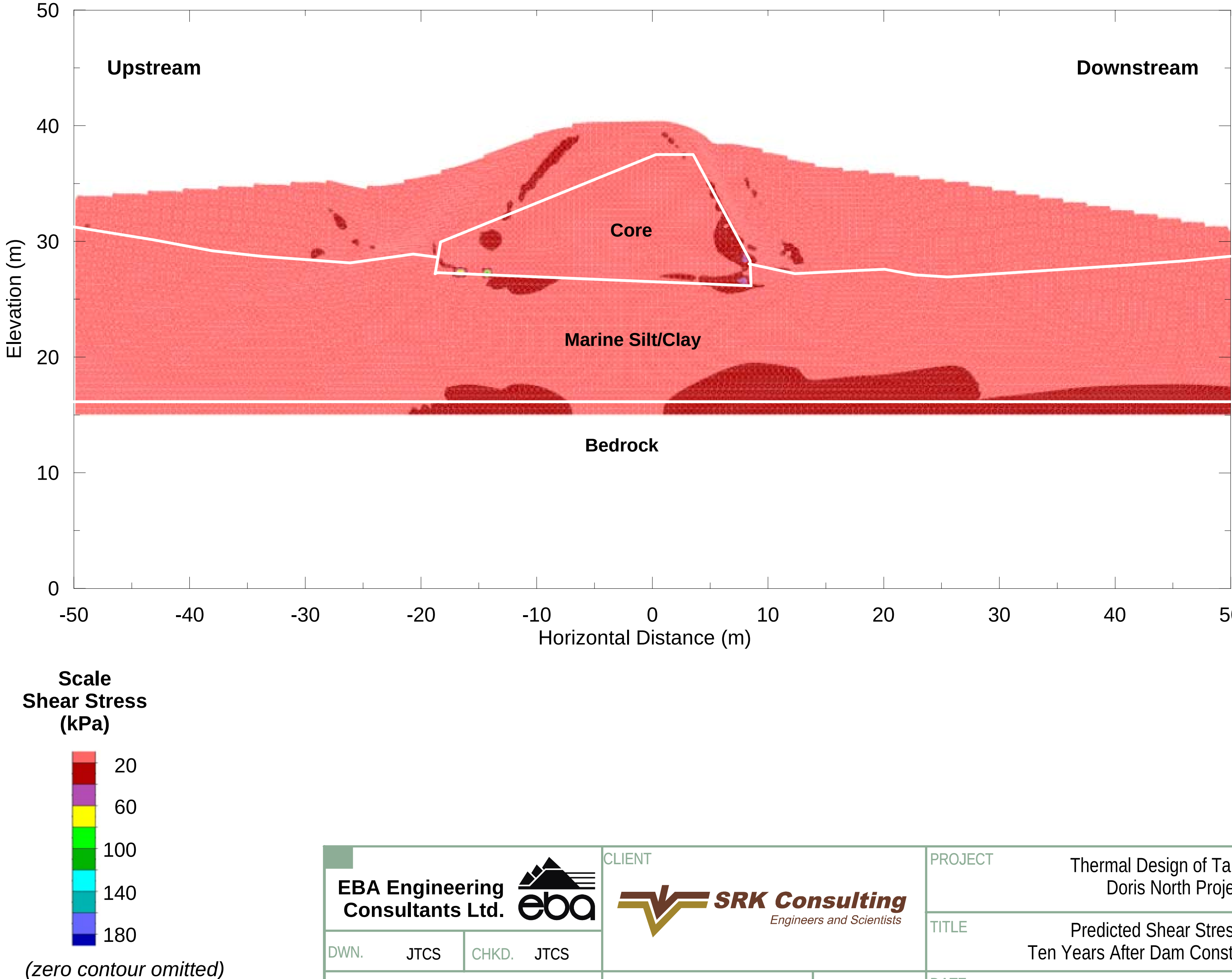

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DWN. JTCS	CHKD. JTCS	TITLE	Predicted Shear Stress Distribution Ten Years After Dam Construction, North Dam
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			Figure 29

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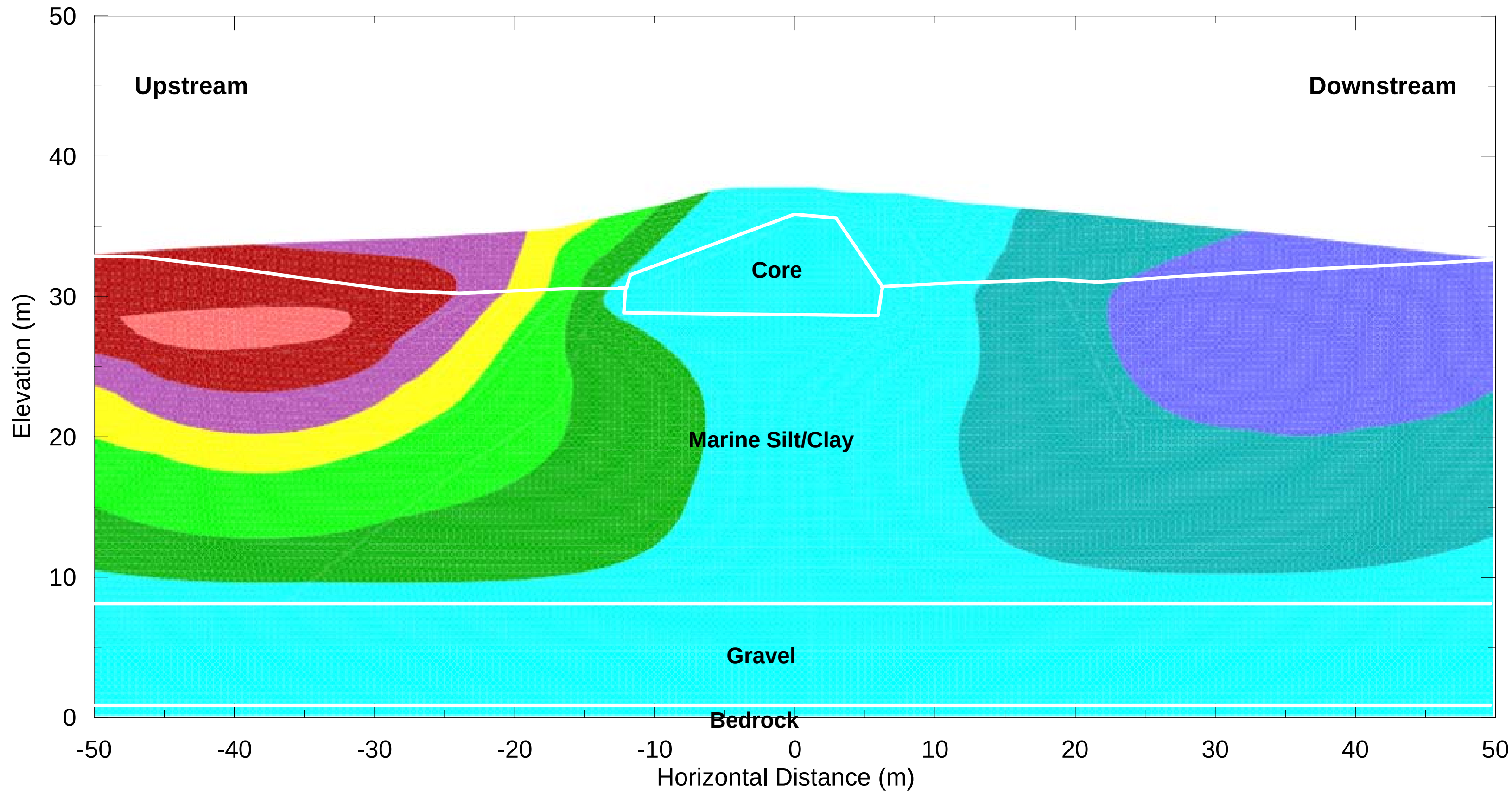

Note: Negative Displacement Upstream; Positive Displacement Downstream

Scale
Lateral Displacement
(m)

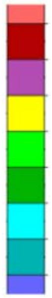

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			Figure 30

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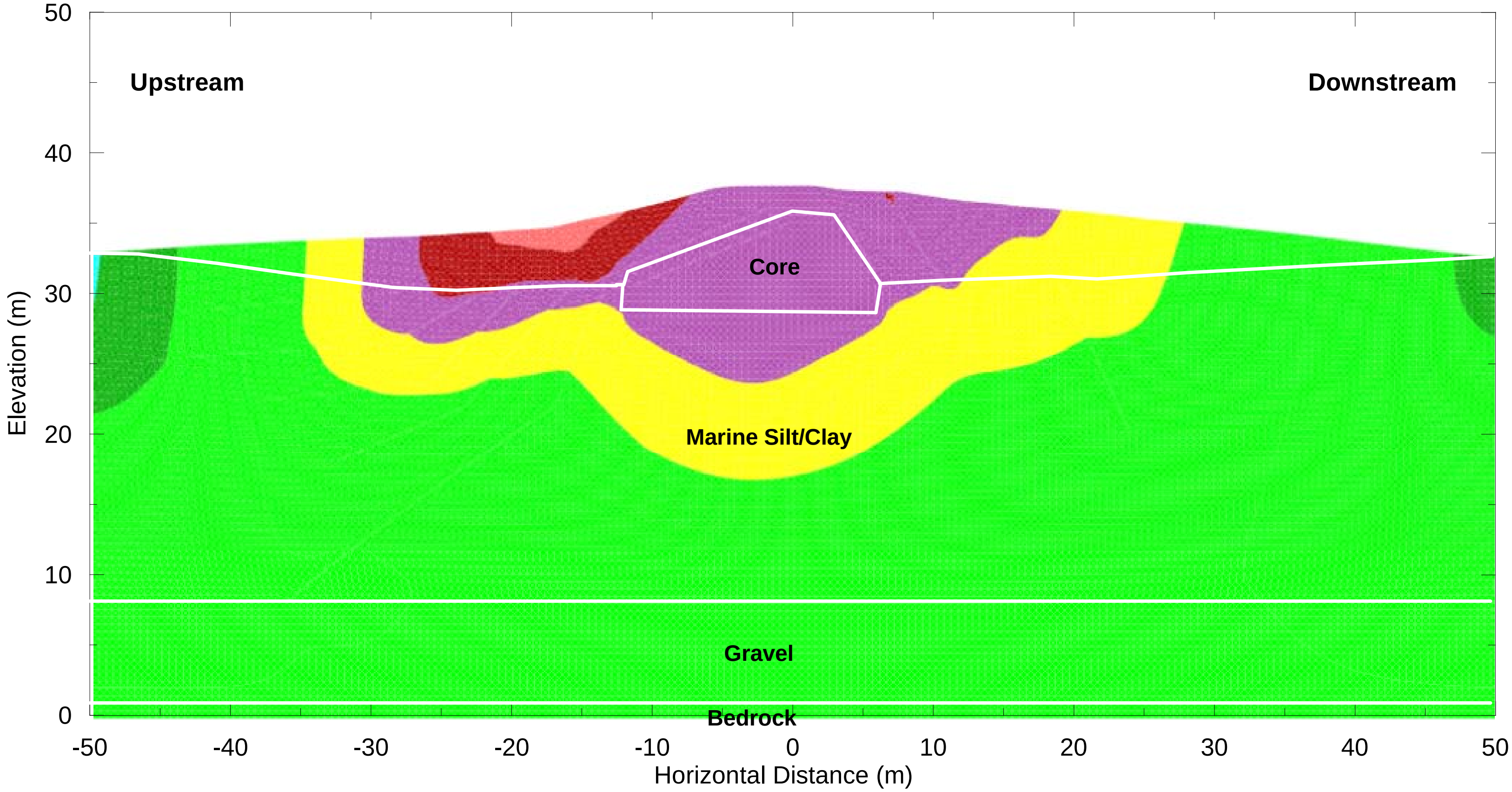

Scale
Vertical Displacement
(m)

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-1.5	
-1.0	
-0.5	
0.5	
1.0	

(zero contour omitted)

Note: Negative Displacement Downwards; Positive Displacement Upwards

EBA Engineering Consultants Ltd.	CLIENT: SRK Consulting — Engineers and Scientists	PROJECT	Thermal Design of Tailings Dams Doris North Project, NU
DWN. JTCS / CHKD. JTCS		TITLE	Predicted Vertical Creep Deformations Ten Years After Dam Construction, South Dam
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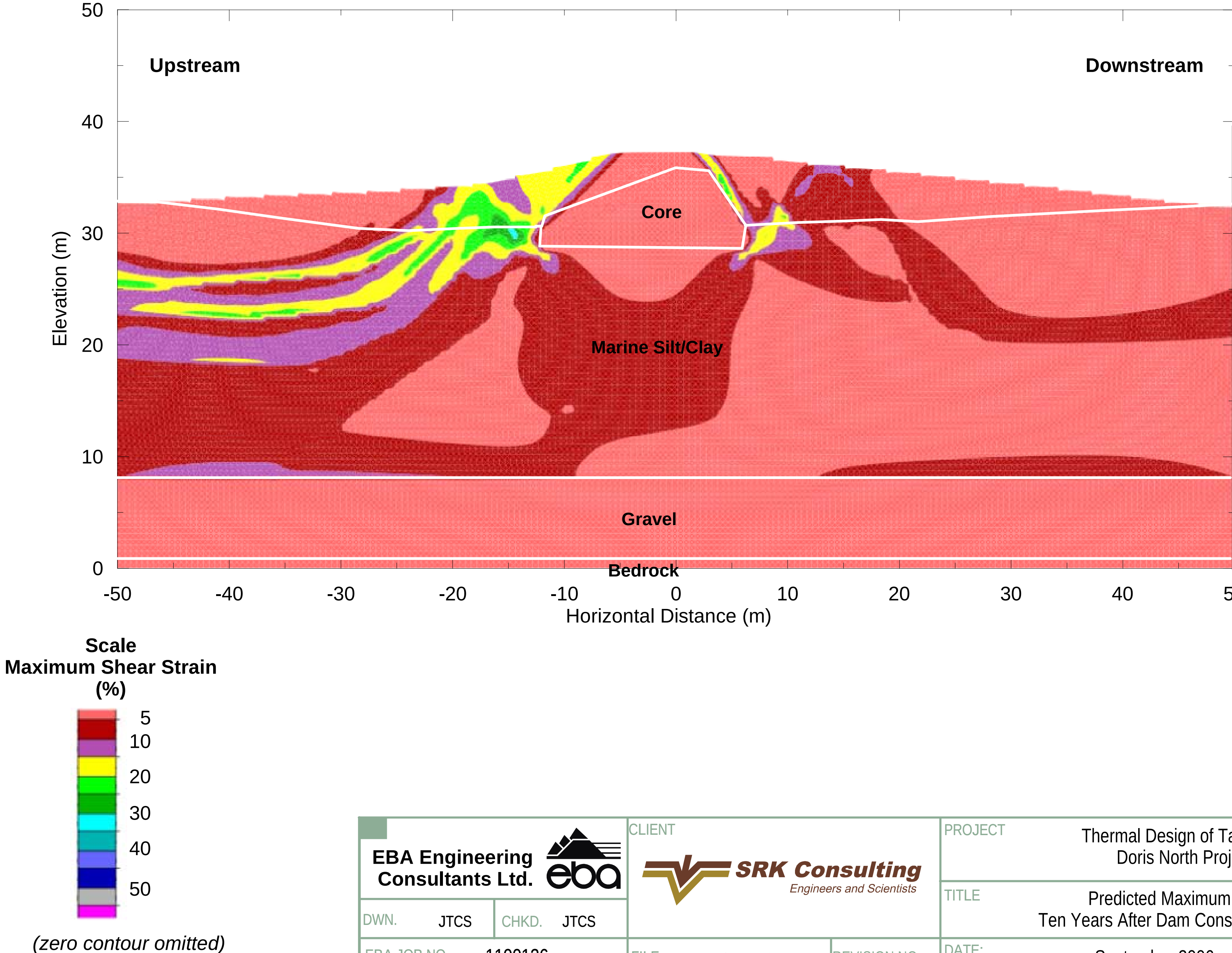

EBA Engineering Consultants Ltd.	CLIENT SRK Consulting Engineers and Scientists	PROJECT	Thermal Design of Tailings Dams Doris North Project, NU
DWN. JTCS / CHKD. JTCS		TITLE	Predicted Maximum Shear Strain Ten Years After Dam Construction, South Dam
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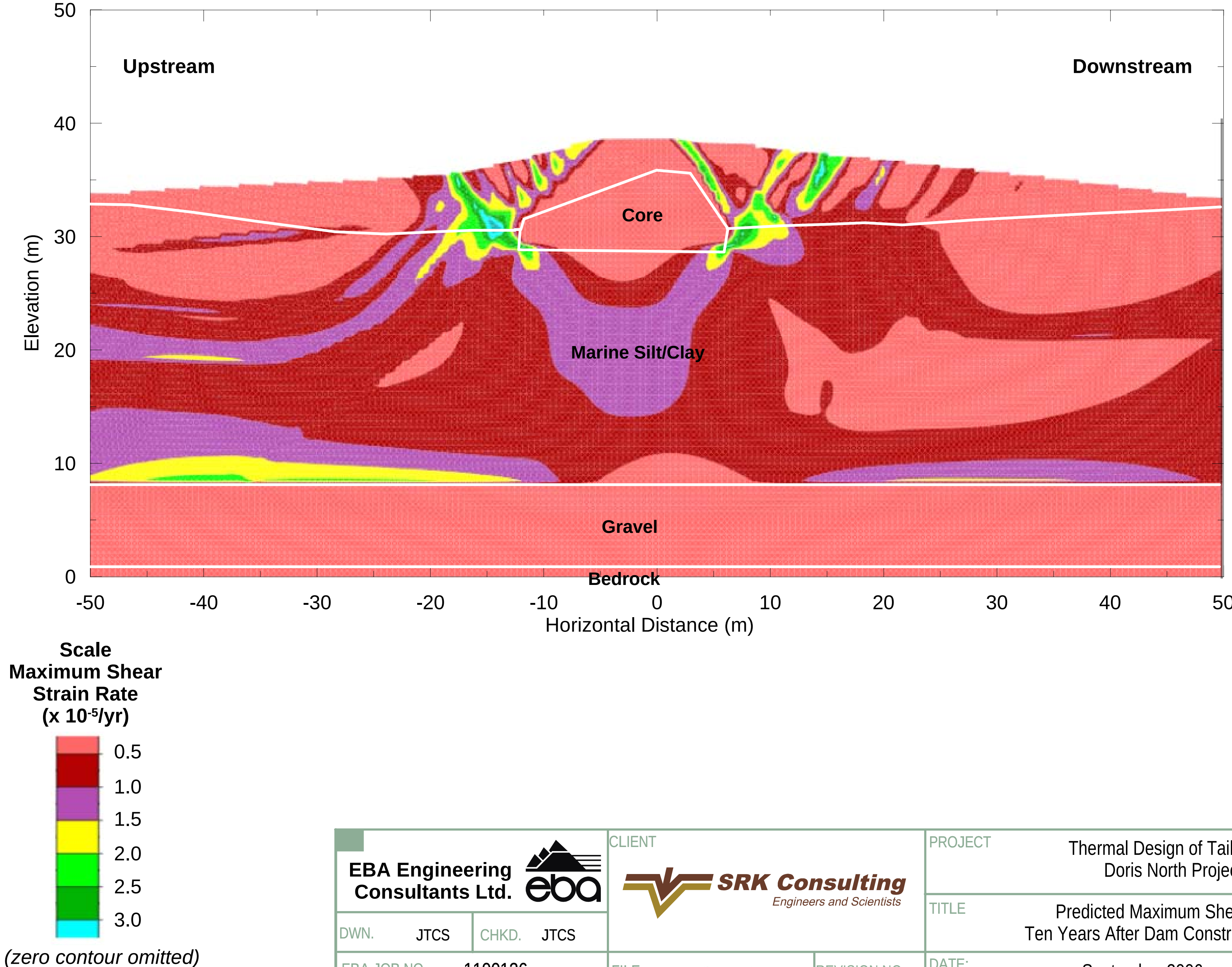

EBA Engineering Consultants Ltd.	CLIENT SRK Consulting Engineers and Scientists	PROJECT	Thermal Design of Tailings Dams Doris North Project, NU
DWN. JTCS / CHKD. JTCS		TITLE	Predicted Maximum Shear Strain Rate Ten Years After Dam Construction, South Dam
EBA JOB NO. 1100126	FILE: 1100126fig33.grf / REVISION NO.:	DATE: September 2006	Figure 33

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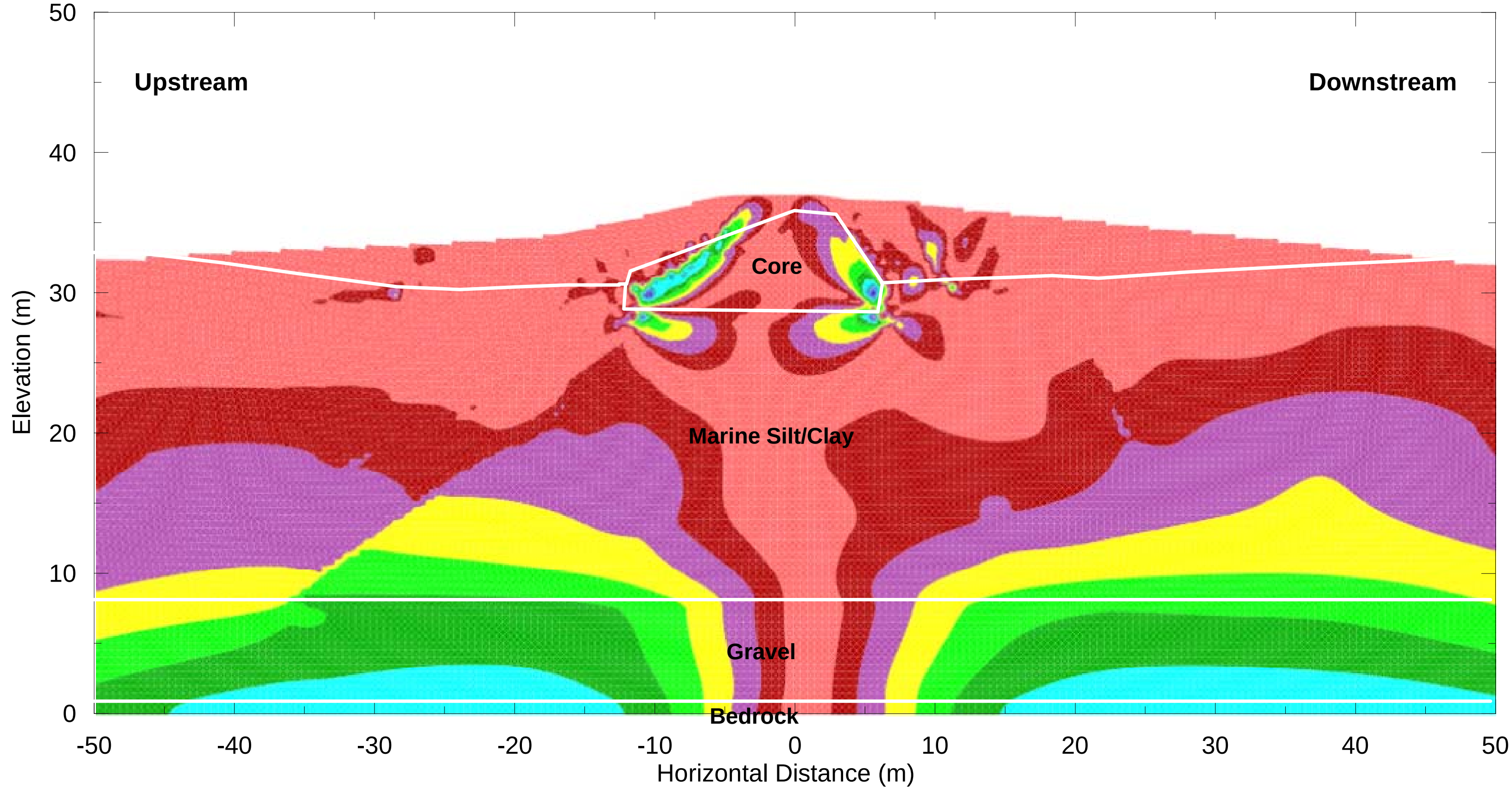

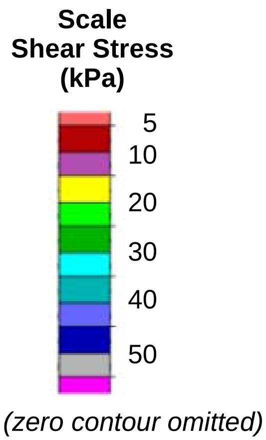

EBA Engineering Consultants Ltd.	CLIENT: SRK Consulting, Engineers and Scientists	PROJECT: Thermal Design of Tailings Dams, Doris North Project, NU	
DWN. JTCS / CHKD. JTCS		TITLE: Predicted Shear Stress Distribution, Ten Years After Dam Construction, South Dam	
EBA JOB NO. 1100126	FILE: 1100126fig34.grf / REVISION NO.:	DATE: September 2006	Figure 34

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Appendix C

SRK Technical Memorandum re: Water Cover Design for Tail Lake

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Technical Memorandum

To:	Brian Labadie	**Date:**	September 16, 2005
cc:	Project File	**From:**	Maritz Rykaart, Ben Wickland
Subject:	Water Cover Design for Tail Lake	**Project #:**	1CM014.006

1 Introduction

This technical memorandum documents the design procedure, calculations and assumptions for the minimum water cover thickness of Tail Lake. Tail Lake will be used to sub-aqueously deposit tailings from the Doris North Project, and upon final closure there will be a permanent water cover over the tailings of 4.0 m. The calculations documented in this memorandum provide justification that this water cover is adequate.

The primary purpose of a water cover is to ensure that the covered mine waste, in this case tailings, is kept from oxidizing. Oxidizing will result in geochemical changes to the tailings, which in turn will result in poor quality water. It is generally understood that a stagnant water column of 0.3 m is sufficient to prevent oxidization of the underlying waste; however, in nature the water column cannot be stagnant, and as a result the tailings bed stability is affected through physical processes such as wave action, seiching, seasonal lake turnover, currents, and ice entrainment. The general rule of thumb is therefore to ensure a water cover of at least 1.0 m, to counter these processes. Such rules of thumb are however only a guideline, and cannot be used for an actual water cover design.

According to the MEND 1998 guidelines (MEND 1998), the objective of water cover design is: *"…to provide an adequate depth of water to ensure the consolidated bed of tailings is not entrained or remobilized during operation and after closure of the pond."* The water cover must be deep enough that the tailings do not become re-suspended due to wind generated waves and currents. Re-suspension occurs when the resistance of the bed of tailings is overcome by action of overlying water. The resistance of the bed is dependent on particle size, density, and cohesion. The action of the overlying water-wave action is dependent on:

- fetch length, the maximum distance of water over which waves may be generated,
- wind speed, for a maximum return period, and
- wind direction, duration.

This technical memorandum presents the design calculations for a minimum water cover thickness to prevent re-suspension from occurring.

2 Water Cover Design Approach

The current state-of-the art in water cover design is the procedure documented in MEND (1998). According to this guideline, there are five processes that affect bed stability; seiching, seasonal lake turnover, currents, wave action and ice entrainment. The guideline suggest that for small tailings impoundments (less than 5 km^2 water body area), and a water depth of 0 to 10 m, that only wave action and ice entrainment need to be accounted for in the design. Since the Tail Lake water body will vary in size between 81 and 130 ha (0.8 to 1.3 km^2), and its depth is between 4.0 and 9.2 m (this is based on the water level in Tail Lake ranging between 28.3 m and 33.5 m, with the tailings at an elevation of 24.3 m), it clearly falls within this category.

Note that the surface areas quoted for Tail Lake in this technical memorandum is based on the engineering stage curve for Tail Lake which includes the areas leading up to the North and South Dams. The actual body of water in Tail Lake at the normal water elevation of 28.3 m is 76.6 ha (as reported in the NNLP) in size; however, if the surface area leading up to the dams are included, the area increases to about 81 ha.

For re-suspension due to wave action, the MEND (1998) guideline uses the method proposed by Lawrence *et al*. (1991) to determine minimum water cover depth, but couples his approach with a critical bed velocity computation derived from the work of Komar and Miller (1975a,b). Since the modification adopted by MEND (1998) is less conservative than the original Lawrence *et al*. (1991) method, SRK have selected to use both methods in calculating a safe water cover thickness for Tail Lake. Both of these methods provide a way of calculating the minimum water cover depth at which no tailings re-suspension will occur, i.e. if the minimum water cover depth requirement is satisfied, then there will be no re-suspension of tailings.

Mian and Yanful (2001) and Bennet and Yanful (2001) has been documenting their research on water covers, and suggest that the procedures for water cover design, such as those proposed by Lawrence *et al*. (1991) and MEND (1998) are perhaps too conservative, and that water cover design should be based on an allowable re-suspension value, i.e. the water cover can be designed to allow some re-suspension provided that that amount of re-suspension would not result in exceedence of water quality criteria. This research has culminated in the development of a proposed new design methodology for selecting an optimum water cover depth (Samad and Yanful 2005). This method calculates the bed erosion for any specific water cover depth, using a similar wave theory approach as Lawrence *et al*. (1991), but refines it to account for shallow water waves and counter current flow. Furthermore, Samad and Yanful (2005) suggest that the tailings impoundment should be divided into a grid, and a minimum water cover depth requirement at each grid point should be calculated. This refinement accounts for changes in fetch distance and bathymetry at each grid point, and generally results in a reduced minimum water cover depth requirement. The grid method proposed by Samad and Yanful (2005) is less conservative than the methods described by MEND (1998) and Lawrence *et al*. (1991) and was therefore not applied to Tail Lake.

3 Minimum Water Cover Design

3.1 Primary Design Assumptions and Input Data

The primary design variables required for the water cover design using the MEND (1998) and Lawrence *et al*. (1991) methods are summarized in Table 1.

Table 1. Values of water cover design variables

Parameter	Baseline Design Value	Possible Range	Source
Fetch Distance [F]	1,350 m	500 to 3,500	Topographical maps of Tail Lake
Wind Speed [U, U_w]	11.1 m/s	6.1 to 22.2 m/s	Cambridge Bay hourly wind speed data
Threshold Velocity [U_t]	0.04 m/s	0.005 to 0.1 m/sec	Lawrence *et al*. (1991)
Wave Height Ratio [R]	1	Constant	Lawrence *et al*. (1991) & MEND (1998)
Median Particle Size [D_{50}]	0.06 mm	0.0001 to 0.08 mm	SRK 2005
Sediment Density	1,230 kg/m^3	Constant	SRK 2005

3.2 Results

Results of the water cover design calculations are presented in Figures 1, 2, 3 and 4. Each of these figures show the minimum water cover as calculated using both the conservative Lawrence *et al*. (1991) and the less conservative MEND (1998) methods. Figure 1 demonstrates the sensitivity of the calculation to fetch distance. As the fetch distance increases, the minimum water cover depth increases, with the MEND (1998) method suggesting that the water cover should be between 0.4 and 1.6 m over the likely range of fetch distances applicable at Tail Lake. Similarly, according the Lawrence *et al*. (1991) method, the range in water cover should be between 0.8 and 3.3 m.

The effect of wind speed on the water cover is illustrated in Figure 2. With increasing wind speed, the minimum water cover increases. According to the MEND (1998) method, the water cover should be between 0.5 and 1.7 m, whilst the equivalent water cover according to the Lawrence *et al*. (1991) method, should be between 1.0 and 3.0 m.

The MEND (1998) method uses the median particle size as a variable to account for bed shear stress, whilst the Lawrence *et al*. (1991) method uses the particle threshold velocity to account for bed shear stress. Figures 3 and 4 present the effect that different values of these properties have on the minimum water cover. As can be seen in Figure 3, as the median particle size increase, the required water cover decreases. For the range of likely particle sizes in the Doris North Project this will result in a range in water cover between 0.8 and 2.0 m. Similarly, as the threshold velocity increases, the water cover reduces for a likely range of 1.2 to 2.8 m of water cover, as illustrated in Figure 4.

For the chosen design parameters as listed in Table 1, the minimum water cover, depending on the calculation method used, ranges between 0.8 and 1.7 m. Using the values in the range of design parameters for each variable that would result in the most significant water cover, i.e. the maximum fetch distance, the maximum wind speed, the smallest median particle size and the lowest threshold velocity, results in a minimum water cover requirement of between 2.2 and 3.6 m, depending on which method is used. This is however a worst case scenario, included to demonstrate sensitivity of the calculation methods.

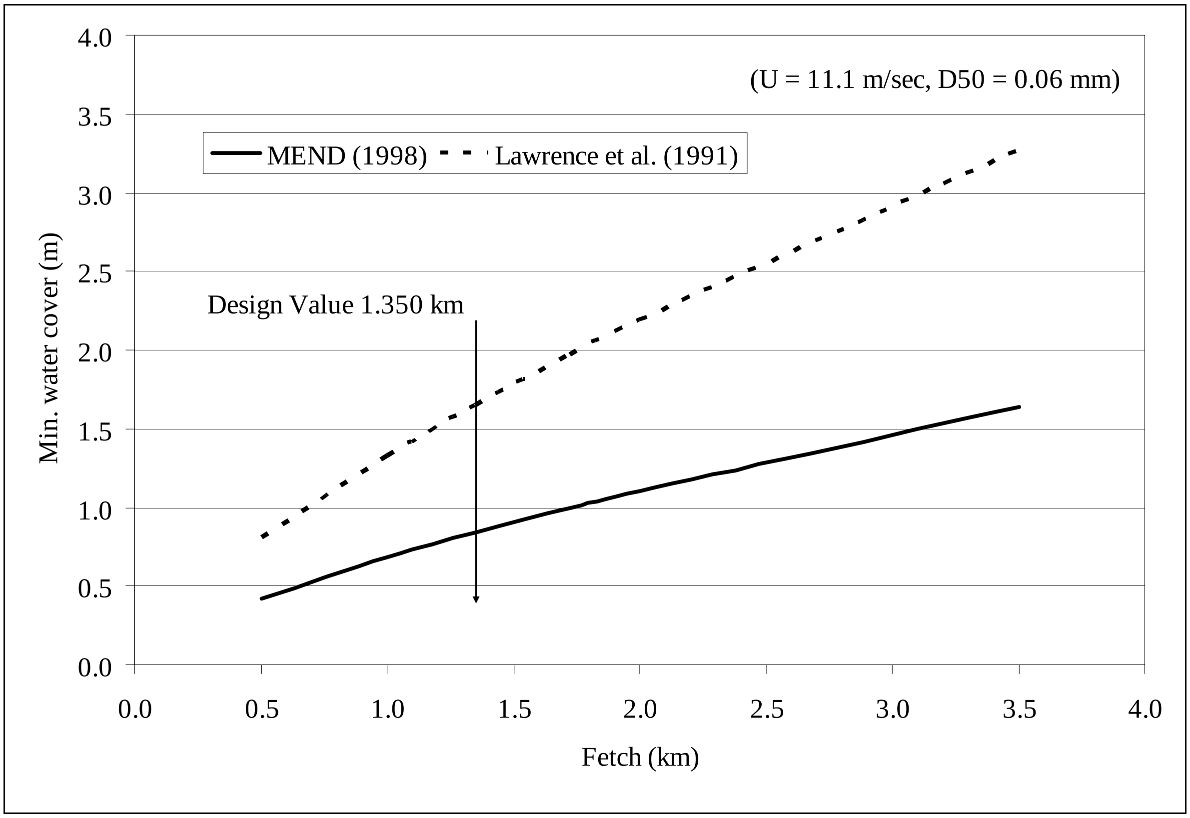

Figure 1. Water cover versus fetch distance

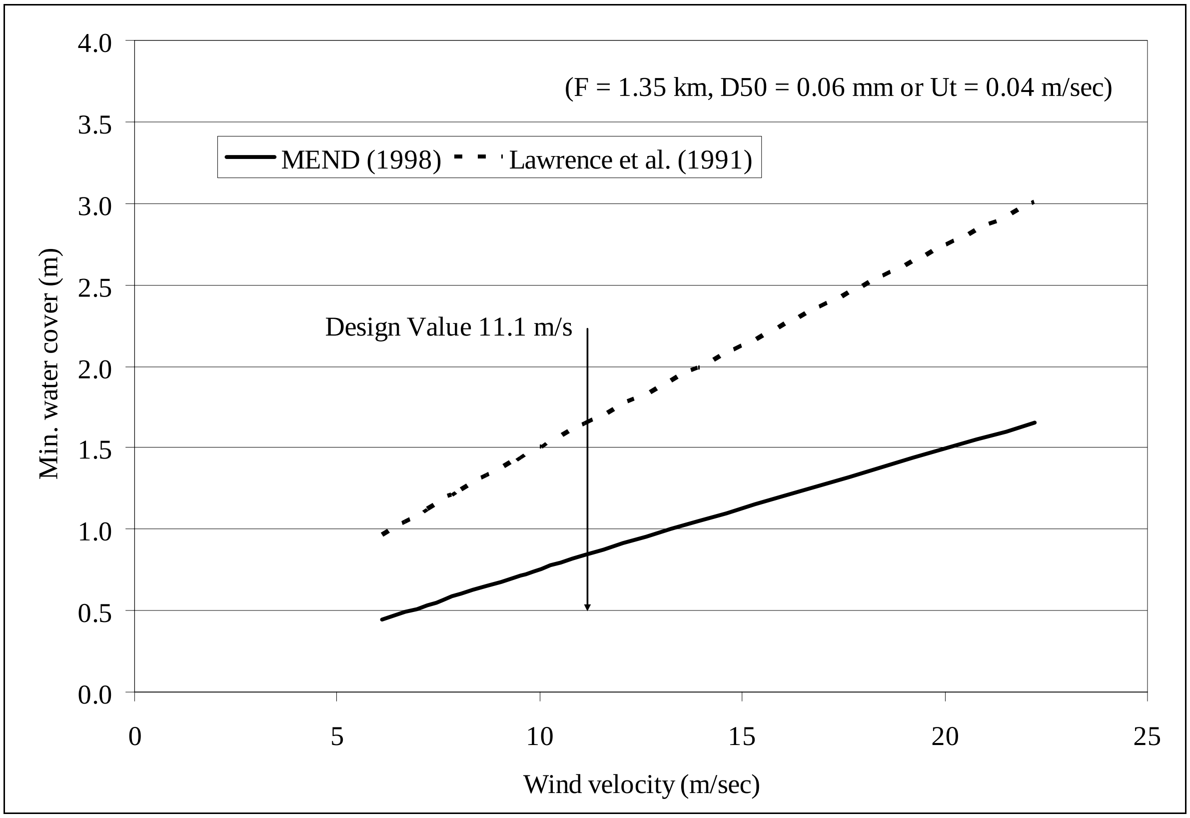

Figure 3. Water cover versus wind velocity

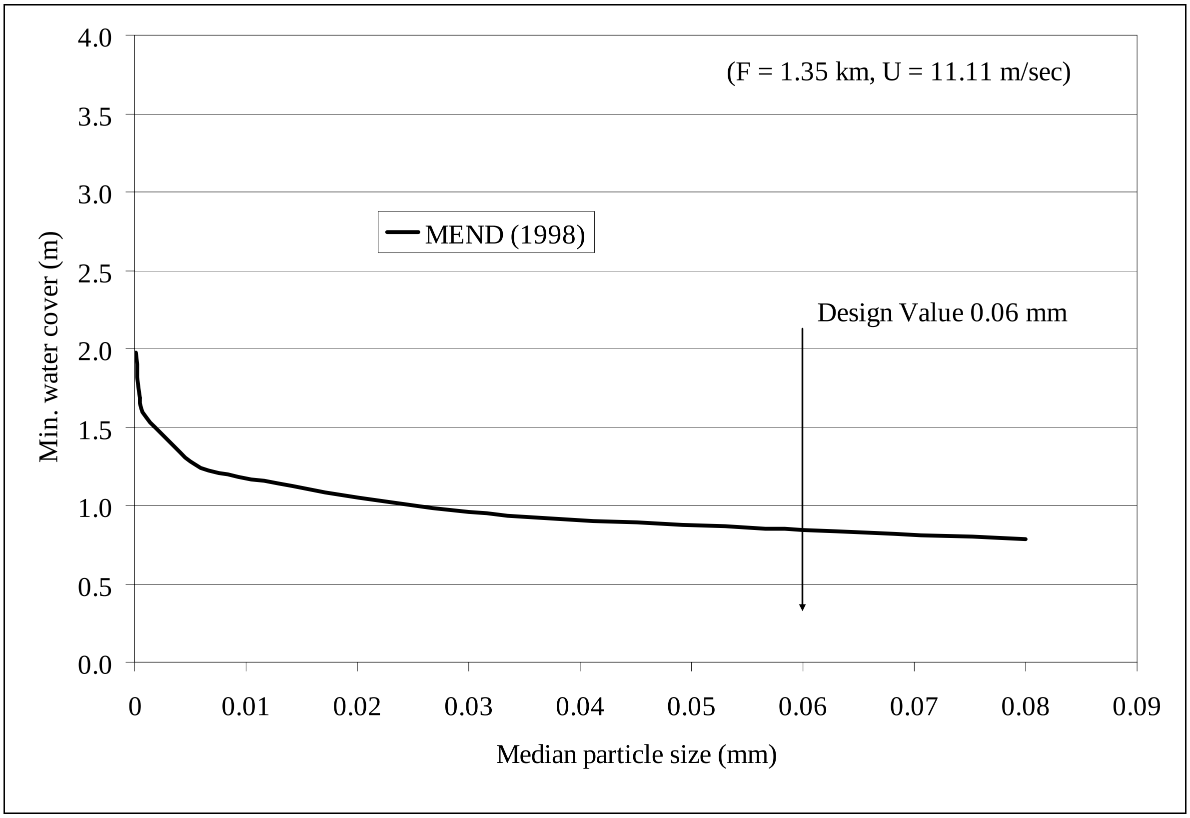

Figure 3. Water cover versus median particle size

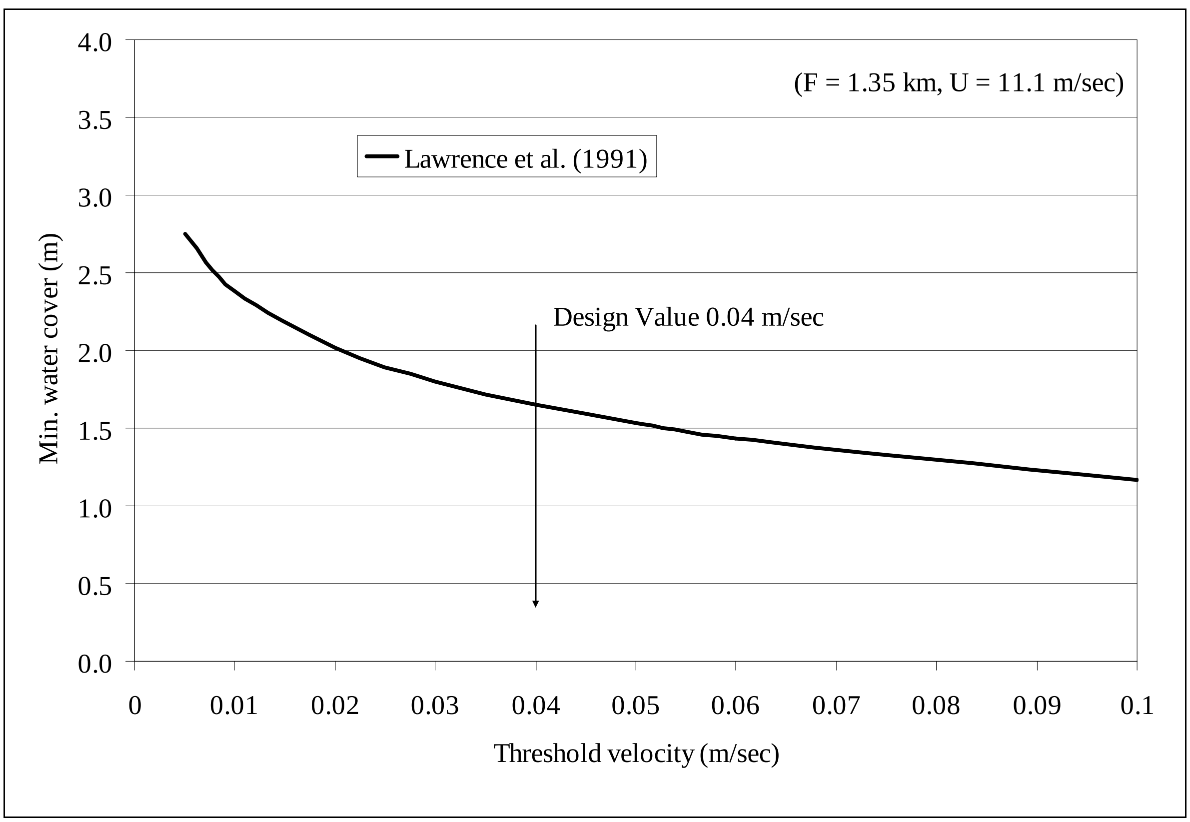

Figure 4. Water cover versus threshold velocity

3.3 Validity of Lawrence *et al*. (1991) and MEND (1998) Results

The water covers determined using the Lawrence *et al*. (1991) and MEND (1998) procedures assumes that wave development is consistent with deep water wave theory. Deep water wave theory applies when the ratio of water depth over wavelength is less than 0.5, which is a condition which is typically not met for shallow water covers (typically less than 5 m deep). Under such circumstances, shallow water wave theory must be applied, which results in calculating smaller significant wave heights and shorter significant wave periods.

Both the Lawrence *et al*. (1991) and MEND (1998) design procedures suggest that the water cover design does not apply if the deep water wave condition cannot be met; however, they do not propose a solution to overcome this problem. Samad and Yanful (2005) does provide a procedure to calculate the significant wave height and period using shallow wave theory, and SRK conducted a sensitivity analysis on the range of input parameters evaluated for Tail Lake to determine how much the significant wave height and significant wave period would vary if the appropriate wave theory was applied. The results of this sensitivity analysis are presented in Figures 5 and 6. SRK then substituted the appropriate shallow water wave theory significant wave height and wave period values into the Lawrence *et al*. (1991) and MEND (1998) design procedures and concluded that there was an overall variance in the design water cover of 4%, which only applied to shallow covers of less than 1 m thick. Therefore, SRK is satisfied that the design water covers are appropriate.

To summarize, the minimum water covers, based on wave action for the Doris North Project will be between 0.83 and 1.7 m, depending on which calculation method is used (this assumes a correction for the shallow wave theory). However, since the MEND (1998) method is considered the current state-of-the art method in calculating minimum water covers, the overall recommended minimum water cover due to wave action is 0.83 m.

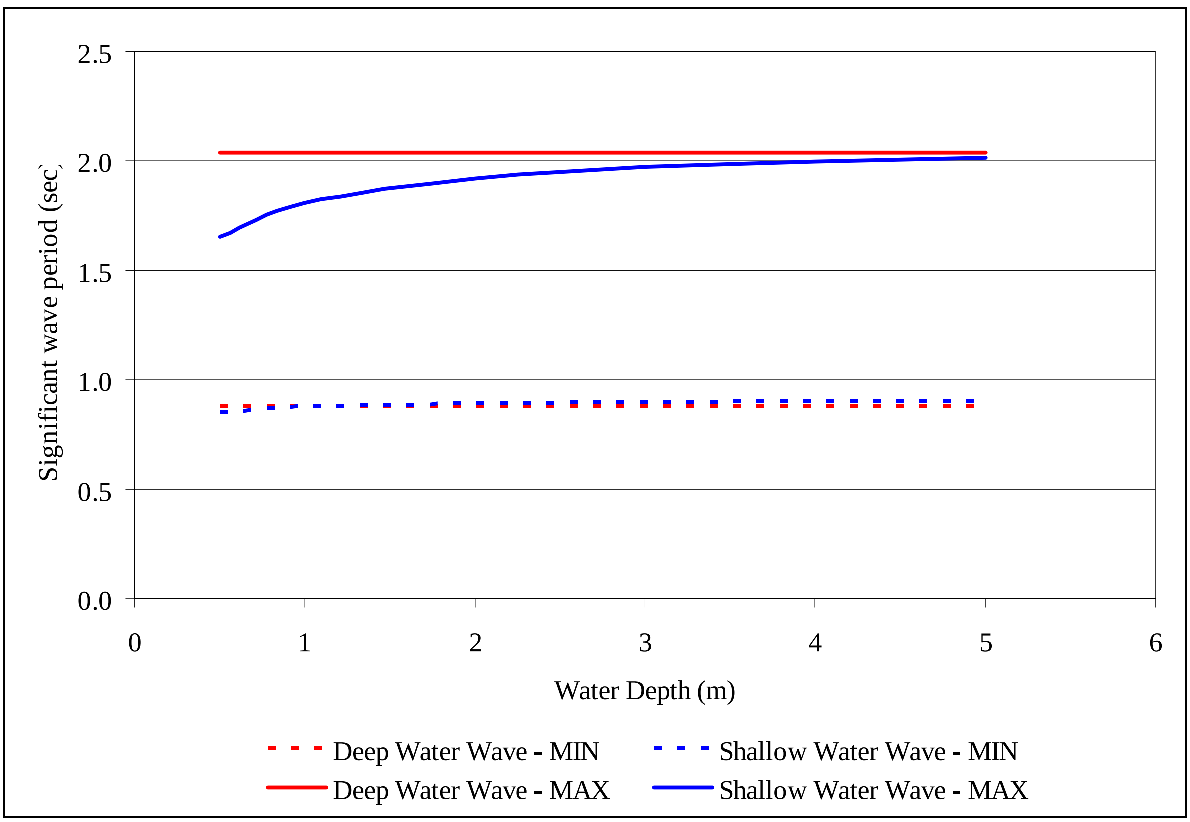

Figure 5. Variation of the significant wave period over different water covers using both shallow and deep water wave theory

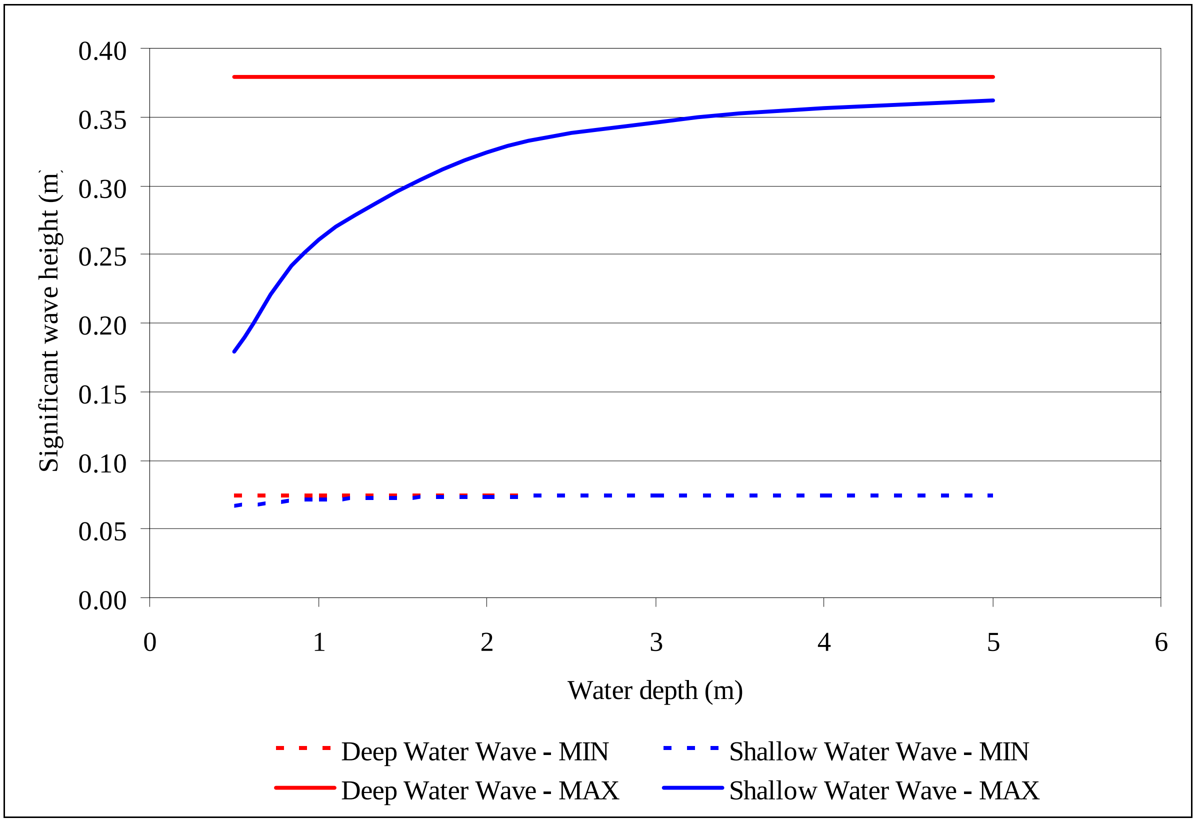

Figure 6. Variation of the significant wave height over different water covers using both shallow and deep water wave theory

3.4 Ice Entrainment

The MEND (1998) guideline recommends that the minimum water cover should be at least 10% greater than the maximum lake ice thickness that the pond might incur. A detailed study of lake ice thickness has not been conducted at Tail Lake; however, select ice thickness measurements during water sample and drilling programs suggest that the maximum lake ice thickness varies between 1.9 m and 2.2 m. Regional studies on lake ice thickness confirm that a reasonable maximum ice thickness at Tail Lake is probably around 2.2 m. Therefore, the minimum water cover to prevent tailings re-suspension through ice entrainment is 2.2 m + 10% = 2.42 m.

This value is greater than the selected design criteria for minimum water cover due to wave action, and therefore the specified minimum water cover for Tail Lake will be dominated by ice the ice entrainment value of 2.42 m. Furthermore, since the operating water cover would be 4.0 m, there is a significant factor of safety against ice entrainment. Conversely, the tailings surface could be up to 1.58 m above the design elevation of 24.3 m before ice entrainment would start to contribute towards tailings re-suspension.

Providing a 1.0 m allowance for an uneven final tailings deposition surface, would result in the minimum water cover depth being reduced to 3.0 m, which in turn implies that the factor of safety against ice entrainment reduces slightly, but still remain significant. Figure 7 presents a schematic of Tail Lake, including the deposition zones of tailings, confirming that at any given time, assuming level tailings surface, the minimum water cover depth of Tail Lake would be 4.0 m.

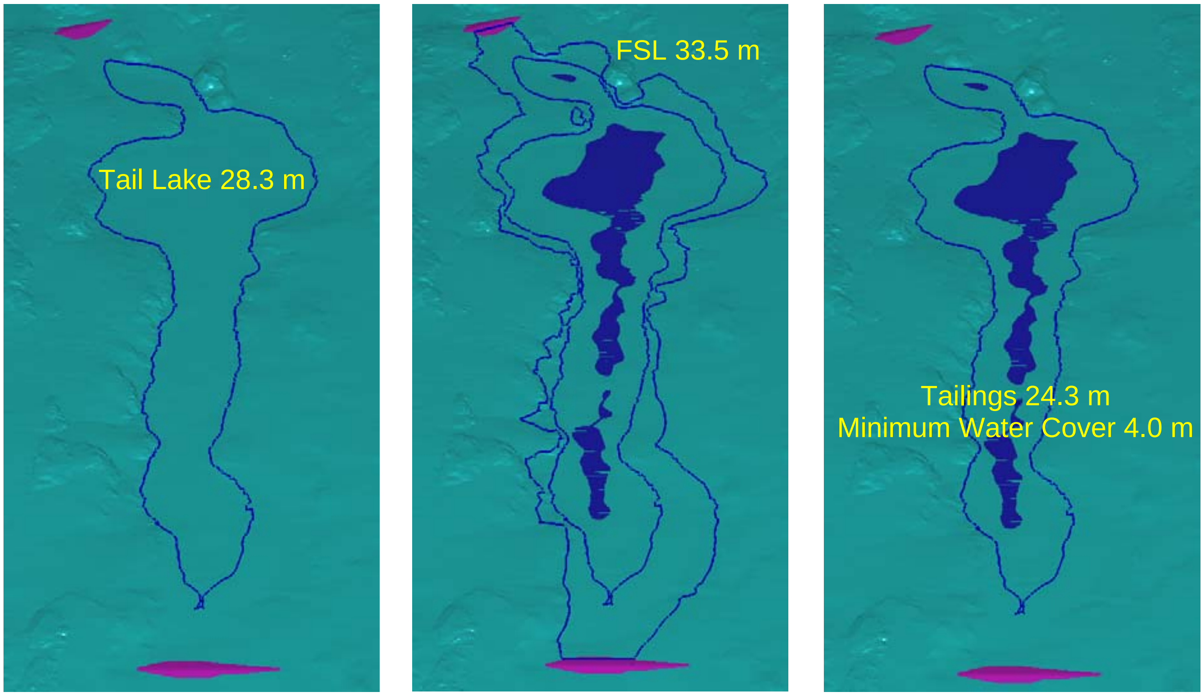

Figure 7. Schematic of tailings deposition location in Tail Lake

3.5 Extreme Drought Conditions

The design guideline by MEND (1998) states that the water cover should be designed taking into account standard water balance principles; however, it does not provide any procedure for taking into account drought conditions. Yanful (2005) documents a detailed procedure to account for drought conditions in the evaluation of a minimum water cover design.

Due to the substantial factor of safety available for the minimum water cover at Tail Lake, SRK opted to consider the effect of a severe drought on the water cover using a simplified procedure. The basic assumptions of this analysis can be summarized as follows:

- Tail Lake elevation at start of drought = 28.3 m (i.e. the post closure scenario)
- 5-year long drought
- Zero precipitation for entire duration (no rain or snow)
- 20% above average lake evaporation (i.e. 220 mm + 20% = 264 mm)

Applying these conditions, would result in a final lake water elevation in Tail Lake after the drought of 27.0 m. At this time, the minimum water cover depth over the tailings (at elevation 24.3 m) would be 2.7 m.

Furthermore, it should be noted that the total volume of water lost during this simulated drought is just under 1.0 million m^3, or 48% of the total volume of free water in Tail Lake (i.e. the volume excluding tailings). Under average climatic conditions it would take two years before the water level will reach the natural outflow elevation of 28.3 m, providing ample time for settlement, should any particles be re-suspended in any way.

This evaluation of a drought is extremely conservative, but still the minimum design water cover criteria are upheld, for wave action and ice entrainment. As before, providing a 1.0 m allowance for an uneven final tailings deposition surface would result in the minimum water cover depth during an extreme drought being reduced to 1.7 m. Under such a scenario, the minimum water cover requirement against wave action would still be upheld; however, ice entrainment can occur.

This is however not a significant concern, since as described above under such severe drought conditions, Tail Lake water cannot flow out of the basin, since the natural outflow elevation is at 28.3 m. Considering the fact that it would take two years before outflow would start again ice entrainment during drought conditions is not considered a concern.

3.6 Minimum Water Depth Requirement for Bed Stability

Table 2 summarizes the minimum water cover requirements to ensure bed stability as described in the preceding sections. It is clear that the dominating process in determining the water cover is ice entrainment. Therefore, the minimum water cover for Tail Lake should be 2.42 m. This implies that the tailings surface can have undulations up to 1.58 m high, allowing a substantial safety margin.

Furthermore, as demonstrated in the preceding sections, using the most conservative calculation method, and the worst case input variables, the maximum water cover would have to be 3.6 m, which still leaves a safety margin of 0.4 m. There is therefore no doubt that the 4.0 m water cover is sufficient to prevent tailings re-suspension in Tail Lake.

Table 2. Summary of minimum water cover requirements for Tail Lake

Condition	Design Value
Planned final tailings surface	24.3 m
Final water level in Tail Lake	28.3 m
Planned water cover thickness	4.0 m
Possible loss in water cover thickness due to uneven tailings deposition	1.0 m (remaining water cover = 3.0 m)
Possible loss in water cover thickness due to drought conditions	1.3 m (remaining water cover = 2.7 m)
Possible loss in water cover thickness due to uneven tailings deposition and drought conditions simultaneously	2.3 m (remaining water cover = 1.7 m)
Minimum water cover due to wave action (deep water wave theory)	0.80 m
Minimum water cover due to wave action (shallow water wave theory)	0.83 m
Minimum water cover due to ice plucking	2.42 m

4 References

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Appendix D

Winter 2006 Geotechnical Field Investigation (SRK 2006)

Winter 2006 Geotechnical Field Investigation and Geophysical Survey at Tail Lake, Doris North Project, Nunavut, Canada

Prepared for

Miramar Hope Bay Limited

Prepared by

SRK Consulting
Engineers and Scientists

August 2006

Winter 2006 Geotechnical Field Investigation and Geophysical Survey at Tail Lake, Doris North Project, Nunavut, Canada

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SRK Project Number 1CM014.008-210

August 2006

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Principal Engineer

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1 Introduction

1.1 Background

Miramar Hope Bay Limited (MHBL) is in the process of preparing final detailed engineering designs for the Doris North Project located in the Hope Bay Belt, Nunavut. MHBL contracted SRK Consulting (Canada) Inc. (SRK) to carry out additional geotechnical field investigations to support the final design of the tailings impoundment. This field program, which was carried out in April and May 2006 was specifically designed to achieve the following objectives:

- Confirmation and infill foundation characterization drilling upstream and downstream of the two tailings dams, i.e. the North and South Dams.
- Carry out annual thermistor maintenance on the 32 thermistors that has been installed since 2003 in the belt, and to update the thermal database.
- Attempt to conduct a geophysical survey of the ice-rich permafrost overburden around Tail Lake and along the two dam footprints, to possibly allow for a more comprehensive characterization of potential shoreline erosion zones.

This report presents the results of the study as described.

1.2 Summary of Field Program

The confirmation and infill drill program was to include ten drill holes, three at each dam, one along the North Dam spillway, and the remaining three at selected locations around Tail Lake. Unseasonably warm conditions however resulted in the program being shut down after completing only two drill holes at the South Dam (Figure 2).

All the thermistors were physically inspected by an SRK engineer and regular maintenance was carried out on thermistors to ensure that they remain operational as long as possible. Data was manually collected from all thermistors during the summer season, and this report includes all updated data received to the end of September 2006.

A geophysical survey was attempted to try and determine the ice content in the permafrost overburden. A specialist subcontractor tried four different geophysical techniques with varying degrees of success. Geophysical techniques are not well suited to ice-rich permafrost in a saline environment, and ultimately the only useful information that could be gleaned was depth to bedrock in shallow overburden zones using Ground Penetrating Radar.

Throughout the field program the weather conditions was relatively unseasonable, and highly variable. Winds were generally from the north and northeast at 5-20 km/h, with daytime temperatures reaching 8°C and overnight lows down to of -25°C. During the program, conditions ranged from sunny clear skies to overcast with blizzards and freezing rain.

2 Methodology

2.1 Drilling

The Tail Lake boreholes were drilled using the HQ3 (61mm core, 96mm hole diameter) triple tube diamond coring system with a Boyle 17 hydraulic drill rig. To ensure recovery of the ice-rich overburden the drilling fluid had to be chilled to below 8^{o}C. A chiller was not available, so the chilled brine was made by mixing water from Tail Lake with sodium chloride and adding snow and ice to cool the liquid down. Due to the unseasonably warm weather the brine could seldom be chilled to lower than about -2^{o}C.

From past experience the maximum run length of the drill was set at about 1.5 m. As recovery dropped, run lengths were reduced even further. Drilling was done using 2 crews, working 12-hour shifts.

SRK engineers Messrs. Alvin Tong, E.I.T. and Lowell Wade, E.I.T. supervised the drill, logged the core, and collected representative soil samples for geotechnical testing. Samples were shipped to EBA Engineering's soil testing laboratories in Yellowknife and Edmonton. All remaining core is stored in core boxes, outside, under ambient conditions at Windy Camp.

The drill hole locations were set out by MHBL according to co-ordinates provide by SRK. Survey details of the completed drill holes are listed in Table 1.

Table 1: As-Built Drill Hole Coordinates

Hole ID	Northing[1]	Easting[1]	Inclination
SRK06-01	7555903.0	435623.0	-90°
SRK06-12	7555939.0	435590.0	-90°

1. UTM Projection NAD 83 Zone 13.

2.2 Laboratory Testing

A total of 24 bulk (i.e. disturbed) soil samples were collected and shipped to the laboratory. Seven of these samples were ultimately subjected to basic foundation indicator and salinity testing. Table 2 summarizes the samples collected and the testing carried out.

Table 2: Laboratory Testing Program

Sample [ID:Depth (Type)][1]	Natural Moisture Content	Particle Size Distribution		Atterberg Limits	Salinity
		Sieve	Hydrometer		
SRK06-01-01: 2.0m (CL)[2]					
SRK06-01-02: 4.4m (CL)					
SRK06-01-03: 5.4m (CL)	✓	✓	✓	✓	✓
SRK06-01-04: 8.0m (CL)					
SRK06-01-05: 9.5m (CL)					
SRK06-01-06: 12.0m (CL)	✓	✓	✓	✓	✓
SRK06-01-07: 16.0m (CL)					
SRK06-01-08: 18.0m (CL)					
SRK06-01-09: 19.3m (CL)					
SRK06-01-10: 21.3m (CL)	✓	✓	✓	✓	✓
SRK06-02-01: 0.6m (CL)	✓	✓	✓	✓	✓
SRK06-02-02: 3.7m (CL)					
SRK06-02-03: 5.5m (CL)					
SRK06-02-04: 7.3m (CL)					
SRK06-02-05: 10.3m (CL)					
SRK06-02-06: 11.8m (CL)	✓	✓	✓	✓	✓
SRK06-02-07: 13.2m (CL)					
SRK06-02-08: 14.7m (CL)					
SRK06-02-09: 16.7m (CL)					
SRK06-02-10: 19.0m (CL)	✓	✓	✓	✓	✓
SRK06-02-11: 24.5m (ML)[3]					
SRK06-02-12: 25.7m (ML)					
SRK06-02-13: 28.6m (ML)	✓	✓	✓	✓	✓
SRK06-02-14: 31.0m (ML)					

1. Soil type is designated soil symbol according to the Unified Soil Classification System (USCS).
2. CL = Clay.
3. ML = Silt.

2.3 Thermistor Maintenance

A total of 33 thermistor strings has been installed at the Doris North project site since 2003. Table 3 summarize the details of these strings, and their locations are depicted on Figure 3. An SRK engineer visited each of the 31 strings that are still operational, to collect data and to conduct maintenance and repair as necessary. Miramar staff continued to take regular readings of all thermistor strings during the summer months and Appendix C-1 and C-2 contain the complete updated data for all strings up to September 30, 2006.

Table 3: Doris North Project Site Thermistors

Drill Hole Number	String Serial Number	Number of Beads	String Status	Reference Document
SRK-11	00577-2	5	Working	SRK 2003a
SRK-13	00577-1	5	Broken – unrepairable	SRK 2003a
SRK-14	690007	6	Working	SRK 2003a
SRK-15	690012	10	Working	SRK 2003a
SRK-16	00577-3	5	Working	SRK 2003a
SRK-19	690006	6	Working	SRK 2003b
SRK-20	690009	6	Working	SRK 2003b
SRK-22	690003	6	Working	SRK 2003b
SRK-23	690008	6	Working	SRK 2003b
SRK-24	690001	6	Working	SRK 2003b
SRK-26	690002	6	Working	SRK 2003b
SRK-28	690011	6	Working	SRK 2003b
SRK-32	690010	6	Working	SRK 2003a
SRK-33	690005	6	Working	SRK 2003a
SRK-34A	690004	6	Working	SRK 2003a
SRK-35	690000	6	Working	SRK 2003b
SRK-37	690013	10	Working	SRK 2003a
SRK-38	TS0015	8	Working	SRK 2003a
SRK-39	TS0011	8	Working	SRK 2003a
SRK-40	TS0014	8	Working	SRK 2003a
SRK-41	TS0012	9	Working, 9th bead broken	SRK 2003a
SRK-42	TS0013	8	Working	SRK 2003a
SRK-43	TS0010	8	Working	SRK 2003a
SRK-50	TS1618	13	Working	SRK 2005a
SRK-51	TS2048	12	Working	SRK 2005b
SRK-52	TS2047	12	Working	SRK 2005b
SRK-53	TS1625	6	Working	SRK 2005b
SRK-54	TS1626	6	Working	SRK 2005a
SRK-55	TS1624	6	Broken – unrepairable	SRK 2005a
SRK-56	TS1621	6	Working, last 3 beads broken	SRK 2005a
SRK-57	TS1623	6	Working, two internal beads broken	SRK 2005b
SRK-58	TS1622	6	Working	SRK 2005b
SRK-62	TS2046	12	Working	SRK 2005b

2.4 Geophysics

SRK contracted Associated Mining Consultants Ltd. (AMCL) to carry out a two-phase geophysical survey on the ice-rich saline permafrost soils along the two dam alignments and along the entire Tail Lake perimeter. The first phase entailed carrying out a test survey using four different geophysical techniques, to determine which technique would be best suited to achieve the study objectives. The four techniques used included electrical imaging, time domain electromagnetics, seismic refraction and ground penetrating radar. The test sections was at the two dam locations, which could readily be correlated with good quality drill hole data.

Based on the results of the phase one test surveys, it was concluded that the second phase coverage would only be conducted using the ground-penetrating radar (GPR). The entire lake perimeter along the proposed full supply level (FSL) of 33.5 m was subsequently surveyed using the GPR.

3 Results of Drilling Program

3.1 Summary of Drill Hole Profiles

3.1.1 SRK06-01

SRK06-01 is a vertical hole that extends to a depth of 24.5 m. Sample recovery was about 90% over the entire length of the hole.

The stratigraphy consists of 0.2 m of surface organics and peat overlying 6.2 m of frozen sandy silt. Below this layer there was a 16.1 m thick layer of ice-rich silt and clay. The next soil unit is a thin veneer of silty sand with gravel, immediately above Gabbro bedrock, which is at 24.3 m.

3.1.2 SRK06-02

SRK06-02 is a vertical hole that extends to a depth of 35.6 m. During the drilling of this hole the brine could not be sufficiently chilled, with the resultant effect that only about a 65% core recovery was achieved.

This hole consists of 0.5 m of surface organics and peat overlying 5.0 m of sandy silt, overlying a 13.0 m thick layer of ice-rich silt and clay. This unit was followed by a thin layer of sand and gravel after which Gabbro bedrock was encountered at a depth of 34.7 m.

3.2 Laboratory Testing Results

Seven samples were subjected to basic foundation indicator testing, with the primary results summarized in Table 4. Complete laboratory data sheets are included as Appendix C.

Table4: Results of Foundation Indicator Testing

Sample [ID:Depth (Type)]	Salinity (ppt)	Water Content (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)
SRK06-01-03: 5.4m (CL)	67	27.0	29	17	12
SRK06-01-06: 12.0m (CL)	44	57.3	44	22	22
SRK06-01-10: 21.3m (CL)	67	27.1	38	20	18
SRK06-02-01: 0.6m (CL)	6	63.3	33	22	11
SRK06-02-06: 11.8m (CL)	6	46.3	43	22	21
SRK06-02-10: 19.0m (CL)	80	68.0	37	19	18
SRK06-02-13: 28.6m (ML)	86	20.8	N/A	N/A	N/A

4 Results of Geophysical Survey

Since geophysical mapping of ice-rich saline permafrost poses significant technical challenges, four different techniques was first tried along the North and South Dam center lines where drill hole data was readily available with which to calibrate the geophysics. Electrical imaging (OhmMapper), time domain electromagnetic (TEM), and ground penetrating radar (GPR) was tested at the South Dam and seismic refraction and TEM was tested at the North Dam.

The OhmMapper results showed poor penetration into the conductive clays close to surface. The signal was limited to the first 2 or 3 m of the profile after which it becomes noisy and the data showed poor correlation if any with the drill hole data.

TEM data was also very noisy, and although a number of different field settings were tested, the inverted model could not converge to an acceptable solution.

The seismic refraction data did yield some interesting results, and it was possible, at least for some tested sections, to accurately map the boundary between frozen overburden and bedrock. Unfortunately, the interpreted profile was not supported by the drill holes in all locations, and AMCL concluded that the small contrast in velocity between frozen soil and the underlying basalt is probably the primary reason.

Subsequently, the OhmMapper, TEM and seismic refraction technique was not used in the second phase of the study.

The GPR did yield reasonably useful data; however, the penetration was limited to between 5 and 10 m. Within the limit of penetration, the GPR could also be used to indicate the silt and clay to sand and gravel interfaces. Appendix D contains the complete AMCL report, which includes complete profiles of the Tail Lake perimeter along which the GPR survey was done.

5 Discussion

The drilling program could not be completed as planned due to unseasonably warm conditions, which prevented the drilling fluid from being chilled sufficiently. The two holes that could be completed at the South Dam confirm that the foundation conditions along the dam centerline is consistent with that at some distance immediately upstream and downstream of the dam centerline. This provides sufficient confidence that the current foundation information available for the two tailings dams is sufficient.

Of the four geophysical techniques tested, only the GPR yielded useful data. The maximum penetration achieved with the GPR was limited to between 5 and 10 m, and did manage to identify the frozen ground to bedrock interface if it fell within the penetration depth. The GPR could also in some instances identify the silt and clay interface with sand and gravel.

The entire Tail Lake perimeter along the proposed full supply level (35.5 m) was profiled using the GPR, and provides some infill information useful in characterizing the potential for shoreline erosion around the lake.

This report, **"Winter 2006 Field Investigation and Geophysical Survey at Tail Lake, Doris North Project, Nunavut, Canada"**, has been prepared by SRK Consulting (Canada) Inc.

Prepared by:

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Principal Engineer

6 References

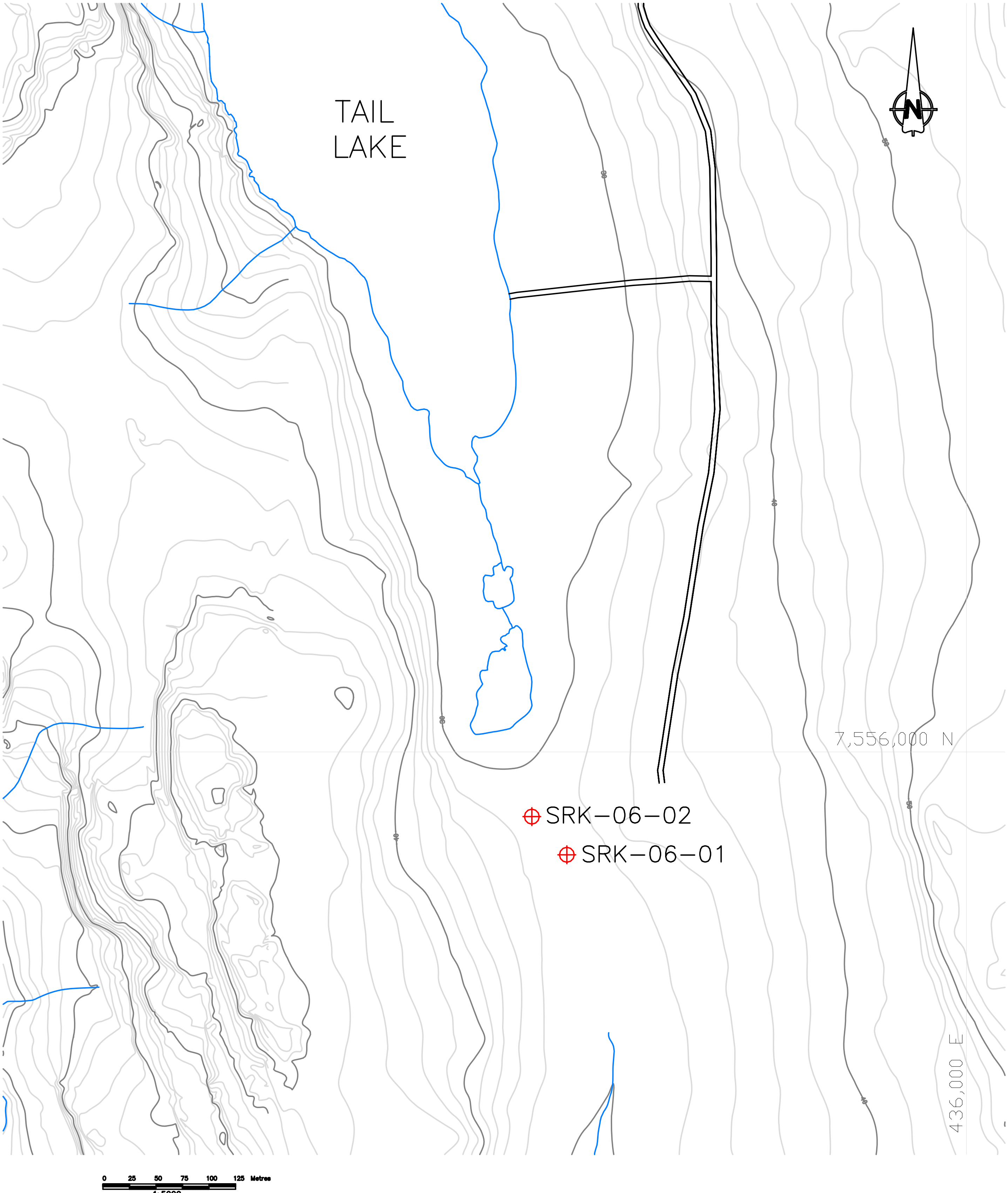
SRK Consulting (Canada) Inc., 2003a. *Tailings Impoundment Preliminary Design, Doris North Project, Nunavut, Canada.* Report submitted to Miramar Hope Bay Ltd., Project No. 1CM014.01, October.

SRK Consulting (Canada) Inc., 2003b. *Surface Infrastructure Preliminary Design, Doris North Project, Nunavut, Canada.* Report submitted to Miramar Hope Bay Ltd., Project No. 1CM014.01, October.

SRK Consulting (Canada) Inc., 2005a. *Summer 2004 Geotechnical Field Investigation at Tail Lake, Doris North Project, Nunavut, Canada.* Report submitted to Miramar Hope Bay Ltd., Project No. 1CM014.04-050, April.

SRK Consulting (Canada) Inc., 2005b. *Winter 2005 Geotechnical Field Investigation at Tail Lake, Doris North Project, Nunavut, Canada.* Report submitted to Miramar Hope Bay Ltd., Project No. 1CM014.04-0110, October.

Figures



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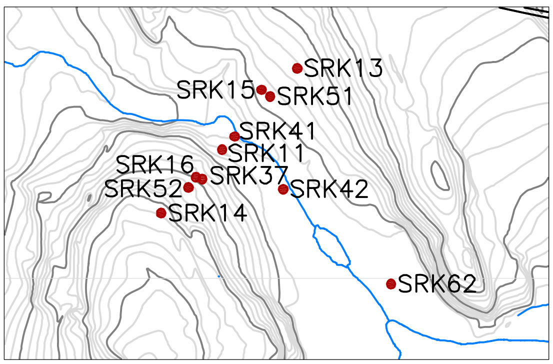
Vancouver

MIRAMAR HOPE BAY LIMITED

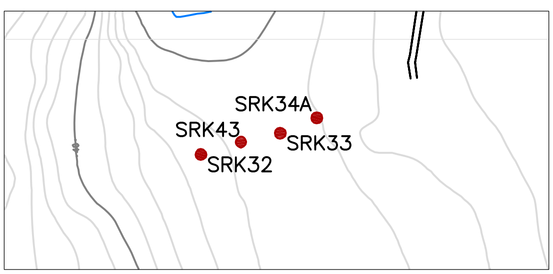
Doris North Project
Winter 2006 Geotechnical Field Investigations

Winter 2006 Drillhole Locations

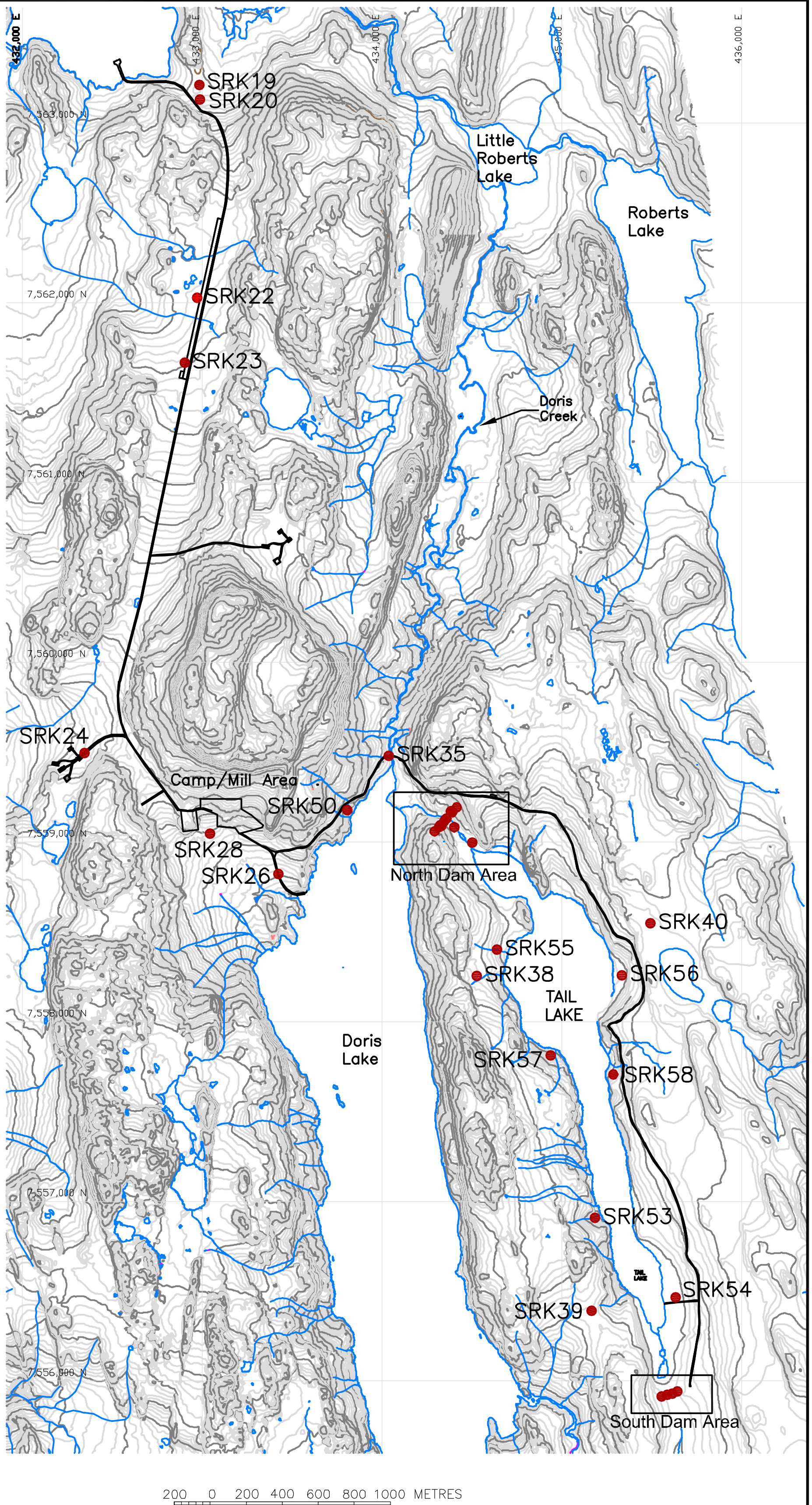
SRK JOB NO.: 1CM014.008	Doris North Project	DATE: Aug. 2006	APPROVED: EMR	FIGURE: 1
FILE NAME: Autocad-2006\Phase 111 Jetty Design\ SITE-MAP.dwg				



North Dam Area



South Dam Area



SRK Consulting Engineers and Scientists Vancouver	MIRAMAR HOPE BAY LIMITED	Doris North Project Winter 2006 Geotechnical Field Investigations
		Thermistor Locations
SRK JOB NO.: 1CM014.008	Doris North Project	DATE: Aug. 2006 — APPROVED: EMR — FIGURE: 2
FILE NAME: Site-Plan-2006_Thermistors.dwg		

Appendix A
Drill Logs

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BOREHOLE LOG

PROJECT: Doris North - Detailed Infrastructure Design
LOCATION: Tail Lake South Dam
FILE No: HOPE BAY (1CM014.008)
BORING DATE: 2006-05-03 **TO** 2006-05-04
DIP: 90.00 **AZIMUTH:**
COORDINATES: 7555903.00 N 435623.00 E **DATUM:**

BOREHOLE: SRK06-01
PAGE: 1 **OF** 2
DRILL TYPE: Triple tube (HQ)
DRILL: Boyles 17
CASING: None

SAMPLE CONDITION
- Remoulded
- Undisturbed
- Lost
- Core

TYPE OF SAMPLER
- DC Diamond core barrel
- GS Grab sample
- SS Split spoon

LABORATORY AND IN SITU TESTS
- C Consolidation
- D Bulk density (kg/m3)
- Dr Specific gravity
- Ksat Saturated hydraulic cond. (cm/s)
- Ku Thermal conductivity Unfrozen (W / m°C)
- Kf Thermal conductivity Frozen (W / m°C)
- PS Particle size analysis

ELEVATION - m / DEPTH - m	DESCRIPTION	SAMPLE TYPE AND NUMBER	RECOVERY %	N or RQD
0.00				
0.00 / -0.20	Organic Peat, Nbn. 10% ice.			
0.20 / -0.26	Ice + Clayey SILT, Tan, 80%			
0.26 / -1.55	Sandy SILT, Tan, with traces of organic (Peaty), Nbe, 20% ice			
1.55 / -1.60	Ice + Sandy SILT, very small amount of organic, 80% ice			
1.60 / -2.80	Sandy SILT with traces of clay, Vr, 6cm thick ice lenses at 2m, 2.4m, 2.6m. 50% ice. Tested brine salinity at 9% and -9c	SRK06-01-01	100	0
2.80 / -4.40	Sandy SILT with traces of clay, Vr, grey, 30% ice	SRK06-01-02	100	0
4.40 / -5.40	Snady SILT with trace of clay, trace of organic at 4.4-4.6m, Vs, 30% ice			
5.40 / -5.70	Sandy SILT, grey, medium toughness, poorly graded, Nbn, 5% ice	SRK06-01-03	100	0
5.70 / -6.40	Sandy SILT as above			
6.40 / -8.00	Silty CLAY, dark grey, dense, Nbn, 5% ice. From 7.5-8m no ice content observed due to thawing. Water pump failed during the drilling unawarely, core came out hot and thawed. Tried to repair pump after notification	SRK06-01-04	100	0
8.00 / -9.50	Silty CLAY, dark grey, very dense, No ice contect observed due to another pump failure			
9.50 / -10.70	Silty CLAY, grey, dense, Vr, 10% ice	SRK06-01-05	100	0
10.70 / -12.50	Silty CLAY, grey with black layers, Vr, 15-20% ice, 2.8m thick ice lenses, clear ice	SRK06-01-06	100	0
12.50 / -13.80	Silty CLAY, dark grey, dense, Vs, 10% ice. Tested brine at 12% salinity and -8c			
13.80 / -15.50	LOSS			
15.50 / -17.00	Silty CLAY, dark grey, dense, Vr, 10% ice. 1.8m thick ice lenses	SRK06-01-07	100	0
17.00 / -18.50	Silty CLAY, dark grey, dense, Vr, 10% ice, 2.5m thick ice lenses	SRK06-01-08	100	0
18.50 / -19.25	Silty CLAY, dark grey, dense, Vr, 5% ice, 1.5cm thick ice lenses			
19.25 / -19.27	ICE			
	Silty CLAY, grey / Silty CLAY, not frozened, firm	SRK06-01-09	100	0

WELL DETAILS & WATER LEVEL - m | SYMBOL | CONDITION | LABORATORY and IN SITU TESTS | WATER CONTENT and LIMITS (%) W_P W W_L 20 40 60 80 100 120

Z:\06_REFERENCE_MATERIALS\geotec.log\templates\loglog_SRK_m23_HopeBay_20m.sty PLOTTED: 2006-08-30 16:19hrs

SRK Consulting
Engineers and Scientists

BOREHOLE LOG

PROJECT: Doris North - Detailed Infrastructure Design	**BOREHOLE:** SRK06-01
LOCATION: Tail Lake South Dam	**PAGE:** 2 **OF** 2
FILE No: HOPE BAY (1CM014.008)	**DRILL TYPE:** Triple tube (HQ)
BORING DATE: 2006-05-03 **TO** 2006-05-04	**DRILL:** Boyles 17
DIP: 90.00 **AZIMUTH:**	**CASING:** None
COORDINATES: 7555903.00 N 435623.00 E **DATUM:**	

SAMPLE CONDITION
- ☒ Remoulded
- ▨ Undisturbed
- ■ Lost
- ◧ Core

TYPE OF SAMPLER
- DC Diamond core barrel
- GS Grab sample
- SS Split spoon

LABORATORY AND IN SITU TESTS
- C Consolidation
- D Bulk density (kg/m3)
- Dr Specific gravity
- Ksat Saturated hydraulic cond. (cm/s)
- Ku Thermal conductivity Unfrozen (W / m°C)
- Kf Thermal conductivity Frozen (W / m°C)
- PS Particle size analysis

DEPTH - ft	DEPTH - m	WELL DETAILS & WATER LEVEL - m	ELEVATION - m / DEPTH - m	DESCRIPTION	SYMBOL	TYPE AND NUMBER	CONDITION	RECOVERY %	N or RQD	LABORATORY and IN SITU TESTS	WATER CONTENT and LIMITS (%) W_P W W_L 20 40 60 80 100 120
70	21		-19.29 / 19.29	Ice, layered, cloudy							
	22		-19.32 / 19.32	Silty CLAY, not frozened, firm consistency, medium toughness, medium plasticity, no dilatency, moist, lensed structure. Soil has mottle appearance		SRK06-01-10	☒	100	0		
75			-19.60 / 19.60	Ice, as above							
	23		-19.65 / 19.65	Silty CLAY, as above							
			-20.30 / 20.30	LOSS							
	24		-21.80 / 21.80	Silty CLAY, as above							
80			-22.03 / 22.03	Silty CLAY, as above, Vr, 5% ice, clear ice							
	25		-22.30 / 22.30	Medium SAND, well graded, Nbe to occasional 5mm clear ice lenses, reddish brown, silt/clay, grey							
85	26		-22.60 / 22.60	Silty SAND, well graded, soft consistency, laminated structure, moist, low toughness, low plasticity, Nbe. Lots of excess water when thaw in hand.							
	27		-23.30 / 23.30	Medium SAND, as above, washed from hole as water pressure had to be increased to drill bedrock							
90	28		-24.30 / 24.30	BEDROCK, grabbo.							
			-25.00 / 25.00	EOH							
95	29										
	30										
100	31										
105	32										
	33										
110	34										
115	35										
	36										
120	37										
125	38										
	39										
130											

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BOREHOLE LOG

PROJECT: Doris North - Detailed Infrastructure Design
LOCATION: Tail Lake South Dam
FILE No: HOPE BAY (1CM014.008)
BORING DATE: 2006-05-06 **TO** 2006-05-07
DIP: 90.00 **AZIMUTH:**
COORDINATES: 7555939.00 N 435590.00 E **DATUM:**

BOREHOLE: SRK06-02
PAGE: 1 **OF** 2
DRILL TYPE: Triple tube (HQ)
DRILL:
CASING: None

SAMPLE CONDITION
- Remoulded
- Undisturbed
- Lost
- Core

TYPE OF SAMPLER
- DC Diamond core barrel
- GS Grab sample
- SS Split spoon

LABORATORY AND IN SITU TESTS
- C Consolidation
- D Bulk density (kg/m3)
- Dr Specific gravity
- Ksat Saturated hydraulic cond. (cm/s)
- Ku Thermal conductivity Unfrozen (W / m°C)
- Kf Thermal conductivity Frozen (W / m°C)
- PS Particle size analysis

STRATIGRAPHY

ELEVATION - m / DEPTH - m	DESCRIPTION
0.00 / -0.10	Sandy CLAY, high organic content, topsoil/peat, Nbn, 10% ice, dark brown
0.10 / -0.50	Sandy SAND, with a trace of clay. Nbn, less than 5% ice, with some organic, dense
0.50 / -0.60	Ice + SAND, poorly graded, 90% ice
0.60 / -2.00	Sandy SILT, poorly graded, light grey, Vs, 40% ice, ice lenses approx. 1cm thick.
2.00 / -2.20	Sandy SILT, as above
2.20 / -2.50	Ice + sandy SILT, poorly graded, light grey, 80% ice
2.50 / -3.50	LOSS LOSS
3.50 / -3.70	Ice + sandy SILT, poorly graded, light grey, 70% ice
3.70 / -4.40	Silty SAND, brown, poorly graded, Nbn, 5% ice
4.40 / -5.00	Sandy SILT, light grey, poorly graded, low plasticity, no ice observed due to thawign of drilling. Thaw due to plugging of bit from muddy return
5.00 / -5.25	LOSS
5.25 / -5.50	Silty SAND, brown, poorly graded, Nbn, 5% ice
5.50 / -5.75	Silty CLAY, dark grey very dence Nbn, 5% ice
5.75 / -6.00	LOSS
6.00 / -7.25	Silty CLAY, dark grey, very dense, Vr, 10% ice, 1cm thick ice lenses
7.25 / -8.75	Silty CLAY, dark grey, very dense, Vr, 20% ice, 2cm thick ice lenses
8.75 / -10.25	Silty CLAY, dark grey, very dense, Vr, 20% ice, 3cm thick ice lenses
10.25 / -10.55	LOSS
10.55 / -11.75	Silty CLAY, dark grey, very dense, Vr, 20% ice, 2cm thick ice lenses
11.75 / -12.10	Silty CLAY, Vr, 5% ice, laminated. Tested brine at 8% and -2c
12.10 / -12.30	Silty CLAY, Vr, 70% ice, brown ice (possibly due to drilling
12.30 / -12.50	Silty CLAY, grey, with black laminated interbeddings of 2-4cm thick, Vr, 15% ice, clear ice without inclusions, ice lenses less 2.5cm thick. Soil is between 2-4cm thick.
12.50 / -13.20	LOSS
13.20 / -14.00	Silty CLAY, as above
14.00 / -14.65	LOSS
14.65 / -15.50	Slity CLAY, as above, Nbe with occasional Vx, 5% ice
15.50 / -16.88	LOSS
16.88 / -17.00	Silty CLAY, as above
17.00 / -18.35	LOSS. Tested brine at -6c and 7% salinity
18.35 / -18.50	Silty CLAY, as above
18.50 / -19.00	LOSS
19.00	Silty fine SAND with clay, soft

SAMPLES

DEPTH - m (approx.)	TYPE AND NUMBER	RECOVERY %	N or RQD
2	SRK06-02-01	100	0
5	SRK06-02-02	0	0
7	SRK06-02-03	0	0
8	SRK06-02-04	0	0
10	SRK06-02-05	0	0
12	SRK06-02-06	100	0
14	SRK06-02-07	0	0
15	SRK06-02-08	0	0
18	SRK06-02-09	0	0
20	SRK06-02-10	100	0

LABORATORY and IN SITU TESTS

WATER CONTENT and LIMITS (%): W_P W W_L; 20 40 60 80 100 120

SRK Consulting
Engineers and Scientists

BOREHOLE LOG

PROJECT: Doris North - Detailed Infrastructure Design
LOCATION: Tail Lake South Dam
FILE No: HOPE BAY (1CM014.008)
BORING DATE: 2006-05-06 **TO** 2006-05-07
DIP: 90.00 **AZIMUTH:**
COORDINATES: 7555939.00 N 435590.00 E **DATUM:**

BOREHOLE: SRK06-02

DRILL TYPE: Triple tube (HQ)
DRILL:
CASING: None

SAMPLE CONDITION
- Remoulded
- Undisturbed
- Lost
- Core

TYPE OF SAMPLER
- DC Diamond core barrel
- GS Grab sample
- SS Split spoon

LABORATORY AND IN SITU TESTS
- C Consolidation
- D Bulk density (kg/m3)
- Dr Specific gravity
- Ksat Saturated hydraulic cond. (cm/s)
- Ku Thermal conductivity Unfrozen (W / m°C)
- Kf Thermal conductivity Frozen (W / m°C)
- PS Particle size analysis

Elevation - m / Depth - m	Description	Type and Number	Recovery %	N or RQD
20.00 – -21.05 / 21.05	consistency, moist, laminiated fine sand less then 2.5cm, silty clay less then 2.5cm, low toughness, low plasticity, ice lenses approx. 2.5cm thick, with minor occasional Vx, total of 3% ice			
21.05 – -21.50 / 21.50	LOSS			
21.50	Clayey SILT, Vr, 30% ice			
– -24.50	LOSS			
24.50 – -25.70	Silty SAND, mottled. Vs, 7% ice, ice lenses less than 1cm thick. Tested brine at -1.8c and 8% salinity	SRK06-02-11	0	0
25.70 – -26.00	Medium SAND, well graded to coarse sand, Vs, 7% ice, ice lenses less than 1cm thick, large cobble at bottom of the hole	SRK06-02-12	0	0
26.00 – -26.55	LOSS			
26.55 – -27.02	Coarse SAND, well graded, Nbe, 7% ice			
27.02	Fine to medium SAND with silty clay interbeds. Layers at 5-10cm thick			
– -29.00	Granite Boulders with coarse sand interbed. Well graded. Nbe, 7% ice	SRK06-02-13	0	0
29.00 – -30.97	LOSS	SRK06-02-14	0	0
30.97 – -31.13	Coarse SAND, Nbe, with occasional 2mm thick ice layers, 7% ice			
31.13 – -34.73	LOSS			
34.73 – -35.58 / 35.58	BEDROCK, Qtz veined follow fractures at 30 degrees, slickensided surfaces, black discoloration on surface, undulations faces.			
	EOH			

LABORATORY and IN SITU TESTS

WATER CONTENT and LIMITS (%): W_P W W_L — 20 40 60 80 100 120

Appendix B
Laboratory Test Results

EBA Engineering Consultants Ltd.

MOISTURE CONTENT TEST RESULTS

Project: SRK 2006 Testing Services
Hope Bay Gold Project
BH No:

Project No.: 1780176
Date Tested: 1-Jun-06

Location: Hope Bay, NT
By: DKKS

Client: SRK Consulting

Test No.	SampleNo.	Depth(m)	Wet+Tare	Dry+Tare	Tare	% Moisture Content
SRK06-01-03	4150-3	N/A	660.9	522.8	12.2	27.0
SRK06-01-06	4150-6	N/A	441.9	285.4	12.5	57.3
SRK06-01-10	4150-10	N/A	707.9	559.7	12.3	27.1
SRK06-02-01	4150-11	N/A	518.4	322.1	12.2	63.3
SRK06-02-06	4150-16	N/A	586.1	405	14.2	46.3
SRK06-02-10	4150-20	N/A	826.9	497.8	13.9	68.0
SRK06-02-13	4150-23	N/A	903.8	750.3	13.9	20.8
SRK06-11-01	4150-25	N/A	705.0	593.4	12.4	19.2
SRK06-12-02	4150-27	N/A	270.2	189.5	12.1	45.5
SRK06-12-03	4150-28	N/A	640.9	441.3	12.4	46.5
SRK06-13-01	4150-29	N/A	292.4	207.0	12.2	43.8
SRK06-13-02	4150-30	N/A	701.6	474.3	12.5	49.2
SRK06-14-02	4150-32	N/A	242.8	173.1	12.2	43.3
SRK06-15-01	4150-34	N/A	288.9	229.8	12.3	27.2
SRK06-15-02	4150-35	N/A	603.9	425.1	12.3	43.3
SRK06-16-01	4150-37	N/A	654.0	479.5	12.2	37.3
SRK06-16-02	4150-38	N/A	176.8	108.6	12.1	70.7
SRK06-17-01	4150-40	N/A	793.9	662.5	13.9	20.3
SRK06-17-02	4150-41	N/A	693.0	514.5	13.9	35.7
SRK06-17-03	4150-42	N/A	262.5	186.8	12.4	43.4

EBA Engineering Consultants Ltd.

POREWATER SALINITY

Project:	Hope Bay Gold	Sample No.:	SRK06
Project No.:	0701-1780176	Date Tested:	06-06-28
Client:	Miramar Hope Bay Limited	Tested By:	KP

Sample Number	Depth (m)	Salinity (ppt)
01-03		67
01-06		44
01-10		67
02-01		6
02-06		60
02-10		80
02-13		86
11-01		89

EBA Engineering Consultants Ltd.

GRAIN SIZE DISTRIBUTION

Project: SRK 2006 Testing Services.Hope Bay Gold Project

Project Number: 1780176

Client: SRK Consulting Inc.

Attention: Mr. Alvin Tong

Date Tested: June 14-16, 2006

Sample ID: SRK06-01-03

Depth: n/a

Sample Number: n/a

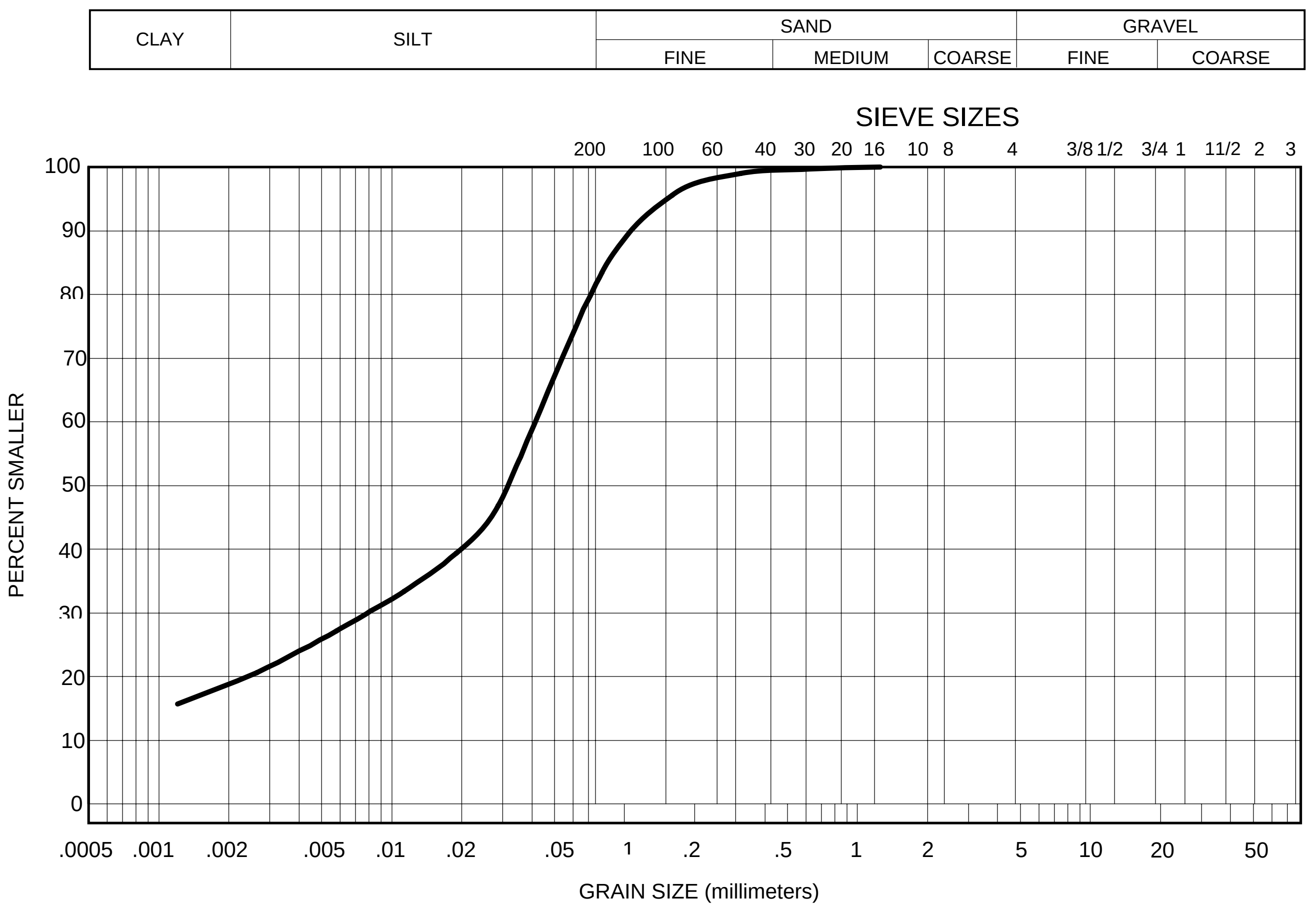
Lab Number: 4150-3

Soil Description: SILT, some clay, some sand

Natural Moisture Content: 27.0%

Remarks: LL=29%, PL=17%, PI=12%

SIEVE	PERCENTAGE PASSING
2.5	
1.25	
0.630	100
0.315	99
0.160	96
0.08	83
0.029	47
0.019	39
0.0113	33
0.0081	30
0.0058	27
0.0026	21
0.0012	16



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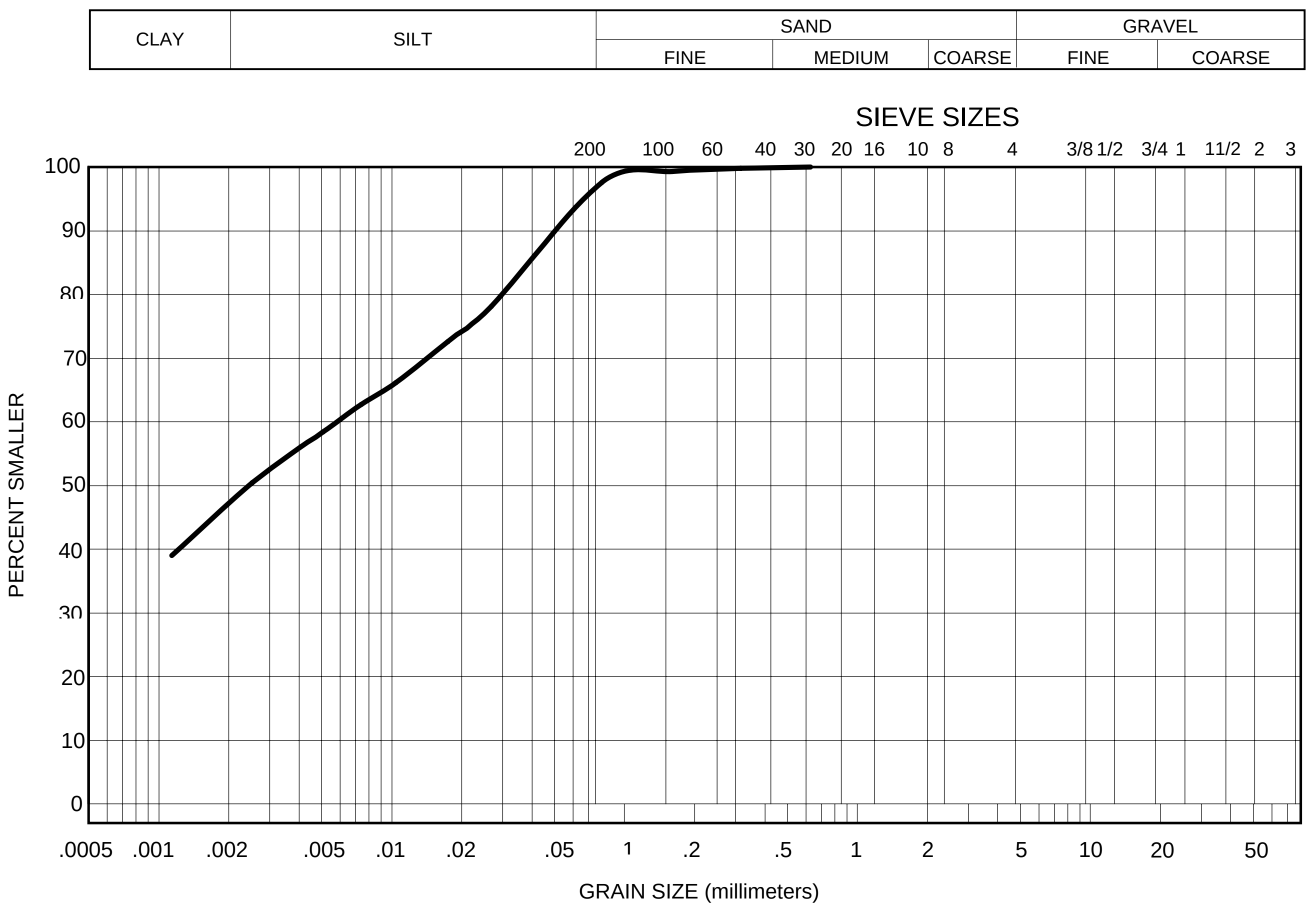
EBA Engineering Consultants Ltd.

GRAIN SIZE DISTRIBUTION

Project: SRK 2006 Testing Services.Hope Bay Gold Project
Project Number: 1780176
Client: SRK Consulting Inc.
Attention: Mr. Alvin Tong
Date Tested: June 14-16, 2006
Sample ID: SRK06-01-06
Depth: n/a
Sample Number: n/a
Lab Number: 4150-6
Soil Description: SILT and CLAY, trace sand
Natural Moisture Content: 57.3%
Remarks: LL=44%, PL=22%, PI=22%

SIEVE	PERCENTAGE PASSING
2.5	
1.25	
0.630	100
0.315	100
0.160	99
0.08	98
0.027	78
0.017	73
0.0104	66
0.0074	63
0.0051	58
0.0025	50
0.0011	39



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EBA Engineering Consultants Ltd.

GRAIN SIZE DISTRIBUTION

Project: SRK 2006 Testing Services.Hope Bay Gold Project

Project Number: 1780176

Client: SRK Consulting Inc.

Attention: Mr. Alvin Tong

Date Tested: June 14-16, 2006

Sample ID: SRK06-01-10

Depth: n/a

Sample Number: n/a

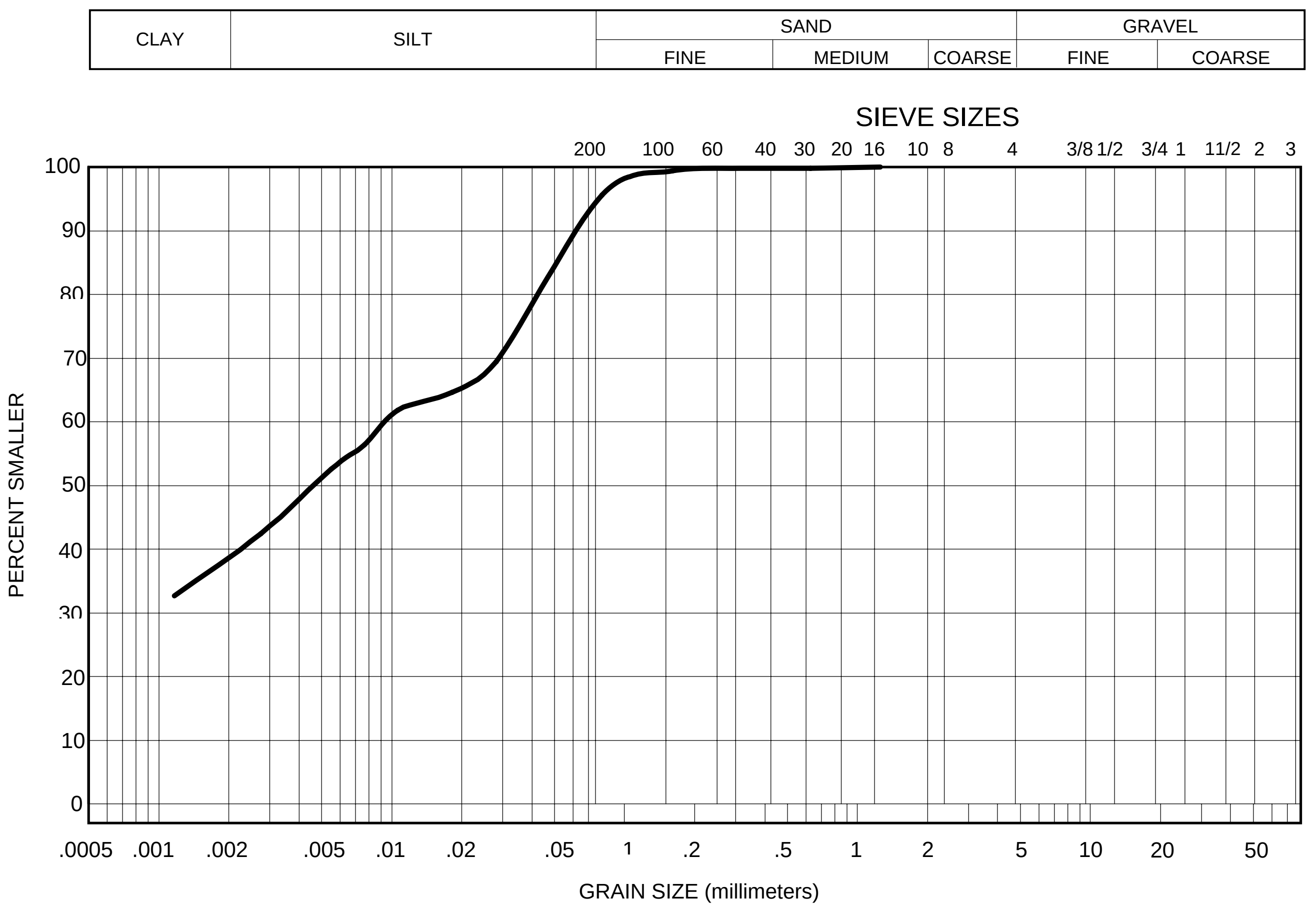
Lab Number: 4150-10

Soil Description: SILT and CLAY, trace sand

Natural Moisture Content: 27.1%

Remarks: LL=38%, PL=20%, PI=18%

SIEVE	PERCENTAGE PASSING
2.5	
1.25	
0.630	
0.315	100
0.160	99
0.08	96
0.028	69
0.018	65
0.0106	62
0.0077	56
0.0055	53
0.0027	42
0.0012	33



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GRAIN SIZE DISTRIBUTION

Project: SRK 2006 Testing Services.Hope Bay Gold Project

Project Number: 1780176

Client: SRK Consulting Inc.

Attention: Mr. Alvin Tong

Date Tested: June 14-16, 2006

Sample ID: SRK06-02-01

Depth: n/a

Sample Number: n/a

Lab Number: 4150-11

Soil Description: SILT, clayey, some sand

Natural Moisture Content: 63.3%

Remarks: LL=33%, PL=22%, PI=11%

SIEVE, mm	PERCENTAGE PASSING
2.5	100
1.25	99
0.630	99
0.315	98
0.160	96
0.08	88
0.029	64
0.019	56
0.0111	49
0.0080	44
0.0058	39
0.0028	31
0.0012	20

CLAY	SILT	SAND			GRAVEL	
		FINE	MEDIUM	COARSE	FINE	COARSE

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EBA Engineering Consultants Ltd.

GRAIN SIZE DISTRIBUTION

Project: SRK 2006 Testing Services.Hope Bay Gold Project

Project Number: 1780176

Client: SRK Consulting Inc.

Attention: Mr. Alvin Tong

Date Tested: June 13-14,15-16, 2006

Sample ID: SRK06-02-06

Depth: n/a

Sample Number: n/a

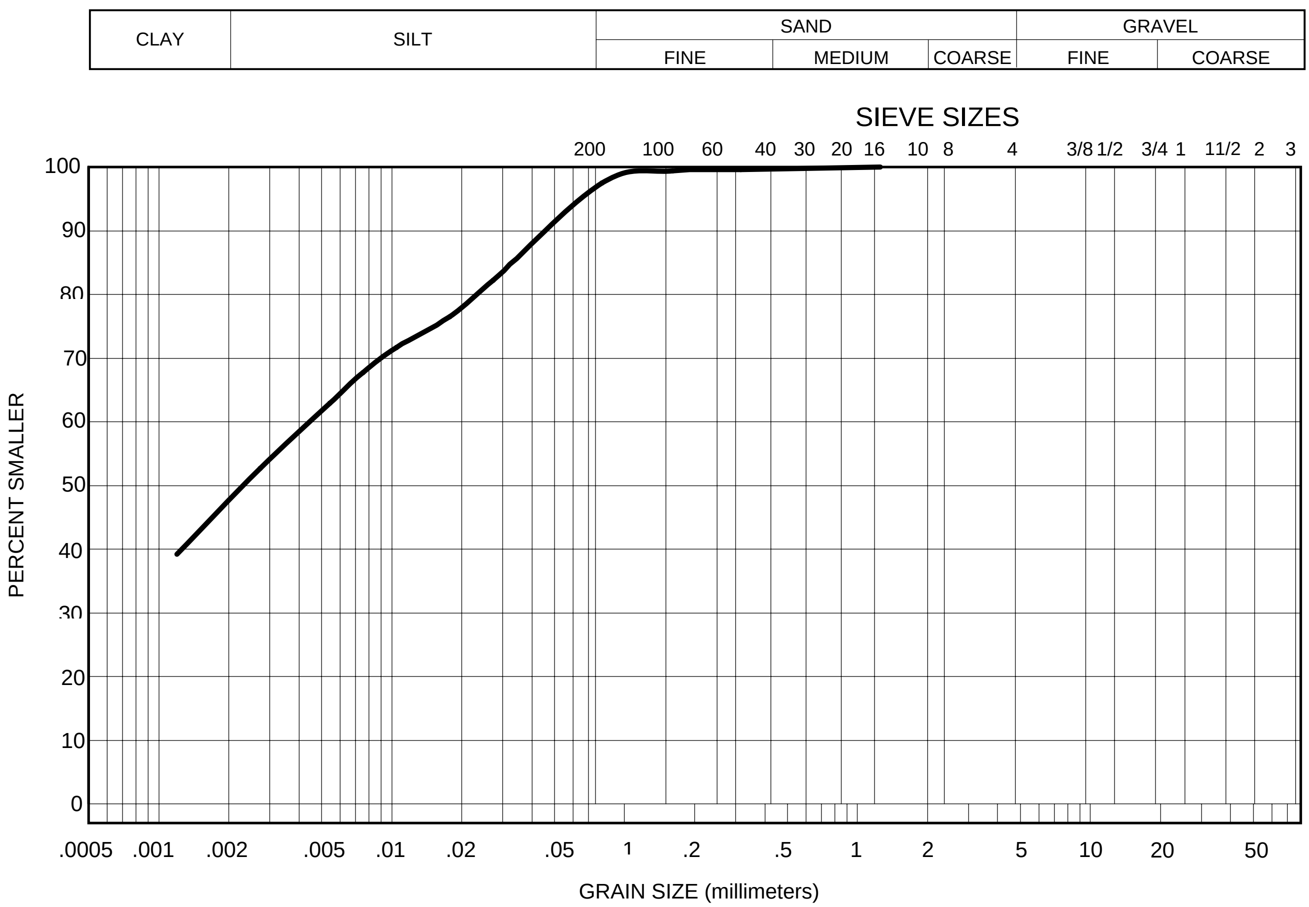
Lab Number: 4150-16

Soil Description: SILT and CLAY, trace sand

Natural Moisture Content: 46.3%

Remarks: LL=43%, PL=22%, PI=21%

SIEVE, mm	PERCENTAGE PASSING
2.5	
1.25	
0.630	
0.315	100
0.160	99
0.08	97
0.027	82
0.018	76
0.0105	72
0.0075	68
0.0054	63
0.0027	53
0.0012	39



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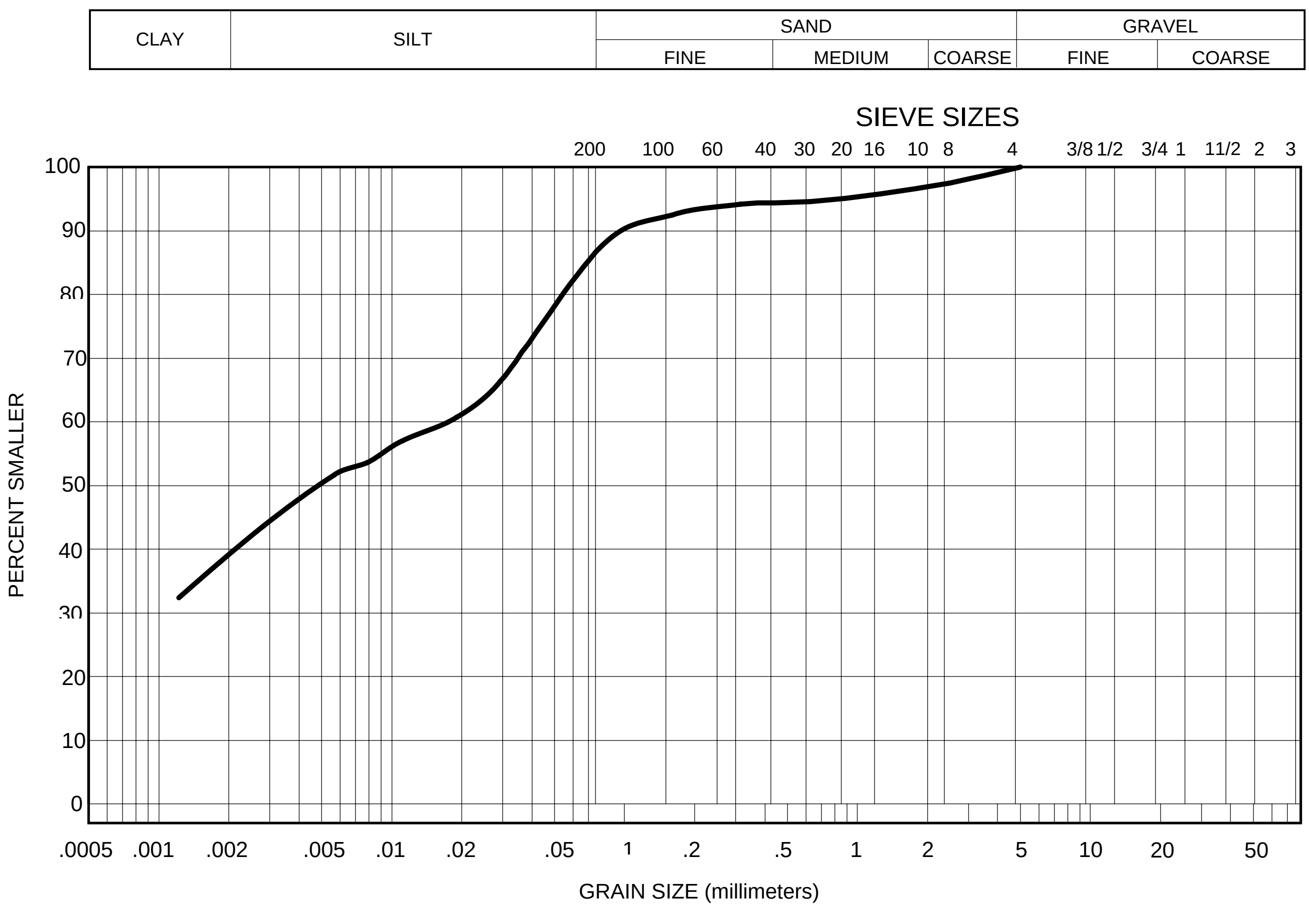
GRAIN SIZE DISTRIBUTION

Project: SRK 2006 Testing Services.Hope Bay Gold Project
Project Number: 1780176
Client: SRK Consulting Inc.
Attention: Mr. Alvin Tong
Date Tested: June 13-14,15-16, 2006
Sample ID: SRK06-02-10
Depth: n/a
Sample Number: n/a
Lab Number: 4150-20
Soil Description: SILT and CLAY, some sand
Natural Moisture Content: 68.0%
Remarks: LL=37%, PL=19%, PI=18%

SIEVE, mm	PERCENTAGE PASSING
5.0	100
2.5	97
1.25	96
0.630	95
0.315	94
0.160	92
0.08	88
0.029	66
0.019	61
0.0111	57
0.0078	54
0.0057	52
0.0028	44
0.0012	32



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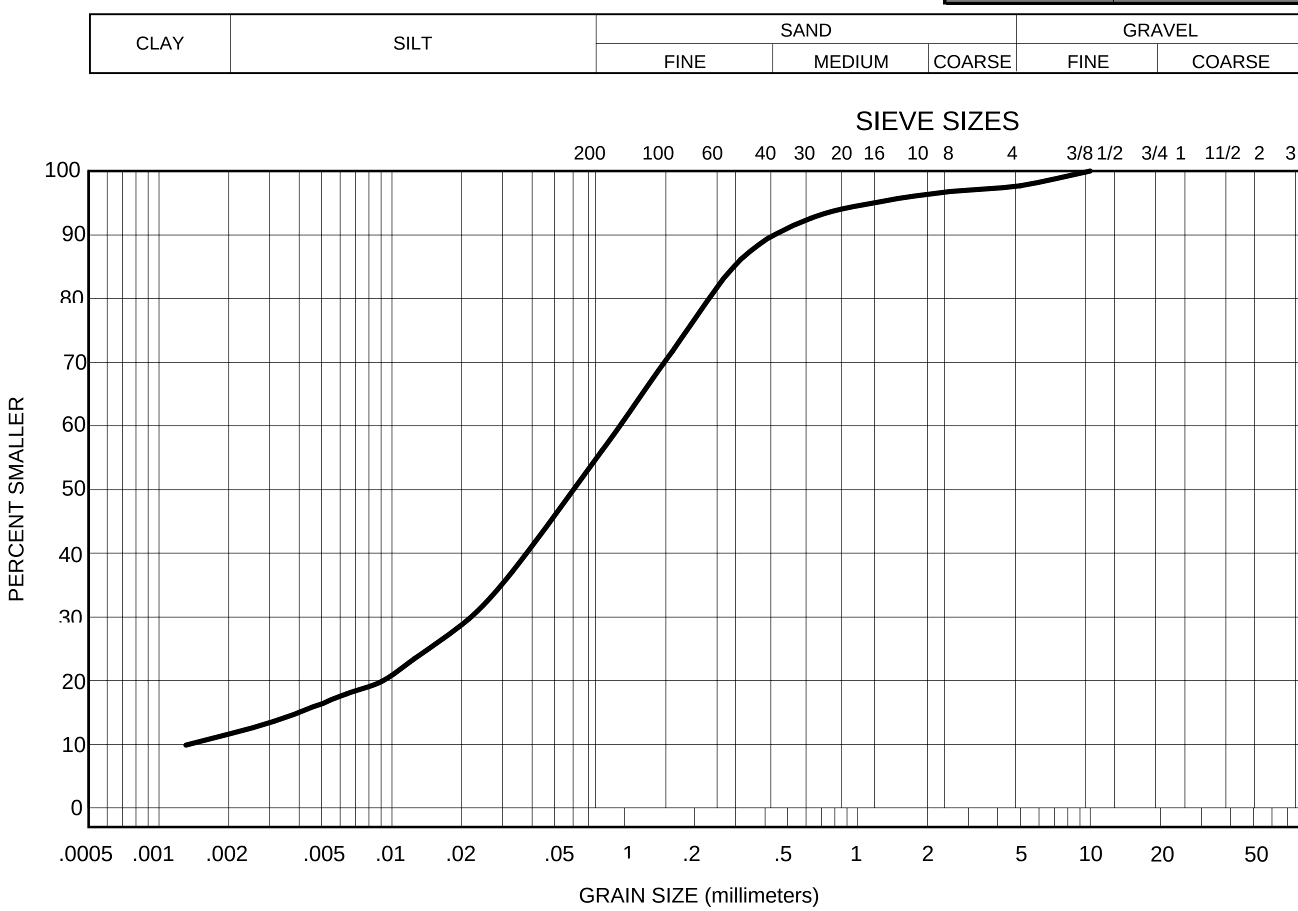
EBA Engineering Consultants Ltd.

GRAIN SIZE DISTRIBUTION

Project: SRK 2006 Testing Services.Hope Bay Gold Project
Project Number: 1780176
Client: SRK Consulting Inc.
Attention: Mr. Alvin Tong
Date Tested: June 13-14, 2006
Sample ID: SRK06-02-13
Depth: n/a
Sample Number: n/a
Lab Number: 4150-23
Soil Description: SILT and SAND, some clay, trace gravel
Natural Moisture Content: 20.8%
Remarks: N.P.

SIEVE, mm	PERCENTAGE PASSING
10.0	100
5.0	98
2.5	97
1.25	95
0.630	93
0.315	86
0.160	72
0.08	56
0.033	37
0.021	30
0.0125	23
0.0090	20
0.0064	18
0.0031	14
0.0013	10



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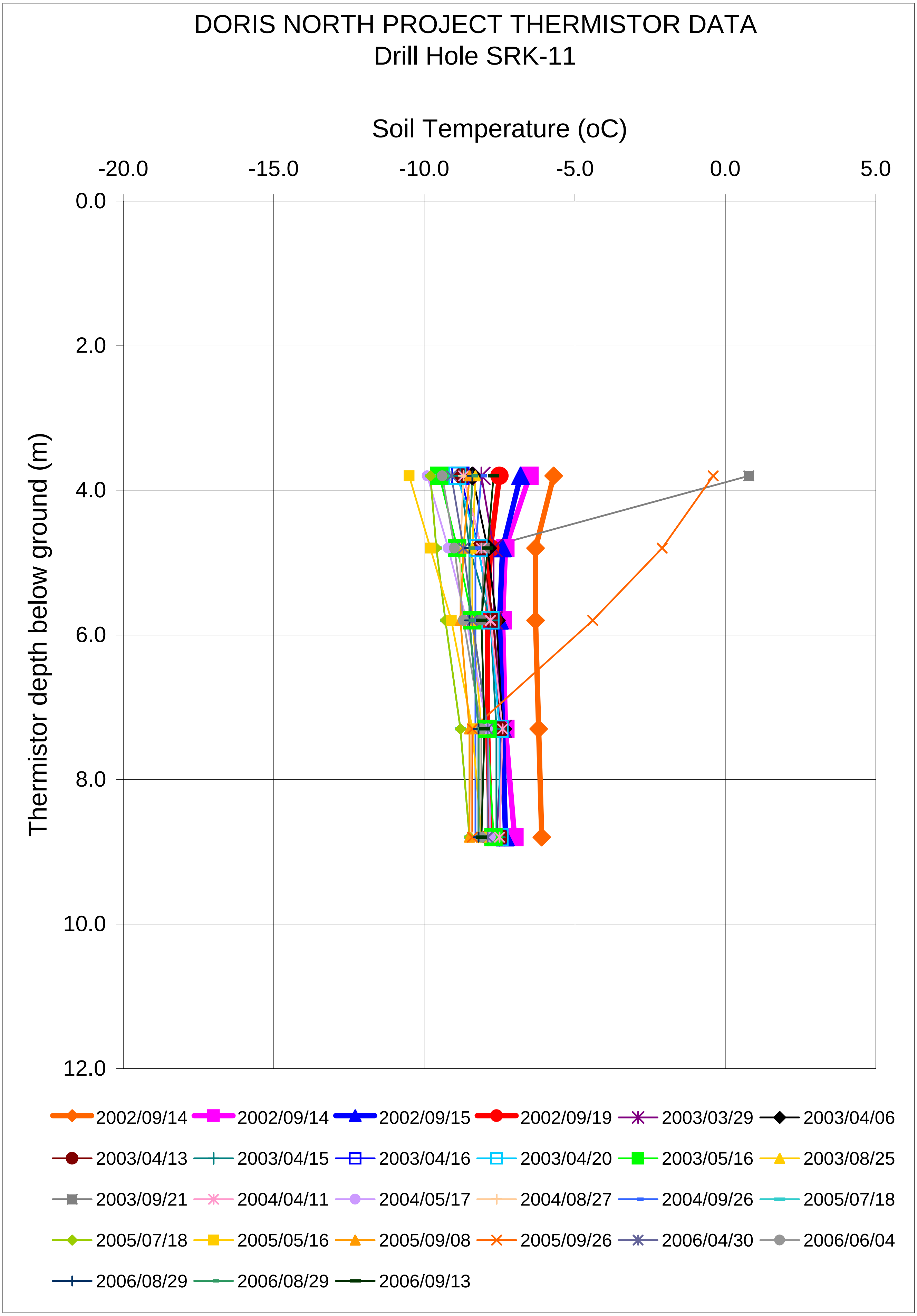
Appendix C
Thermistor String Data

Appendix C-1

Thermistor String Data - Figures


DORIS NORTH PROJECT THERMISTOR DATA
Drill Hole SRK-11
Soil Temperature (oC)
-20.0
-15.0
-10.0
-5.0
0.0
5.0
Thermistor depth below ground (m)
0.0
2.0
4.0
6.0
8.0
10.0
12.0
2002/09/14
2002/09/14
2002/09/15
2002/09/19
2003/03/29
2003/04/06
2003/04/13
2003/04/15
2003/04/16
2003/04/20
2003/05/16
2003/08/25
2003/09/21
2004/04/11
2004/05/17
2004/08/27
2004/09/26
2005/07/18
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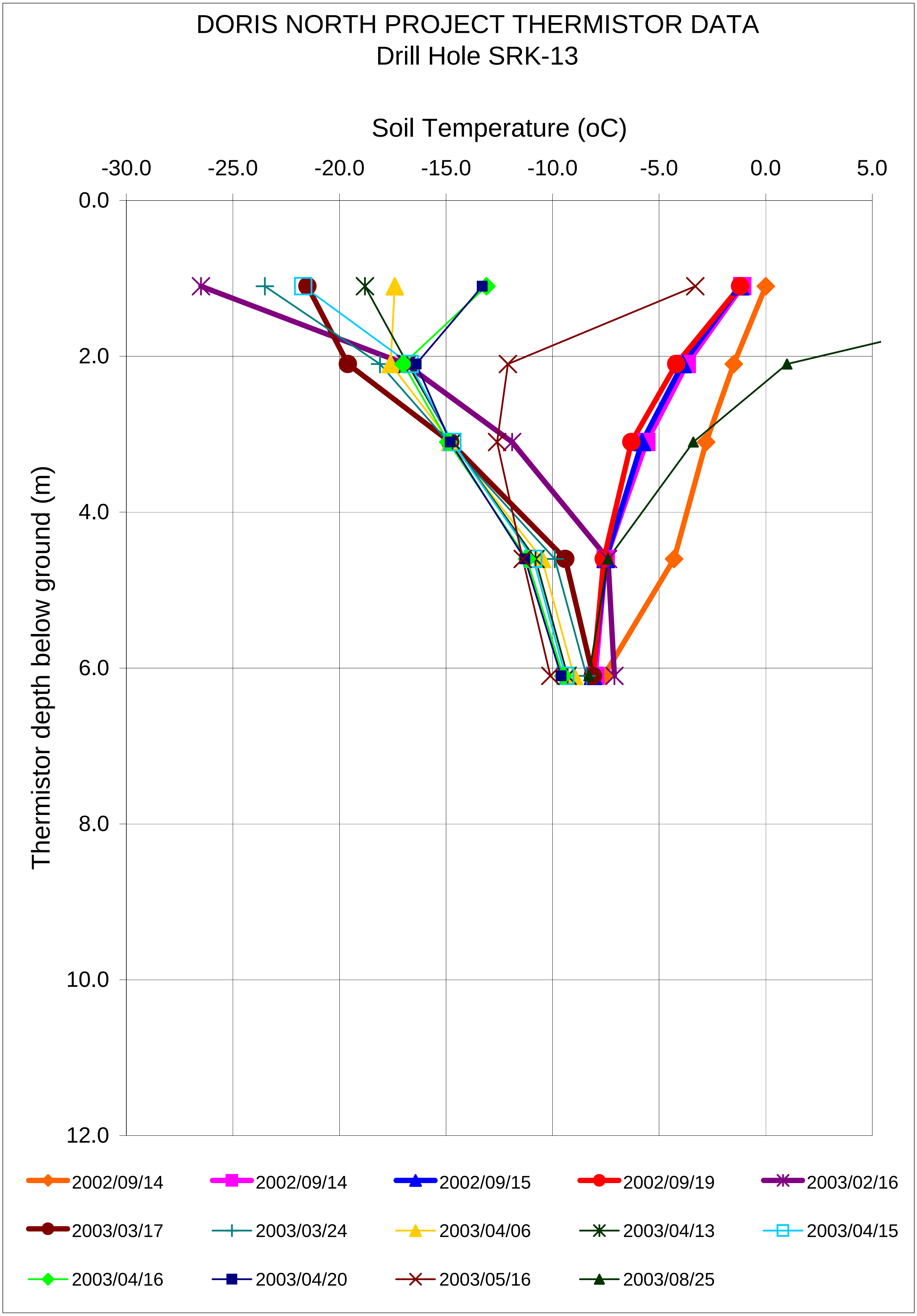
2006/08/29
2006/09/13



DORIS NORTH PROJECT THERMISTOR DATA
Drill Hole SRK-13
Soil Temperature (oC)
-30.0
-25.0
-20.0
-15.0
-10.0
-5.0
0.0
5.0
Thermistor depth below ground (m)
0.0
2.0
4.0
6.0
8.0
10.0
12.0
2002/09/14
2002/09/14
2002/09/15
2002/09/19
2003/02/16
2003/03/17
2003/03/24
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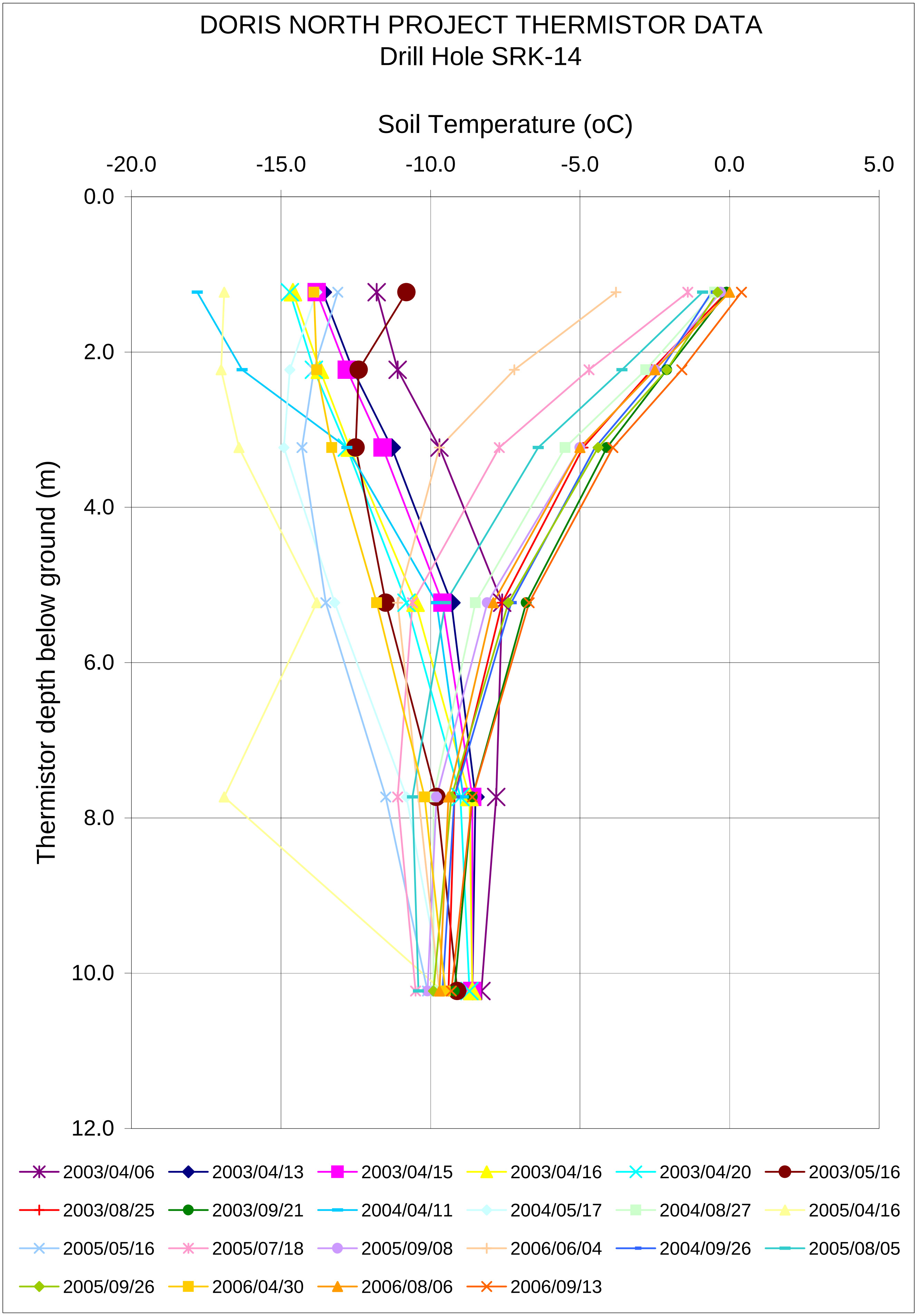
2003/05/16
2003/08/25



DORIS NORTH PROJECT THERMISTOR DATA
Drill Hole SRK-14
Soil Temperature (oC)
-20.0
-15.0
-10.0
-5.0
0.0
5.0
0.0
2.0
4.0
6.0
8.0
10.0
12.0
Thermistor depth below ground (m)
2003/04/06
2003/04/13
2003/04/15
2003/04/16
2003/04/20
2003/05/16
2003/08/25
2003/09/21
2004/04/11
2004/05/17
2004/08/27
2005/04/16
2005/05/16
2005/07/18
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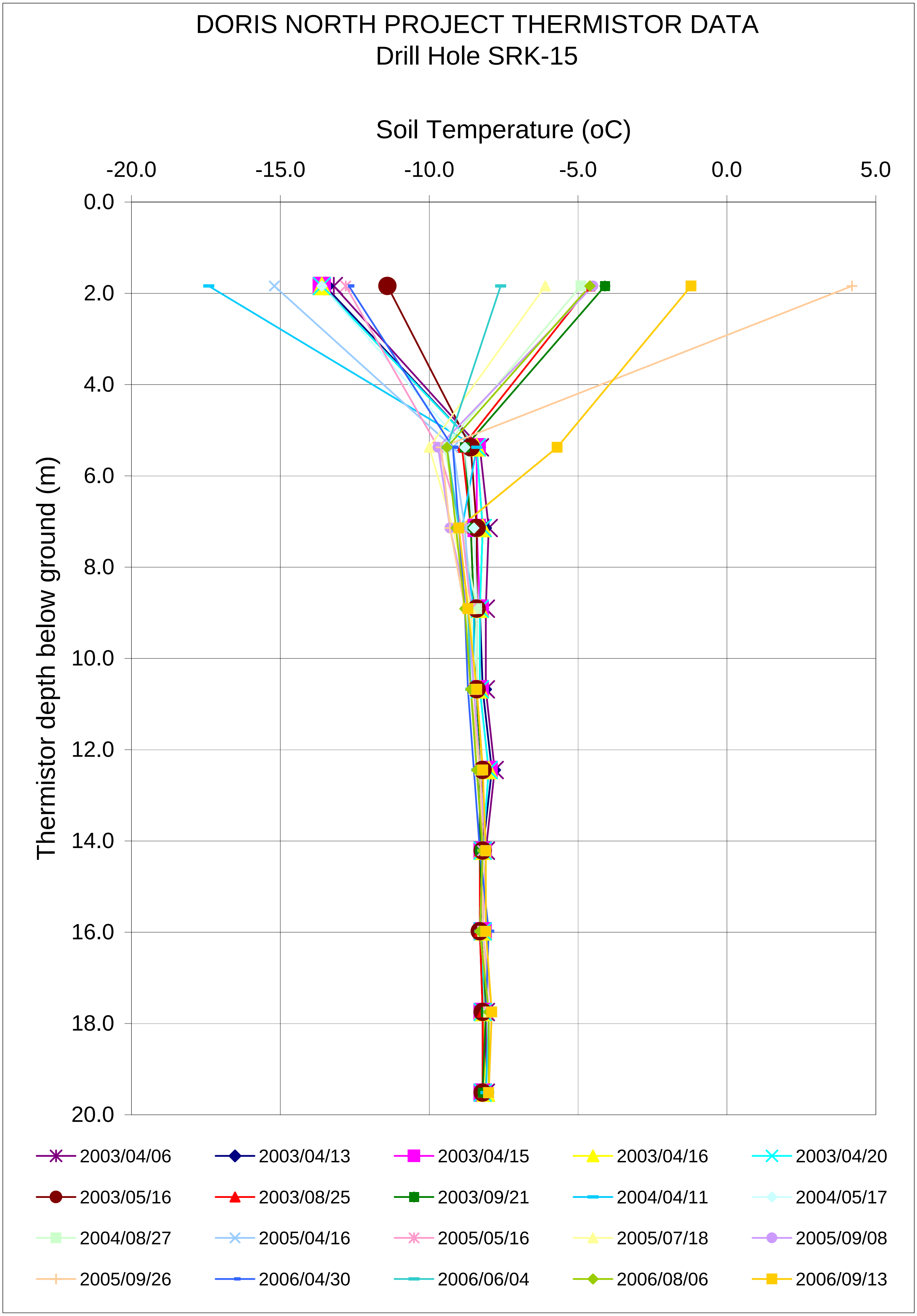
2006/08/06
2006/09/13


DORIS NORTH PROJECT THERMISTOR DATA
Drill Hole SRK-15
Soil Temperature (oC)
-20.0
-15.0
-10.0
-5.0
0.0
5.0
Thermistor depth below ground (m)
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
18.0
20.0
2003/04/06
2003/04/13
2003/04/15
2003/04/16
2003/04/20
2003/05/16
2003/08/25
2003/09/21
2004/04/11
2004/05/17
2004/08/27
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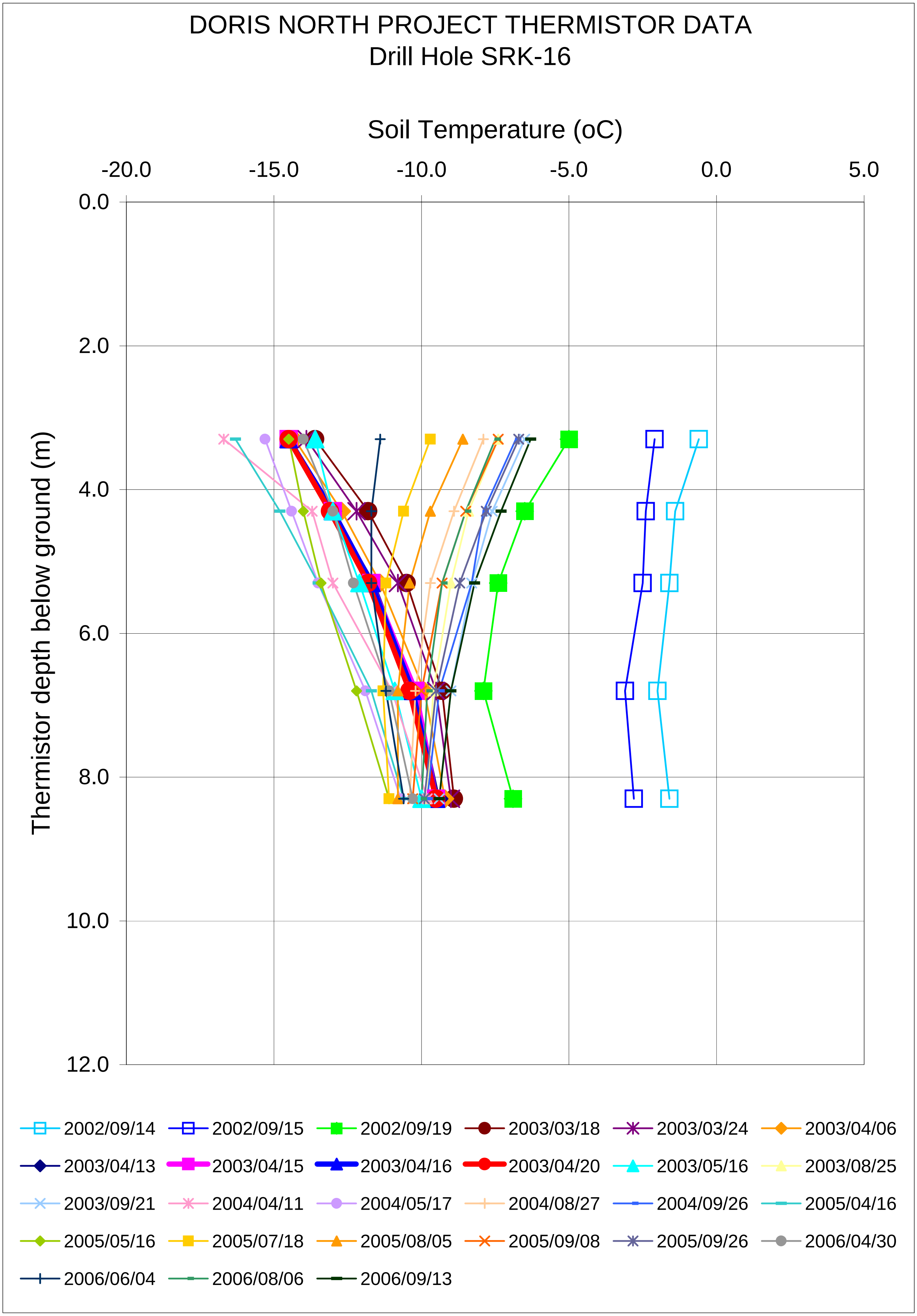
2006/08/06
2006/09/13



DORIS NORTH PROJECT THERMISTOR DATA
Drill Hole SRK-16
Soil Temperature (oC)
-20.0
-15.0
-10.0
-5.0
0.0
5.0
0.0
2.0
4.0
6.0
8.0
10.0
12.0
Thermistor depth below ground (m)
2002/09/14
2002/09/15
2002/09/19
2003/03/18
2003/03/24
2003/04/06
2003/04/13
2003/04/15
2003/04/16
2003/04/20
2003/05/16
2003/08/25
2003/09/21
2004/04/11
2004/05/17
2004/08/27
2004/09/26
2005/04/16
2005/05/16
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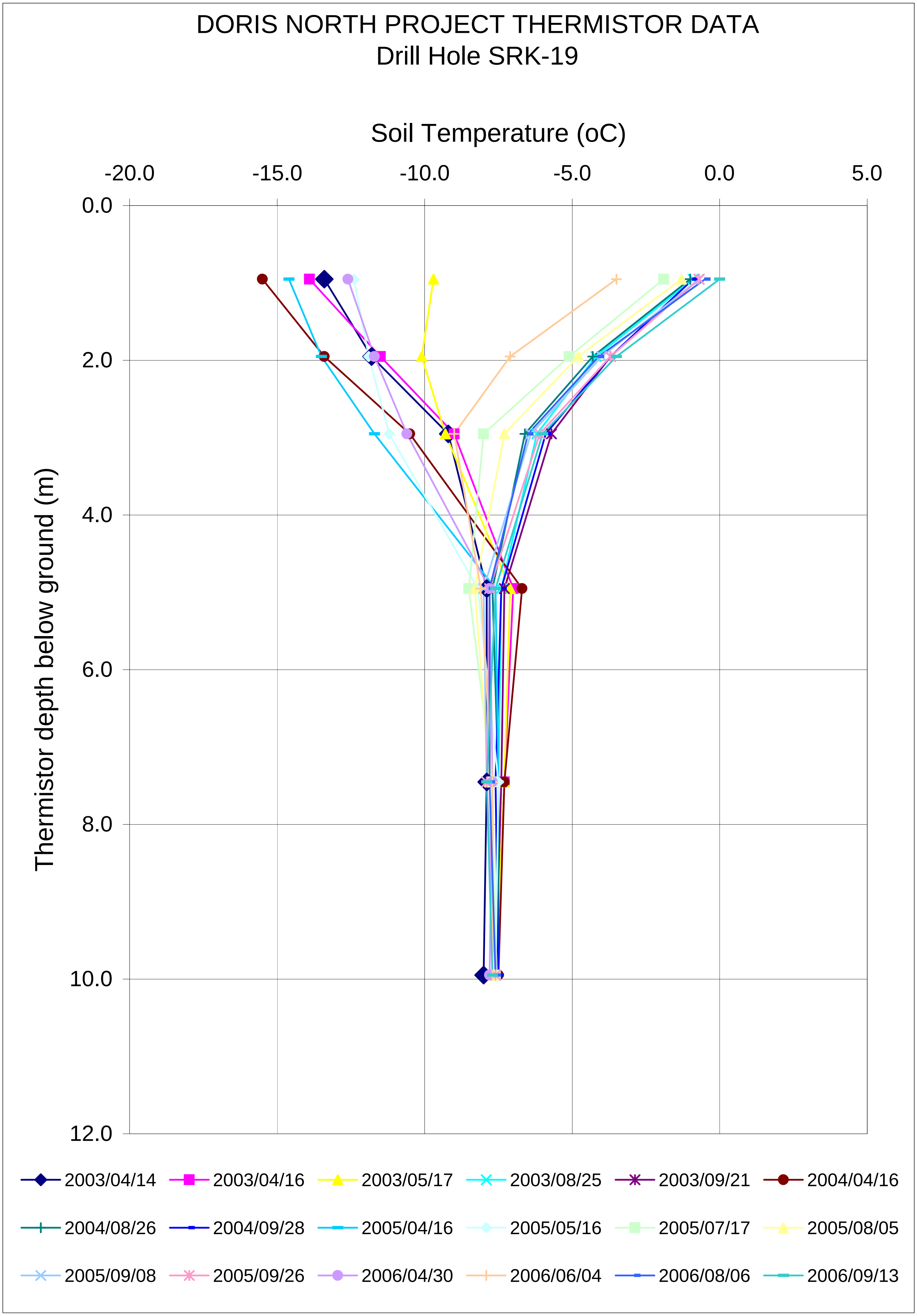
2006/04/30
2006/06/04
2006/08/06
2006/09/13



DORIS NORTH PROJECT THERMISTOR DATA
Drill Hole SRK-19
Soil Temperature (oC)
-20.0
-15.0
-10.0
-5.0
0.0
5.0
0.0
2.0
4.0
6.0
8.0
10.0
12.0
Thermistor depth below ground (m)
2003/04/14
2003/04/16
2003/05/17
2003/08/25
2003/09/21
2004/04/16
2004/08/26
2004/09/28
2005/04/16
2005/05/16
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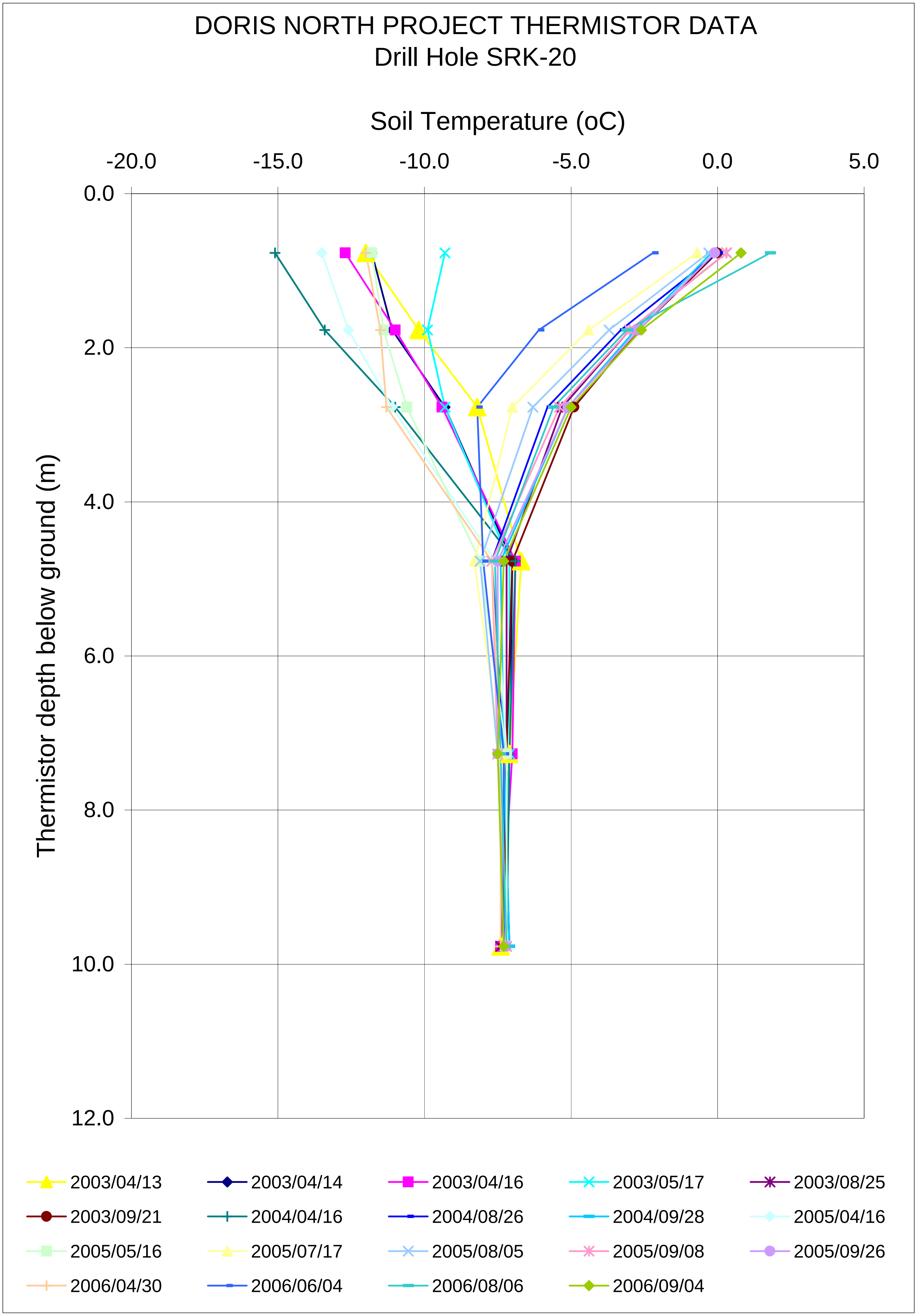
2005/09/26
2006/04/30
2006/06/04
2006/08/06
2006/09/13



DORIS NORTH PROJECT THERMISTOR DATA
Drill Hole SRK-20
Soil Temperature (oC)
-20.0
-15.0
-10.0
-5.0
0.0
5.0
Thermistor depth below ground (m)
0.0
2.0
4.0
6.0
8.0
10.0
12.0
2003/04/13
2003/04/14
2003/04/16
2003/05/17
2003/08/25
2003/09/21
2004/04/16
2004/08/26
2004/09/28
2005/04/16
2005/05/16
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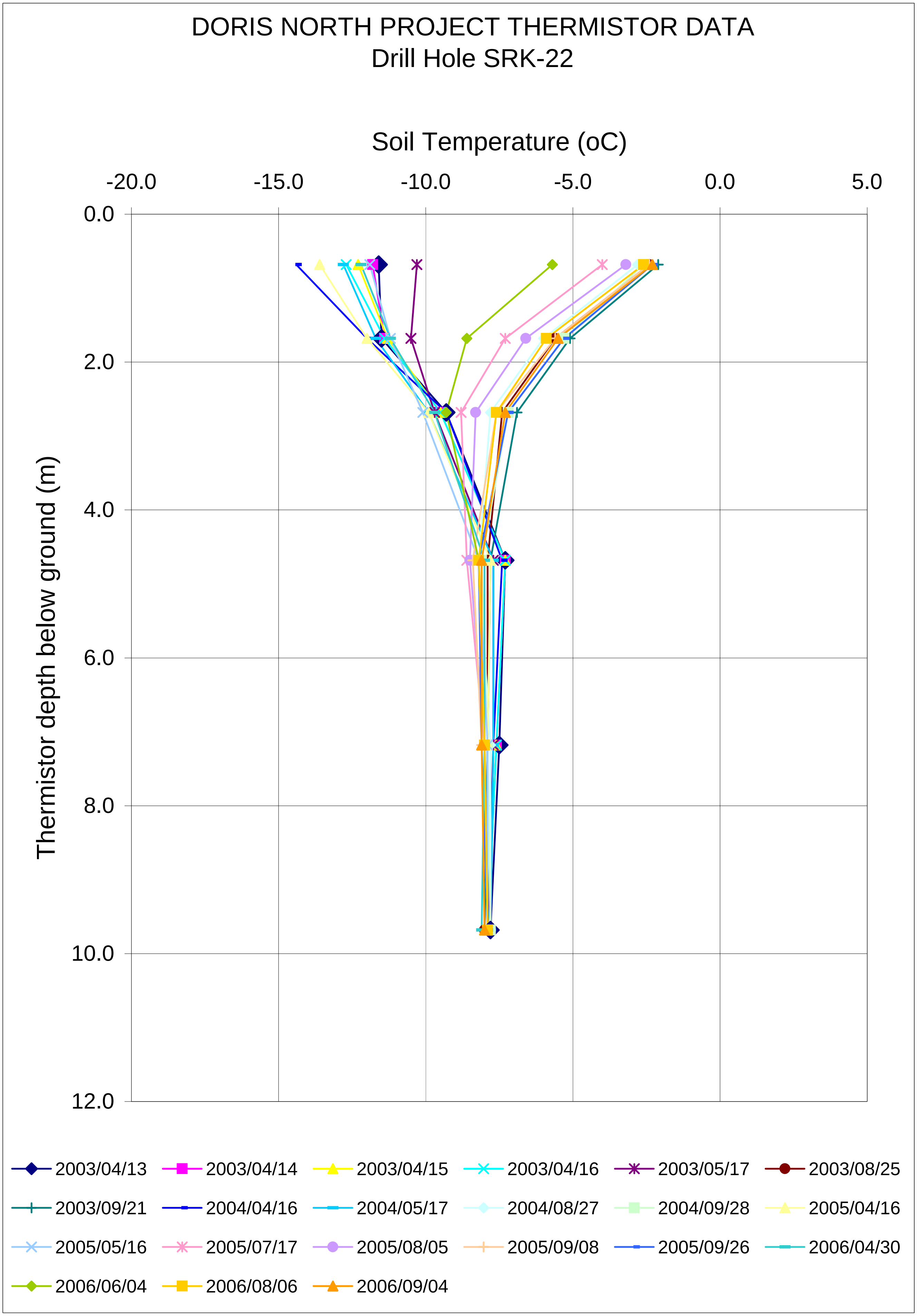
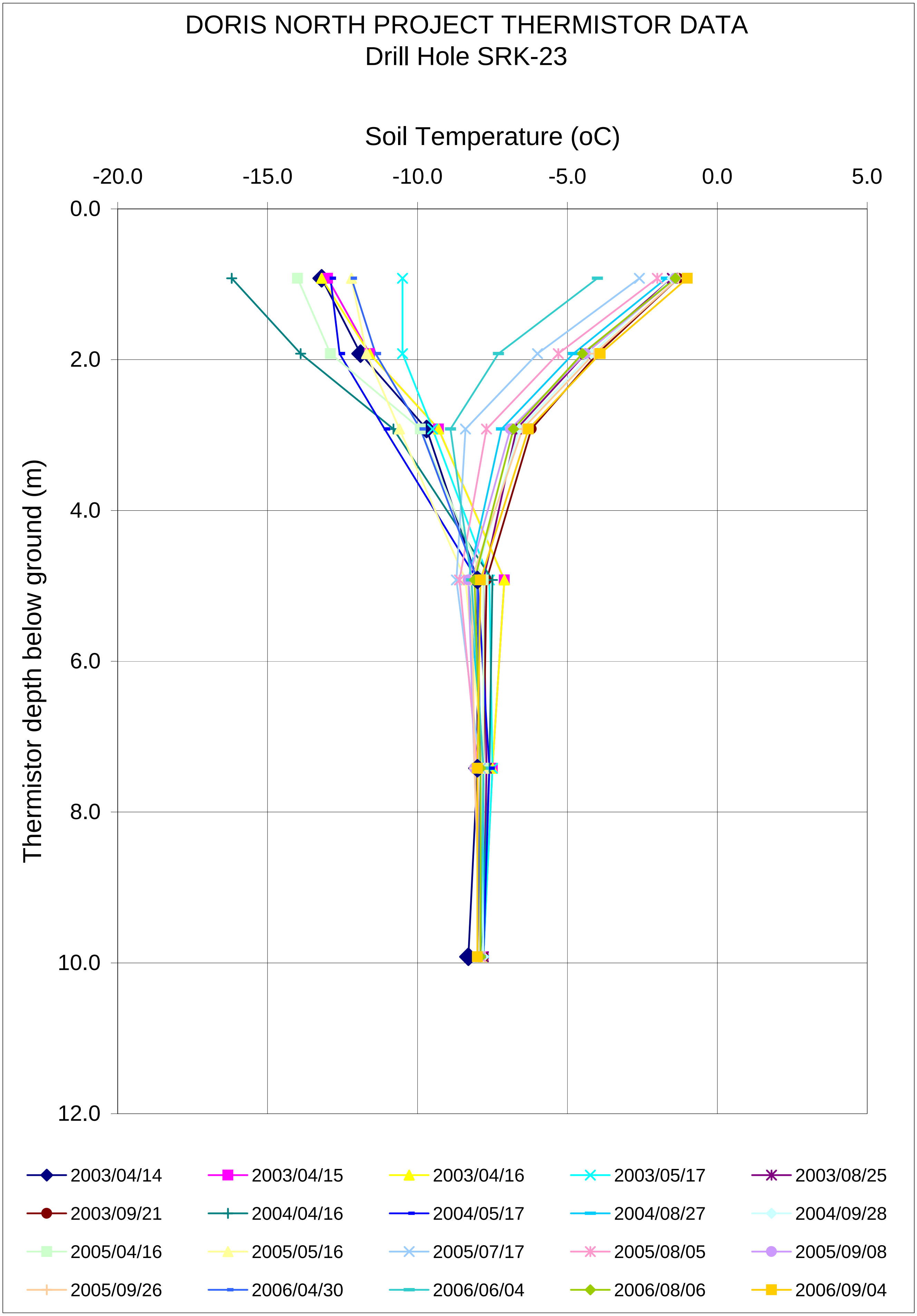
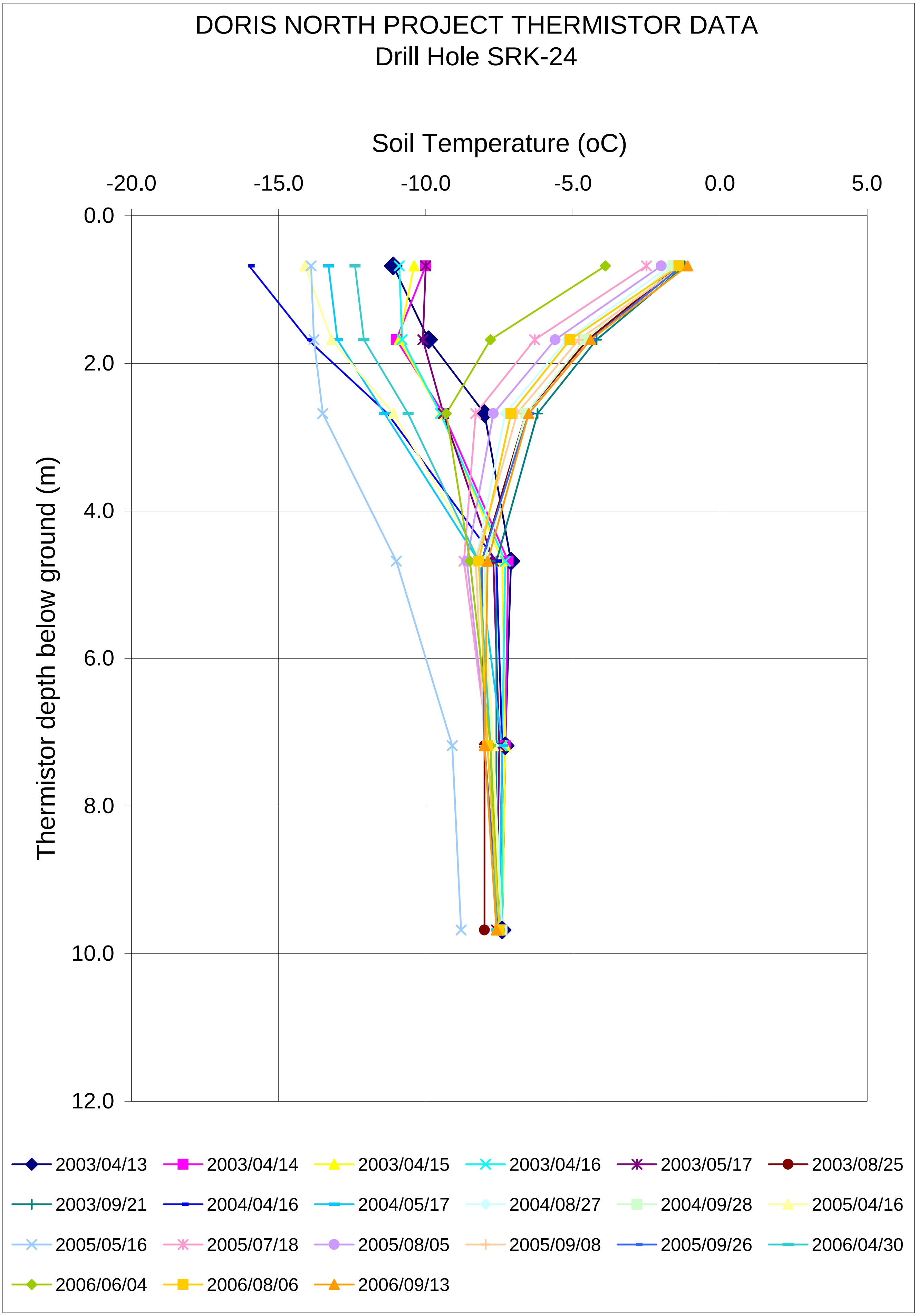
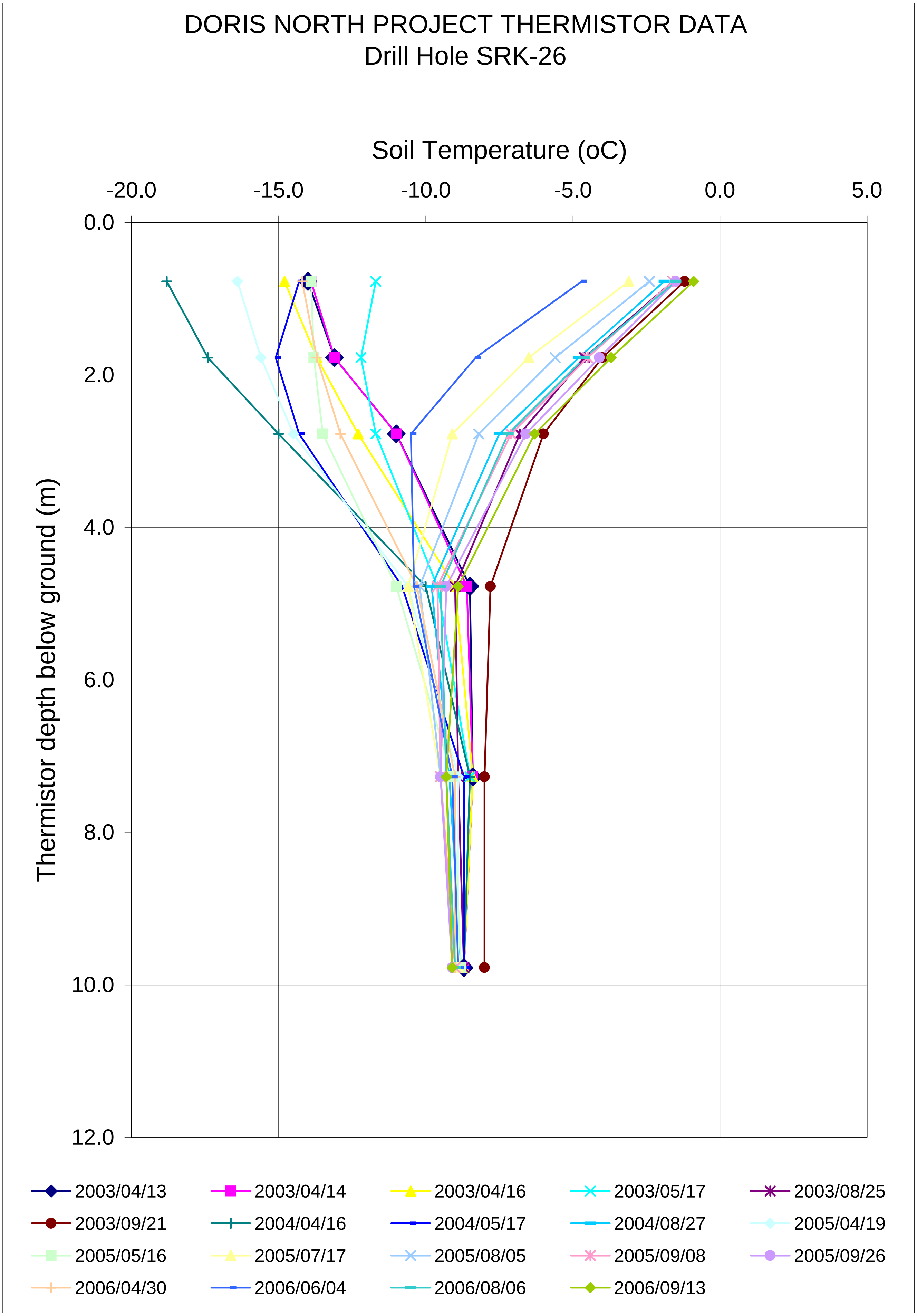
2006/06/04
2006/08/06
2006/09/04


DORIS NORTH PROJECT THERMISTOR DATA
Drill Hole SRK-22
Soil Temperature (oC)
-20.0
-15.0
-10.0
-5.0
0.0
5.0
0.0
2.0
4.0
6.0
8.0
10.0
12.0
Thermistor depth below ground (m)
2003/04/13
2003/04/14
2003/04/15
2003/04/16
2003/05/17
2003/08/25
2003/09/21
2004/04/16
2004/05/17
2004/08/27
2004/09/28
2005/04/16
2005/05/16
2005/07/17
2005/08/05
2005/09/08
2005/09/26
2006/04/30
2006/06/04
2006/08/06
2006/09/04

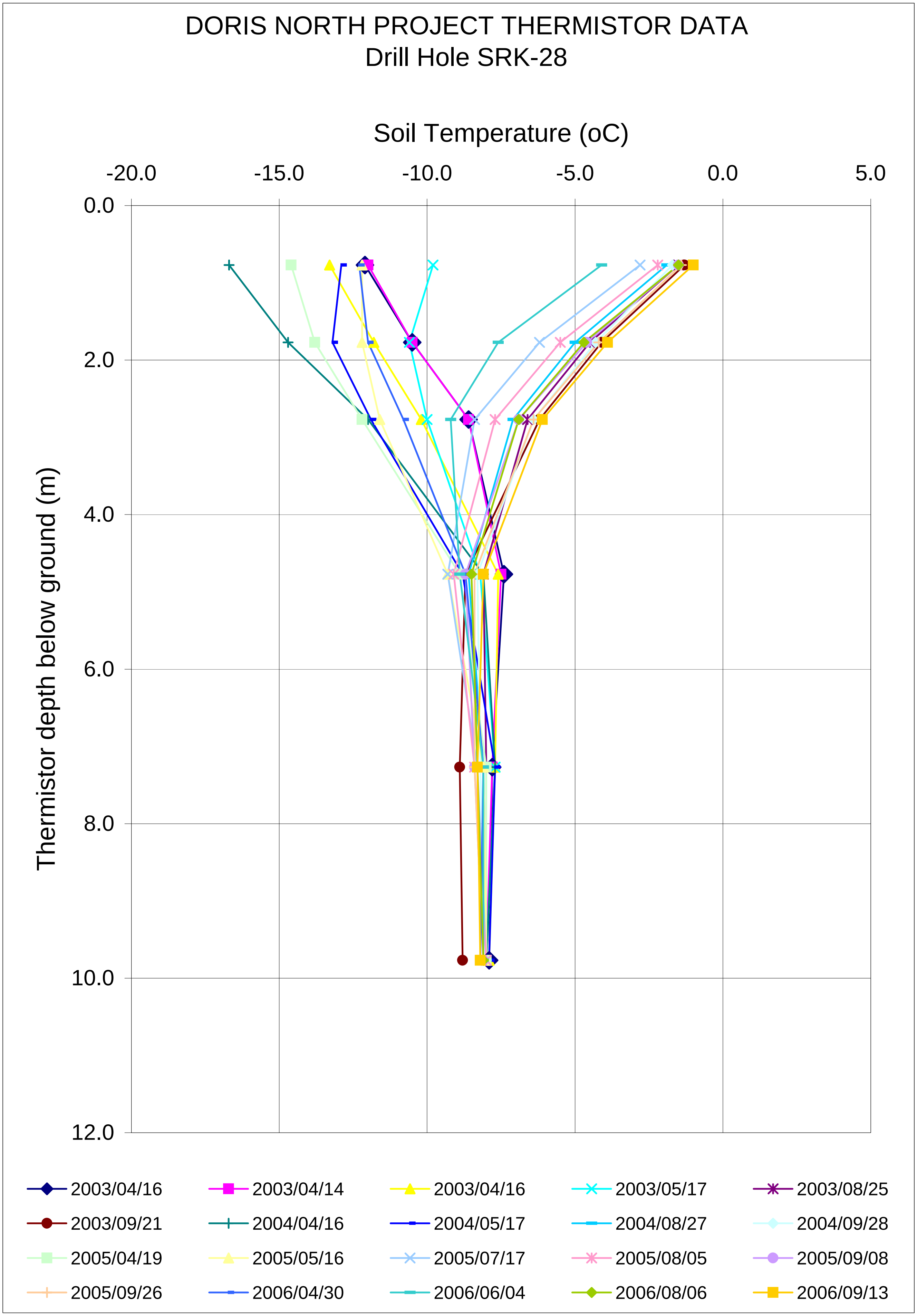

DORIS NORTH PROJECT THERMISTOR DATA
Drill Hole SRK-23
Soil Temperature (oC)
-20.0
-15.0
-10.0
-5.0
0.0
5.0
Thermistor depth below ground (m)
0.0
2.0
4.0
6.0
8.0
10.0
12.0
2003/04/14
2003/04/15
2003/04/16
2003/05/17
2003/08/25
2003/09/21
2004/04/16
2004/05/17
2004/08/27
2004/09/28
2005/04/16
2005/05/16
2005/07/17
2005/08/05
2005/09/08
2005/09/26
2006/04/30
2006/06/04
2006/08/06
2006/09/04

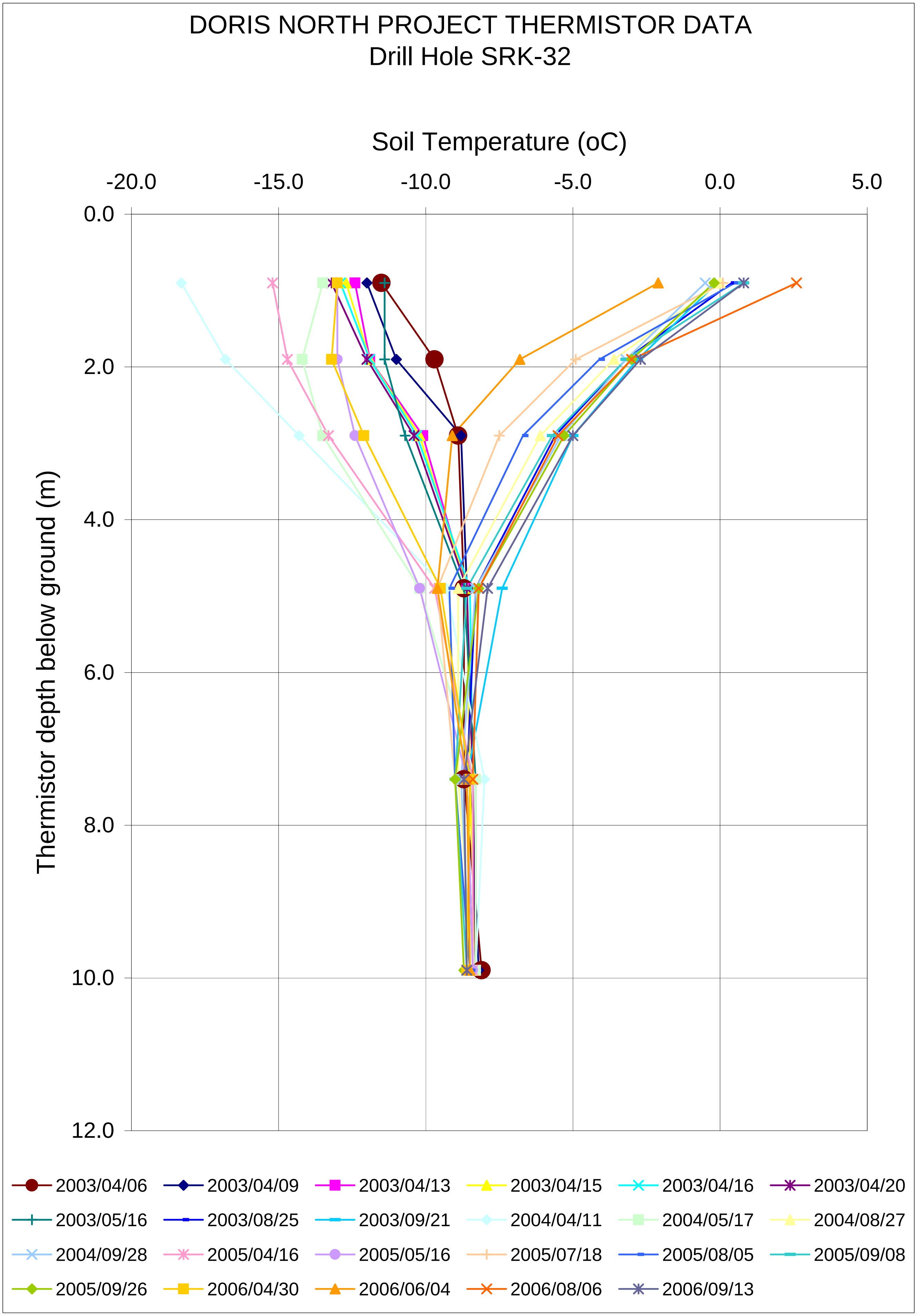


DORIS NORTH PROJECT THERMISTOR DATA
Drill Hole SRK-24
Soil Temperature (oC)
-20.0
-15.0
-10.0
-5.0
0.0
5.0
Thermistor depth below ground (m)
0.0
2.0
4.0
6.0
8.0
10.0
12.0
2003/04/13
2003/04/14
2003/04/15
2003/04/16
2003/05/17
2003/08/25
2003/09/21
2004/04/16
2004/05/17
2004/08/27
2004/09/28
2005/04/16
2005/05/16
2005/07/18
2005/08/05
2005/09/08
2005/09/26
2006/04/30
2006/06/04
2006/08/06
2006/09/13

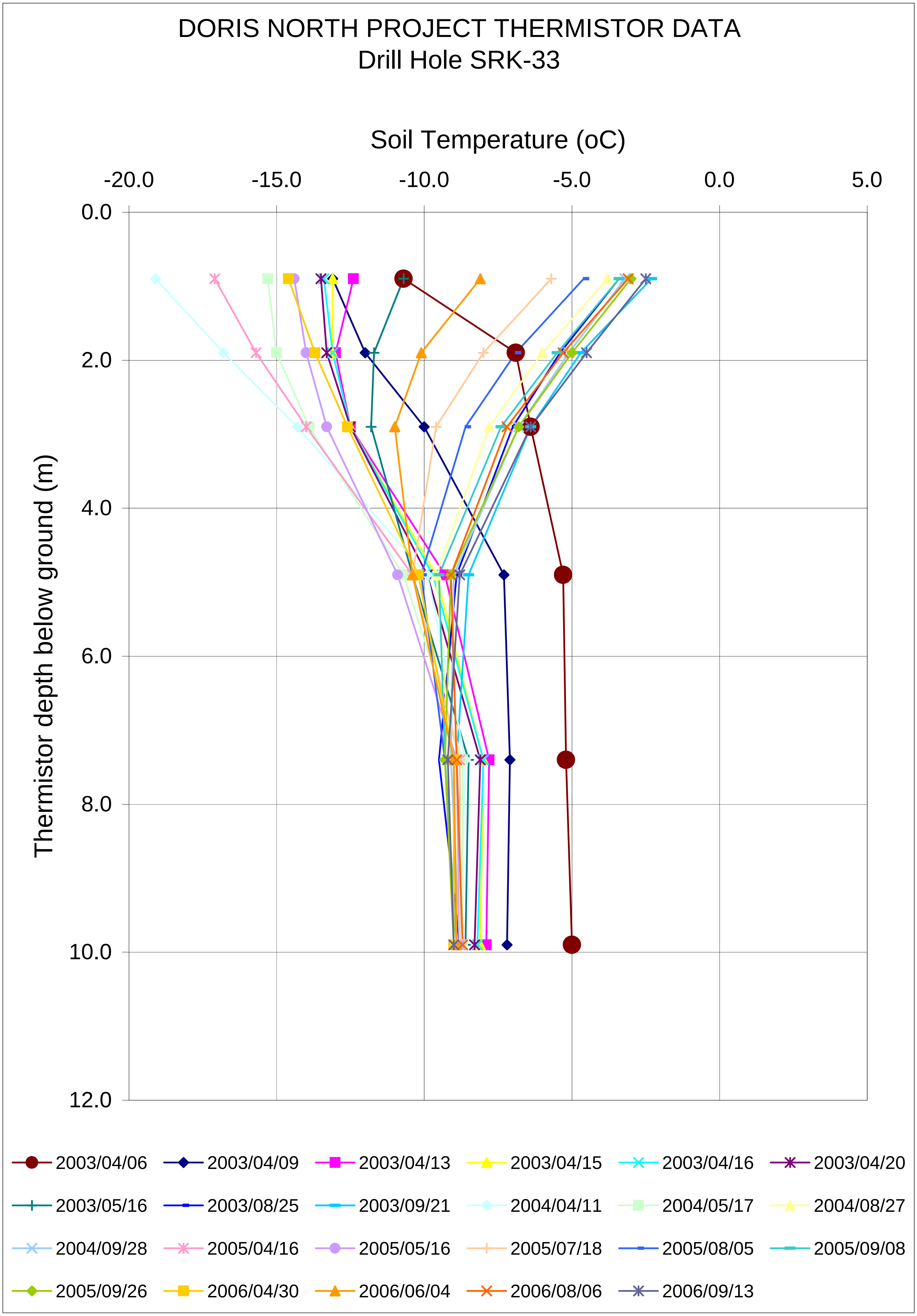


DORIS NORTH PROJECT THERMISTOR DATA
Drill Hole SRK-26
Soil Temperature (oC)
-20.0
-15.0
-10.0
-5.0
0.0
5.0
0.0
2.0
4.0
6.0
8.0
10.0
12.0
Thermistor depth below ground (m)
2003/04/13
2003/04/14
2003/04/16
2003/05/17
2003/08/25
2003/09/21
2004/04/16
2004/05/17
2004/08/27
2005/04/19
2005/05/16
2005/07/17
2005/08/05
2005/09/08
2005/09/26
2006/04/30
2006/06/04
2006/08/06
2006/09/13

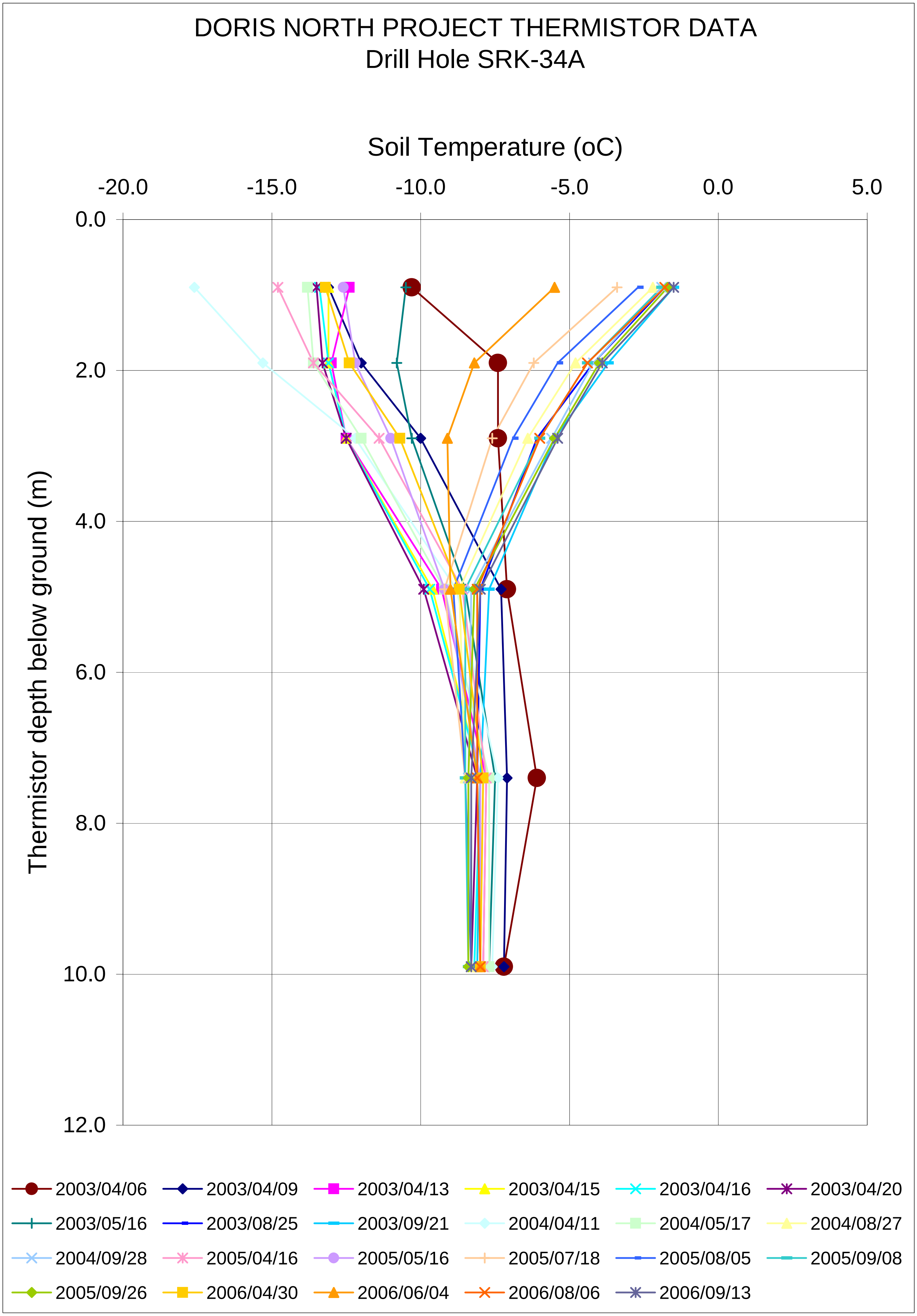

DORIS NORTH PROJECT THERMISTOR DATA
Drill Hole SRK-28
Soil Temperature (oC)
-20.0
-15.0
-10.0
-5.0
0.0
5.0
Thermistor depth below ground (m)
0.0
2.0
4.0
6.0
8.0
10.0
12.0
2003/04/16
2003/04/14
2003/04/16
2003/05/17
2003/08/25
2003/09/21
2004/04/16
2004/05/17
2004/08/27
2004/09/28
2005/04/19
2005/05/16
2005/07/17
2005/08/05
2005/09/08
2005/09/26
2006/04/30
2006/06/04
2006/08/06
2006/09/13

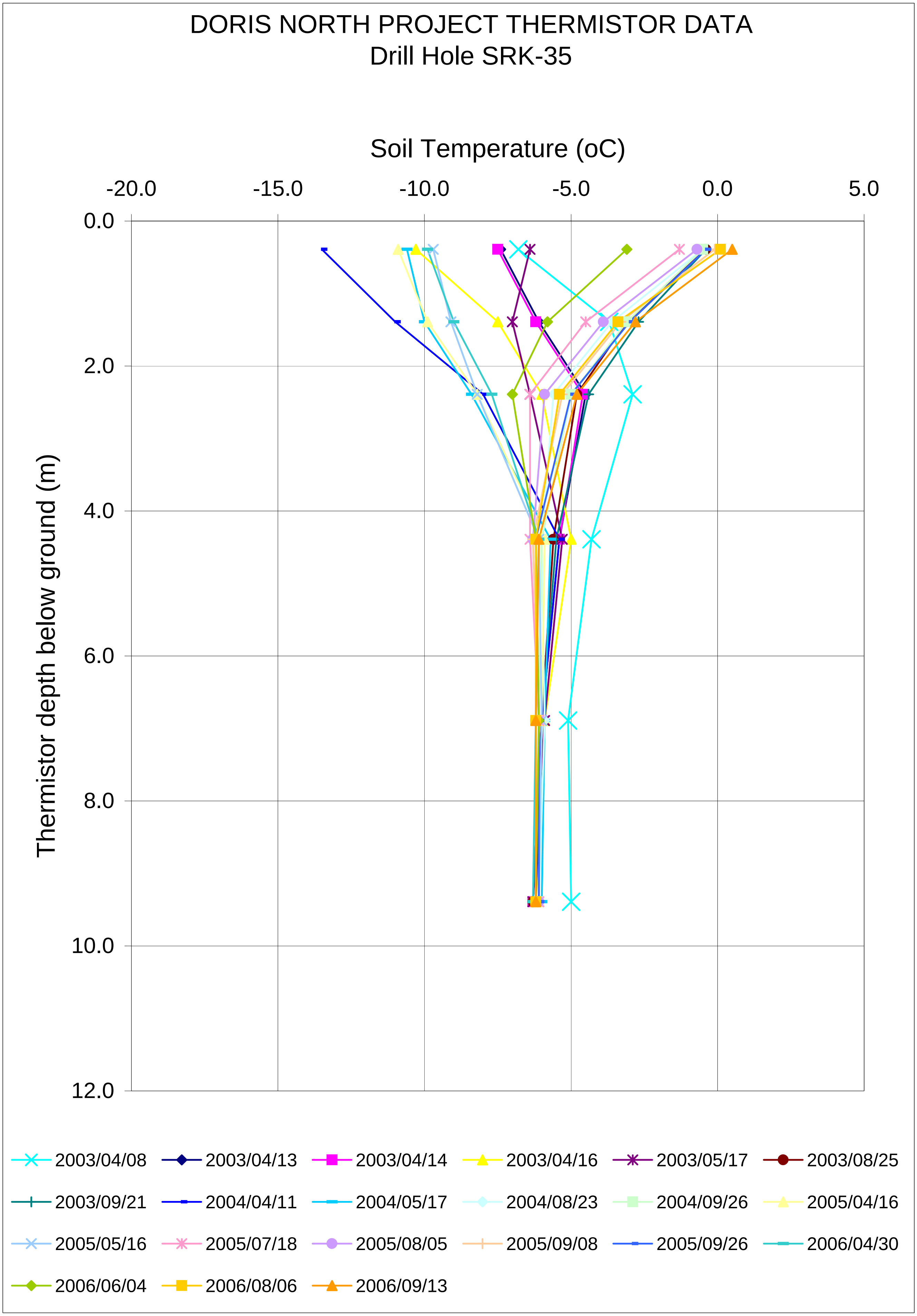


DORIS NORTH PROJECT THERMISTOR DATA
Drill Hole SRK-32
Soil Temperature (oC)
-20.0
-15.0
-10.0
-5.0
0.0
5.0
Thermistor depth below ground (m)
0.0
2.0
4.0
6.0
8.0
10.0
12.0
2003/04/06
2003/04/09
2003/04/13
2003/04/15
2003/04/16
2003/04/20
2003/05/16
2003/08/25
2003/09/21
2004/04/11
2004/05/17
2004/08/27
2004/09/28
2005/04/16
2005/05/16
2005/07/18
2005/08/05
2005/09/08
2005/09/26
2006/04/30
2006/06/04
2006/08/06
2006/09/13

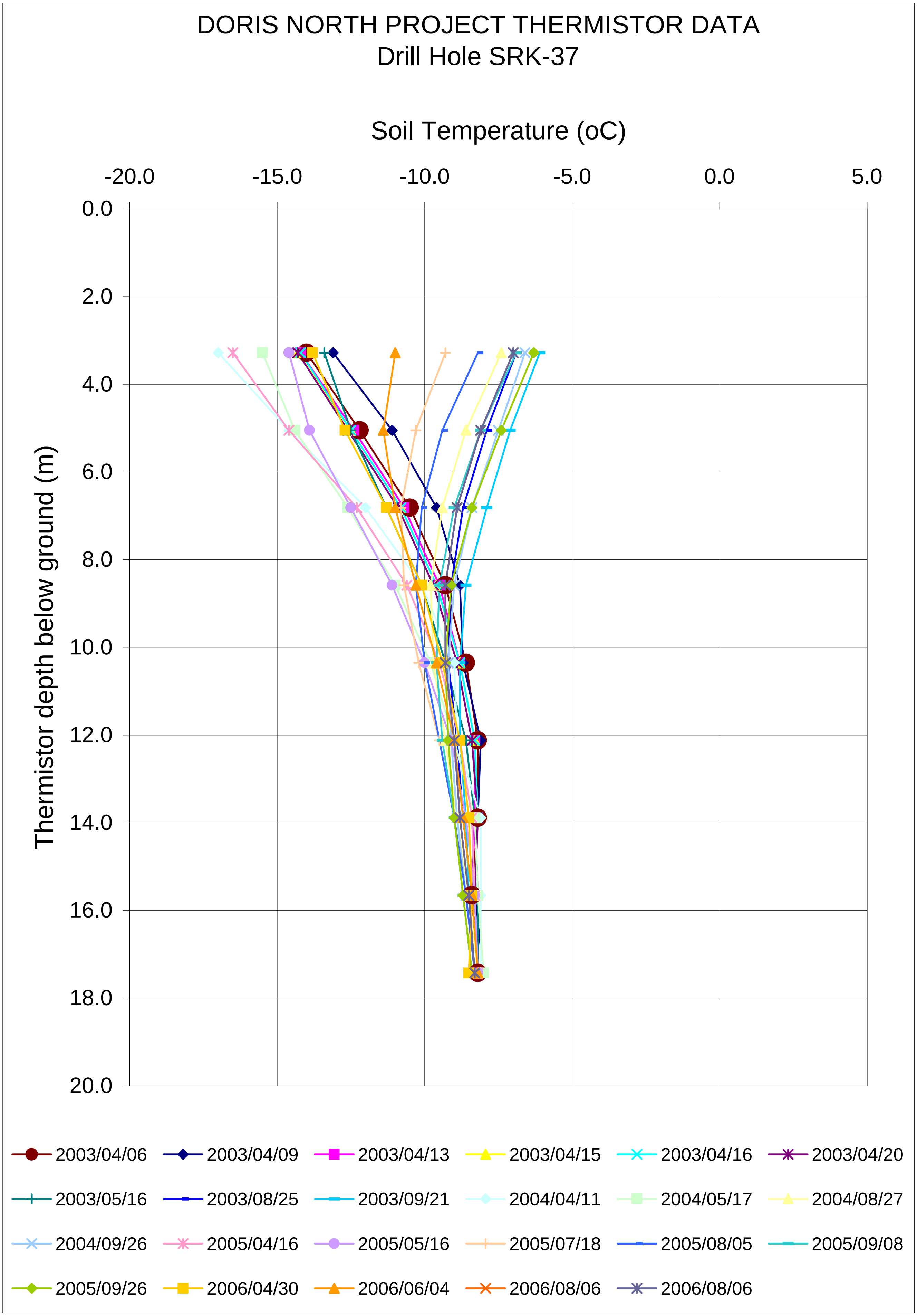


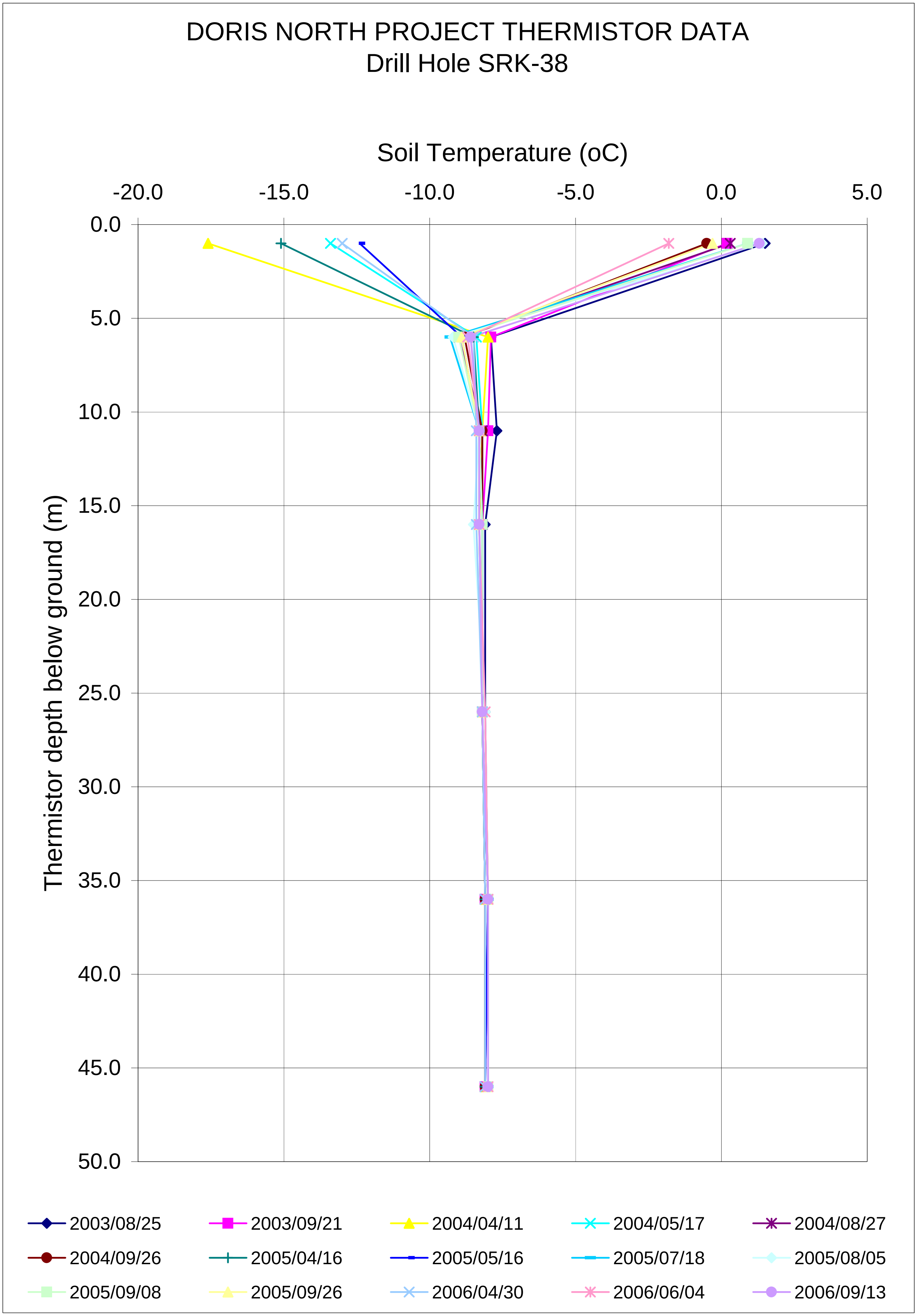
DORIS NORTH PROJECT THERMISTOR DATA
Drill Hole SRK-33
Soil Temperature (oC)
-20.0
-15.0
-10.0
-5.0
0.0
5.0
0.0
2.0
4.0
6.0
8.0
10.0
12.0
Thermistor depth below ground (m)
2003/04/06
2003/04/09
2003/04/13
2003/04/15
2003/04/16
2003/04/20
2003/05/16
2003/08/25
2003/09/21
2004/04/11
2004/05/17
2004/08/27
2004/09/28
2005/04/16
2005/05/16
2005/07/18
2005/08/05
2005/09/08
2005/09/26
2006/04/30
2006/06/04
2006/08/06
2006/09/13


DORIS NORTH PROJECT THERMISTOR DATA
Drill Hole SRK-34A
Soil Temperature (oC)
-20.0
-15.0
-10.0
-5.0
0.0
5.0
0.0
2.0
4.0
6.0
8.0
10.0
12.0
Thermistor depth below ground (m)
2003/04/06
2003/04/09
2003/04/13
2003/04/15
2003/04/16
2003/04/20
2003/05/16
2003/08/25
2003/09/21
2004/04/11
2004/05/17
2004/08/27
2004/09/28
2005/04/16
2005/05/16
2005/07/18
2005/08/05
2005/09/08
2005/09/26
2006/04/30
2006/06/04
2006/08/06
2006/09/13

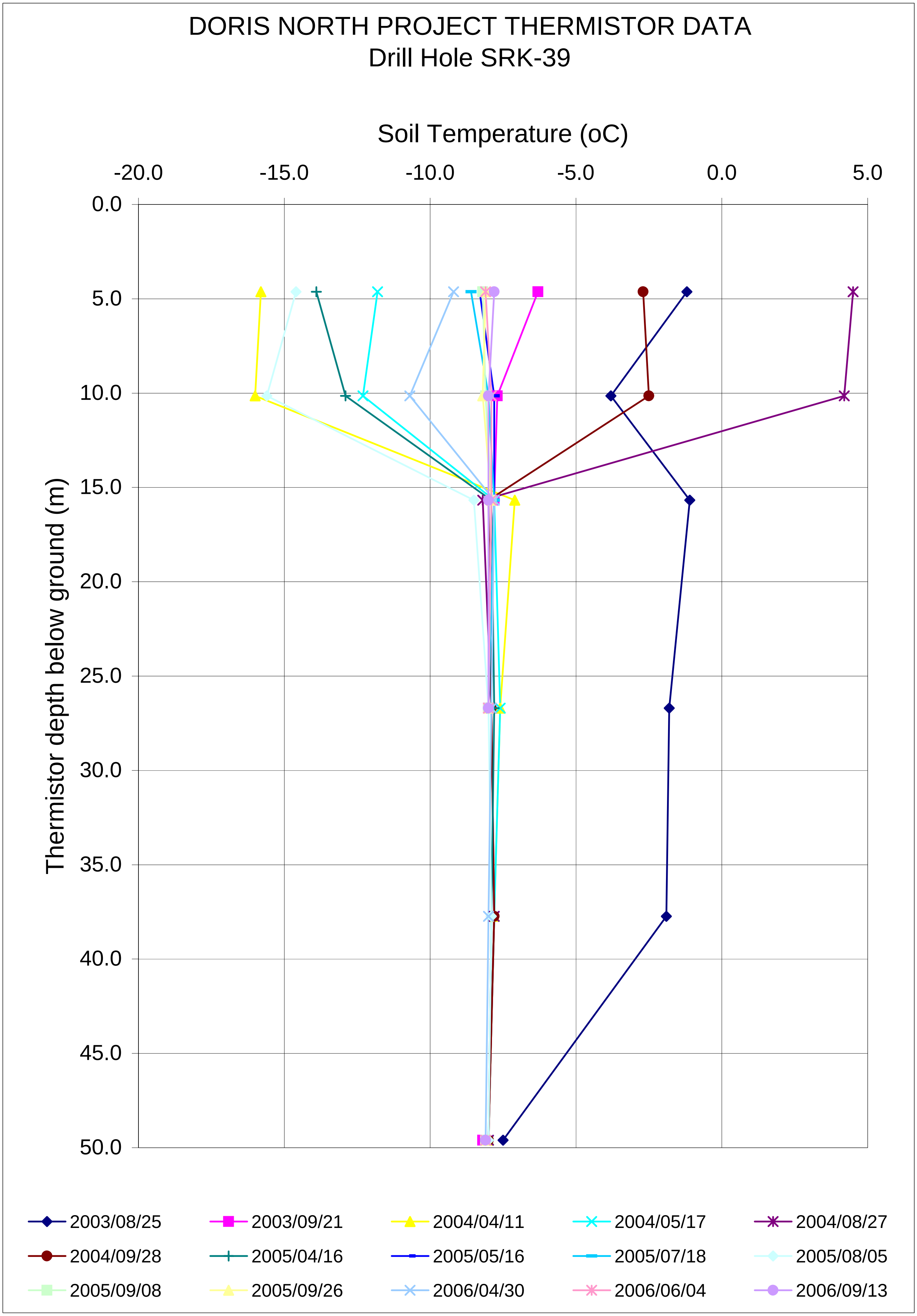


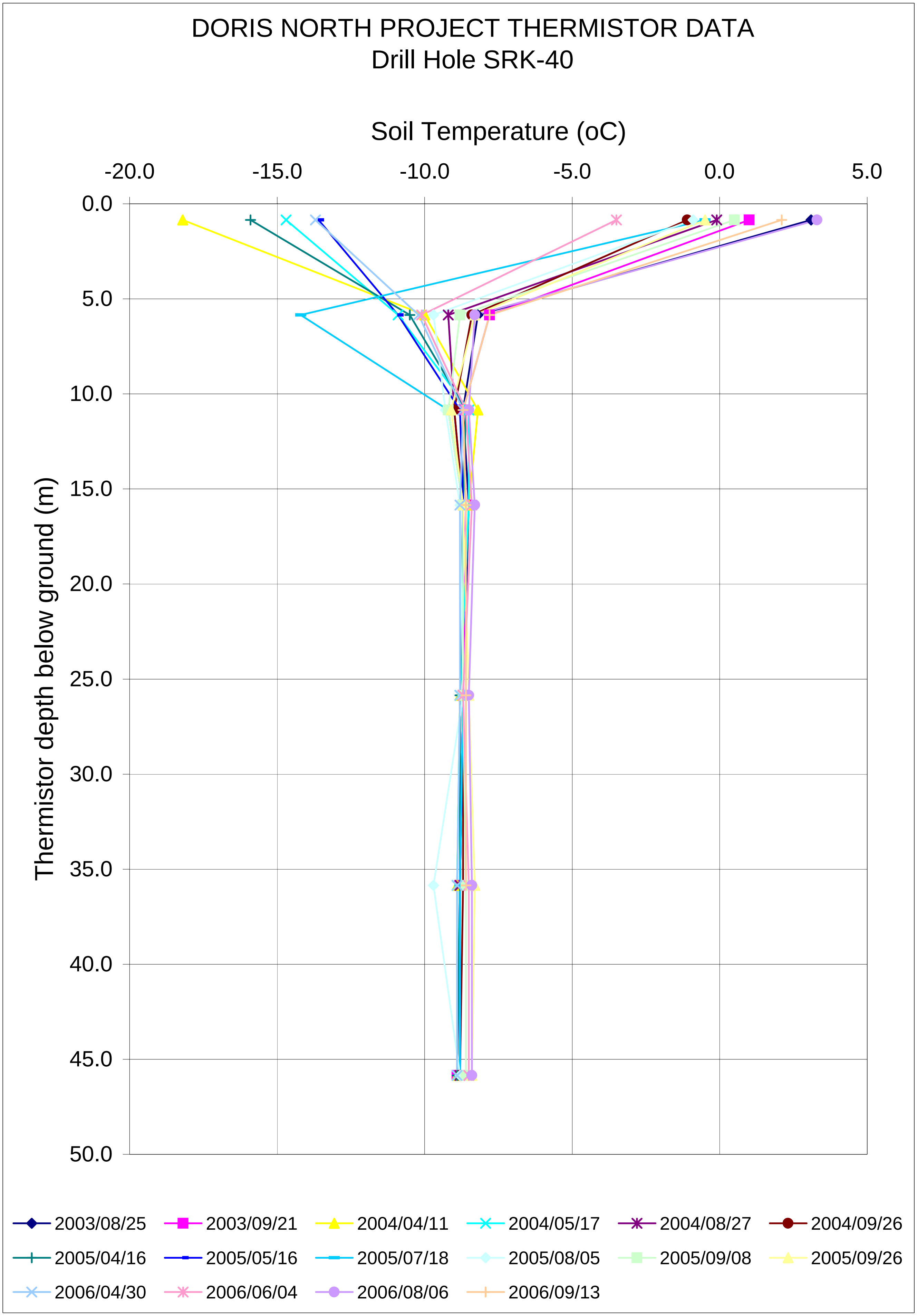
DORIS NORTH PROJECT THERMISTOR DATA
Drill Hole SRK-35
Soil Temperature (oC)
-20.0
-15.0
-10.0
-5.0
0.0
5.0
0.0
2.0
4.0
6.0
8.0
10.0
12.0
Thermistor depth below ground (m)
2003/04/08
2003/04/13
2003/04/14
2003/04/16
2003/05/17
2003/08/25
2003/09/21
2004/04/11
2004/05/17
2004/08/23
2004/09/26
2005/04/16
2005/05/16
2005/07/18
2005/08/05
2005/09/08
2005/09/26
2006/04/30
2006/06/04
2006/08/06
2006/09/13


DORIS NORTH PROJECT THERMISTOR DATA
Drill Hole SRK-37
Soil Temperature (oC)
-20.0
-15.0
-10.0
-5.0
0.0
5.0
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
18.0
20.0
Thermistor depth below ground (m)
2003/04/06
2003/04/09
2003/04/13
2003/04/15
2003/04/16
2003/04/20
2003/05/16
2003/08/25
2003/09/21
2004/04/11
2004/05/17
2004/08/27
2004/09/26
2005/04/16
2005/05/16
2005/07/18
2005/08/05
2005/09/08
2005/09/26
2006/04/30
2006/06/04
2006/08/06
2006/08/06

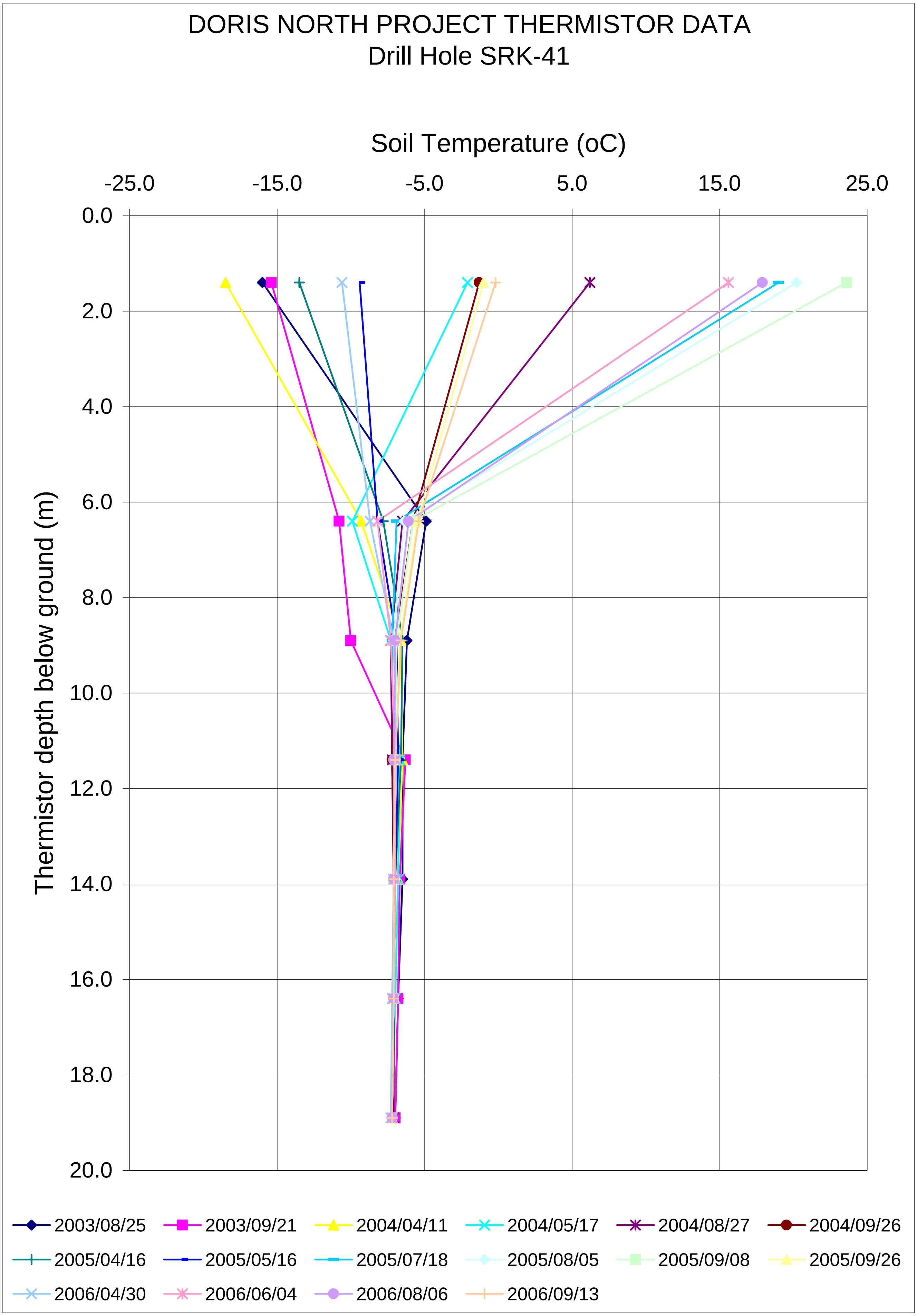


DORIS NORTH PROJECT THERMISTOR DATA
Drill Hole SRK-38
Soil Temperature (oC)
-20.0
-15.0
-10.0
-5.0
0.0
5.0
Thermistor depth below ground (m)
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
50.0
2003/08/25
2003/09/21
2004/04/11
2004/05/17
2004/08/27
2004/09/26
2005/04/16
2005/05/16
2005/07/18
2005/08/05
2005/09/08
2005/09/26
2006/04/30
2006/06/04
2006/09/13

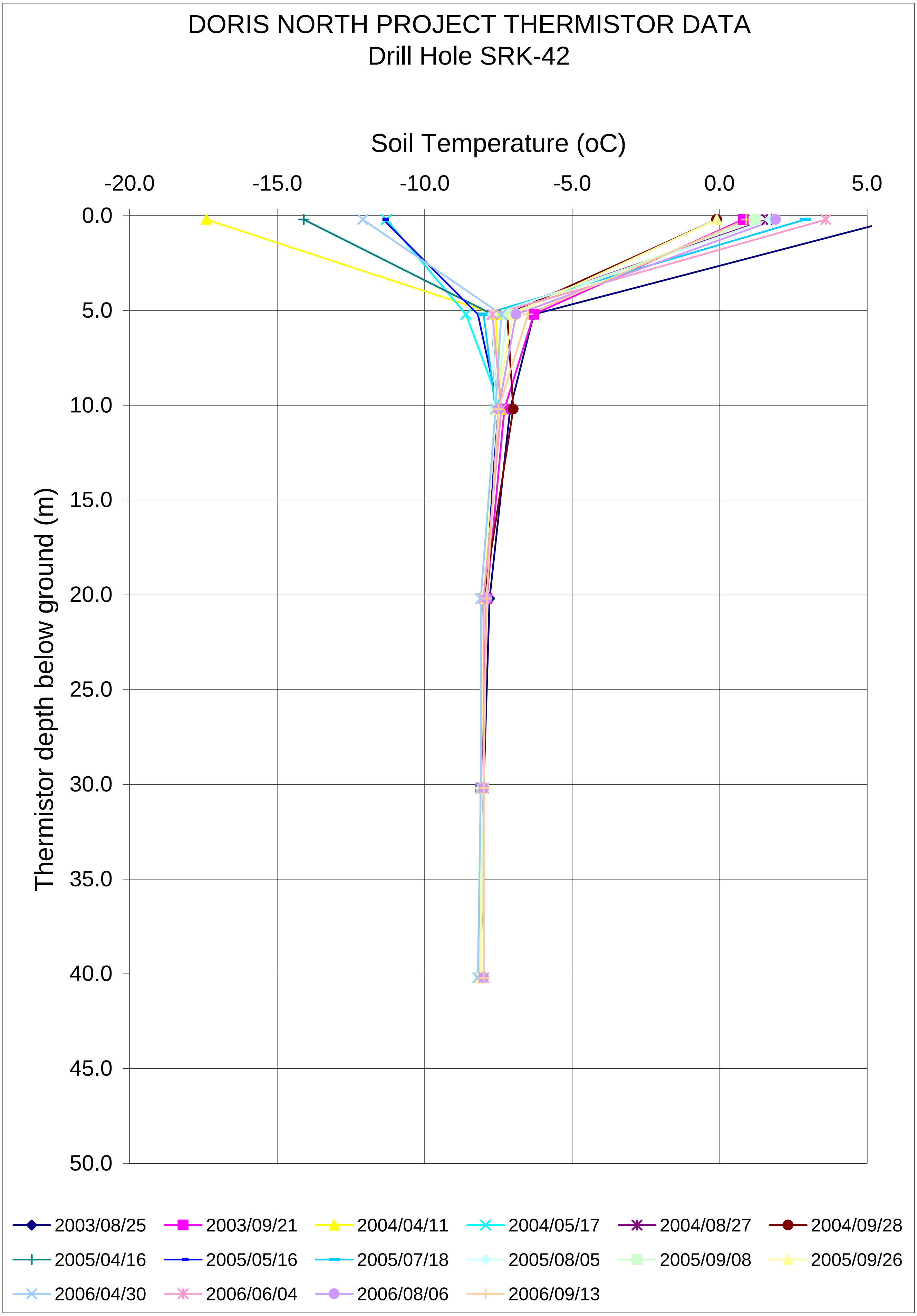

DORIS NORTH PROJECT THERMISTOR DATA
Drill Hole SRK-39
Soil Temperature (oC)
-20.0
-15.0
-10.0
-5.0
0.0
5.0
Thermistor depth below ground (m)
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
50.0
2003/08/25
2003/09/21
2004/04/11
2004/05/17
2004/08/27
2004/09/28
2005/04/16
2005/05/16
2005/07/18
2005/08/05
2005/09/08
2005/09/26
2006/04/30
2006/06/04
2006/09/13

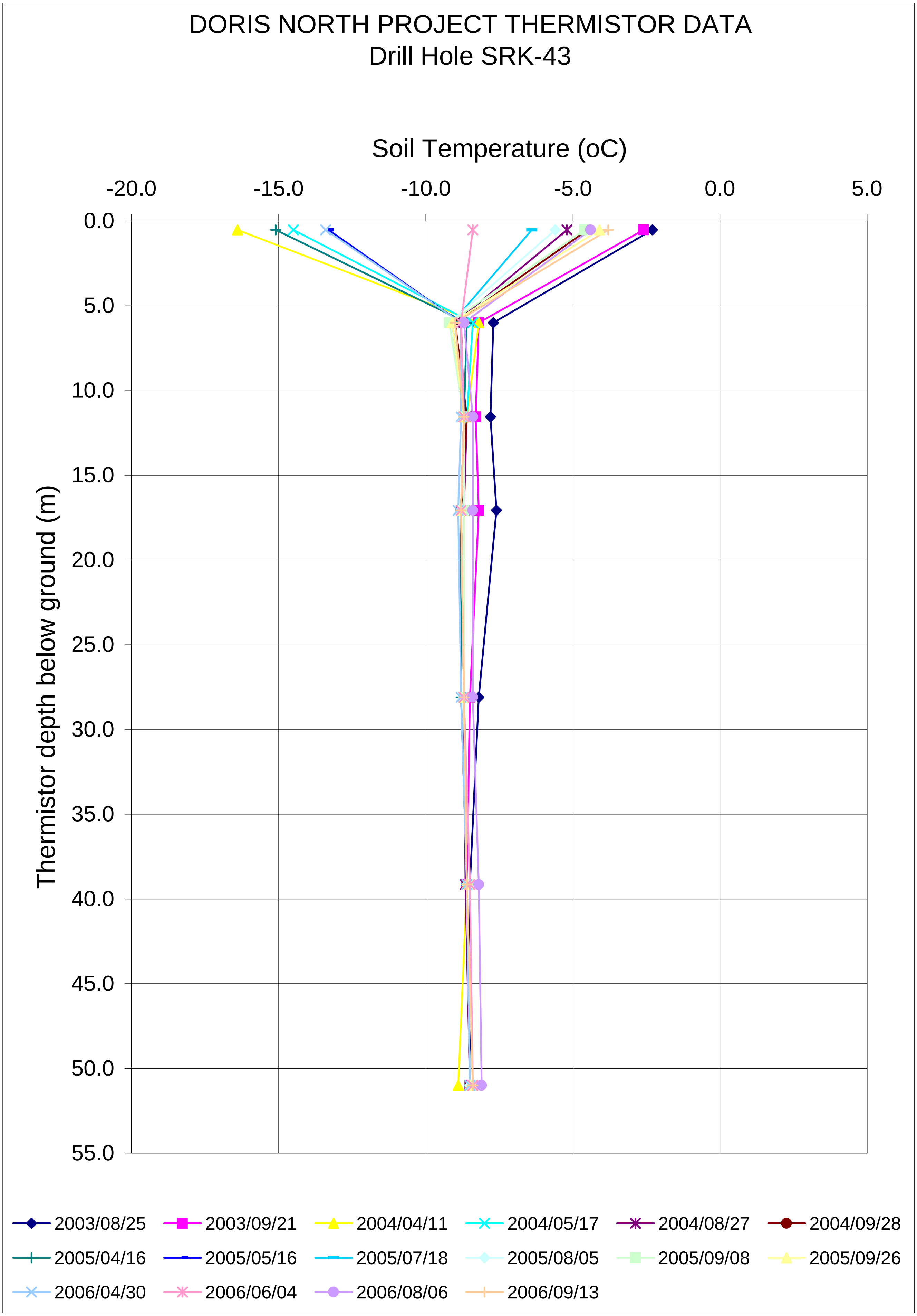


DORIS NORTH PROJECT THERMISTOR DATA
Drill Hole SRK-40
Soil Temperature (oC)
-20.0
-15.0
-10.0
-5.0
0.0
5.0
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
50.0
Thermistor depth below ground (m)
2003/08/25
2003/09/21
2004/04/11
2004/05/17
2004/08/27
2004/09/26
2005/04/16
2005/05/16
2005/07/18
2005/08/05
2005/09/08
2005/09/26
2006/04/30
2006/06/04
2006/08/06
2006/09/13

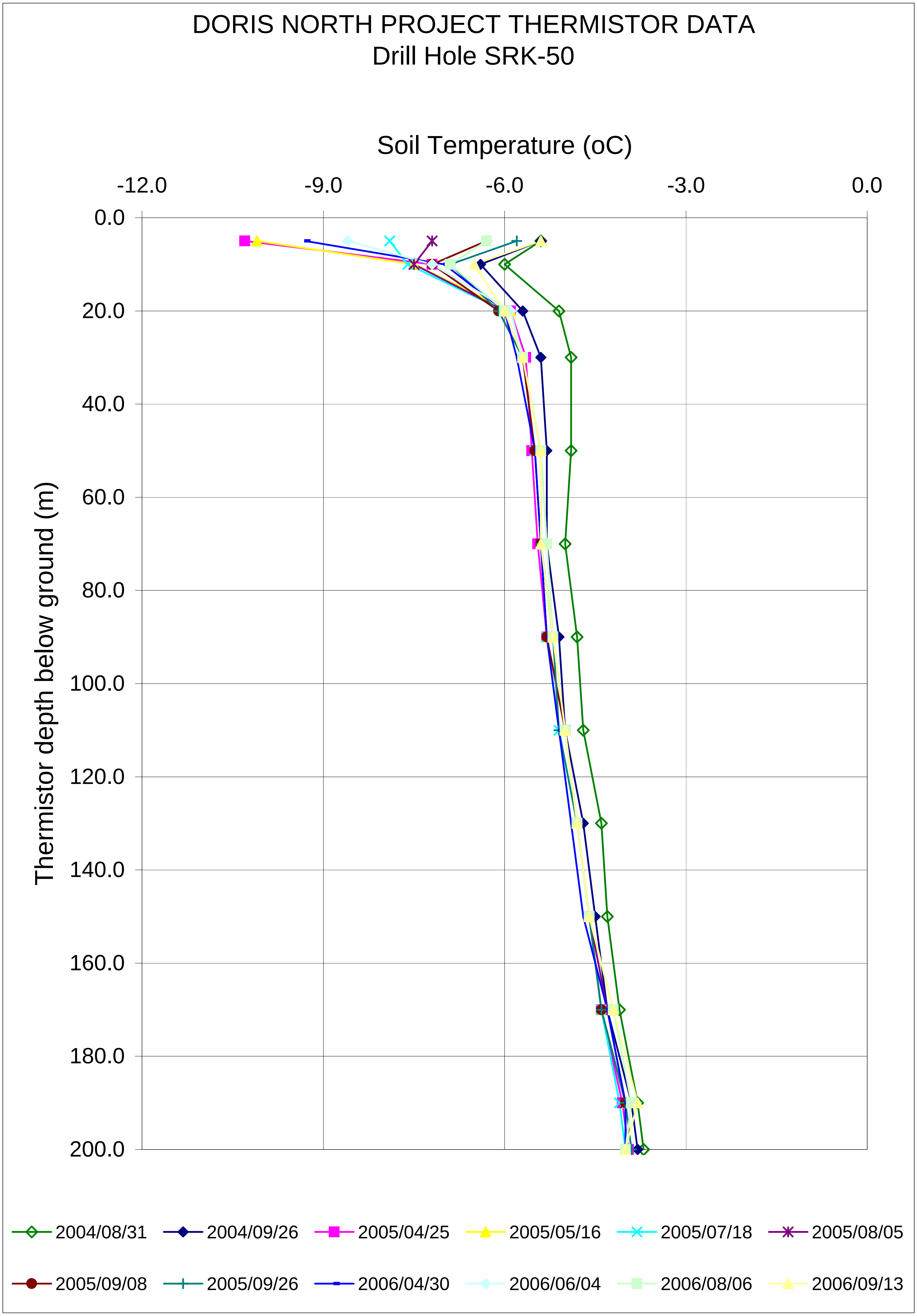


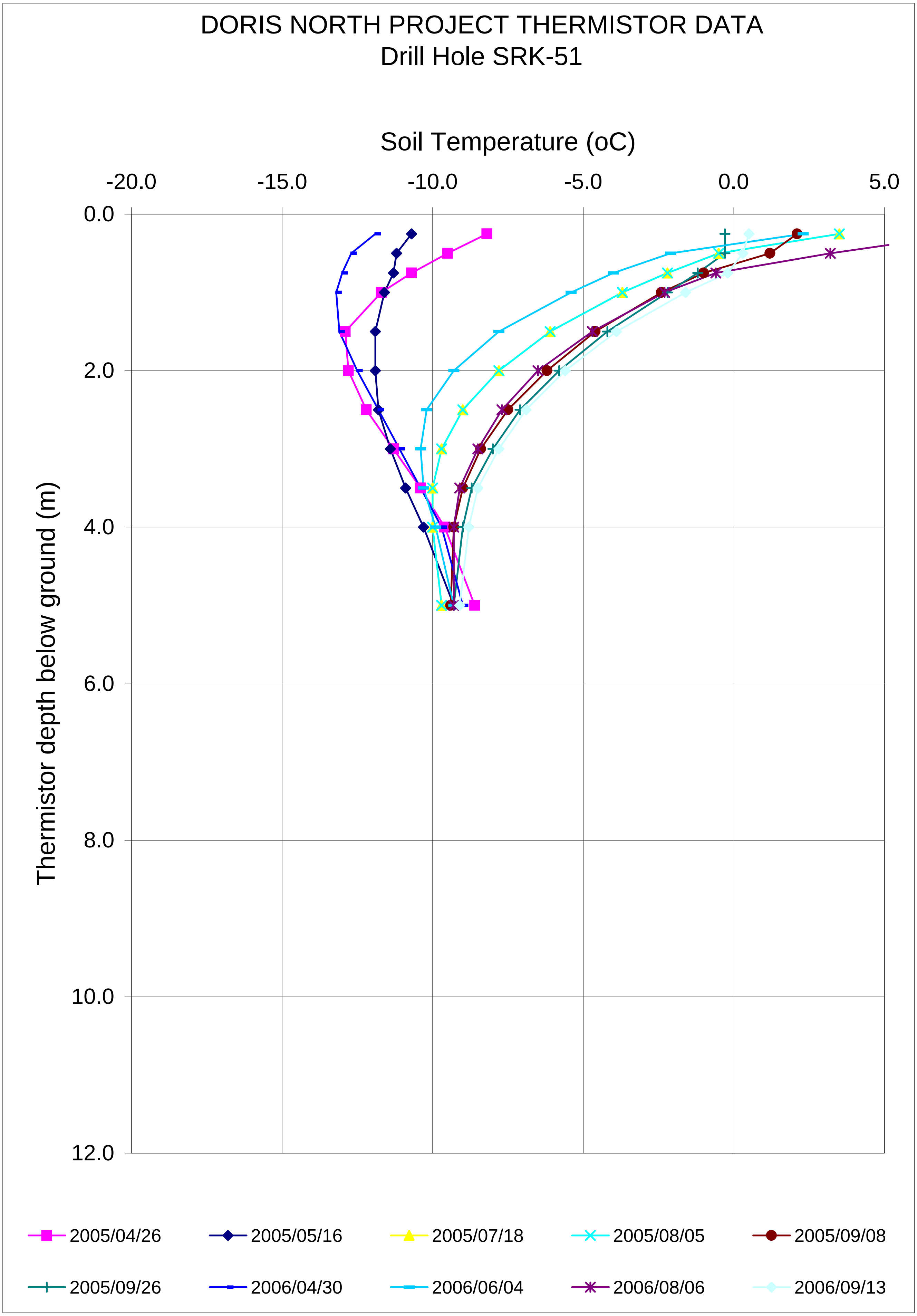
DORIS NORTH PROJECT THERMISTOR DATA
Drill Hole SRK-41
Soil Temperature (oC)
-25.0
-15.0
-5.0
5.0
15.0
25.0
0.0
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
18.0
20.0
Thermistor depth below ground (m)
2003/08/25
2003/09/21
2004/04/11
2004/05/17
2004/08/27
2004/09/26
2005/04/16
2005/05/16
2005/07/18
2005/08/05
2005/09/08
2005/09/26
2006/04/30
2006/06/04
2006/08/06
2006/09/13


DORIS NORTH PROJECT THERMISTOR DATA
Drill Hole SRK-42
Soil Temperature (oC)
-20.0
-15.0
-10.0
-5.0
0.0
5.0
Thermistor depth below ground (m)
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
50.0
2003/08/25
2003/09/21
2004/04/11
2004/05/17
2004/08/27
2004/09/28
2005/04/16
2005/05/16
2005/07/18
2005/08/05
2005/09/08
2005/09/26
2006/04/30
2006/06/04
2006/08/06
2006/09/13

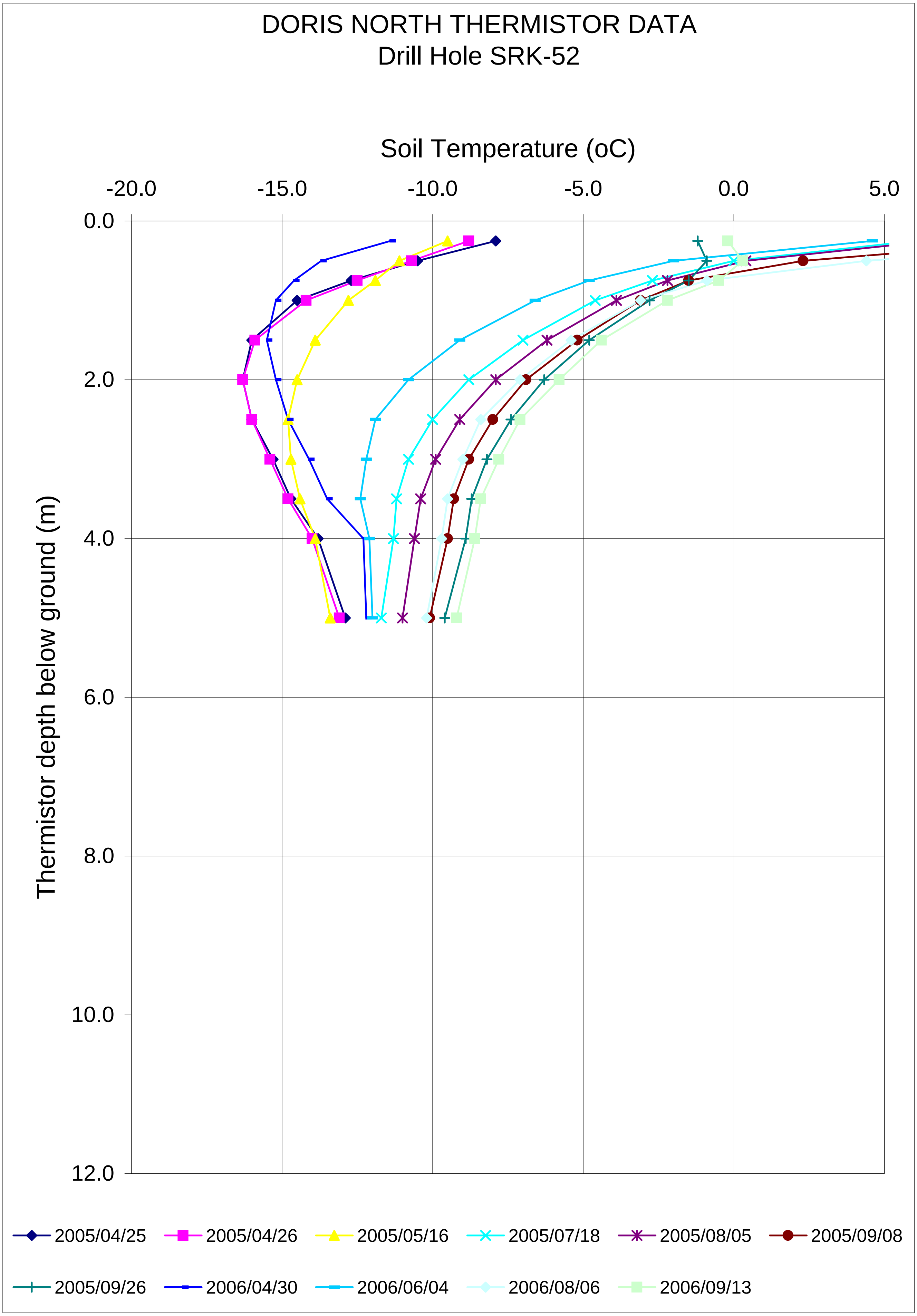


DORIS NORTH PROJECT THERMISTOR DATA
Drill Hole SRK-43
Soil Temperature (oC)
-20.0
-15.0
-10.0
-5.0
0.0
5.0
Thermistor depth below ground (m)
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0
45.0
50.0
55.0
2003/08/25
2003/09/21
2004/04/11
2004/05/17
2004/08/27
2004/09/28
2005/04/16
2005/05/16
2005/07/18
2005/08/05
2005/09/08
2005/09/26
2006/04/30
2006/06/04
2006/08/06
2006/09/13

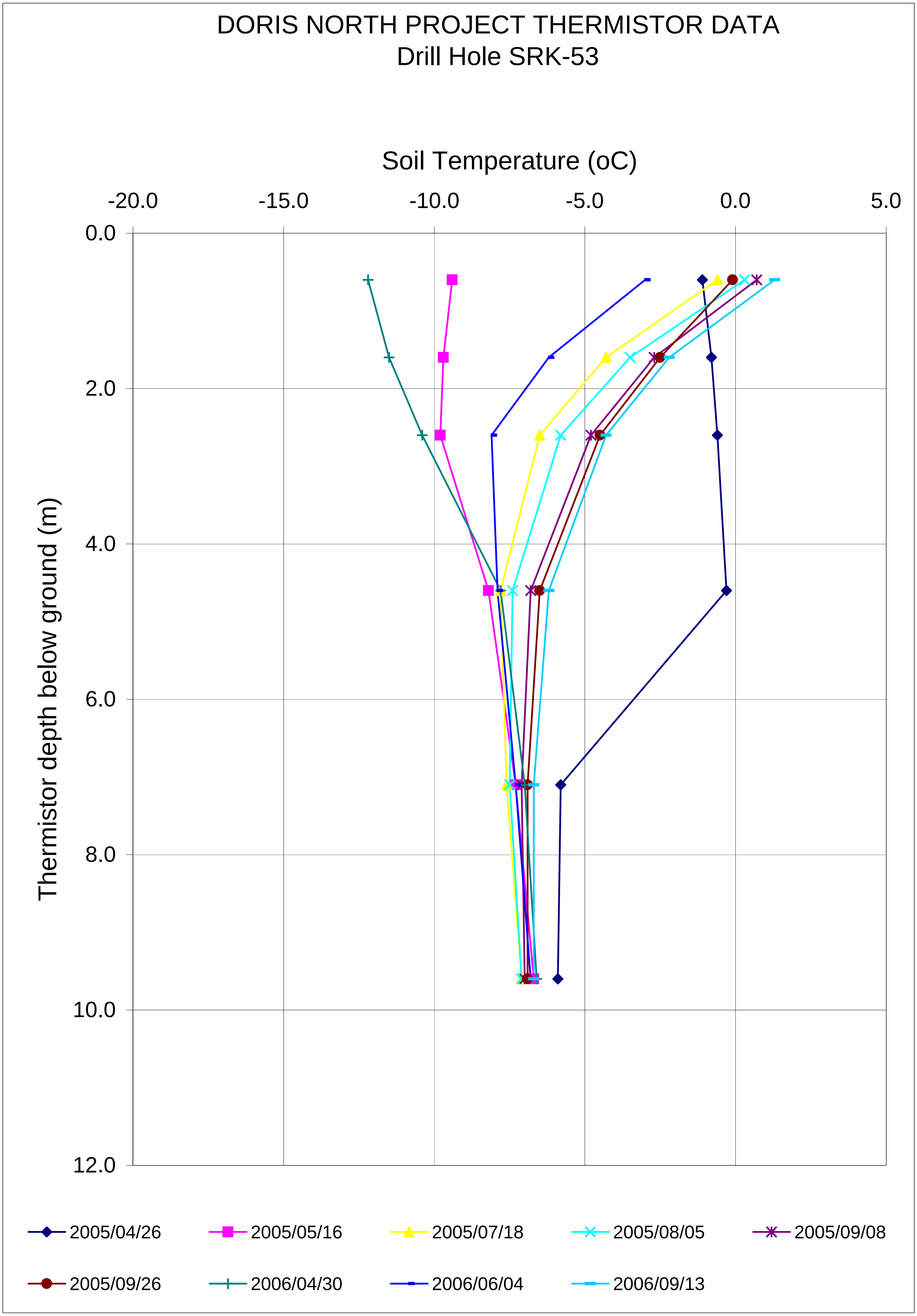

DORIS NORTH PROJECT THERMISTOR DATA
Drill Hole SRK-50
Soil Temperature (oC)
-12.0
-9.0
-6.0
-3.0
0.0
Thermistor depth below ground (m)
0.0
20.0
40.0
60.0
80.0
100.0
120.0
140.0
160.0
180.0
200.0
2004/08/31
2004/09/26
2005/04/25
2005/05/16
2005/07/18
2005/08/05
2005/09/08
2005/09/26
2006/04/30
2006/06/04
2006/08/06
2006/09/13



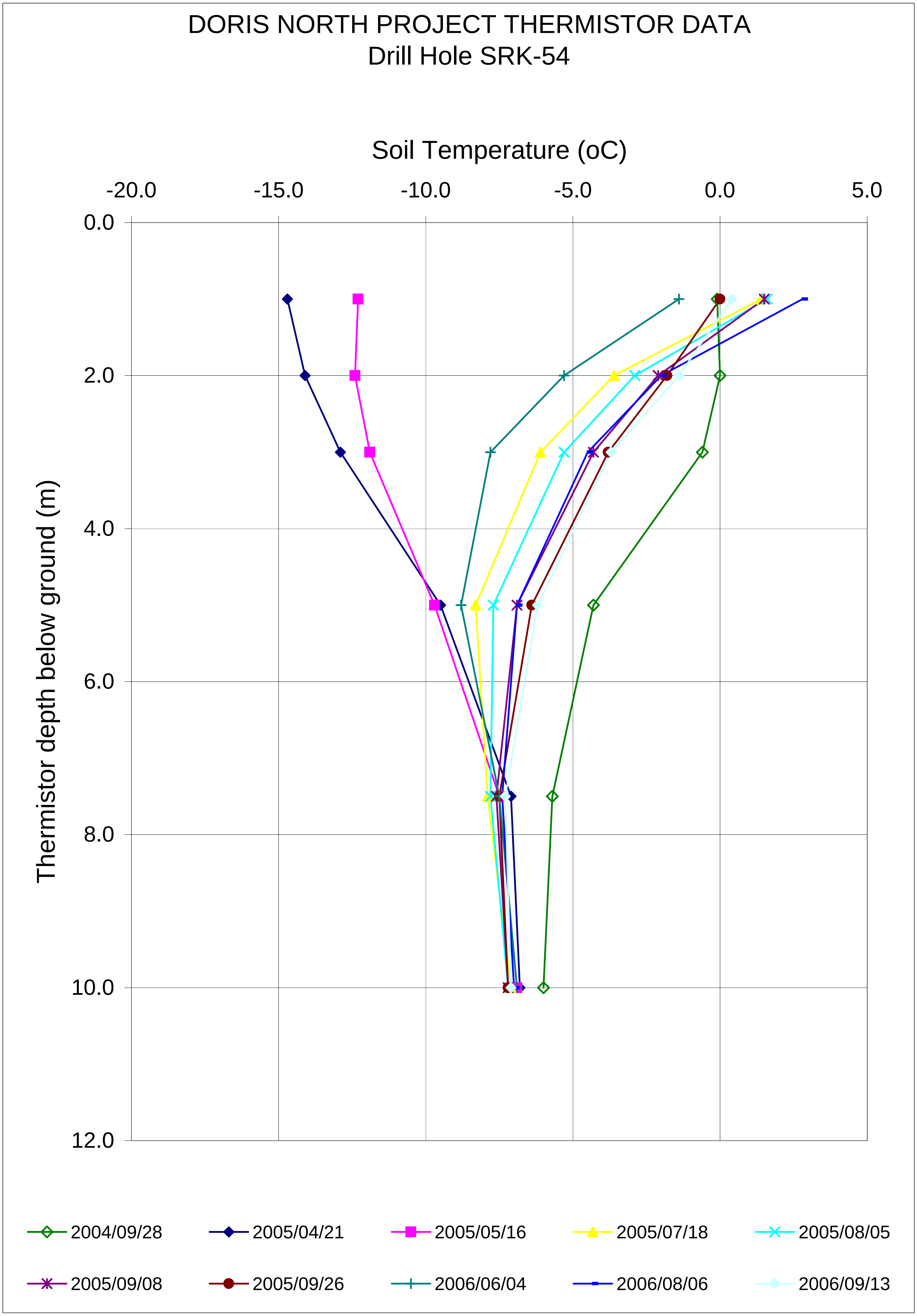
DORIS NORTH PROJECT THERMISTOR DATA
Drill Hole SRK-51
Soil Temperature (oC)
-20.0
-15.0
-10.0
-5.0
0.0
5.0
Thermistor depth below ground (m)
0.0
2.0
4.0
6.0
8.0
10.0
12.0
2005/04/26
2005/05/16
2005/07/18
2005/08/05
2005/09/08
2005/09/26
2006/04/30
2006/06/04
2006/08/06
2006/09/13

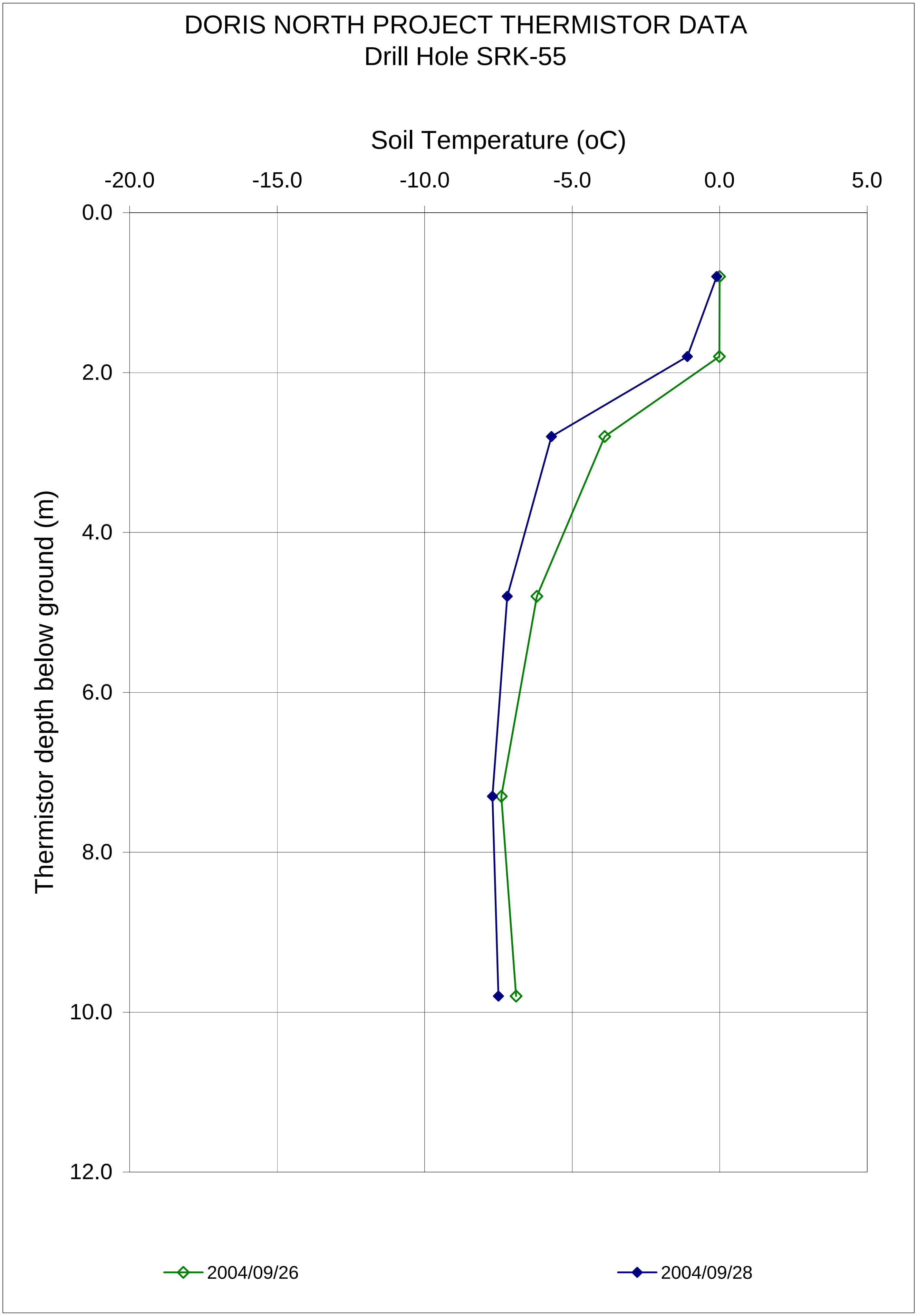


DORIS NORTH THERMISTOR DATA
Drill Hole SRK-52
Soil Temperature (oC)
-20.0
-15.0
-10.0
-5.0
0.0
5.0
0.0
2.0
4.0
6.0
8.0
10.0
12.0
Thermistor depth below ground (m)
2005/04/25
2005/04/26
2005/05/16
2005/07/18
2005/08/05
2005/09/08
2005/09/26
2006/04/30
2006/06/04
2006/08/06
2006/09/13

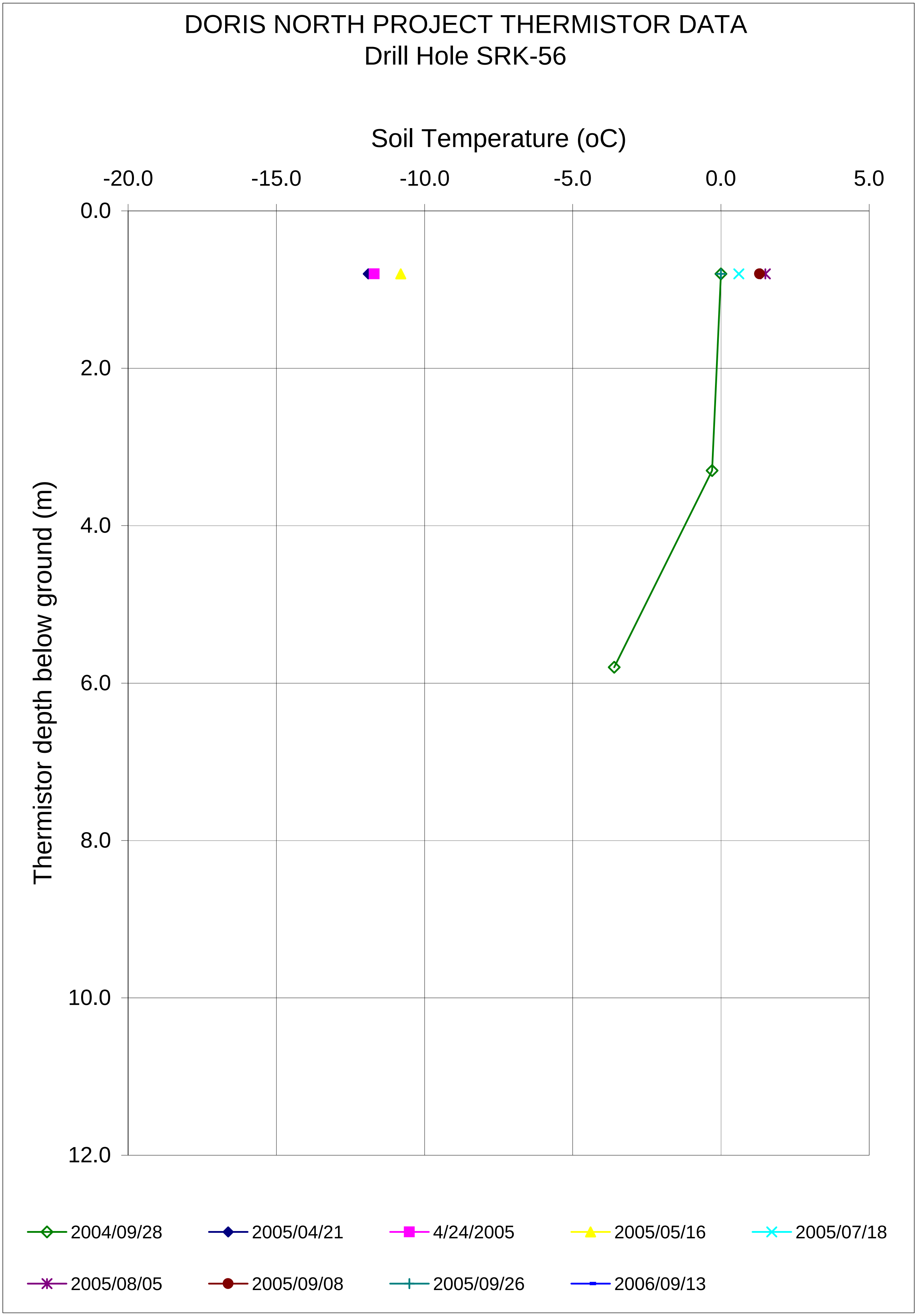


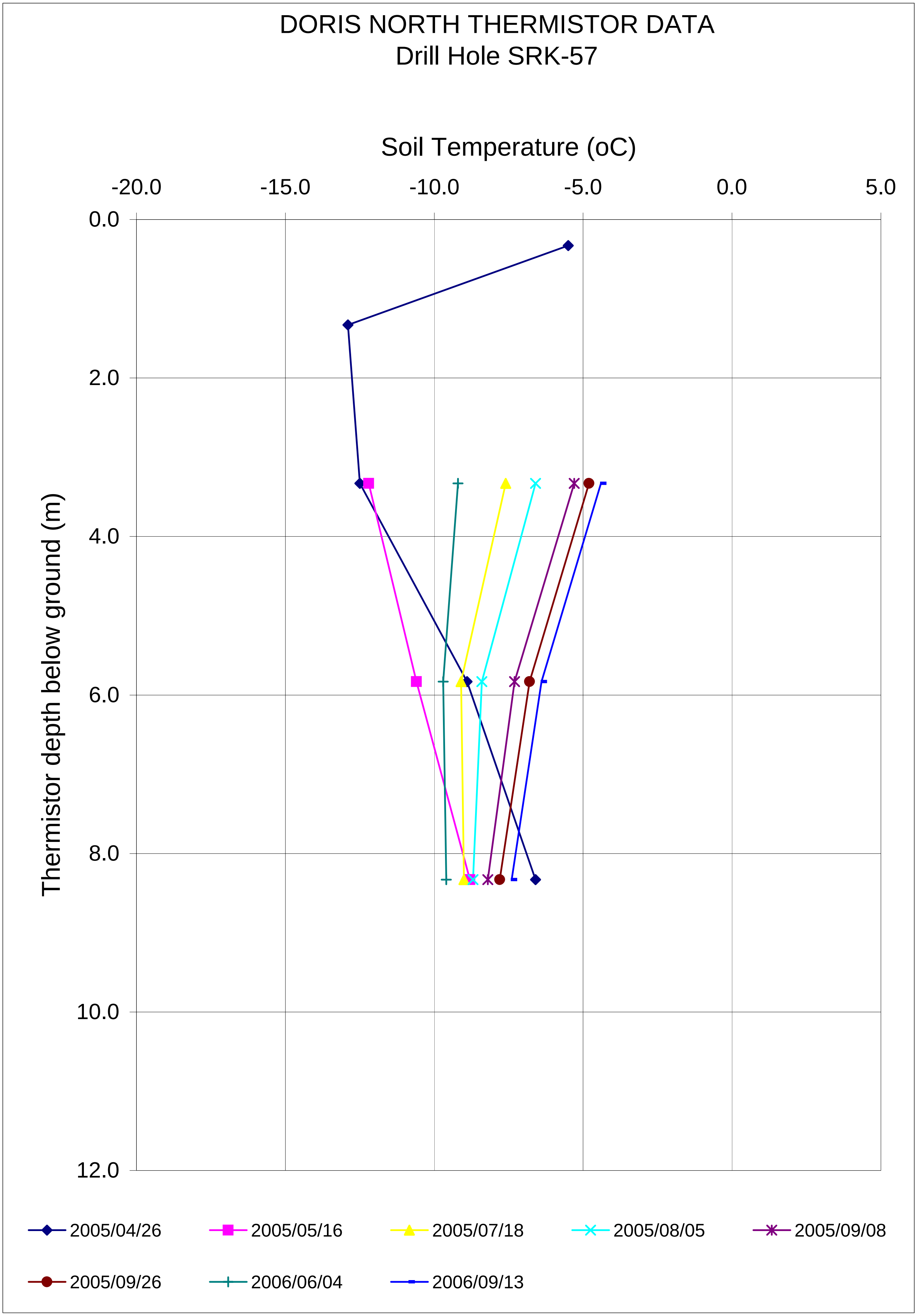
DORIS NORTH PROJECT THERMISTOR DATA
Drill Hole SRK-53
Soil Temperature (oC)
-20.0
-15.0
-10.0
-5.0
0.0
5.0
0.0
2.0
4.0
6.0
8.0
10.0
12.0
Thermistor depth below ground (m)
2005/04/26
2005/05/16
2005/07/18
2005/08/05
2005/09/08
2005/09/26
2006/04/30
2006/06/04
2006/09/13


DORIS NORTH PROJECT THERMISTOR DATA
Drill Hole SRK-54
Soil Temperature (oC)
-20.0
-15.0
-10.0
-5.0
0.0
5.0
Thermistor depth below ground (m)
0.0
2.0
4.0
6.0
8.0
10.0
12.0
2004/09/28
2005/04/21
2005/05/16
2005/07/18
2005/08/05
2005/09/08
2005/09/26
2006/06/04
2006/08/06
2006/09/13

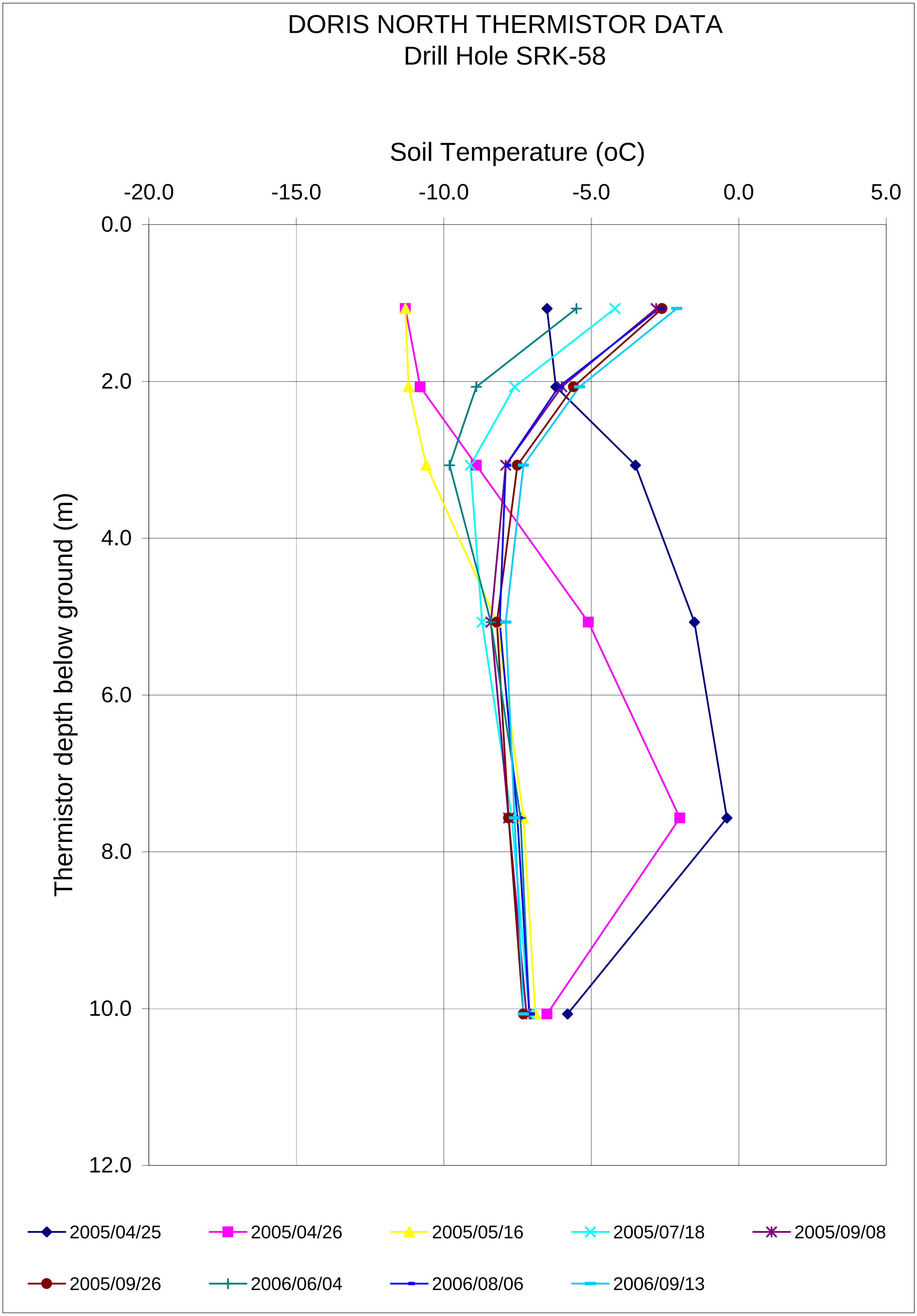


DORIS NORTH PROJECT THERMISTOR DATA
Drill Hole SRK-55
Soil Temperature (oC)
-20.0
-15.0
-10.0
-5.0
0.0
5.0
0.0
2.0
4.0
6.0
8.0
10.0
12.0
Thermistor depth below ground (m)
2004/09/26
2004/09/28

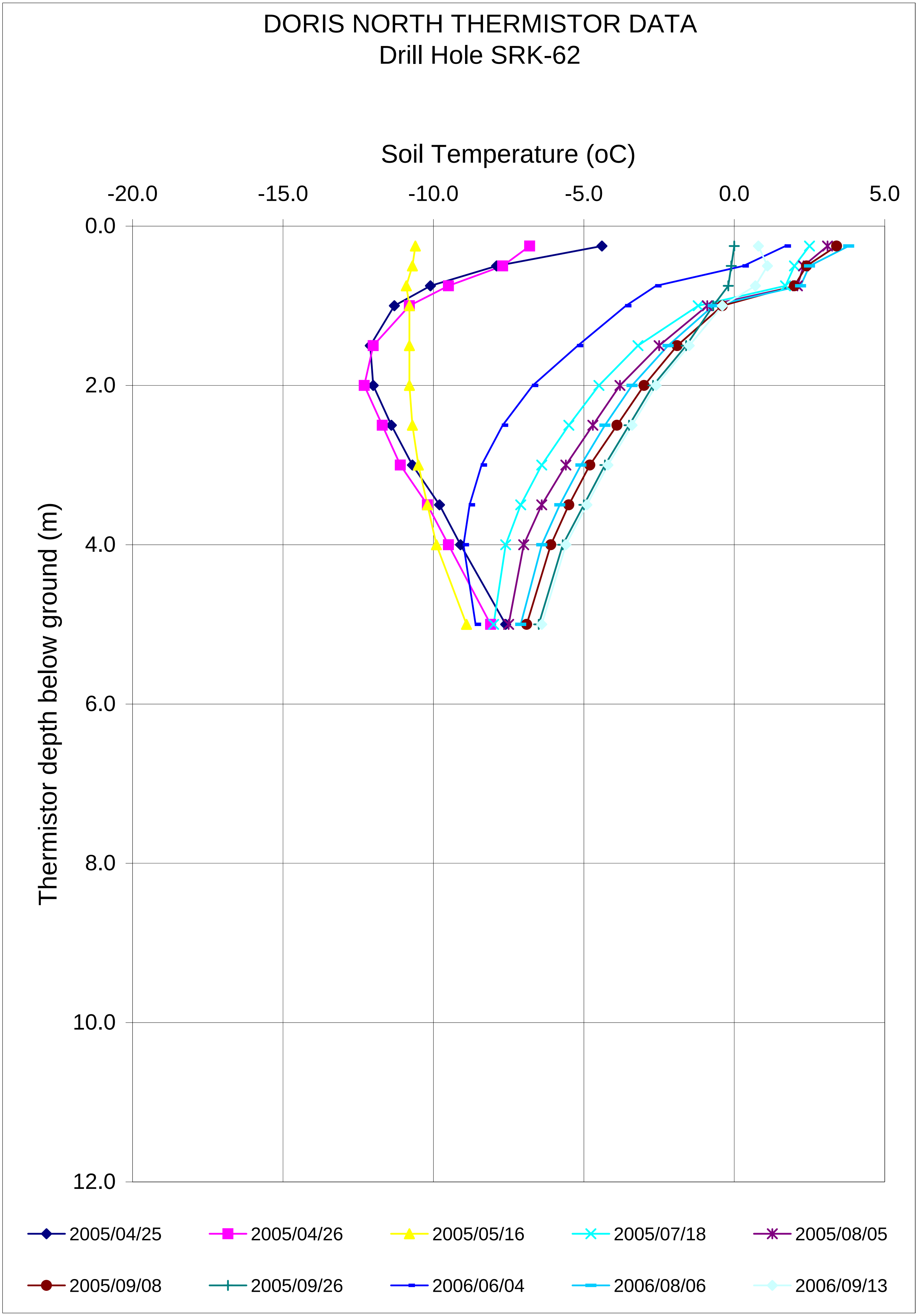

DORIS NORTH PROJECT THERMISTOR DATA
Drill Hole SRK-56
Soil Temperature (oC)
-20.0
-15.0
-10.0
-5.0
0.0
5.0
0.0
2.0
4.0
6.0
8.0
10.0
12.0
Thermistor depth below ground (m)
2004/09/28
2005/04/21
4/24/2005
2005/05/16
2005/07/18
2005/08/05
2005/09/08
2005/09/26
2006/09/13



DORIS NORTH THERMISTOR DATA
Drill Hole SRK-57
Soil Temperature (oC)
-20.0
-15.0
-10.0
-5.0
0.0
5.0
0.0
2.0
4.0
6.0
8.0
10.0
12.0
Thermistor depth below ground (m)
2005/04/26
2005/05/16
2005/07/18
2005/08/05
2005/09/08
2005/09/26
2006/06/04
2006/09/13



DORIS NORTH THERMISTOR DATA
Drill Hole SRK-58
Soil Temperature (oC)
-20.0
-15.0
-10.0
-5.0
0.0
5.0
0.0
2.0
4.0
6.0
8.0
10.0
12.0
Thermistor depth below ground (m)
2005/04/25
2005/04/26
2005/05/16
2005/07/18
2005/09/08
2005/09/26
2006/06/04
2006/08/06
2006/09/13


DORIS NORTH THERMISTOR DATA
Drill Hole SRK-62
Soil Temperature (oC)
-20.0
-15.0
-10.0
-5.0
0.0
5.0
Thermistor depth below ground (m)
0.0
2.0
4.0
6.0
8.0
10.0
12.0
2005/04/25
2005/04/26
2005/05/16
2005/07/18
2005/08/05
2005/09/08
2005/09/26
2006/06/04
2006/08/06
2006/09/13

Appendix C-2
Thermistor String Data - Tables

DORIS NORTH PROJECT THERMISTOR DATA

Drill Hole SRK-11		Bead No.	Bead 1	Bead 2	Bead 3	Bead 4	Bead 5
Read By	**Date**	**Bead Location from Top (m)**	**5.0**	**6.0**	**7.0**	**8.5**	**10.0**
		Bead Depth (m)	**3.8**	**4.8**	**5.8**	**7.3**	**8.8**
Andrew Doe (SRK)	2002/09/14	**Temperature (Celsius)**	-5.7	-6.3	-6.3	-6.2	-6.1
Andrew Doe (SRK)	2002/09/14		-6.5	-7.3	-7.4	-7.3	-7.0
Andrew Doe (SRK)	2002/09/15		-6.8	-7.4	-7.5	-7.4	-7.3
Dwayne Winsor (Miramar)	2002/09/19		-7.5	-7.8	-7.9	-7.9	-7.8
Dylan McGreggor (SRK)	2003/03/24					-7.9	-7.4
Dylan MacGregor (SRK)	2003/03/29		-8.1	-7.7	-7.7	-7.4	-7.6
Sebastian Fortin (SRK)	2003/04/06		-8.4	-7.9	-7.6	-7.4	-7.5
Dan Mackie (SRK)	2003/04/13		-8.7	-8.1	-7.7	-7.5	-7.5
Dan Mackie (SRK)	2003/04/15		-8.8	-8.5	-7.8	-7.6	-7.6
Dan Mackie (SRK)	2003/04/16		-8.8	-8.2	-7.8	-7.5	-7.5
Dan Mackie (SRK)	2003/04/20		-8.9	-8.2	-7.8	-7.5	-7.5
Jay Hallman (Miramar)	2003/05/16		-9.5	-8.9	-8.4	-7.9	-7.7
Dylan MacGregor (SRK)	2003/08/25		-8.3	-8.4	-8.4	-8.1	-8.1
Mike Cripps (Miramar)	2003/09/21		0.8	-8.0	-8.1	-8.0	-8.1
Dylan MacGregor (SRK)	2004/04/11		-8.7	-8.1	-7.8	-7.4	-7.5
Thorpe/Lindsay (Miramar)	2004/05/17		-9.9	-9.2	-8.6	-7.9	-7.8
Dylan MacGregor (SRK)	2004/08/27		-8.7	-8.8	-8.8	-8.5	-8.4
Quinn Jordan-Knox (SRK)	2004/09/26		-8.1	-8.3	-8.3	-8.3	-8.3
Dylan MacGregor (SRK)	2005/04/16		-9.9	-9.1	-8.6	-7.9	-7.9
D Kary (Miramar)	2005/05/16		-10.5	-9.8	-9.1	-8.4	-8.1
Jay Hallman (Miramar)	2005/07/18		-9.8	-9.6	-9.3	-8.8	-8.5
JRH (Miramar)	2005/08/05		-9.3	-9.2	-9.1	-8.7	-8.6
D. Kary (Miramar)	2005/09/08		-8.5	-8.7	-8.8	-8.5	-8.5
E Ballent (Miramar)	2005/09/26		-0.4	-2.1	-4.4	-8.4	-8.4
L.Wade / A. Tong (SRK)	2006/04/30		-9.1	-8.7	-8.4	-7.9	-7.9
Jay Hallman (Miramar)	2006/06/04		-9.4	-9.0	-8.7	-8.1	-8.1
S Gary/J Hugh (Miramar)	2006/08/29		-8.4	-8.5	-8.5	-8.2	-8.2
H.Johnson (Miramar)	2006/09/13		-7.7	-7.9	-8.1	-8	-8.1

DORIS NORTH PROJECT THERMISTOR DATA							
Drill Hole SRK-13		**Bead No.**	**Bead 1**	**Bead 2**	**Bead 3**	**Bead 4**	**Bead 5**
Read By	**Date**	**Bead Location from Top (m)**	**5.0**	**6.0**	**7.0**	**8.5**	**10.0**
		Bead Depth (m)	**1.1**	**2.1**	**3.1**	**4.6**	**6.1**
Andrew Doe (SRK)	2002/09/14	**Temperature (Celsius)**	0.0	-1.5	-2.8	-4.3	-7.6
Andrew Doe (SRK)	2002/09/14		-1.1	-3.7	-5.6	-7.5	-8.0
Andrew Doe (SRK)	2002/09/15		-1.2	-3.9	-5.8	-7.5	-8.1
Dwayne Winsor (Miramar)	2002/09/19		-1.2	-4.2	-6.3	-7.6	-8.1
Dwayne Winsor (Miramar)	2003/02/16		-26.5	-16.9	-11.9	-7.4	-7.1
Maritz Rykaart (SRK)	2003/03/17		-21.5	-19.6	-14.8	-9.4	-8.1
Dylan MacGregor (SRK)	2003/03/24		-23.5	-18.1	-14.9	-9.9	-8.4
Sebastian Fortin (SRK)	2003/04/06		-17.4	-17.6	-14.8	-10.5	-9.0
Dan Mackie (SRK)	2003/04/13		-18.8	-16.8	-14.7	-10.8	-9.3
Dan Mackie (SRK)	2003/04/15		-21.7	-16.7	-14.7	-10.9	-9.4
Dan Mackie (SRK)	2003/04/16		-13.1	-17.0	-14.9	-11.2	-9.5
Dan Mackie (SRK)	2003/04/20		-13.3	-16.4	-14.8	-11.3	-9.6
Jay Hallman (Miramar)	2003/05/16		-3.3	-12.1	-12.6	-11.4	-10.1
Dylan MacGregor (SRK)	2003/08/25		16.4	1.0	-3.4	-7.4	-8.3
Thermistor Permanently Damaged - Not Repairable							

DORIS NORTH PROJECT THERMISTOR DATA

Drill Hole SRK-14		Bead No.	Bead 1	Bead 2	Bead 3	Bead 4	Bead 5	Bead 6
Read By	**Date**	**Bead Location from Top (m)**	**2.0**	**3.0**	**4.0**	**6.0**	**8.5**	**11.0**
		Bead Depth (m)	**1.2**	**2.2**	**3.2**	**5.2**	**7.7**	**10.2**
Sebastian Fortin (SRK)	2003/04/06	**Temperature (Celsius)**	-11.8	-11.1	-9.7	-7.6	-7.8	-8.3
Dan Mackie (SRK)	2003/04/13		-13.6	-12.6	-11.3	-9.3	-8.5	-8.6
Dan Mackie (SRK)	2003/04/15		-13.8	-12.8	-11.6	-9.6	-8.6	-8.6
Dan Mackie (SRK)	2003/04/16		-14.6	-13.7	-12.7	-10.5	-8.7	-8.6
Dan Mackie (SRK)	2003/04/20		-14.7	-13.9	-12.8	-10.8	-9.0	-8.7
Jay Hallman (Miramar)	2003/05/16		-10.8	-12.4	-12.5	-11.5	-9.8	-9.1
Dylan MacGregor (SRK)	2003/08/25		-0.1	-2.6	-4.9	-7.6	-9.2	-9.4
Mike Cripps (Miramar)	2003/09/21		-0.1	-2.1	-4.1	-6.8	-8.6	-9.2
Dylan MacGregor (SRK)	2004/04/11		-17.8	-16.3	-12.8	-9.8	-8.9	
Thorpe/Lindsay (Miramar)	2004/05/17		-13.8	-14.7	-14.9	-13.2	-10.8	-9.6
Dylan MacGregor (SRK)	2004/08/27		-0.5	-2.8	-5.5	-8.5	-9.9	-9.9
Quinn Jordan-Knox (SRK)	2004/09/26		-0.6	-2.3	-4.5	-7.3	-9.2	-9.6
Dylan MacGregor (SRK)	2005/04/16		-16.9	-17	-16.4	-13.8	-16.9	-9.6
D Kary (Miramar)	2005/05/16		-13.1	-13.9	-14.3	-13.5	-11.5	-10.1
Jay Hallman (Miramar)	2005/07/18		-1.4	-4.7	-7.7	-10.6	-11.1	-10.5
JRH (Miramar)	2005/08/05		-0.9	-3.6	-6.4	-9.5	-10.6	-10.4
D Kary (Miramar)	2005/09/08		-0.3	-2.5	-5.0	-8.1	-9.8	-10.1
E Ballent (Miramar)	2005/09/26		-0.4	-2.1	-4.4	-7.4	-9.3	-9.9
L. Wade / A. Tong (SRK)	2006/04/30		-13.9	-13.8	-13.3	-11.8	-10.2	-9.5
Jay Hallman (Miramar)	2006/06/04		-3.8	-7.2	-9.7	-11.1	-10.4	-9.7
Gary S/Hugh J. (Miramar)	2006/08/06		0.0	-2.5	-5.0	-7.9	-9.4	-9.7
H.Johnson (Miramar)	2006/09/13		0.4	-1.6	-3.9	-6.7	-8.6	-9.3

DORIS NORTH PROJECT THERMISTOR DATA

Drill Hole SRK-15		Bead No.	Bead 1	Bead 2	Bead 3	Bead 4	Bead 5	Bead 6	Bead 7	Bead 8	Bead 9	Bead 10
Read By	Date	Bead Location from Top (m)	6.0	11.0	13.5	16.0	18.5	21.0	23.5	26.0	28.5	31.0
		Inclined Bead Depth (m)	2.6	7.6	10.1	12.6	15.1	17.6	20.1	22.6	25.1	27.6
		Vert. Bead Depth (m)	1.8	5.4	7.1	8.9	10.7	12.4	14.2	16.0	17.7	19.5
Sebastian Fortin (SRK)	2003/04/06	Temperature (Celsius)	-13.2	-8.3	-8.0	-8.1	-8.1	-7.8	-8.1	-8.2	-8.1	-8.1
Dan Mackie (SRK)	2003/04/13		-13.5	-8.4	-8.2	-8.3	-8.2	-7.9	-8.2	-8.2	-8.2	-8.2
Dan Mackie (SRK)	2003/04/15		-13.6	-8.4	-8.4	-8.3	-8.3	-8.0	-8.2	-8.2	-8.2	-8.2
Dan Mackie (SRK)	2003/04/16		-13.6	-8.4	-8.2	-8.3	-8.3	-8.0	-8.2	-8.2	-8.2	-8.1
Dan Mackie (SRK)	2003/04/20		-13.6	-8.4	-8.2	-8.3	-8.3	-8.0	-8.2	-8.2	-8.2	-8.2
Jay Hallman (Miramar)	2003/05/16		-11.4	-8.6	-8.4	-8.4	-8.4	-8.2	-8.2	-8.3	-8.2	-8.2
Dylan MacGregor (SRK)	2003/08/25		-4.6	-8.9	-8.6	-8.5	-8.4	-8.3	-8.3	-8.3	-8.2	-8.2
Mike Cripps (Miramar)	2003/09/21		-4.1	-8.8	-8.6	-8.5	-8.4	-8.3	-8.3	-8.2	-8.1	-8.2
Dylan MacGregor (SRK)	2004/04/11		-17.4	-8.4	-8.9	-8.5	-8.5	-8.3	-8.2	-8.3	-8.0	-8.1
Thorpe/Lindsay (Miramar)	2004/05/17		-13.6	-8.8	-8.5	-8.4	-8.5	-8.3	-8.2	-8.3	-8.0	-8.0
Dylan MacGregor (SRK)	2004/08/27		-4.9	-9.5	-8.9	-8.4	-8.4	-8.2	-8.1	-8.2	-8.0	-8.0
Quinn Jordan-Knox (SRK)	2004/09/28		-4.3	-9.4	-9.0	-8.5	-8.4	-8.2	-8.1	-8.2	-8.0	-8.0
Dylan MacGregor (SRK)	2005/04/16		-15.2	-9.2	-8.8	-8.6	-8.5	-8.3	-8.2	-8.2	-8.0	-8.0
D Kary (Miramar)	2005/05/16		-12.8	-9.7	-8.9	-8.6	-8.5	-8.3	-8.2	-8.2	-8.0	-8.0
Jay Hallman (Miramar)	2005/07/18		-6.1	-10.0	-9.2	-8.6	-8.5	-8.3	-8.1	-8.2	-8.0	-8.0
JRH (Miramar)	2005/08/05		-5.4	-9.9	-9.2	-8.7	-8.5	-8.3	-8.1	-8.2	-8.0	-8.0
D Kary (Miramar)	2005/09/08		-4.5	-9.7	-9.3	-8.7	-8.5	-8.3	-8.1	-8.2	-7.9	-8.0
E Ballent (Miramar)	2005/09/26		4.2	-9.6	-9.3	-8.8	-8.6	-8.3	-8.2	-8.2	-8.0	-8.0
L. Wade / A. Tong (SRK)	2006/04/30		-12.7	-9.2	-9.0	-8.8	-8.7	-8.5	-8.3	-8.0	-8.1	
Jay Hallman (Miramar)	2006/06/04		-7.6	-9.4	-9.0	-8.7	-8.6	-8.4	-8.2	-8.3	-8.0	-8.0
Gary S./ Hugh J. (Miramar)	2006/08/06		-4.6	-9.4	-9.1	-8.8	-8.6	-8.4	-8.2	-8.3	-8.0	-8.0
H.Johnson (Miramar)	2006/09/13		-1.2	-5.7	-9.0	-8.7	-8.4	-8.2	-8.1	-8.1	-7.9	-8.0

DORIS NORTH PROJECT THERMISTOR DATA

Drill Hole SRK-16

Read By	Date	Bead No.	Bead 1	Bead 2	Bead 3	Bead 4	Bead 5
		Bead Location from Top (m)	5.0	6.0	7.0	8.5	10.0
		Bead Depth (m)	3.3	4.3	5.3	6.8	8.3
Andrew Doe (SRK)	2002/09/14	Temperature (Celsius)	-0.6	-1.4	-1.6	-2.0	-1.6
Andrew Doe (SRK)	2002/09/15		-2.1	-2.4	-2.5	-3.1	-2.8
Dwayne Winsor (Miramar)	2002/09/19		-5.0	-6.5	-7.4	-7.9	-6.9
Dylan MacGregor (SRK)	2003/03/18		-13.6	-11.8	-10.5	-9.3	-8.9
Dylan MacGregor (SRK)	2003/03/24		-13.9	-12.2	-10.8	-9.5	-9.0
Sebastian Fontin (SRK)	2003/04/06		-14.3	-12.7	-11.4	-9.9	-9.2
Dan Mackie (SRK)	2003/04/13		-14.5	-13.0	-11.6	-10.2	-9.4
Dan Mackie (SRK)	2003/04/15		-14.5	-13.0	-11.7	-10.2	-9.5
Dan Mackie (SRK)	2003/04/16		-14.5	-13.0	-11.7	-10.3	-9.5
Dan Mackie (SRK)	2003/04/20		-14.5	-13.1	-11.8	-10.4	-9.5
Jay Hallman (Miramar)	2003/05/16		-13.6	-13.0	-12.1	-10.9	-10.0
Dylan MacGregor (SRK)	2003/08/25		-7.4	-8.4	-9.0	-9.6	-9.8
Mike Cripps (Miramar)	2003/09/21		-6.5	-7.6	-8.3	-9.0	-9.4
Dylan MacGregor (SRK)	2004/04/11		-16.7	-13.7	-13.0	-11.0	-9.8
Thorpe/Lindsay (Miramar)	2004/05/17		-15.3	-14.4	-13.5	-11.9	-10.7
Dylan MacGregor (SRK)	2004/08/27		-7.9	-8.9	-9.7	-10.2	-10.4
Quinn Jordan-Knox (SRK)	2004/09/26		-6.8	-7.9	-8.3	-9.4	-9.8
Dylan MacGregor (SRK)	2005/04/16		-16.3	-14.8	-13.5	-11.7	-10.6
D Kary (Miramar)	2005/05/16		-14.5	-14.0	-13.4	-12.2	-11.1
Jay Hallman (Miramar)	2005/07/18		-9.7	-10.6	-11.2	-11.3	-11.1
JRH (Miramar)	2005/08/05		-8.6	-9.7	-10.4	-10.8	-10.8
D Kary (Miramar)	2005/09/08		-7.4	-8.5	-9.3	-10.0	-10.3
E Ballent (Miramar)	2005/09/26		-6.7	-7.8	-8.7	-9.5	-9.9
L. Wade / A. Tong (SRK)	2006/04/30		-14.0	-13.0	-12.3	-11.1	-10.3
Jay Hallman (Miramar)	2006/06/04		-11.4	-11.7	-11.7	-11.2	-10.6
Gary S./Hugh J. (Miramar)	2006/08/06		-7.5	-8.5	-9.3	-9.8	-10.0
H.Johnson (Miramar)	2006/09/13		-6.3	-7.3	-8.2	-9.0	-9.4

DORIS NORTH PROJECT THERMISTOR DATA

Drill Hole SRK-19

Read By	Date	Bead No.	Bead 1	Bead 2	Bead 3	Bead 4	Bead 5	Bead 6
		Bead Location from Top (m)	**2.0**	**3.0**	**4.0**	**6.0**	**8.5**	**11.0**
		Bead Depth (m)	**1.0**	**2.0**	**3.0**	**5.0**	**7.5**	**10.0**
Dan Mackie (SRK)	2003/04/14	**Temperature (Celsius)**	-13.4	-11.8	-9.2	-7.9	-7.9	-8.0
Dan Mackie (SRK)	2003/04/16		-13.9	-11.5	-9.0	-7.0	-7.3	-7.6
Jay Hallman (Miramar)	2003/05/17		-9.7	-10.1	-9.3	-7.1	-7.3	-7.6
Dylan MacGregor (SRK)	2003/08/25		-0.9	-4.2	-6.2	-7.4	-7.5	-7.6
Mike Cripps (Miramar)	2003/09/21		-0.7	-3.7	-5.7	-7.3	-7.4	-7.6
Dylan MacGregor (SRK)	2004/04/16		-15.5	-13.4	-10.5	-6.7	-7.3	-7.5
Dylan MacGregor (SRK)	2004/08/26		-1.0	-4.3	-6.6	-7.7	-7.5	-7.5
Quinn Jordan-Knox (SRK)	2004/09/28		-0.9	-3.7	-5.9	-7.4	-7.6	-7.5
Dylan MacGregor (SRK)	2005/04/16		-14.6	-13.5	-11.7	-7.6	-7.5	-7.6
D Kary (Miramar)	2005/05/16		-12.4	-11.9	-11.2	-8.2	-7.5	-7.6
Gabrielle (Miramar)	2005/07/17		-1.9	-5.1	-8.0	-8.5	-7.7	-7.6
JRH (Miramar)	2005/08/05		-1.3	-4.8	-7.3	-8.3	-7.8	-7.6
D Kary (Miramar)	2005/09/08		-0.7	-4.0	-6.4	-8.0	-7.9	-7.6
E Ballent (Miramar)	2005/09/26		-0.7	-3.7	-6.1	-7.8	-7.9	-7.6
L. Wade / A. Tong (SRK)	2006/04/30		-12.6	-11.7	-10.6	-7.8	-7.7	-7.8
Jay Hallman (Miramar)	2006/06/04		-3.5	-7.1	-9.0	-8.1	-7.7	-7.7
Gary S./ Hugh J. (Miramar)	2006/08/06		-0.5	-4.1	-6.5	-7.8	-7.8	-7.6
J.Hallman (Miramar)	2006/09/13		0.0	-3.5	-6.0	-7.6	-7.9	-7.7

DORIS NORTH PROJECT THERMISTOR DATA								
Drill Hole SRK-20		**Bead No.**	**Bead 1**	**Bead 2**	**Bead 3**	**Bead 4**	**Bead 5**	**Bead 6**
Read By	**Date**	**Bead Location from Top (m)**	**2.0**	**3.0**	**4.0**	**6.0**	**8.5**	**11.0**
		Bead Depth (m)	**0.8**	**1.8**	**2.8**	**4.8**	**7.3**	**9.8**
Dan Mackie (SRK)	2003/04/13	**Temperature (Celsius)**	-12.0	-10.2	-8.2	-6.7	-7.1	-7.4
Dan Mackie (SRK)	2003/04/14		-11.8	-11.1	-9.3	-7.0	-7.1	-7.4
Dan Mackie (SRK)	2003/04/16		-12.7	-11.0	-9.4	-6.9	-7.0	-7.4
Jay Hallman (Miramar)	2003/05/17		-9.3	-9.9	-9.3	-7.1	-7.1	-7.4
Dylan MacGregor (SRK)	2003/08/25		0.3	-3.0	-5.3	-7.2	-7.2	-7.4
Mike Cripps (Miramar)	2003/09/21		0.0	-2.7	-4.9	-7.0	-7.2	-7.3
Dylan MacGregor (SRK)	2004/04/16		-15.1	-13.4	-11	-6.9	-7.1	-7.2
Dylan MacGregor (SRK)	2004/08/26		0.0	-3.3	-5.8	-7.7	-7.3	-7.1
Quinn Jordan-Knox (SRK)	2004/09/28		-0.2	-2.8	-5.1	-7.4	-7.3	-7.1
Dylan MacGregor (SRK)	2005/04/16		-13.5	-12.6	-11.1	-7.6	-7.2	-7.2
D Kary (Miramar)	2005/05/16		-11.8	-11.4	-10.6	-8.1	-7.2	-7.2
Gabrielle (Miramar)	2005/07/17		-0.7	-4.4	-7.0	-8.3	-7.4	-7.2
JRH (Miramar)	2005/08/05		-0.3	-3.7	-6.3	-8.1	-7.5	-7.2
D Kary (Miramar)	2005/09/08		0.3	-3.0	-5.4	-7.7	-7.5	-7.2
E Ballent (Miramar)	2005/09/26		-0.1	-2.7	-5.1	-7.5	-7.5	-7.2
L. Wade / A. Tong (SRK)	2006/04/30		-12	-11.5	-11.3	-7.7	-7.4	-7.4
Jay Hallman (Miramar)	2006/06/04		-2.2	-6.1	-8.2	-8.0	-7.3	-7.3
Gary S./Hugh J. (Miramar)	2006/08/06		1.8	-3.1	-5.6	-7.6	-7.4	-7.2
J.Hallman (Miramar)	2006/09/04		0.8	-2.6	-5.0	-7.3	-7.5	-7.3

DORIS NORTH PROJECT THERMISTOR DATA								
Drill Hole SRK-22		**Bead No.**	**Bead 1**	**Bead 2**	**Bead 3**	**Bead 4**	**Bead 5**	**Bead 6**
Read By	**Date**	**Bead Location from Top (m)**	**2.0**	**3.0**	**4.0**	**6.0**	**8.5**	**11.0**
		Bead Depth (m)	**0.7**	**1.7**	**2.7**	**4.7**	**7.2**	**9.7**
Dan Mackie (SRK)	2003/04/13	**Temperature (Celsius)**	-11.6	-11.5	-9.3	-7.3	-7.5	-7.8
Dan Mackie (SRK)	2003/04/14		-11.8	-11.4	-9.5	-7.3	-7.6	-7.9
Dan Mackie (SRK)	2003/04/15		-12.3	-11.3	-9.5	-7.3	-7.6	-7.9
Dan Mackie (SRK)	2003/04/16		-12.7	-11.4	-9.5	-7.3	-7.6	-7.9
Jay Hallman (Miramar)	2003/05/17		-10.3	-10.5	-9.7	-7.7	-7.7	-7.9
Dylan MacGregor (SRK)	2003/08/25		-2.4	-5.6	-7.4	-7.9	-7.9	-8.0
Mike Cripps (Miramar)	2003/09/21		-2.1	-5.1	-6.9	-7.8	-7.9	-8.0
Dylan MacGregor (SRK)	2004/04/16		-14.4	-12.0	-9.3	-7.4	-7.7	-7.8
Thorpe/Lindsay (Miramar)	2004/05/17		-12.8	-11.7	-9.9	-7.7	-7.7	-7.8
Dylan MacGregor (SRK)	2004/08/27		-2.8	-6.0	-7.8	-8.2	-7.8	-7.8
Quinn Jordan-Knox (SRK)	2004/09/28		-2.6	-5.3	-7.2	-8.1	-7.9	-7.8
Dylan MacGregor (SRK)	2005/04/16		-13.6	-12.0	-9.9	-7.8	-7.9	-7.9
D Kary (Miramar)	2005/05/16		-11.9	-11.2	-10.1	-8.2	-7.9	-7.9
Gabrielle (Miramar)	2005/07/17		-4.0	-7.3	-8.8	-8.6	-8.0	-7.9
JRH (Miramar)	2005/08/05		-3.2	-6.6	-8.3	-8.5	-8.0	-7.9
D Kary (Miramar)	2005/09/08		-2.4	-5.6	-7.6	-8.4	-8.1	-7.9
E Ballent (Miramar)	2005/09/26		-2.3	-5.3	-7.2	-8.2	-8.1	-7.9
L. Wade / A. Tong (SRK)	2006/04/30		-12.2	-11.2	-9.7	-8.0	-8.0	-8.1
Jay Hallman (Miramar)	2006/06/04		-5.7	-8.6	-9.3	-8.2	-8.0	-7.9
Gary S./Hugh J. (Miramar)	2006/08/06		-2.6	-5.9	-7.6	-8.2	-8.0	-7.9
J. Hallman (Miramar)	2006/09/04		-2.3	-5.5	-7.3	-8.1	-8.1	-8.0

DORIS NORTH PROJECT THERMISTOR DATA

Drill Hole SRK-23		Bead No.	Bead 1	Bead 2	Bead 3	Bead 4	Bead 5	Bead 6
Read By	**Date**	**Bead Location from Top (m)**	**2.0**	**3.0**	**4.0**	**6.0**	**8.5**	**11.0**
		Bead Depth (m)	**0.9**	**1.9**	**2.9**	**4.9**	**7.4**	**9.9**
Dan Mackie (SRK)	2003/04/14	**Temperature (Celsius)**	-13.2	-11.9	-9.7	-8.0	-8.0	-8.3
Dan Mackie (SRK)	2003/04/15		-13.0	-11.6	-9.3	-7.1	-7.5	-7.8
Dan Mackie (SRK)	2003/04/16		-13.2	-11.6	-9.3	-7.1	-7.5	-7.8
Jay Hallman (Miramar)	2003/05/17		-10.5	-10.5	-9.5	-7.6	-7.5	-7.8
Dylan MacGregor (SRK)	2003/08/25		-1.5	-4.4	-6.7	-7.8	-7.7	-7.8
Mike Cripps (Miramar)	2003/09/21		-1.3	-4.0	-6.2	-7.7	-7.8	-7.8
Dylan MacGregor (SRK)	2004/04/16		-16.2	-13.9	-10.8	-7.5	-7.6	-7.9
Thorpe/Lindsay (Miramar)	2004/05/17		-12.9	-12.6	-11.1	-8.0	-7.6	-7.8
Dylan MacGregor (SRK)	2004/08/27		-1.7	-4.8	-7.2	-8.3	-7.8	-7.8
Quinn Jordan-Knox (SRK)	2004/09/28		-1.5	-4.2	-6.6	-8.1	-7.9	-7.8
Dylan MacGregor (SRK)	2005/04/16		-14.0	-12.9	-9.9	-7.8	-7.8	-7.9
D Kary (Miramar)	2005/05/16		-12.2	-11.7	-10.6	-8.4	-7.8	-7.9
Gabrielle (Miramar)	2005/07/17		-2.6	-6.0	-8.4	-8.7	-7.9	-7.9
JRH (Miramar)	2005/08/05		-2.0	-5.3	-7.7	-8.6	-8.0	-7.9
D Kary (Miramar)	2005/09/08		-1.4	-4.4	-6.9	-8.3	-8.1	-7.9
E Ballent (Miramar)	2005/09/26		-1.3	-4.1	-6.5	-8.2	-8.1	-7.9
L. Wade / A. Tong (SRK)	2006/04/30		-12.2	-11.4	-9.9	-8.0	-7.9	-8.0
Jay Hallman (Miramar)	2006/06/04		-4.0	-7.3	-8.9	-8.2	-7.8	-7.9
Gary S./ Hugh J.	2006/08/06		-1.4	-4.5	-6.8	-8.1	-7.9	-7.9
J.Hallman (Miramar)	2006/09/04		-1.0	-3.9	-6.3	-7.9	-8.0	-8.0

DORIS NORTH PROJECT THERMISTOR DATA

Drill Hole SRK-24		Bead No.	Bead 1	Bead 2	Bead 3	Bead 4	Bead 5	Bead 6
Read By	**Date**	**Bead Location from Top (m)**	**2.0**	**3.0**	**4.0**	**6.0**	**8.5**	**11.0**
		Bead Depth (m)	**0.7**	**1.7**	**2.7**	**4.7**	**7.2**	**9.7**
Dan Mackie (SRK)	2003/04/13	**Temperature (Celsius)**	-11.1	-9.9	-8.0	-7.1	-7.3	-7.4
Dan Mackie (SRK)	2003/04/14		-10.0	-11.0	-9.4	-7.2	-7.3	-7.4
Dan Mackie (SRK)	2003/04/15		-10.4	-10.9	-9.5	-7.4	-7.3	-7.4
Dan Mackie (SRK)	2003/04/16		-10.9	-10.8	-9.5	-7.3	-7.4	-7.4
Jay Hallman (Miramar)	2003/05/17		-10.0	-10.1	-9.4	-7.7	-7.5	-7.6
Dylan MacGregor (SRK)	2003/08/25		-1.4	-4.5	-6.6	-8.1	-8.0	-8.0
Mike Cripps (Miramar)	2003/09/21		-1.2	-4.2	-6.2	-7.6	-7.6	-7.6
Dylan MacGregor (SRK)	2004/04/16		-16.0	-14.0	-11.3	-7.6	-7.4	-7.5
Thorpe/Lindsay (Miramar)	2004/05/17		-13.3	-13.0	-11.4	-8.2	-7.4	-7.5
Dylan MacGregor (SRK)	2004/08/27		-1.7	-5.2	-7.3	-8.3	-7.7	-7.4
Quinn Jordan-Knox (SRK)	2004/09/28		-1.6	-4.6	-6.6	-8.0	-7.8	-7.4
Dylan MacGregor (SRK)	2005/04/16		-14.1	-13.2	-11.1	-8.1	-7.7	-7.5
D Kary (Miramar)	2005/05/16		-13.9	-13.8	-13.5	-11.0	-9.1	-8.8
Jay Hallman (Miramar)	2005/07/18		-2.5	-6.3	-8.3	-8.7	-7.9	-7.5
JRH (Miramar)	2005/08/05		-2.0	-5.6	-7.7	-8.6	-7.9	-7.5
D Kary (Miramar)	2005/09/08		-1.3	-4.8	-6.9	-8.3	-8.0	-7.5
E Ballent (Miramar)	2005/09/26		-1.3	-4.4	-6.5	-8.1	-8.0	-7.5
L. Wade / A. Tong (SRK)	2006/04/30		-12.4	-12.1	-10.6	-8.2	-7.8	-7.6
Jay Hallman (Miramar)	2006/06/04		-3.9	-7.8	-9.3	-8.5	-7.8	-7.5
Gary S./Hugh J. (Miramar)	2006/08/06		-1.4	-5.1	-7.1	-8.2	-7.9	-7.5
H.Johnson (Miramar)	2006/09/13		-1.1	-4.4	-6.5	-7.9	-8.0	-7.6

DORIS NORTH PROJECT THERMISTOR DATA

Drill Hole SRK-26

Read By	Date	Bead No.	Bead 1	Bead 2	Bead 3	Bead 4	Bead 5	Bead 6
		Bead Location from Top (m)	**2.0**	**3.0**	**4.0**	**6.0**	**8.5**	**11.0**
		Bead Depth (m)	**0.8**	**1.8**	**2.8**	**4.8**	**7.3**	**9.8**
Dan Mackie (SRK)	2003/04/13	**Temperature (Celsius)**	-14.0	-13.1	-11.0	-8.5	-8.4	-8.7
Dan Mackie (SRK)	2003/04/14		-13.9	-13.1	-11.0	-8.6	-8.4	-8.7
Dan Mackie (SRK)	2003/04/16		-14.8	-13.7	-12.3	-9.0	-8.4	-8.7
Jay Hallman (Miramar)	2003/05/17		-11.7	-12.2	-11.7	-9.6	-8.5	-8.7
Dylan MacGregor (SRK)	2003/08/25		-1.6	-4.6	-6.8	-9.0	-8.9	-8.7
Mike Cripps (Miramar)	2003/09/21		-1.2	-4.0	-6.0	-7.8	-8.0	-8.0
Dylan MacGregor (SRK)	2004/04/16		-18.8	-17.4	-15.0	-10.0	-8.5	-8.7
Thorpe/Lindsay (Miramar)	2004/05/17		-14.3	-15.1	-14.3	-10.8	-8.7	-8.7
Dylan MacGregor (SRK)	2004/08/27		-1.9	-4.8	-7.5	-9.8	-9.2	-8.8
Dylan MacGregor (SRK)	2005/04/19		-16.4	-15.6	-14.5	-10.6	-8.9	-8.9
D Kary (Miramar)	2005/05/16		-13.9	-13.8	-13.5	-11.0	-9.1	-8.8
Gabrielle (Miramar)	2005/07/17		-3.1	-6.5	-9.1	-10.6	-9.5	-8.9
JRH (Miramar)	2005/08/05		-2.4	-5.6	-8.2	-10.2	-9.5	-9.0
D Kary (Miramar)	2005/09/08		-1.6	-4.5	-7.1	-9.6	-9.5	-9.0
E Ballent (Miramar)	2005/09/26		-1.5	-4.1	-6.6	-9.3	-9.5	-9.1
L. Wade / A. Tong (SRK)	2006/04/30		-14.2	-13.7	-12.9	-10.3	-9.0	-9.0
Jay Hallman (Miramar)	2006/06/04		-4.7	-8.3	-10.5	-10.4	-9.1	-8.9
Gary S./Hugh J. (Miramar)	2006/08/06		-1.5	-4.6	-7.2	-9.5	-9.3	-9.0
H.Johnson (Miramar)	2006/09/13		-0.9	-3.7	-6.3	-8.9	-9.3	-9.1

DORIS NORTH PROJECT THERMISTOR DATA								
Drill Hole SRK-28		**Bead No.**	**Bead 1**	**Bead 2**	**Bead 3**	**Bead 4**	**Bead 5**	**Bead 6**
Read By	**Date**	**Bead Location from Top (m)**	**2.0**	**3.0**	**4.0**	**6.0**	**8.5**	**11.0**
		Bead Depth (m)	**0.8**	**1.8**	**2.8**	**4.8**	**7.3**	**9.8**
Dan Mackie (SRK)	2003/04/13	**Temperature (Celsius)**	-12.1	-10.5	-8.6	-7.4	-7.8	-7.9
Dan Mackie (SRK)	2003/04/14		-12.0	-10.5	-8.6	-7.5	-7.8	-8.0
Dan Mackie (SRK)	2003/04/16		-13.3	-11.8	-10.2	-7.6	-7.7	-7.9
Jay Hallman (Miramar)	2003/05/17		-9.8	-10.6	-10.0	-8.2	-7.7	-8.0
Dylan McGreggor (SRK)	2003/08/25		-1.5	-4.5	-6.6	-8.1	-8.0	-8.0
Mike Cripps (Miramar)	2003/09/21		-1.3	-4.1	-6.2	-8.7	-8.9	-8.8
Dylan MacGregor (SRK)	2004/04/16		-16.7	-14.7	-12.0	-8.1	-7.7	-8.0
Thorpe/Lindsay (Miramar)	2004/05/17		-12.9	-13.2	-11.9	-8.8	-7.7	-7.9
Dylan MacGregor (SRK)	2004/08/27		-1.9	-5.0	-7.1	-8.6	-8.1	-8.0
Quinn Jordan-Knox (SRK)	2004/09/28		-1.7	-4.3	-6.4	-8.3	-8.2	-8.0
Dylan MacGregor (SRK)	2005/04/19		-14.6	-13.8	-12.2	-8.9	-8.0	-8.0
D Kary (Miramar)	2005/05/16		-12.2	-12.2	-11.6	-9.3	-8.1	-8.0
Gabrielle (Miramar)	2005/07/17		-2.8	-6.2	-8.4	-9.3	-8.3	-8.0
JRH (Miramar)	2005/08/05		-2.2	-5.5	-7.7	-9.1	-8.4	-8.0
D Kary (Miramar)	2005/09/08		-1.5	-4.6	-6.9	-8.7	-8.4	-8.1
E Ballent (Miramar)	2005/09/26		-1.4	-4.2	-6.4	-8.4	-8.4	-8.1
L. Wade / A. Tong (SRK)	2006/04/30		-12.3	-12.0	-10.8	-8.7	-8.1	-8.2
Jay Hallman (Miramar)	2006/06/04		-4.1	-7.6	-9.2	-8.9	-8.1	-8.1
Gary S./Hugh J. (Miramar)	2006/08/06		-1.5	-4.7	-6.9	-8.5	-8.3	-8.1
H.Johnson (Miramar)	2006/09/13		-1.0	-3.9	-6.1	-8.1	-8.3	-8.2

DORIS NORTH PROJECT THERMISTOR DATA

Drill Hole SRK-32		Bead No.	Bead 1	Bead 2	Bead 3	Bead 4	Bead 5	Bead 6
Read By	**Date**	**Bead Location from Top (m)**	**2.0**	**3.0**	**4.0**	**6.0**	**8.5**	**11.0**
		Bead Depth (m)	**0.9**	**1.9**	**2.9**	**4.9**	**7.4**	**9.9**
Sebastian Fortin (SRK)	2003/04/06	**Temperature (Celsius)**	-11.5	-9.7	-8.9	-8.7	-8.7	-8.1
Dylan MacGregor (SRK)	2003/04/09		-12.0	-11.0	-8.8	-8.6	-8.5	-8.2
Dan Mackie (SRK)	2003/04/13		-12.4	-11.9	-10.1	-8.6	-8.5	-8.3
Dan Mackie (SRK)	2003/04/15		-12.7	-11.9	-10.2	-8.6	-8.5	-8.3
Dan Mackie (SRK)	2003/04/16		-12.9	-11.9	-10.3	-8.5	-8.4	-8.3
Dan Mackie (SRK)	2003/04/20		-13.2	-12.0	-10.4	-8.6	-8.4	-8.3
Jay Hallman (Miramar)	2003/05/16		-11.4	-11.4	-10.7	-8.7	-8.3	-8.3
Dylan MacGregor (SRK)	2003/08/25		0.4	-3.2	-5.6	-8.3	-8.6	-8.4
Mike Cripps (Miramar)	2003/09/21		-0.1	-2.8	-5.0	-7.4	-8.6	-8.4
Dylan MacGregor (SRK)	2004/04/11		-18.3	-16.8	-14.3	-9.3	-8.0	-8.3
Thorpe/Lindsay (Miramar)	2004/05/17		-13.5	-14.2	-13.5	-10.2	-8.3	-8.3
Dylan MacGregor (SRK)	2004/08/27		0.0	-3.6	-6.1	-8.9	-8.9	-8.4
Quinn Jordan-Knox (SRK)	2004/09/28		-0.5	-3.2	-5.4	-8.3	-8.8	-8.5
Dylan MacGregor (SRK)	2005/04/16		-15.2	-14.7	-13.3	-9.7	-8.4	-8.4
D Kary (Miramar)	2005/05/16		-13.0	-13.0	-12.4	-10.2	-8.6	-8.4
Jay Hallman (Miramar)	2005/07/18		0.1	-4.9	-7.5	-9.6	-9.0	-8.5
JRH (Miramar)	2005/08/05		0.5	-4.1	-6.7	-9.2	-9.0	-8.5
D Kary (Miramar)	2005/09/08		0.8	-3.2	-5.7	-8.6	-9.0	-8.6
E Ballent (Miramar)	2005/09/26		-0.2	-3.0	-5.3	-8.2	-9.0	-8.7
L. Wade / A. Tong (SRK)	2006/04/30		-13.0	-13.2	-12.1	-9.5	-8.5	-8.6
Jay Hallman (Miramar)	2006/06/04		-2.1	-6.8	-9.1	-9.6	-8.6	-8.5
Gary S./Hugh J. (Miramar)	2006/08/06		2.6	-3.0	-5.5	-8.2	-8.4	
H.Johnson (Miramar)	2006/09/13		0.8	-2.7	-5.0	-7.9	-8.7	-8.6

DORIS NORTH PROJECT THERMISTOR DATA

Drill Hole SRK-33

Read By	Date	Bead No.	Bead 1	Bead 2	Bead 3	Bead 4	Bead 5	Bead 6
		Bead Location from Top (m)	2.0	3.0	4.0	6.0	8.5	11.0
		Bead Depth (m)	0.9	1.9	2.9	4.9	7.4	9.9
Sebastian Fortin (SRK)	2003/04/06	Temperature (Celsius)	-10.7	-6.9	-6.4	-5.3	-5.2	-5.0
Dylan MacGregor (SRK)	2003/04/09		-13.1	-12.0	-10.0	-7.3	-7.1	-7.2
Dan Mackie (SRK)	2003/04/13		-12.4	-13.0	-12.5	-9.3	-7.8	-7.9
Dan Mackie (SRK)	2003/04/15		-13.1	-13.1	-12.5	-9.6	-8.0	-8.1
Dan Mackie (SRK)	2003/04/16		-13.4	-13.1	-12.5	-9.7	-8.0	-8.2
Dan Mackie (SRK)	2003/04/20		-13.5	-13.3	-12.5	-9.9	-8.1	-8.3
Jay Hallman (Miramar)	2003/05/16		-10.7	-11.7	-11.8	-10.4	-8.5	-8.6
Dylan MacGregor (SRK)	2003/08/25		-3.4	-5.4	-7.0	-8.9	-9.5	-8.8
Mike Cripps (Miramar)	2003/09/21		-2.3	-4.7	-6.4	-8.5	-8.9	-8.8
Dylan MacGregor (SRK)	2004/04/11		-19.1	-16.8	-14.3	-9.9	-8.6	-8.8
Thorpe/Lindsay (Miramar)	2004/05/17		-15.3	-15.0	-13.9	-10.7	-8.7	-8.7
Dylan MacGregor (SRK)	2004/08/27		-3.8	-6.0	-7.8	-9.6	-9.1	-8.8
Quinn Jordan-Knox (SRK)	2004/09/28		-3.2	-5.1	-6.8	-9.0	-9.1	-8.8
Dylan MacGregor (SRK)	2005/04/16		-17.1	-15.7	-14.0	-10.4	-8.8	-8.8
D Kary (Miramar)	2005/05/16		-14.4	-14.0	-13.3	-10.9	-8.9	-8.8
Jay Hallman (Miramar)	2005/07/18		-5.7	-8.0	-9.6	-10.4	-8.8	-8.8
JRH (Miramar)	2005/08/05		-4.6	-6.9	-8.6	-10.1	-9.3	-8.9
D Kary (Miramar)	2005/09/08		-3.4	-5.5	-7.4	-9.5	-9.3	-8.9
E Ballent (Miramar)	2005/09/26		-3.0	-5.0	-6.8	-9.1	-9.3	-9.0
L. Wade / A. Tong (SRK)	2006/04/30		-14.6	-13.7	-12.6	-10.2	-9.0	-9.0
Jay Hallman (Miramar)	2006/06/04		-8.1	-10.1	-11.0	-10.4	-9.0	-8.9
Gary S./Hugh J. (Miramar)	2006/08/06		-3.1	-5.3	-7.2	-9.1	-8.9	-8.7
H.Johnson (Miramar)	2006/09/13		-2.5	-4.5	-6.4	-8.8	-9.2	-9.0

DORIS NORTH PROJECT THERMISTOR DATA								
Drill Hole SRK-34A		**Bead No.**	**Bead 1**	**Bead 2**	**Bead 3**	**Bead 4**	**Bead 5**	**Bead 6**
Read By	**Date**	**Bead Location from Top (m)**	**2.0**	**3.0**	**4.0**	**6.0**	**8.5**	**11.0**
		Bead Depth (m)	**0.9**	**1.9**	**2.9**	**4.9**	**7.4**	**9.9**
Sebastian Fortin (SRK)	2003/04/06	**Temperature (Celsius)**	-10.3	-7.4	-7.4	-7.1	-6.1	-7.2
Dylan MacGregor (SRK)	2003/04/09		-13.1	-12.0	-10.0	-7.3	-7.1	-7.2
Dan Mackie (SRK)	2003/04/13		-12.4	-13.0	-12.5	-9.3	-7.8	-7.9
Dan Mackie (SRK)	2003/04/15		-13.1	-13.1	-12.5	-9.6	-8.0	-8.1
Dan Mackie (SRK)	2003/04/16		-13.4	-13.1	-12.5	-9.7	-8.0	-8.2
Dan Mackie (SRK)	2003/04/20		-13.5	-13.3	-12.5	-9.9	-8.1	-8.3
Jay Hallman (Miramar)	2003/05/16		-10.5	-10.8	-10.3	-8.5	-7.5	-7.7
Dylan MacGregor (SRK)	2003/08/25		-1.8	-4.2	-6.1	-8.0	-8.1	-8.0
Mike Cripps (Miramar)	2003/09/21		-1.5	-3.7	-5.5	-7.7	-8.0	-8.1
Dylan MacGregor (SRK)	2004/04/11		-17.6	-15.3	-12.2	-8.8	-7.4	-7.6
Thorpe/Lindsay (Miramar)	2004/05/17		-13.8	-13.6	-12.0	-9.2	-7.7	-7.7
Dylan MacGregor (SRK)	2004/08/27		-2.2	-4.8	-6.4	-8.7	-8.5	-8.3
Quinn Jordan-Knox (SRK)	2004/09/28		-1.9	-4.2	-5.6	-8.3	-8.4	-8.3
Dylan MacGregor (SRK)	2005/04/16		-14.8	-13.6	-11.4	-8.6	-7.8	-7.9
D Kary (Miramar)	2005/05/16		-12.6	-12.2	-11.0	-9.2	-8.0	-8.0
Jay Hallman (Miramar)	2005/07/18		-3.4	-6.2	-7.6	-9.2	-8.5	-8.3
JRH (Miramar)	2005/08/05		-2.7	-5.4	-6.9	-8.9	-8.5	-8.3
D Kary (Miramar)	2005/09/08		-1.9	-4.4	-6.0	-8.5	-8.5	-8.4
E Ballent (Miramar)	2005/09/26		-1.7	-4.0	-5.5	-8.2	-8.4	-8.4
L. Wade / A. Tong (SRK)	2006/04/30		-13.2	-12.4	-10.7	-8.7	-7.9	-8.0
Jay Hallman (Miramar)	2006/06/04		-5.5	-8.2	-9.1	-9.0	-8.1	-8.0
Gary S./Hugh J. (Miramar)	2006/08/06		-1.8	-4.4	-6.0	-8.1	-8.1	-8.0
H.Johnson (Miramar)	2006/09/13		-1.5	-3.9	-5.4	-8.0	-8.3	-8.3

DORIS NORTH PROJECT THERMISTOR DATA								
Drill Hole SRK-35		**Bead No.**	**Bead 1**	**Bead 2**	**Bead 3**	**Bead 4**	**Bead 5**	**Bead 6**
Read By	**Date**	**Bead Location from Top (m)**	**2.0**	**3.0**	**4.0**	**6.0**	**8.5**	**11.0**
		Bead Depth (m)	**0.4**	**1.4**	**2.4**	**4.4**	**6.9**	**9.4**
Sebastian Fortin (SRK)	2003/04/08	**Temperature (Celsius)**	-6.8	-3.7	-2.9	-4.3	-5.1	-5.0
Dan Mackie (SRK)	2003/04/13		-7.4	-6.1	-4.5	-5.4	-6.0	-6.3
Dan Mackie (SRK)	2003/04/14		-7.5	-6.2	-4.6	-5.4	-6.0	-6.3
Dan Mackie (SRK)	2003/04/16		-10.3	-7.5	-6.0	-5.0	-5.9	-6.2
Jay Hallman (Miramar)	2003/05/17		-6.4	-7.0	-6.4	-5.3	-5.9	-6.3
Dylan MacGregor (SRK)	2003/08/25		-0.4	-3.1	-4.8	-5.6	-6.0	-6.3
Mike Cripps (Miramar)	2003/09/21		-0.4	-2.7	-4.4	-5.5	-6.0	-6.3
Dylan MacGregor (SRK)	2004/04/11		-13.5	-11.0	-8.0	-5.4	-6.0	-6.2
Thorpe/Lindsay (Miramar)	2004/05/17		-10.6	-10.0	-8.4	-5.7	-5.9	-6.0
Dylan MacGregor (SRK)	2004/08/23		-0.5	-3.6	-5.6	-6.0	-5.9	-6.1
Quinn Jordan-Knox (SRK)	2004/09/26		-0.5	-3.1	-5.0	-6.0	-6.1	-6.1
Dylan MacGregor (SRK)	2005/04/16		-10.9	-9.9	-8.2	-5.9	-6.0	-6.1
D Kary (Miramar)	2005/05/16		-9.7	-9.1	-8.2	-6.1	-6.0	-6.1
Jay Hallman (Miramar)	2005/07/18		-1.3	-4.5	-6.4	-6.4	-6.1	-6.1
JRH (Miramar)	2005/08/05		-0.7	-3.9	-5.9	-6.3	-6.1	-6.1
D Kary (Miramar)	2005/09/08		-0.1	-3.3	-5.3	-6.3	-6.1	-6.1
E Ballent (Miramar)	2005/09/26		-0.4	-3.0	-5.0	-6.2	-6.1	-6.1
L. Wade / A. Tong (SRK)	2006/04/30		-9.9	-9.0	-7.7	-6.1	-6.2	-6.3
Jay Hallman (Miramar)	2006/06/04		-3.1	-5.8	-7.0	-6.2	-6.1	-6.2
Gary S./Hugh J. (Miramar)	2006/08/06		0.1	-3.4	-5.4	-6.2	-6.2	-6.2
H.Johnson (Miramar)	2006/09/13		0.5	-2.8	-4.8	-6.1	-6.2	-6.2

DORIS NORTH PROJECT THERMISTOR DATA

Drill Hole SRK-37

Read By	Date	Bead No.	Bead 1	Bead 2	Bead 3	Bead 4	Bead 5	Bead 6	Bead 7	Bead 8	Bead 9	Bead 10
		Bead Location from Top (m)	**6.0**	**11.0**	**13.5**	**16.0**	**18.5**	**21.0**	**23.5**	**26.0**	**28.5**	**31.0**
		Inclined Bead Depth (m)	**0.0**	**4.6**	**7.1**	**9.6**	**12.1**	**14.6**	**17.1**	**19.6**	**22.1**	**24.6**
		Vert. Bead Depth (m)	**0.0**	**3.3**	**5.0**	**6.8**	**8.6**	**10.4**	**12.1**	**13.9**	**15.7**	**17.4**
Sebastian Fortin (SRK)	2003/04/06	**Temperature (Celsius)**	-14.7	-14.0	-12.2	-10.5	-9.3	-8.6	-8.2	-8.2	-8.4	-8.2
Dylan MacGregor (SRK)	2003/04/09		-20.9	-13.1	-11.1	-9.6	-8.8	-8.7	-8.1	-8.2	-8.3	-8.0
Dan Mackie (SRK)	2003/04/13		-23.0	-14.2	-12.4	-10.7	-9.5	-8.8	-8.3	-8.3	-8.4	-8.2
Dan Mackie (SRK)	2003/04/15		-20.9	-14.3	-12.5	-10.8	-9.6	-8.8	-8.3	-8.2	-8.3	-8.2
Dan Mackie (SRK)	2003/04/16		-13.3	-14.2	-12.5	-10.8	-9.6	-8.8	-8.3	-8.2	-8.3	-8.2
Dan Mackie (SRK)	2003/04/20		-10.3	-14.3	-12.6	-10.9	-9.7	-8.9	-8.4	-8.2	-8.3	-8.2
Jay Hallman (Miramar)	2003/05/16		-1.8	-13.4	-12.5	-11.3	-10.1	-9.3	-8.6	-8.3	-8.2	-8.2
Dylan MacGregor (SRK)	2003/08/25		13.0	-6.9	-7.9	-8.7	-9.1	-9.2	-8.9	-8.7	-8.4	-8.2
Mike Cripps (Miramar)	2003/09/21		-5.2	-6.1	-7.1	-7.9	-8.6	-8.8	-8.8	-8.6	-8.5	-8.3
Dylan MacGregor (SRK)	2004/04/11		-19.9	-17.0	-14.6	-12.0	-10.1	-9.0	-8.9	-8.1	-8.1	-8.1
Thorpe/Lindsay (Miramar)	2004/05/17		-3.2	-15.5	-14.4	-12.6	-11.0	-9.8	-9.0	-8.3	-8.2	-8.0
Dylan MacGregor (SRK)	2004/08/27		4.7	-7.4	-8.6	-9.4	-9.8	-9.7	-9.3	-8.9	-8.5	-8.2
Quinn Jordan-Knox (SRK)	2004/09/26		-1.4	-6.6	-7.5	-8.4	-9.0	-9.2	-9.1	-8.9	-8.6	-8.3
Dylan MacGregor (SRK)	2005/04/16		-13.8	-16.5	-14.6	-12.3	-10.6	-9.5	-8.8	-8.4	-8.3	-8.2
D Kary (Miramar)	2005/05/16		-4.1	-14.6	-13.9	-12.5	-11.1	-10.0	-9.1	-8.6	-8.3	-8.2
Jay Hallman (Miramar)	2005/07/18		11.9	-9.3	-10.3	-10.8	-10.7	-10.2	-9.5	-9.0	-8.6	-8.3
JRH (Miramar)	2005/08/05		14.0	-8.2	-9.4	-10.1	-10.3	-10.0	-9.5	-9.0	-8.6	-8.3
D Kary (Miramar)	2005/09/08		15.6	-6.9	-8.1	-9.0	-9.5	-9.6	-9.4	-9.0	-8.7	-8.4
E Ballent (Miramar)	2005/09/26		-1.7	-6.3	-7.4	-8.4	-9.1	-9.3	-9.2	-9.0	-8.7	-8.4
L. Wade / A. Tong (SRK)	2006/04/30		-7.4	-13.8	-12.7	-11.3	-10.1	-9.4	-8.8	-8.5	-8.4	-8.5
Jay Hallman (Miramar)	2006/06/04		9.6	-11.0	-11.4	-11.0	-10.3	-9.6	-9.0	-8.7	-8.4	-8.2
Gary S./Hugh J. (Miramar)	2006/08/06		16.6	-7.0	-8.1	-8.9	-9.3	-9.3	-9.0	-8.8	-8.5	-8.3

DORIS NORTH PROJECT THERMISTOR DATA

Drill Hole SRK-38		Bead No.	Bead 1	Bead 2	Bead 3	Bead 4	Bead 5	Bead 6	Bead 7	Bead 8
Read By	Date	Bead Location from Top (m)	above ground	6.0	11.0	16.0	21.0	31.0	41.0	51.0
		Bead Depth (m)	n/a	1.0	6.0	11.0	16.0	26.0	36.0	46.0
Dylan MacGregor (SRK)	2003/08/25	Temperature (Celsius)		1.5	-7.9	-7.7	-8.1	-8.1	-8.0	-8.1
Mike Cripps (Miramar)	2003/09/21			0.2	-7.9	-8.0	-8.2	-8.2	-8.1	-8.1
Dylan MacGregor (SRK)	2004/04/11			-17.6	-8.0	-8.2	-8.3	-8.2	-8.1	-8.1
Thorpe/Lindsay (Miramar)	2004/05/17			-13.4	-8.4	-8.2	-8.2	-8.2	-8.1	-8.1
Dylan MacGregor (SRK)	2004/08/27			0.3	-9.0	-8.2	-8.2	-8.2	-8.1	-8.1
Quinn Jordan-Knox (SRK)	2004/09/26			-0.5	-8.8	-8.2	-8.2	-8.2	-8.1	-8.1
Dylan MacGregor (SRK)	2005/04/16			-15.1	-8.5	-8.3	-8.3	-8.2	-8.1	-8.1
D Kary (Miramar)	2005/05/16			-12.4	-8.9	-8.3	-8.2	-8.2	-8.0	-8.1
Jay Hallman (Miramar)	2005/07/18			0.9	-9.3	-8.3	-8.2	-8.2	-8.0	-8.0
JRH (Miramar)	2005/08/05		12.0	1.4	-9.2	-8.3	-8.5	-8.1	-8.0	-8.0
D Kary (Miramar)	2005/09/08			0.9	-9.0	-8.3	-8.2	-8.2	-8.0	-8.0
E Ballent (Miramar)	2005/09/26		-2.1	-0.3	-8.9	-8.3	-8.3	-8.2	-8.0	-8.0
L. Wade / A. Tong (SRK)	2006/04/30		-8.1	-13.0	-8.5	-8.4	-8.4	-8.2	-8.1	-8.1
Jay Hallman (Miramar)	2006/06/04		10.7	-1.8	-8.7	-8.3	-8.3	-8.1	-8.0	-8.0
H.Johnson (Miramar)	2006/09/13		-1.7	1.3	-8.6	-8.3	-8.3	-8.2	-8.0	-8.0

DORIS NORTH PROJECT THERMISTOR DATA								
Drill Hole SRK-39		**Bead No.**	**Bead 1**	**Bead 2**	**Bead 3**	**Bead 4**	**Bead 5**	**Bead 6**
Read By	**Date**	**Bead Location from Top (m)**	**21.0**	**26.6**	**32.1**	**43.1**	**54.1**	**66.0**
		Bead Depth (m)	**4.6**	**10.2**	**15.7**	**26.7**	**37.7**	**49.6**
Dylan MacGregor (SRK)	2003/08/25	**Temperature (Celsius)**	-1.2	-3.8	-1.1	-1.8	-1.9	-7.5
Mike Cripps (Miramar)	2003/09/21		-6.3	-7.7	-7.8	-8.0		-8.2
Dylan MacGregor (SRK)	2004/04/11		-15.8	-16.0	-7.1	-7.6	-7.8	-8.0
Thorpe/Lindsay (Miramar)	2004/05/17		-11.8	-12.3	-7.8	-7.6	-7.8	-8.0
Dylan MacGregor (SRK)	2004/08/27		4.5	4.2	-8.2	-7.9	-7.8	-8.0
Quinn Jordan-Knox (SRK)	2004/09/28		-2.7	-2.5	-8.0	-7.9	-7.8	-8.0
Dylan MacGregor (SRK)	2005/04/16		-13.9	-12.9	-7.9	-7.8	-7.9	-8.0
D Kary (Miramar)	2005/05/16		-8.3	-7.8	-7.8	-8.0		-8.1
Jay Hallman (Miramar)	2005/07/18		-8.6	-8.0	-7.8	-8.0		-8.1
JRH (Miramar)	2005/08/05		-14.6	-15.6	-8.5	-8.0	-7.9	-8.0
D Kary (Miramar)	2005/09/08		-8.2	-8.1	-7.9	-8.0		-8.1
E Ballent (Miramar)	2005/09/26		-8.1	-8.2	-7.9	-8.0		-8.1
L. Wade / A. Tong (SRK)	2006/04/30		-9.2	-10.7	-7.8	-7.9	-8.0	-8.1
Jay Hallman (Miramar)	2006/06/04		-8.1	-7.9	-7.9	-8.0		-8.1
H.Johnson (Miramar)	2006/09/13		-7.8	-8.0	-8.0	-8.0		-8.1

DORIS NORTH PROJECT THERMISTOR DATA

Drill Hole SRK-40		Bead No.	Bead 1	Bead 2	Bead 3	Bead 4	Bead 5	Bead 6	Bead 7	Bead 8
Read By	**Date**	**Bead Location from Top (m)**	**above ground**	**6.0**	**11.0**	**16.0**	**21.0**	**31.0**	**41.0**	**51.0**
		Bead Depth (m)	**n/a**	**0.9**	**5.9**	**10.9**	**15.9**	**25.9**	**35.9**	**45.9**
Dylan McGreggor (SRK)	2003/08/25	**Temperature (Celsius)**		3.1	-8.2	-8.7	-8.5	-8.7	-8.8	-8.8
Mike Cripps (Miramar)	2003/09/21			1.0	-7.8	-8.7	-8.6	-8.7	-8.8	-8.9
Dylan MacGregor (SRK)	2004/04/11			-18.2	-10.0	-8.2	-8.5	-8.8	-8.9	-8.9
Thorpe/Lindsay (Miramar)	2004/05/17			-14.7	-10.9	-8.5	-8.5	-8.8	-8.9	-8.9
Dylan MacGregor (SRK)	2004/08/27			-0.1	-9.2	-9.0	-8.7	-8.7	-8.8	-8.8
Quinn Jordan-Knox (SRK)	2004/09/26			-1.1	-8.4	-9.0	-8.7	-8.7	-8.7	-8.8
Dylan MacGregor (SRK)	2005/04/16			-15.9	-10.5	-8.6	-8.7	-8.8	-8.8	-8.9
D Kary (Miramar)	2005/05/16			-13.6	-10.9	-8.8	-8.7	-8.7	-8.8	-8.8
Jay Hallman (Miramar)	2005/07/18			-0.5	-14.2	-9.2	-8.7	-8.7	-8.8	-8.8
JRH (Miramar)	2005/08/05		13.8	-0.9	-9.7	-9.3	-8.8	-8.7	-9.7	-8.8
D Kary (Miramar)	2005/09/08			0.5	-8.8	-9.2	-8.7	-8.7	-8.6	-8.6
E Ballent (Miramar)	2005/09/26			-0.5	-8.3	-9.1	-8.7	-8.5	-8.3	-8.4
L. Wade / A. Tong (SRK)	2006/04/30		-6.7	-13.7	-10.2	-8.7	-8.8	-8.8	-8.9	-8.9
Jay Hallman (Miramar)	2006/06/04		2.9	-3.5	-10.1	-8.6	-8.4	-8.7	-8.5	-8.5
Gary S./Hugh J. (Miramar)	2006/08/06		24.0	3.3	-8.3	-8.5	-8.3	-8.5	-8.4	-8.4
H.Johnson (Miramar)	2006/09/13		-1.1	2.1	-7.8	-8.7	-8.6	-8.6	-8.6	

DORIS NORTH PROJECT THERMISTOR DATA

Drill Hole SRK-41		Bead No.	Bead 1	Bead 2	Bead 3	Bead 4	Bead 5	Bead 6	Bead 7	Bead 8
Read By	Date	Bead Location from Top (m)	3.5	6.0	8.5	11.0	13.5	16.0	18.5	21.0
		Bead Depth (m)	1.4	3.9	6.4	8.9	11.4	13.9	16.4	18.9
Dylan MacGregor (SRK)	2003/08/25	Temperature (Celsius)	-16.0		-4.9	-6.2	-6.5	-6.5	-6.8	-7.0
Mike Cripps (Miramar)	2003/09/21		-15.4	-10.8	-10.0	-6.3	-6.7	-6.8	-7.0	-7.8
Dylan MacGregor (SRK)	2004/04/11		-18.5		-9.3	-6.6	-6.5	-6.8	-7.1	-7.2
Thorpe/Lindsay (Miramar)	2004/05/17		-2.1		-9.9	-7.3	-6.7	-6.8	-7.0	-7.2
Dylan MacGregor (SRK)	2004/08/27		6.2		-6.5	-7.3	-7.2	-7.1	-7.1	-7.1
Quinn Jordan-Knox (SRK)	2004/09/26		-1.3		-5.8	-7.0	-7.2	-7.1	-7.1	-7.2
Dylan MacGregor (SRK)	2005/04/16		-13.5		-7.8	-6.5	-6.6	-7.0	-7.1	-7.2
D Kary (Miramar)	2005/05/16		-9.4		-8.2	-6.9	-6.8	-7.0	-7.1	-7.2
Jay Hallman (Miramar)	2005/07/18		19.0		-6.9	-7.2	-7.0	-7.0	-7.1	-7.2
JRH (Miramar)	2005/08/05		20.2		-6.4	-7.1	-7.1	-7.0	-7.1	-7.2
D Kary (Miramar)	2005/09/08		23.6		-5.8	-6.9	-7.0	-7.1	-7.1	-7.2
E Ballent (Miramar)	2005/09/26		-1.0		-5.5	-6.7	-7.0	-7.1	-7.1	-7.2
L. Wade / A. Tong (SRK)	2006/04/30		-10.6		-8.7	-7.1	-6.9	-7.1	-7.2	-7.3
Jay Hallman (Miramar)	2006/06/04		15.6		-8.2	-7.3	-7.0	-7.0	-7.1	-7.2
Gary S./Hugh J. (Miramar)	2006/08/06		17.9		-6.1	-7.0	-7.1	-7.1	-7.1	-7.2
H.Johnson (Miramar)	2006/09/13		-0.2		-5.4	-6.6	-7.0	-7.1	-7.1	-7.2

DORIS NORTH PROJECT THERMISTOR DATA

Drill Hole SRK-42		Bead No.	Bead 1	Bead 2	Bead 3	Bead 4	Bead 5	Bead 6	Bead 7	Bead 8
Read By	Date	Bead Location from Top (m)	above ground	above ground	11.0	16.0	21.0	31.0	41.0	51.0
		Bead Depth (m)	n/a	n/a	0.2	5.2	10.2	20.2	30.2	40.2
Dylan McGreggor (SRK)	2003/08/25	Temperature (Celsius)			6.0	-6.3	-7.1	-7.8	-8.0	-8.1
Mike Cripps (Miramar)	2003/09/21				0.8	-6.3	-7.3	-7.9	-8.1	-8.1
Dylan MacGregor (SRK)	2004/04/11				-17.4	-7.6	-7.4	-8.0	-8.1	-8.1
Thorpe/Lindsay (Miramar)	2004/05/17				-11.3	-8.6	-7.4	-8.0	-8.1	-8.1
Dylan MacGregor (SRK)	2004/08/27				1.6	-7.7	-7.6	-8.0	-8.1	-8.1
Quinn Jordan-Knox (SRK)	2004/09/28				-0.1	-7.2	-7.0	-8.0	-8.1	-8.1
Dylan MacGregor (SRK)	2005/04/16				-14.1	-7.7	-7.6	-8.0	-8.1	-8.1
D Kary (Miramar)	2005/05/16				-11.4	-8.2	-7.5	-8.0	-8.1	-8.1
Jay Hallman (Miramar)	2005/07/18				2.9	-8.0	-7.6	-8.0	-8.1	-8.1
JRH (Miramar)	2005/08/05		16.4	18.9	1.7	-7.7	-7.6	-8.0	-8.1	-8.1
D Kary (Miramar)	2005/09/08				1.2	-7.2	-7.6	-8.0	-8.0	-8.1
E Ballent (Miramar)	2005/09/26				-0.1	-7.0	-7.6	-8.0	-8.1	-8.1
L. Wade / A. Tong (SRK)	2006/04/30		-5.5	-8.4	-12.1	-7.4	-7.6	-8.1	-8.1	-8.2
Jay Hallman (Miramar)	2006/06/04		14.8	12.2	3.6	-7.7	-7.4	-8.0	-8.0	-8.0
Gary S./Hugh J. (Miramar)	2006/08/06		26.4	27.1	1.9	-6.9	-7.5	-7.9	-8.0	-8.0
H.Johnson (Miramar)	2006/09/13		-0.2	-0.1	0.9	-6.5	-7.5	-7.9	-8.0	-8.0

DORIS NORTH PROJECT THERMISTOR DATA

Drill Hole SRK-43		Bead No.	Bead 1	Bead 2	Bead 3	Bead 4	Bead 5	Bead 6	Bead 7	Bead 8
Read By	**Date**	**Bead Location from Top (m)**	**above ground**	**15.5**	**21.0**	**26.6**	**32.1**	**43.1**	**54.1**	**66.0**
		Bead Depth (m)	**n/a**	**0.5**	**6.0**	**11.6**	**17.1**	**28.1**	**39.1**	**51.0**
Dylan MacGregor (SRK)	2003/08/25	**Temperature (Celsius)**		-2.3	-7.7	-7.8	-7.6	-8.2	-8.5	-8.5
Mike Cripps (Miramar)	2003/09/21			-2.6	-8.2	-8.3	-8.2	-8.5	-8.6	-8.5
Dylan MacGregor (SRK)	2004/04/11			-16.4	-8.2	-8.6	-8.7	-8.7	-8.6	-8.9
Thorpe/Lindsay (Miramar)	2004/05/17			-14.5	-8.4	-8.6	-8.8	-8.7	-8.6	-8.5
Dylan MacGregor (SRK)	2004/08/27			-5.2	-9.0	-8.6	-8.7	-8.7	-8.7	-8.5
Quinn Jordan-Knox (SRK)	2004/09/28			-4.5	-9.0	-8.6	-8.8	-8.7	-8.6	-8.5
Dylan MacGregor (SRK)	2005/04/16			-15.1	-8.6	-8.7	-8.8	-8.8	-8.6	-8.5
D Kary (Miramar)	2005/05/16			-13.3	-8.8	-8.7	-8.8	-8.7	-8.6	-8.5
Jay Hallman (Miramar)	2005/07/18			-6.4	-9.1	-8.7	-8.8	-8.7	-8.6	-8.5
JRH (Miramar)	2005/08/05		14.9	-5.6	-9.2	-8.7	-8.8	-8.7	-8.6	-8.5
D Kary (Miramar)	2005/09/08			-4.6	-9.2	-8.7	-8.7	-8.7	-8.5	-8.4
E Ballent (Miramar)	2005/09/26			-4.1	-9.1	-8.7	-8.8	-8.7	-8.6	-8.5
L. Wade / A. Tong (SRK)	2006/04/30		-10.5	-13.4	-8.8	-8.8	-8.9	-8.8	-8.6	-8.5
Jay Hallman (Miramar)	2006/06/04		13.1	-8.4	-8.8	-8.7	-8.8	-8.7	-8.5	-8.4
Gary S./Hugh J. (Miramar)	2006/08/06		21.0	-4.4	-8.7	-8.4	-8.4	-8.4	-8.2	-8.1
H.Johnson (Miramar)	2006/09/13		-0.7	-3.8	-9.0	-8.7	-8.8	-8.7	-8.6	-8.4

DORIS NORTH PROJECT THERMISTOR DATA															
Drill Hole SRK-50		Bead No.	Bead 1	Bead 2	Bead 3	Bead 4	Bead 5	Bead 6	Bead 7	Bead 8	Bead 9	Bead 10	Bead 11	Bead 12	Bead 13
Read By	Date	Bead Location from Top (m)	5.0	10.0	20.0	30.0	50.0	70.0	90.0	110.0	130.0	150.0	170.0	190.0	200.0
		Bead Depth (m)	5.0	10.0	20.0	30.0	50.0	70.0	90.0	110.0	130.0	150.0	170.0	190.0	200.0
Dylan MacGregor (SRK)	2004/08/31	Temperature (Celsius)	-5.4	-6.0	-5.1	-4.9	-4.9	-5.0	-4.8	-4.7	-4.4	-4.3	-4.1	-3.8	-3.7
Quinn Jordan-Knox (SRK)	2004/09/26		-5.4	-6.4	-5.7	-5.4	-5.3	-5.3	-5.1	-5.0	-4.7	-4.5	-4.3	-3.9	-3.8
Dylan MacGregor (SRK)	2005/04/25		-10.3	-7.2	-5.9	-5.7	-5.6	-5.5	-5.3	-5.0	-4.8	-4.6	-4.4	-4.1	-4.0
D Kary (Miramar)	2005/05/16		-10.1	-7.5	-5.9	-5.7	-5.4	-5.4	-5.3	-5.0	-4.8	-4.6	-4.4	-4.0	-4.0
Jay Hallman (Miramar)	2005/07/18		-7.9	-7.6	-6.0	-5.7	-5.5	-5.4	-5.3	-5.1	-4.8	-4.6	-4.4	-4.1	-4.0
JRH (Miramar)	2005/08/05		-7.2	-7.5	-6.0	-5.7	-5.4	-5.4	-5.2	-5.0	-4.8	-4.6	-4.3	-4.0	-4.0
D Kary (Miramar)	2005/09/08		-6.3	-7.2	-6.1	-5.7	-5.5	-5.4	-5.3	-5.0	-4.8	-4.6	-4.4	-4.0	-4.0
E Ballent (Miramar)	2005/09/26		-5.8	-6.9	-6.1	-5.7	-5.4	-5.4	-5.2	-5.1	-4.8	-4.6	-4.4	-4.0	-3.9
L. Wade / A. Tong (SRK)	2006/04/30		-9.3	-7.0	-6.0	-5.8	-5.5	-5.4	-5.3	-5.1	-4.9	-4.7	-4.3	-4.0	-4.0
Jay Hallman (Miramar)	2006/06/04		-8.6	-7.2	-5.9	-5.7	-5.4	-5.3	-5.2	-5.0	-4.8	-4.6	-4.2	-3.9	-4.0
Gary S./Hugh J. (Miramar)	2006/08/06		-6.3	-6.9	-6.0	-5.7	-5.4	-5.3	-5.2	-5.0	-4.8	-4.6	-4.2	-3.9	-4.0
H.Johnson (Miramar)	2006/09/13		-5.4	-6.5	-6.0	-5.7	-5.4	-5.4	-5.2	-5.0	-4.8	-4.6	-4.2	-3.8	-4.0

DORIS NORTH PROJECT THERMISTOR DATA														
Drill Hole SRK-51		Bead No.	Bead 1	Bead 2	Bead 3	Bead 4	Bead 5	Bead 6	Bead 7	Bead 8	Bead 9	Bead 10	Bead 11	Bead 12
Read By	Date	Bead Location from Top (m)	above ground	1.25	1.50	1.75	2.00	2.50	3.00	3.50	4.00	4.50	5.00	6.00
		Bead Depth (m)	n/a	0.25	0.50	0.75	1.00	1.50	2.00	2.50	3.00	3.50	4.00	5.00
Dylan MacGregor (SRK)	2005/04/26	Temperature (Celsius)	0.3	-8.2	-9.5	-10.7	-11.7	-12.9	-12.8	-12.2	-11.3	-10.4	-9.6	-8.6
D Kary (Miramar)	2005/05/16		-21.8	-10.7	-11.2	-11.3	-11.6	-11.9	-11.9	-11.8	-11.4	-10.9	-10.3	-9.3
Jay Hallman (Miramar)	2005/07/18		21.9	3.5	-0.5	-2.2	-3.7	-6.1	-7.8	-9.0	-9.7	-10.0	-10.0	-9.7
JRH (Miramar)	2005/08/05		20.9	4.0	0.4	-1.7	-3.1	-5.4	-7.1	-8.4	-9.1	-9.6	-9.8	-9.6
D Kary (Miramar)	2005/09/08		27.6	2.1	1.2	-1.0	-2.4	-4.6	-6.2	-7.5	-8.4	-9.0	-9.3	-9.4
E Ballent (Miramar)	2005/09/26		-5.1	-0.3	-0.3	-1.2	-2.2	-4.2	-5.8	-7.1	-8.0	-8.7	-9.0	-9.3
L. Wade / A. Tong (SRK)	2006/04/30		-2.9	-11.9	-12.7	-13.0	-13.2	-13.1	-12.5	-11.8	-11.1	-10.4	-9.7	-9.0
Jay Hallman (Miramar)	2006/06/04		18.6	2.3	-2.1	-4.0	-5.4	-7.8	-9.3	-10.2	-10.4	-10.3	-9.9	-9.3
Gary S./Hugh J. (Miramar)	2006/08/06		18.1	7.7	3.2	-0.6	-2.3	-4.7	-6.5	-7.7	-8.5	-9.1	-9.3	-9.3
H.Johnson (Miramar)	2006/09/13		-0.9	0.5	0.3	-0.2	-1.6	-3.9	-5.6	-6.9	-7.8	-8.5	-8.8	-9.1

DORIS NORTH PROJECT THERMISTOR DATA														
Drill Hole SRK-52		Bead No.	Bead 1	Bead 2	Bead 3	Bead 4	Bead 5	Bead 6	Bead 7	Bead 8	Bead 9	Bead 10	Bead 11	Bead 12
Read By	Date	Bead Location from Top (m)	above ground	1.25	1.50	1.75	2.00	2.50	3.00	3.50	4.00	4.50	5.00	6.00
		Bead Depth (m)	n/a	0.25	0.50	0.75	1.00	1.50	2.00	2.50	3.00	3.50	4.00	5.00
Dylan MacGregor (SRK)	2005/04/25	Temperature (Celsius)	6.0	-7.9	-10.5	-12.7	-14.5	-16.0	-16.3	-16.0	-15.3	-14.7	-13.8	-12.9
Dylan MacGregor (SRK)	2005/04/26		9.2	-8.8	-10.7	-12.5	-14.2	-15.9	-16.3	-16.0	-15.4	-14.8	-14.0	-13.1
D Kary (Miramar)	2005/05/16		-9.8	-9.5	-11.1	-11.9	-12.8	-13.9	-14.5	-14.8	-14.7	-14.4	-13.9	-13.4
Jay Hallman (Miramar)	2005/07/18		21.4	6.0	0.0	-2.7	-4.6	-7.0	-8.8	-10.0	-10.8	-11.2	-11.3	-11.7
JRH (Miramar)	2005/08/05		23.8	6.6	0.4	-2.2	-3.9	-6.2	-7.9	-9.1	-9.9	-10.4	-10.6	-11.0
D Kary (Miramar)	2005/09/08		21.2	10.3	2.3	-1.5	-3.1	-5.2	-6.9	-8.0	-8.8	-9.3	-9.5	-10.1
E Ballent (Miramar)	2005/09/26		-1.4	-1.2	-0.9	-1.5	-2.8	-4.8	-6.3	-7.4	-8.2	-8.7	-8.9	-9.6
L. Wade / A. Tong (SRK)	2006/04/30		-3.9	-11.4	-13.7	-14.6	-15.2	-15.5	-15.2	-14.8	-14.1	-13.5	-12.3	-12.2
Jay Hallman (Miramar)	2006/06/04		13.1	4.6	-2.0	-4.8	-6.6	-9.1	-10.8	-11.9	-12.2	-12.4	-12.1	-12.0
Gary S./Hugh J. (Miramar)	2006/08/06		17.9	12.9	4.4	-0.9	-3.1	-5.4	-7.1	-8.4	-9.0	-9.5	-9.7	-10.2
H.Johnson (Miramar)	2006/09/13		0.1	-0.2	0.3	-0.5	-2.2	-4.4	-5.8	-7.1	-7.8	-8.4	-8.6	-9.2

DORIS NORTH PROJECT THERMISTOR DATA									
Drill Hole SRK-53		Bead No.	Bead 1	Bead 2	Bead 3	Bead 4	Bead 5	Bead 6
Read By	**Date**	**Bead Location from Top (m)**	**2.00**	**3.00**	**4.00**	**6.00**	**8.50**	**11.00**
		Bead Depth (m)	**0.60**	**1.60**	**2.60**	**4.60**	**7.10**	**9.60**
Dylan MacGregor (SRK)	2005/04/26	**Temperature (Celsius)**	-1.1	-0.8	-0.6	-0.3	-5.8	-5.9
D Kary (Miramar)	2005/05/16		-9.4	-9.7	-9.8	-8.2	-7.3	-6.7
Jay Hallman (Miramar)	2005/07/18		-0.6	-4.3	-6.5	-7.8	-7.6	-7.1
JRH (Miramar)	2005/08/05		0.3	-3.5	-5.8	-7.4	-7.5	-7.1
D Kary (Miramar)	2005/09/08		0.7	-2.7	-4.8	-6.8	-7.1	-7.0
E Ballent (Miramar)	2005/09/26		-0.1	-2.5	-4.5	-6.5	-6.9	-6.9
L. Wade / A. Tong (SRK)	2006/04/30		-12.2	-11.5	-10.4	-7.8	-7.0	-6.6
Jay Hallman (Miramar)	2006/06/04		-3.0	-6.2	-8.1	-7.9	-7.3	-6.8
H.Johnson (Miramar)	2006/09/13		1.3	-2.2	-4.3	-6.2	-6.7	-6.7

DORIS NORTH PROJECT THERMISTOR DATA

Drill Hole SRK-54		Bead No.	Bead 1	Bead 2	Bead 3	Bead 4	Bead 5	Bead 6
Read By	**Date**	**Bead Location from Top (m)**	**2.0**	**3.0**	**4.0**	**6.0**	**8.5**	**11.0**
		Bead Depth (m)	**1.0**	**2.0**	**3.0**	**5.0**	**7.5**	**10.0**
Quinn Jordan-Knox (SRK)	2004/09/28	**Temperature (Celsius)**	-0.1	0.0	-0.6	-4.3	-5.7	-6.0
Dylan MacGregor (SRK)	2005/04/21		-14.7	-14.1	-12.9	-9.5	-7.1	-6.8
D Kary (Miramar)	2005/05/16		-12.3	-12.4	-11.9	-9.7	-7.5	-6.9
Jay Hallman (Miramar)	2005/07/18		1.4	-3.6	-6.1	-8.3	-7.9	-7.1
JRH (Miramar)	2005/08/05		1.6	-2.9	-5.3	-7.7	-7.8	-7.2
D Kary (Miramar)	2005/09/08		1.5	-2.1	-4.3	-6.9	-7.6	-7.2
E Ballent (Miramar)	2005/09/26		0.0	-1.8	-3.8	-6.4	-7.5	-7.2
Jay Hallman (Miramar)	2006/06/04		-1.4	-5.3	-7.8	-8.8	-7.5	-6.9
Gary S./Hugh J. (Miramar)	2006/08/06		2.8	-2.0	-4.5	-6.9	-7.4	-7.0
H.Johnson (Miramar)	2006/09/13		0.4	-1.4	-3.7	-6.2	-7.3	-7.1

DORIS NORTH PROJECT THERMISTOR DATA								
Drill Hole SRK-55		**Bead No.**	**Bead 1**	**Bead 2**	**Bead 3**	**Bead 4**	**Bead 5**	**Bead 6**
Read By	**Date**	**Bead Location from Top (m)**	**2.0**	**3.0**	**4.0**	**6.0**	**8.5**	**11.0**
		Bead Depth (m)	**0.8**	**1.8**	**2.8**	**4.8**	**7.3**	**9.8**
Quinn Jordan-Knox (SRK)	2004/09/26	**Temperature (Celsius)**	0.0	0.0	-3.9	-6.2	-7.4	-6.9
Quinn Jordan-Knox (SRK)	2004/09/28		-0.1	-1.1	-5.7	-7.2	-7.7	-7.5
Thermistor Permanently Damaged - Not Repairable								

DORIS NORTH PROJECT THERMISTOR DATA								
Drill Hole SRK-56		**Bead No.**	**Bead 1**	**Bead 2**	**Bead 3**	**Bead 4**	**Bead 5**	**Bead 6**
Read By	**Date**	**Bead Location from Top (m)**	**2.0**	**3.0**	**4.0**	**6.0**	**8.5**	**11.0**
		Bead Depth (m)	**above ground**	**above ground**	**above ground**	**0.8**	**3.3**	**5.8**
Quinn Jordan-Knox (SRK)	2004/09/28	**Temperature (Celsius)**	-2.9	-2.9	-2.6	0.0	-0.3	-3.6
Dylan MacGregor (SRK)	2005/04/21		-12.7	-13.4	-10.7	-11.9		
Dylan MacGregor (SRK)	4/24/2005		1.4	1.7	1.6	-11.7		
D Kary (Miramar)	2005/05/16		-12.8	-8.8	-10.4	-10.8		
Jay Hallman (Miramar)	2005/07/18		20.2	18.4	23.7	0.6		
JRH (Miramar)	2005/08/05		18.9	17.2	22.1	1.5		
D Kary (Miramar)	2005/09/08		26.3	24.0	28.6	1.3		
E Ballent (Miramar)	2005/09/26		-1.4	-1.5	-1.1	0.0		
Jay Hallman (Miramar)	2006/06/04		3.1	3.1	2.3			
Gary S./Hugh J. (Miramar)	2006/08/06		27.0	35.5	31.6			
H.Johnson (Miramar)	2006/09/13		-0.9	-1.5	-0.3			

DORIS NORTH PROJECT THERMISTOR DATA								
Drill Hole SRK-57		**Bead No.**	**Bead 1**	**Bead 2**	**Bead 3**	**Bead 4**	**Bead 5**	**Bead 6**
Read By	**Date**	**Bead Location from Top (m)**	**above ground**	**3.00**	**4.00**	**6.00**	**8.50**	**11.00**
		Bead Depth (m)	**n/a**	**0.33**	**1.33**	**3.33**	**5.83**	**8.33**
Dylan MacGregor (SRK)	2005/04/26	**Temperature (Celsius)**	-6.1	-5.5	-12.9	-12.5	-8.9	-6.6
D Kary (Miramar)	2005/05/16					-12.2	-10.6	-8.8
Jay Hallman (Miramar)	2005/07/18		13.5			-7.6	-9.1	-9.0
JRH (Miramar)	2005/08/05		12.7			-6.6	-8.4	-8.7
D Kary (Miramar)	2005/09/08		7.8			-5.3	-7.3	-8.2
E Ballent (Miramar)	2005/09/26		-1.4			-4.8	-6.8	-7.8
Jay Hallman (Miramar)	2006/06/04		13.5			-9.2	-9.7	-9.6
Gary S./Hugh J. (Miramar)	2006/08/06		33.6	0.9	-0.9	-1.2		
H.Johnson (Miramar)	2006/09/13		0.0			-4.4	-6.4	-7.4

DORIS NORTH PROJECT THERMISTOR DATA								
Drill Hole SRK-58		**Bead No.**	**Bead 1**	**Bead 2**	**Bead 3**	**Bead 4**	**Bead 5**	**Bead 6**
Read By	**Date**	**Bead Location from Top (m)**	**2.00**	**3.00**	**4.00**	**6.00**	**8.50**	**11.00**
		Bead Depth (m)	**1.07**	**2.07**	**3.07**	**5.07**	**7.57**	**10.07**
Dylan MacGregor (SRK)	2005/04/25	**Temperature (Celsius)**	-6.5	-6.2	-3.5	-1.5	-0.4	-5.8
Dylan MacGregor (SRK)	2005/04/26		-11.3	-10.8	-8.9	-5.1	-2	-6.5
D Kary (Miramar)	2005/05/16		-11.3	-11.2	-10.6	-8.2	-7.3	-6.9
Jay Hallman (Miramar)	2005/07/18		-4.2	-7.6	-9.1	-8.7	-7.7	-7.1
D Kary (Miramar)	2005/09/08		-2.8	-6	-7.9	-8.4	-7.8	-7.2
E Ballent (Miramar)	2005/09/26		-2.6	-5.6	-7.5	-8.2	-7.8	-7.3
Jay Hallman (Miramar)	2006/06/04		-5.5	-8.9	-9.8	-8.4	-7.4	-7.1
Gary S./Hugh J. (Miramar)	2006/08/06		-2.7	-6.1	-7.9	-8.1	-7.5	-7.1
H.Johnson (Miramar)	2006/09/13		-2.1	-5.4	-7.3	-7.9	-7.6	-7.3

DORIS NORTH PROJECT THERMISTOR DATA														
Drill Hole SRK-62		**Bead No.**	**Bead 1**	**Bead 2**	**Bead 3**	**Bead 4**	**Bead 5**	**Bead 6**	**Bead 7**	**Bead 8**	**Bead 9**	**Bead 10**	**Bead 11**	**Bead 12**
Read By	**Date**	**Bead Location from Top (m)**	**above ground**	**1.25**	**1.50**	**1.75**	**2.00**	**2.50**	**3.00**	**3.50**	**4.00**	**4.50**	**5.00**	**6.00**
		Bead Depth (m)	**n/a**	**0.25**	**0.50**	**0.75**	**1.00**	**1.50**	**2.00**	**2.50**	**3.00**	**3.50**	**4.00**	**5.00**
Dylan MacGregor (SRK)	2005/04/25	**Temperature (Celsius)**	7.4	-4.4	-7.9	-10.1	-11.3	-12.1	-12.0	-11.4	-10.7	-9.8	-9.1	-7.6
Dylan MacGregor (SRK)	2005/04/26		-7.8	-6.8	-7.7	-9.5	-10.8	-12.0	-12.3	-11.7	-11.1	-10.2	-9.5	-8.1
D Kary (Miramar)	2005/05/16		-6.6	-10.6	-10.7	-10.9	-10.8	-10.8	-10.8	-10.7	-10.5	-10.2	-9.9	-8.9
Jay Hallman (Miramar)	2005/07/18		13.3	2.5	2.0	1.7	-1.2	-3.2	-4.5	-5.5	-6.4	-7.1	-7.6	-8.0
JRH (Miramar)	2005/08/05		14.6	3.1	2.3	2.1	-0.9	-2.5	-3.8	-4.7	-5.6	-6.4	-7.0	-7.5
D Kary (Miramar)	2005/09/08		17.6	3.4	2.4	2.0	-0.4	-1.9	-3.0	-3.9	-4.8	-5.5	-6.1	-6.9
E Ballent (Miramar)	2005/09/26		-1.7	0.0	-0.1	-0.2	-0.7	-1.6	-2.7	-3.5	-4.3	-5.0	-5.7	-6.5
Jay Hallman (Miramar)	2006/06/04		12.2	1.7	0.3	-2.6	-3.6	-5.2	-6.7	-7.7	-8.4	-8.8	-9	-8.6
Gary S./Hugh J. (Miramar)	2006/08/06		21.8	3.8	2.5	2.2	-0.7	-2.2	-3.4	-4.3	-5.1	-5.8	-6.4	-7.1
H.Johnson (Miramar)	2006/09/13		-1.0	0.8	1.1	0.7	-0.4	-1.5	-2.6	-3.4	-4.2	-4.9	-5.6	-6.4

Appendix D
AMCL Geophysical Study Report

IMC

Associated Mining Consultants Ltd.

Geophysical Study for Anomalous Stratigraphy and/or Ice Content Tail Lake, Hope Bay - Nunavut

Prepared for
SRK Consulting Inc.
Vancouver, British Columbia

Submitted by
Associated Mining Consultants Ltd.
Vancouver, British Columbia

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File: 06PQ10

June 29, 2006

SRK Consulting Inc. (Canada)
Suite 800, 1066 West Hastings Street
Vancouver, British Columbia
V6E 3X2

Attention: Maritz Rykaart

Dear Maritz,

Associated Mining Consultants Ltd. (AMCL) is pleased to submit the following report entitled:

Geophysical Study for Anomalous Stratigraphy
and/or Ice Content
Trail Lake, Hope Bay - Nunavut

We would like to express our thanks to SRK Consulting Inc. for the opportunity to provide our services in relation to this project.

If you have any questions, or require any additional information, please do not hesitate to contact our office.

Yours sincerely,

ASSOCIATED MINING CONSULTANTS LTD.

Dave Butler, Ph.D., P.Geo.
Manager, Vancouver Office

Claude Robillard, géoph.
Senior Geophysicist

/cew

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1.0 INTRODUCTION

A geophysical survey was undertaken by Associated Mining Consultants Ltd. (AMCL) from April 4, 13, 2006 at the Hope Bay site in Nunavut to provide information in support of mine facilities/infrastructures design. The primary objectives of the survey were to guide a proposed drilling programme by identifying regions of anomalous stratigraphy and/or ice content, and to map bedrock topography around the perimeter of Tail Lake.

In accordance with AMCL's proposal (AMP 1786) to SRK Consulting Inc., a two-phase approach has been taken to fulfill the objectives. A test survey to determine the most appropriate geophysical methods was conducted first which included electrical imaging, time domain electromagnetics, seismic refraction and ground-penetrating radar. The test survey was conducted at the proposed sites of both the south and north dams, where geophysical data could be readily correlated with drill-hole data.

After phase one was completed, and data analysed in the field, it was decided to proceed only with ground-penetrating radar for phase two of the study, which covered the entire perimeter of Tail Lake.

This report presents the results of both phases of the survey.

1.1 Site Description

Hope Bay is located some 750 km northeast of Yellowknife and 130 km southwest of Cambridge Bay. Figure 1 shows the general location of the area. The survey site at Tail Lake is located approximately 20 km east of the camp and was accessible by skidoo. The lake itself is 3.3 km long and 400 m wide on average.

Figure 1 shows the location and outline of the survey area.

At the time of the survey, the snow cover varied between 0.5 to 1.5 m in the survey area. The two proposed dam areas were easily accessible. The 33.5 m contour line that had to be surveyed around the perimeter of the lake could not be surveyed over some short sections where cliffs and snow drifts were too steep to allow access.

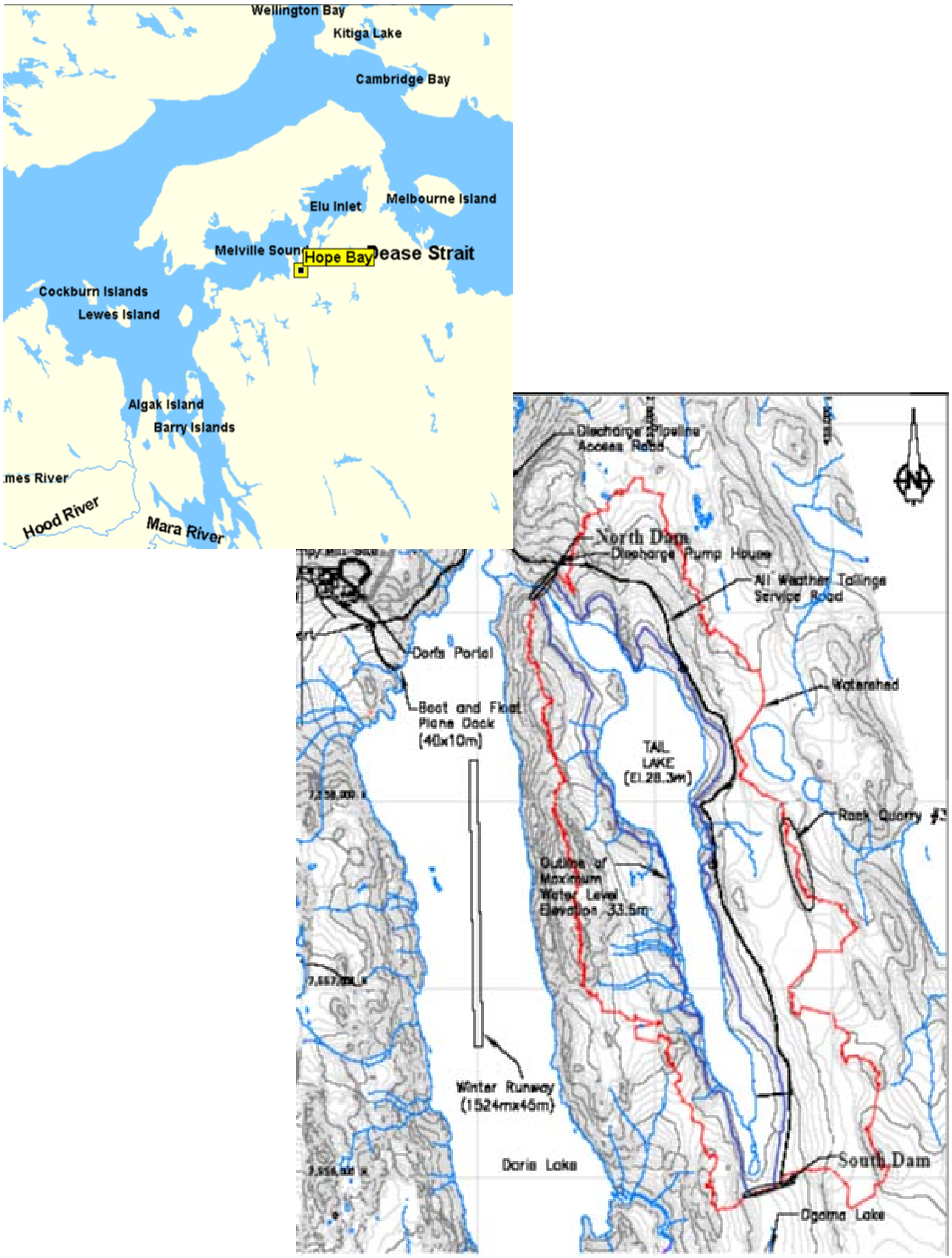


Figure 1: General Location Map

2.0 METHODS

2.1 Seismic Refraction

The seismic refraction method, commonly used to map depth to bedrock, rests on the principle that a sound wave travelling at a particular speed in one material will, on encountering a boundary with a different material, change its direction of travel *if its speed of travel changes*. The degree of the bend in direction (the refraction) is directly related to the contrast in velocity across the boundary. If a wave crosses a boundary at an angle, it will refract towards the boundary if its velocity increases across the boundary, whereas it will refract away from the boundary if its velocity decreases across the boundary.

Generally, earth materials become harder with increasing depth, and harder materials lead to faster wave speeds. Therefore downwards-travelling sound waves generated at the surface will refract upwards as they encounter harder materials at increasing depths. At some point, as shown in Figure 2, the velocity contrast across a boundary will be such that the waves will refract horizontally.

The refracted wave will travel along the layer, leaking energy back towards the surface as it travels. The waves will refract upwards into the slower-velocity material above, and they will continue to refract upwards as they encounter progressively slower-velocity material on the return towards the surface. Since these waves have travelled at velocities much higher than those waves that travelled only along the earth's surface, they will eventually overtake the surface waves, so that at some point on the surface, the first arrival of sound will come from a wave that travelled through the deeper layer. Bedrock is typically the deepest layer encountered in a refraction survey.

The technique therefore measures the travel-times of acoustic waves between a source location and a number of geophones placed at equal increments away from the source. The waves are generated by an external energy source, such as a sledgehammer or a small explosive charge. The sound waves are recorded by a series of geophones (a 'spread') connected to a seismograph. Typically, sound waves are generated at five to seven shot locations per spread, with two of those shots set off at each end of the spread in order to record bedrock information right to the edges of each spread. In this survey, however, shot locations were more tightly spaced, being located between every second geophone. The recorded travel-times are a function of the speeds of sound within the subsurface layers, and the thicknesses and depths of the layers. The depths of investigation in seismic refraction, largely a function of energy source and receiver geometry, are generally in the order of one-fifth of the geophone array dimension.

For this study, the geophones were placed at 8 m intervals, and the seismic energy source was created by striking a steel plate with a sledgehammer.

The success of the method is dependent upon the degree of contrast in velocity between the target layers. Typical acoustic velocities of common geologic materials are listed in Table 1.

The method also requires that velocity increases with depth. Velocity reversals may, at times, result in layers being "hidden" and thus undetectable by the seismic refraction method.

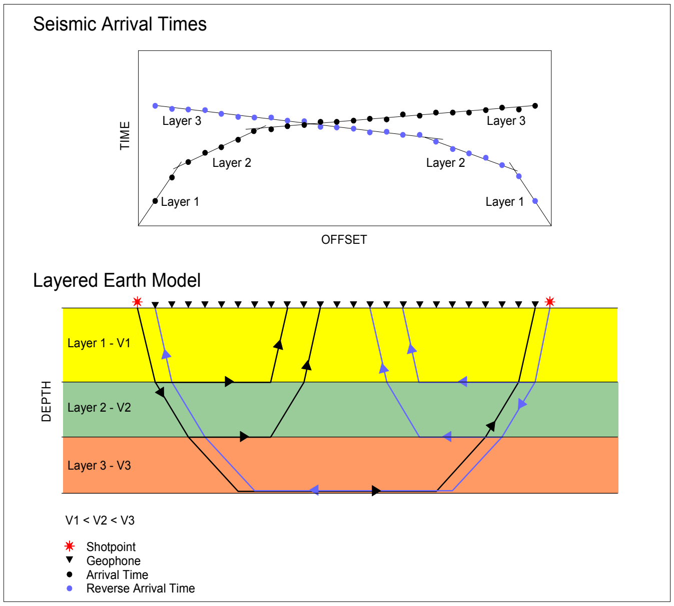


Figure 2: Illustration of seismic refraction method

Table 1: Acoustic Velocities of Common Geological Materials

MATERIAL	v (m/s)
Weathered Surface Material	305 - 610
Gravel, Rubble or Dry Sand	468 - 915
Wet Sand	610 - 1830
Clay	915 - 2750
Sandstone	1830 - 3970
Shale	2750 - 4270
Chalk	1830 - 3970
Limestone	2140 - 6100
Granite	4580 - 5800
Metamorphic Rock	3050 - 7020
Water (dependent on temperature and salt content)	4700 - 5500
Ice	3600 - 3700

2.2 Ground-Penetrating Radar (GPR)

The concept of radio detection and ranging (radar) is fundamentally the precise measurement of outbound and return travel times of high-frequency (10 MHz to 1000 MHz) electromagnetic waves from boundaries of contrasting electrical impedance. Two-dimensional profiles of the subsurface produced by the GPR method are referenced to signal travel times. The conversion of a timescale to one relevant to depth requires the accurate determination of the velocity of the medium traversed, often by the correlation with drill hole logs and/or the results of complementary geophysical methods.

The velocity and attenuation of radar signals within the subsurface depends on the dielectric and conductivity properties of subsurface materials. Variations in the electrical properties of soils and rocks are usually associated with changes in grain size and/or water content which, in turn, cause part of a transmitted signal to be reflected. The reflected signal is detected by the receiver where it is amplified, digitized and stored for subsequent data processing and interpretation. A schematic showing the operation of the GPR is shown in Figure 3.

Ground penetrating radar penetration depth is limited primarily by the conductivity of the subsurface. High proportions of clay and/or total dissolved solids within the groundwater can severely reduce the effective exploration depth. Although depth penetration can be increased by reducing antenna frequency, vertical resolution is compromised proportionally.

A Malå RAMAC ground penetrating radar system was used to acquire subsurface geophysical data along the proposed pipeline watercourse crossings. The system was used in a reflection, or single-fold fixed-offset, profiling mode.

Data were acquired using both 50 MHz and 100 MHz unshielded antennas during phase one and using only the 50 MHz antenna for the perimeter of the lake during phase two.

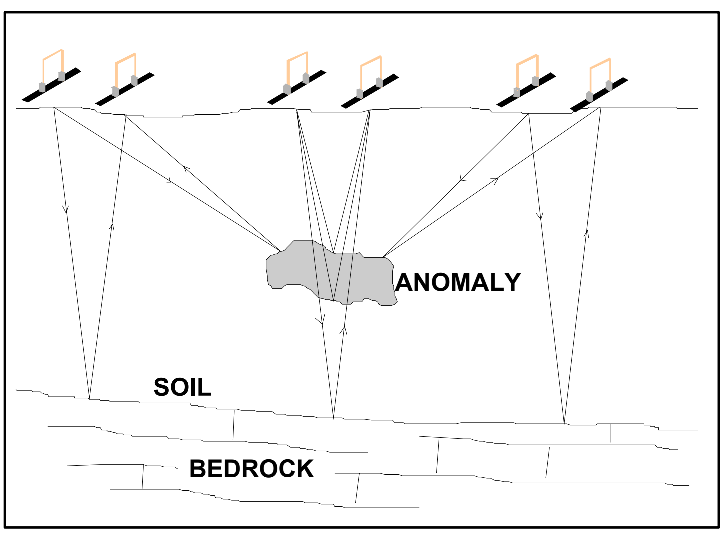


Figure 3: Illustration of the ground penetrating radar (GPR) method

2.3 Transient Electromagnetic (TDEM)

In the TDEM method, an electromagnetic field is generated by passing a square-wave electrical current through a grounded loop of wire, which in this case was laid on the ground surface. In the upper half-space (air), a magnetic field establishes itself almost instantly over the surface of the earth, while in the lower half-space (earth), the magnetic field develops much more slowly, with high-frequency components attenuated in the conductive earth. At the surface of the earth, energy refracts downward into the ground by induction. This energy induces secondary eddy currents in the earth that in turn generate their own magnetic field which travels back to the surface. This returned magnetic field is measured at a site where we wish to know the subsurface resistivity variations. As the excitation field penetrates deeper into the earth, it takes longer for the secondary field to return to the surface. At the receiver site, the returned vertical magnetic field is recorded as a function of time.

In order to measure the vertical magnetic field variations as a function of time, an induction loop receiver is placed on the surface of the ground at approximately 10 m from the side of the individual transmitter dipoles. Depending on the size of the target, sounding typical spacings of 20 to 100 m are used. At every sounding site, the vertical magnetic field changes are recorded as time-varying voltages. These curves, which start at zero time (surface) and continue from several hundred ms to over 15 sec, depending on the conductivity of the sedimentary section, are called transients. The amplitude and shape of the transients are used to determine the resistivity distribution of the sedimentary section, generally to basement, directly below the receiver loop. Bulk changes in earth resistivity with depth cause voltage changes in the recorded curves. At every sounding site, individual transients are stacked in order to improve the signal to noise ratio. Then, resistivity formulas derived from Maxwell's equations are used to calculate apparent resistivity curves as a function of time (depth) at each sounding site. Different apparent resistivity curves are calculated using different time windows. Those time windows are often referred as early-time and late-time.

After apparent resistivities have been calculated for each sounding, these curves are mathematically inverted in terms of a one-dimensional, multi-layered earth with basement the last layer. We use a ridge regression inversion program called TEMIX from Interpex Limited, Golden, Colorado. As many as six layers can be inferred. A schematic of the whole process from data acquisition to inversion is shown in Figure 3.

Using the thicknesses and resistivities derived from the inversions, elevation maps of structurally significant boundaries and structural cross-sections can be prepared. Because resistivity is a function of lithology, the lithologic architecture of the subsurface can be determined by mapping resistivity boundaries.

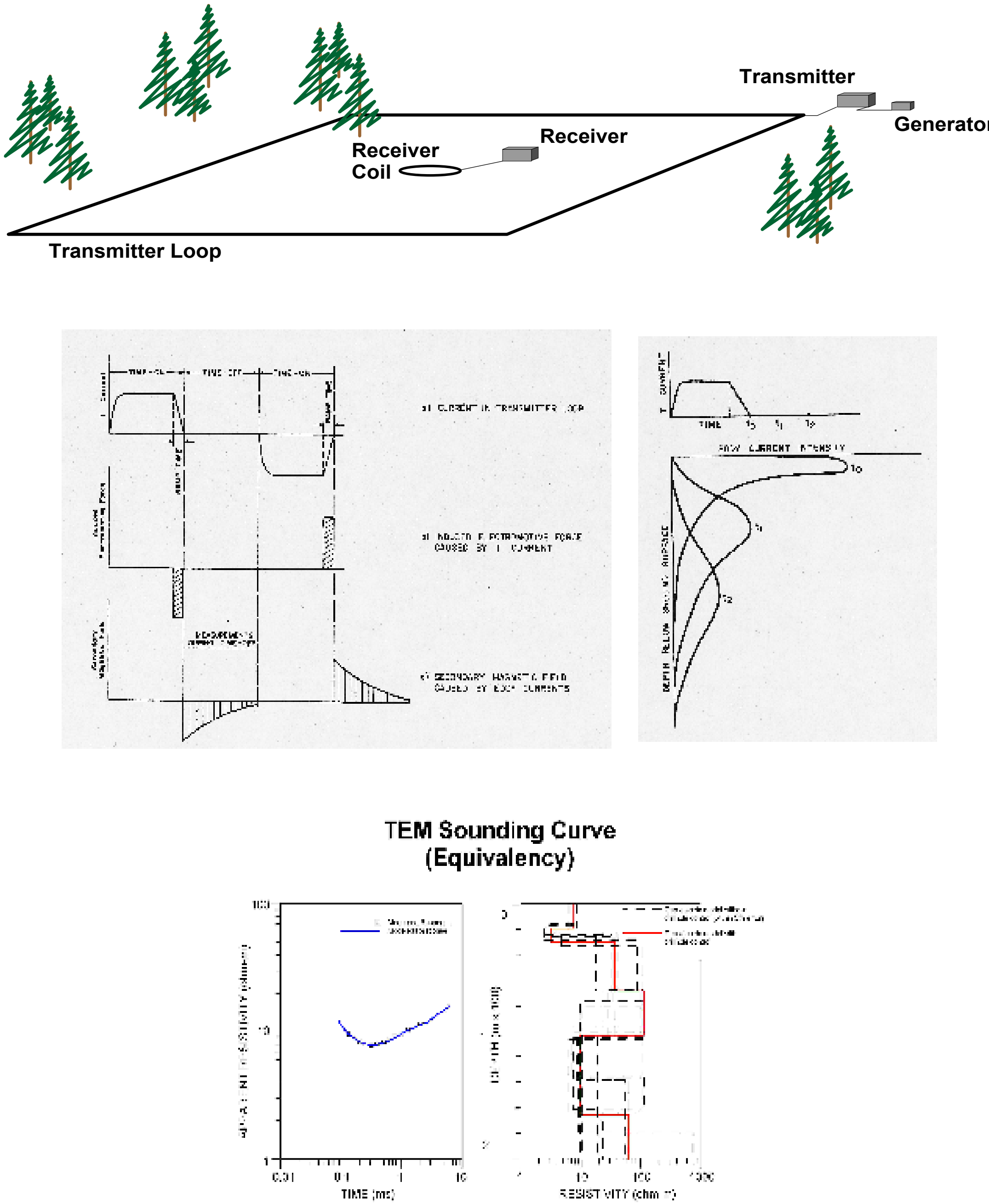


Figure 4: Principle of the TEM method from the data acquisition process (top), the geophysical properties being measured (middle), and the data inversion process (bottom)

2.4 Capacitively Coupled Resistivity Profiling (OhmMapper)

The purpose of electrical surveys is to determine the subsurface resistivity distribution by making measurements on the ground surface. The ground resistivity is related to various geological and physical parameters such as the mineral and fluid content, porosity and degree of water saturation in the rock. Presence of permafrost also has a significant influence on electrical resistivity. As the temperature of the subsurface decreases below 0°, and as the ice content increases, the resistivity of subsurface materials increases substantially as illustrated in Figures 5a and 5b.

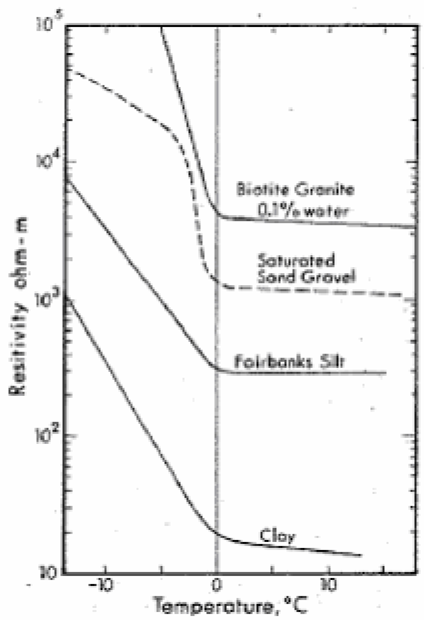


Figure 5a

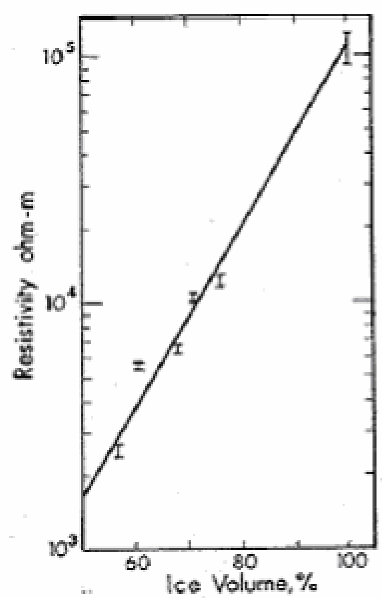


Figure 5b

The resistivity measurements are normally acquired by injecting current into the ground through two current electrodes, and measuring the resulting voltage difference at two potential electrodes. In this survey, we used a capacitively-coupled resistivity meter designed to measure sub-surface resistivity in areas where the use of traditional galvanically coupled (DC) resistivity system is impractical and slow. The OhmMapper consists of an ungrounded dipole transmitter, receiver and data logger. A transmitter electrifies two coaxial cables (transmitter dipole) with an AC current. Current is thus coupled to the earth through the capacitance of the cable. A matched receiver automatically tuned to the transmitter frequency, measures the associated voltage picked up on the receiver's dipole cables. The receiver then transmits a voltage measurement, normalized to current, to the logging console. Apparent resistivity is calculated using the appropriate geometric factor for the capacitively coupled antenna array. The OhmMapper is designed to be pulled along the ground as a streamer. The principle of its operation is shown on Figure 6.

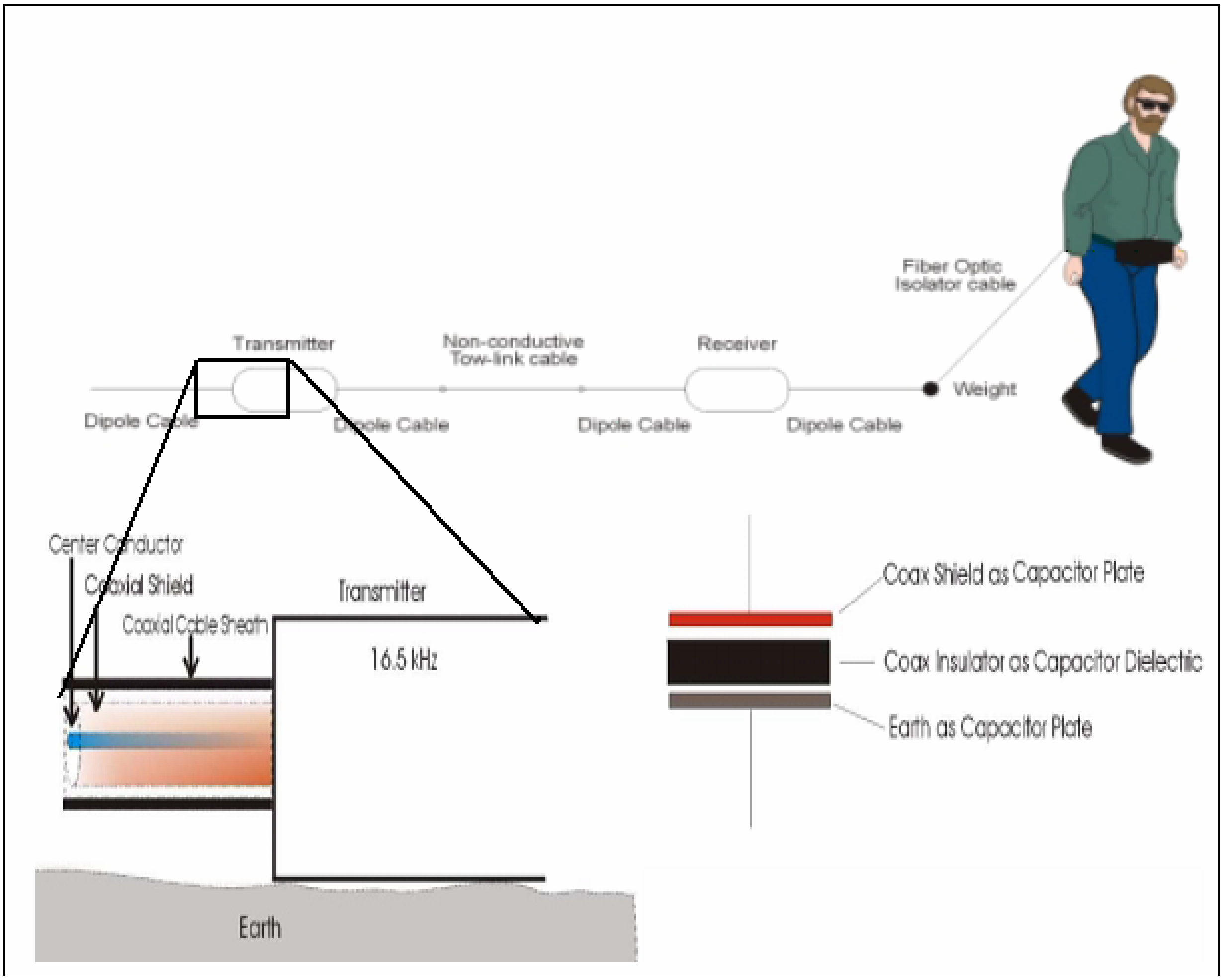


Figure 6: Principle of the OhmMapper system

3.0 RESULTS

During phase one, the OhmMapper, TEM and GPR were tested at the South Dam location and seismic refraction was tested at the North Dam. TEM was also tested at the North Dam for one day when it was too windy to test the seismic refraction method.

The OhmMapper results showed that the method did not allow good penetration into the conductive clays near the surface. The signal is limited to the first 2 or 3 m and then becomes very noisy and could not be inverted past that depth with any confidence as the correlation with available drill hole data becomes inconsistant. The test section is shown on Figure 7.

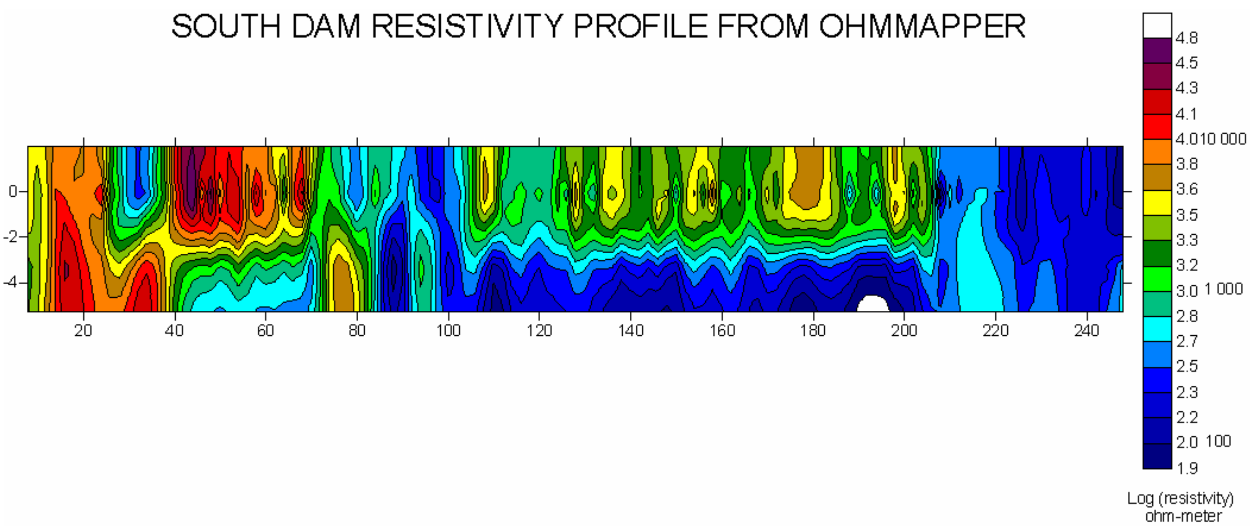


Figure 7: Resistivity section at the South Dam showing poor penetration of the signal

The TEM data were also too noisy and the data could not be inverted to provide a reasonable solution. In the field, the survey parameters were modified to minimize the noise:

- The loop size was increased from 15 x 15 m to 30 x 30 m, and then to 45 x 45 m
- Data was recorded with different sets of gain
- The integration time for taking readings (stacking) was doubled (from 15 to 30 s).

However, the inverted model could not converge to an acceptable solution and it was decided not to proceed with the TEM in phase two.

The seismic refraction data provided some interesting results and for some sections of the profile, it appears to map the boundary between the frozen overburden and the bedrock. However, drill hole data did not support the interpretation. Figure 8 shows the calculated section from the seismic data at the North Dam overlayed on the drill hole data. The correlation on the west side shows that the seismic refractor matches better with the the boundary of the frozen sand. On the east side, the seismic failed to show the subcropping bedrock. The main reason for this miscorrelation is the small contrast in velocity between frozen ground (3000 m/s) and the underlying basalt (3000 to 5000 m/s). Because of that, it is very difficult to see the change in slope (velocity) on the time-distance curves. Another limitation is the poor signal to noise ratio due to using a seismic hammer as a source (use of explosives was not an option for this survey).

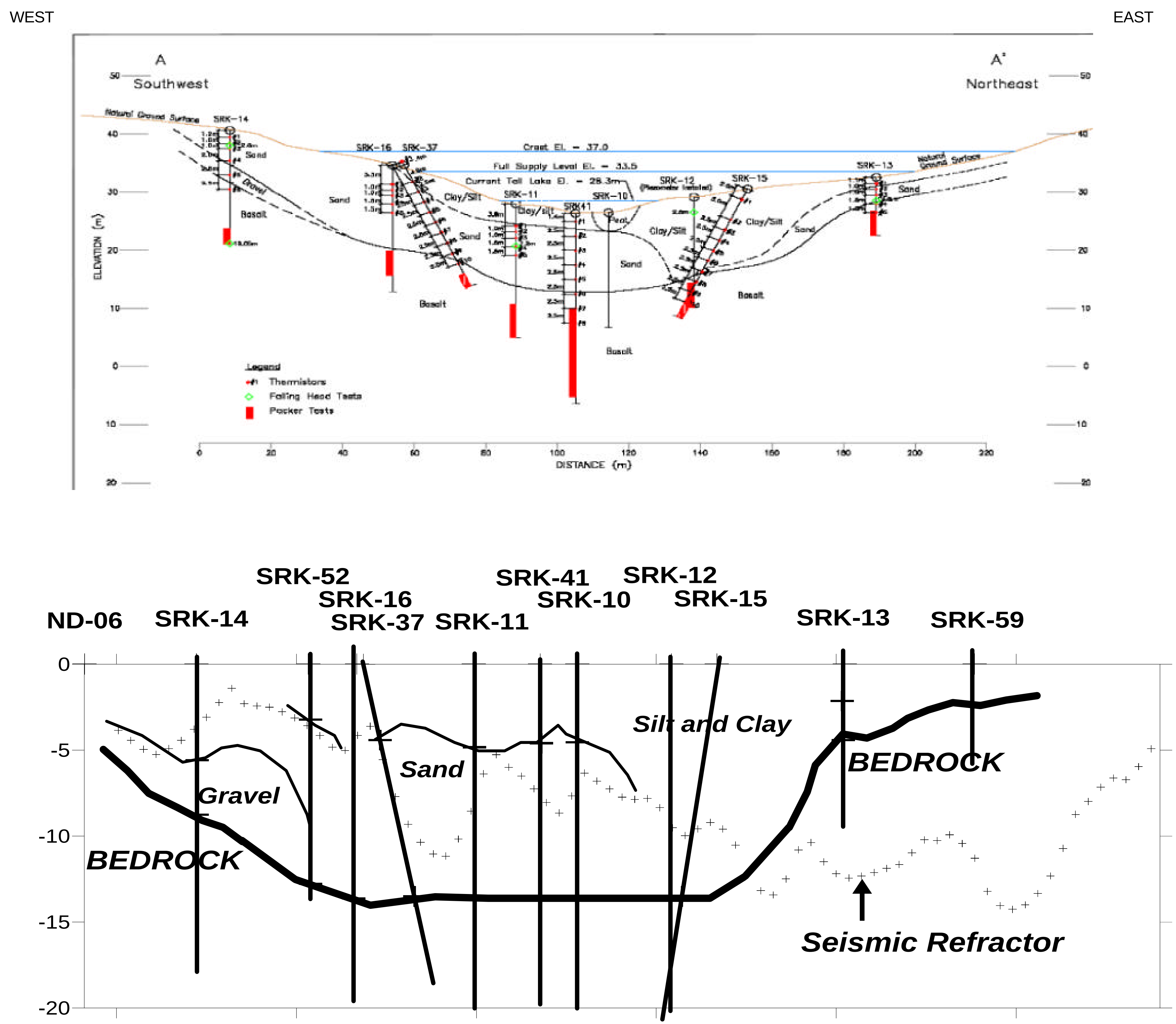
Due to logistics, while waiting for demobilization, more seismic data were acquired at the South Dam. The results are shown in Figure 9. Again, the seismic refractor fails to correlate with the bedrock. On the western portion of the profile, the correlation is even worse as only one velocity could be mapped at 3000 m/s. Similar absence of velocity contrasts on the records occur on three more profiles acquired on the east bank of the lake, and the seismic refraction failed to map bedrock.

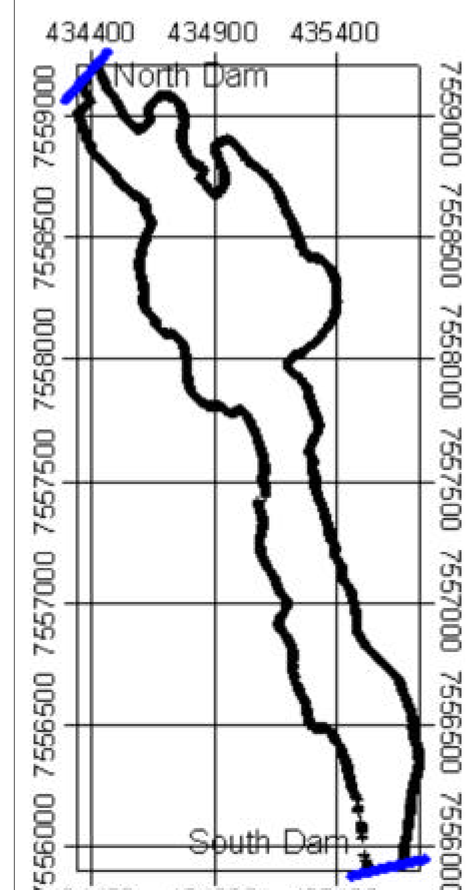
The GPR survey did yield interesting results although its depth of penetration was limited to 5 to 10 m. It succeeded in mapping the silt and clay to sand and gravel interfaces but could not profile the bedrock where it was deeper than 10 m. Figures 10 and 11 show the GPR sections across the South and North dams respectively.

It was decided to use only GPR for the survey around the perimeter of the lake, and possibly use seismic where GPR did not have the penetration to map the bedrock or where the clay near the surface blocked the signal. The results are shown in Appendix 1, with the interpretation ovelayed on the GPR section. Correlation with the available drill hole showed that in general, it differentiated between the silt, clay and sand and could also map bedrock where it was within 5 to 10 m from the surface. On one of the profiles (P6), it showed a dipping reflector that could be associated with faulting or plunging bedrock underneath what could be a very coarse glacial deposit.

4.0 CONCLUSIONS

Of the four geophysical methods used at Tail Lake, only GPR provided valuable information for the objective of identifying regions of anomalous stratigraphy and mapping bedrock. However, its depth of penetration was limited to less than 10 m.





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NORTH DAM
SEISMIC CORRELATION

Figure 8
Project 06PW43
June 2006

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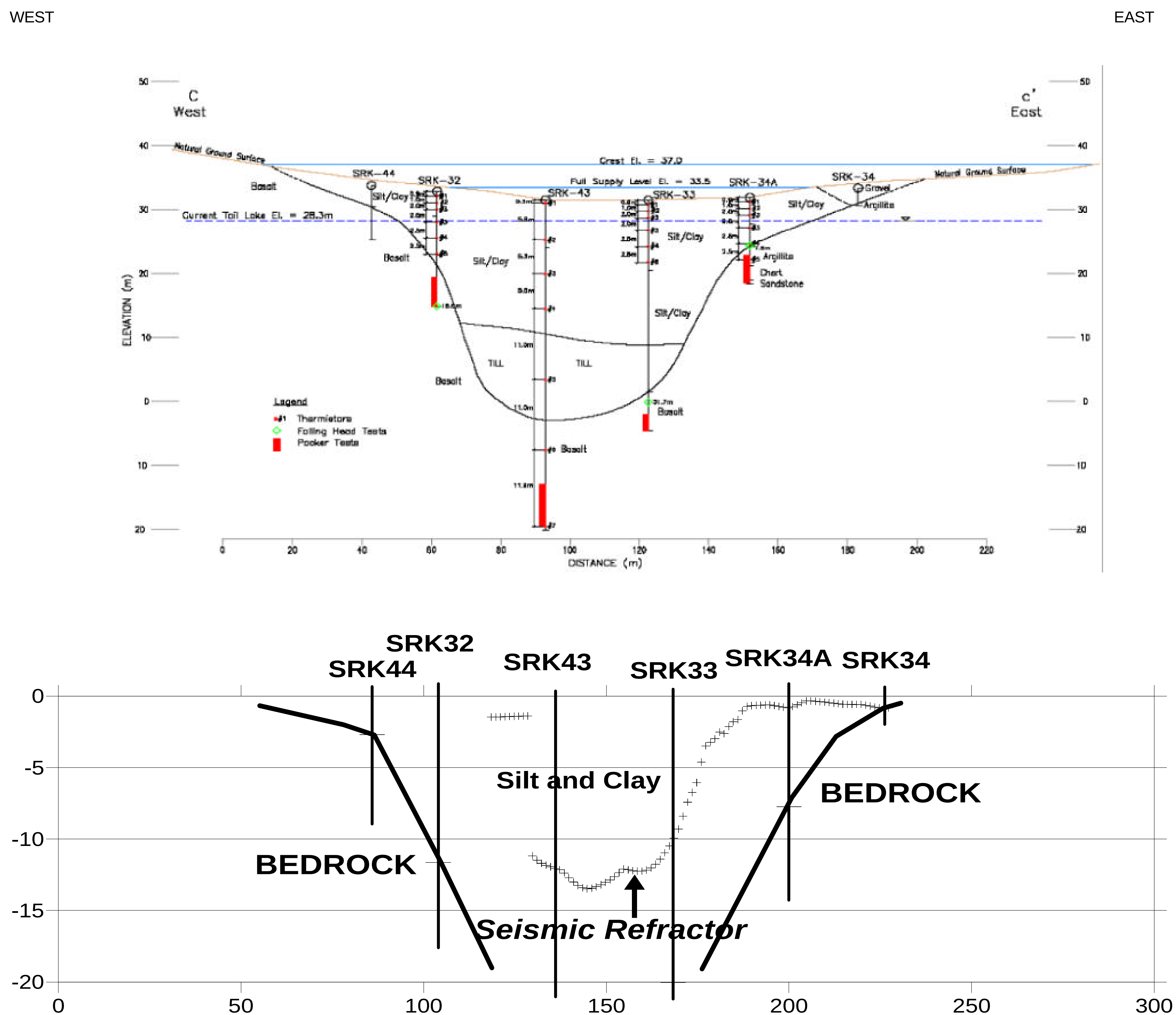

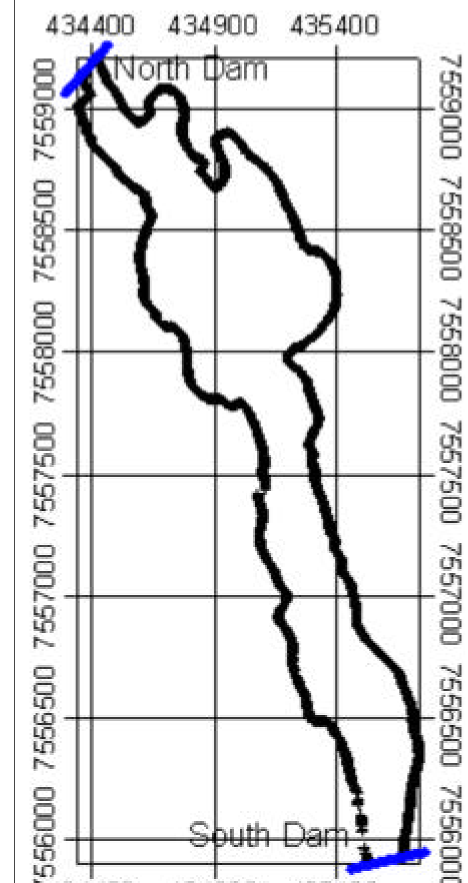

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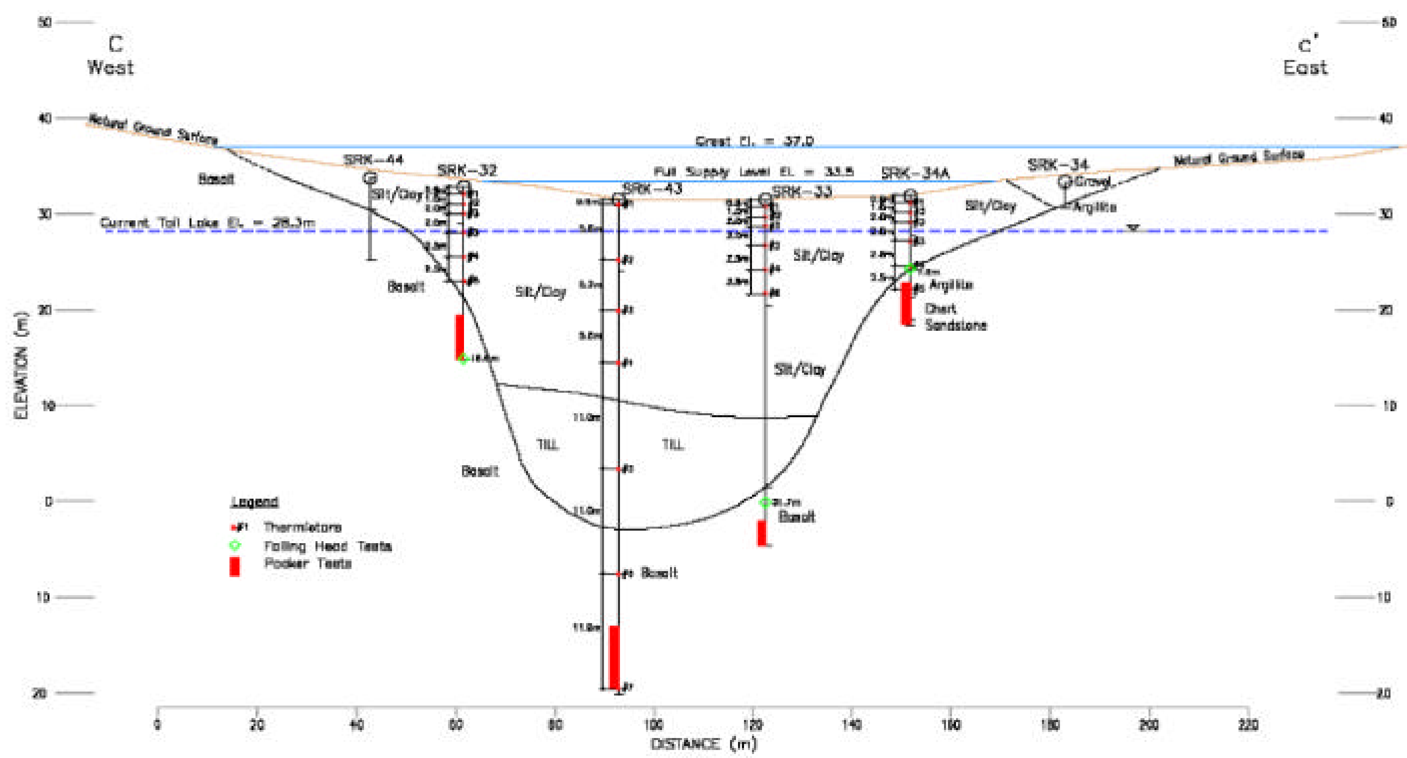
SOUTH DAM
SEISMIC CORRELATION

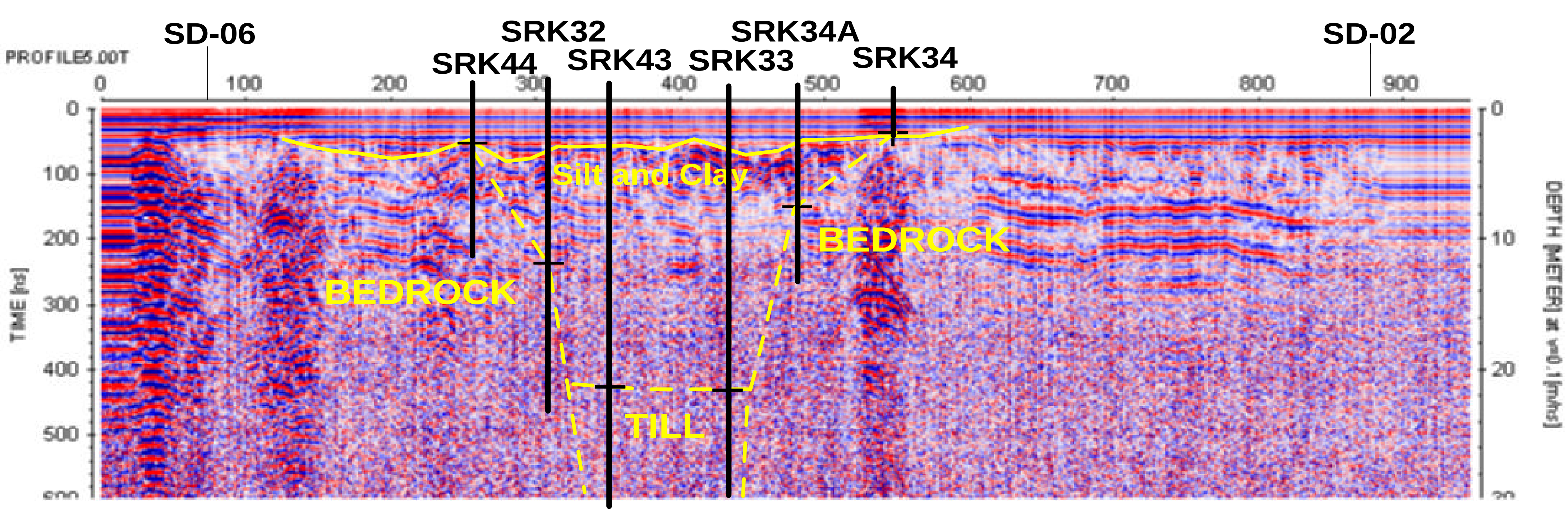
Figure 9
Project 06PW43
June 2006

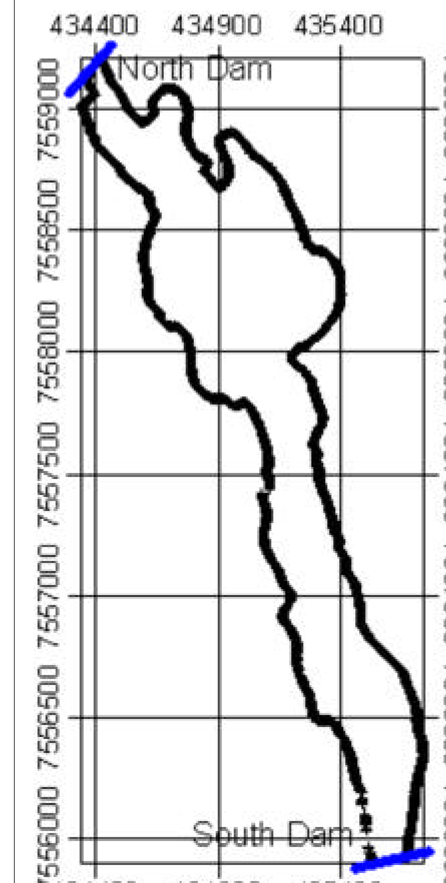
IMC
Associated Mining Consultants Ltd.

WEST

EAST







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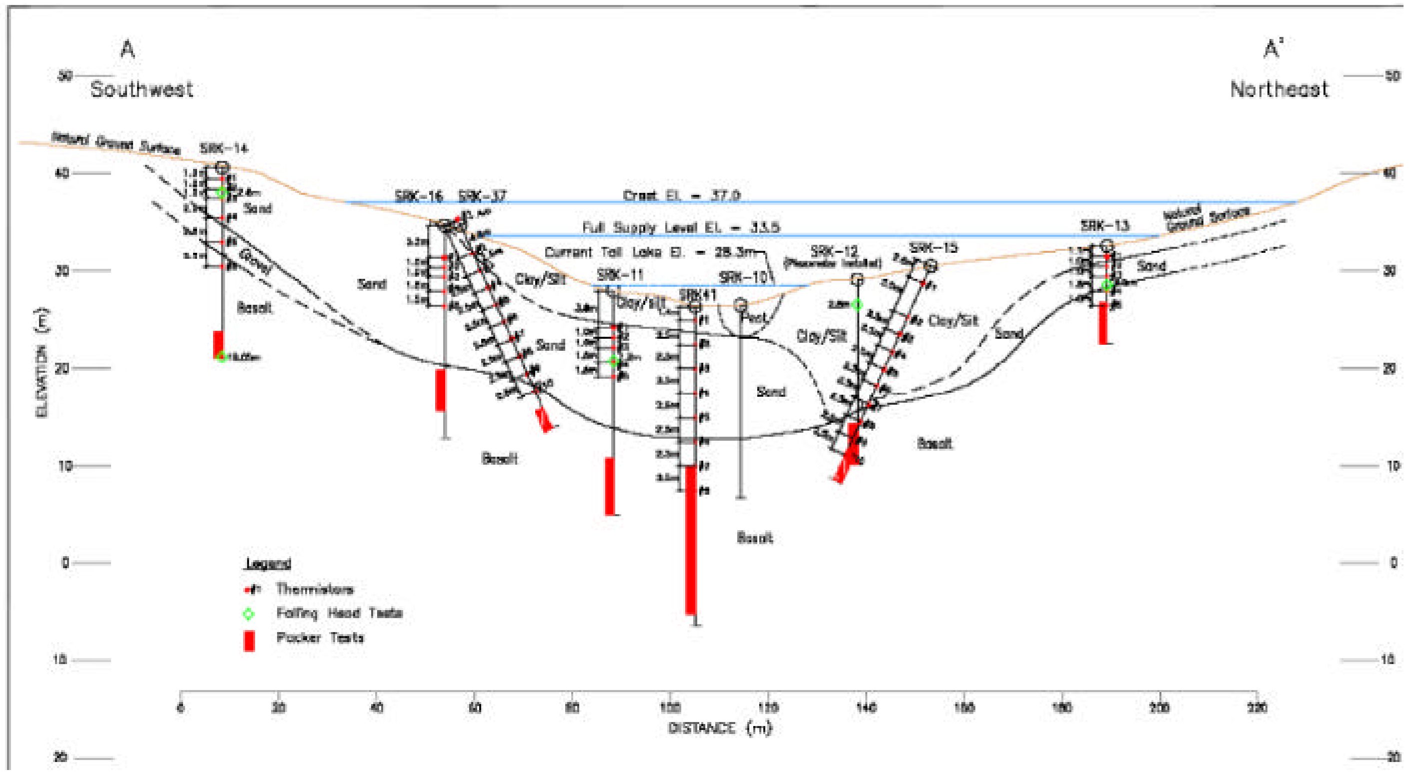
SOUTH DAM
GPR CORRELATION

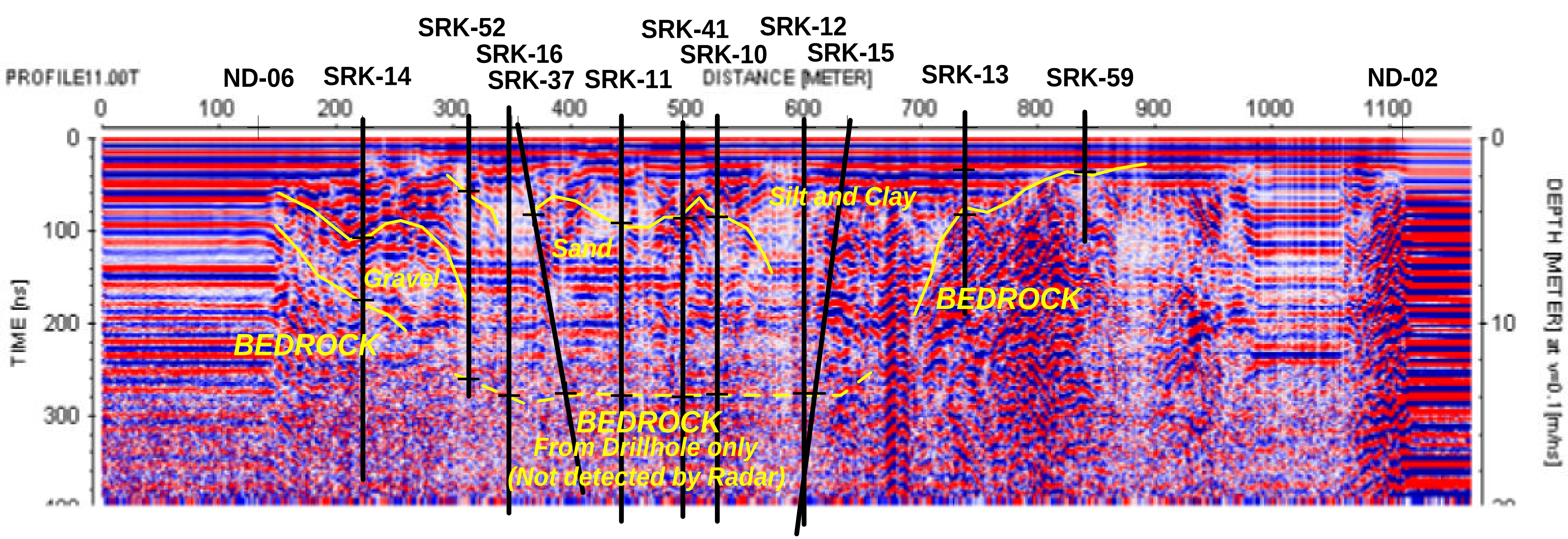
Figure 10
Project 06PW43
June 2006

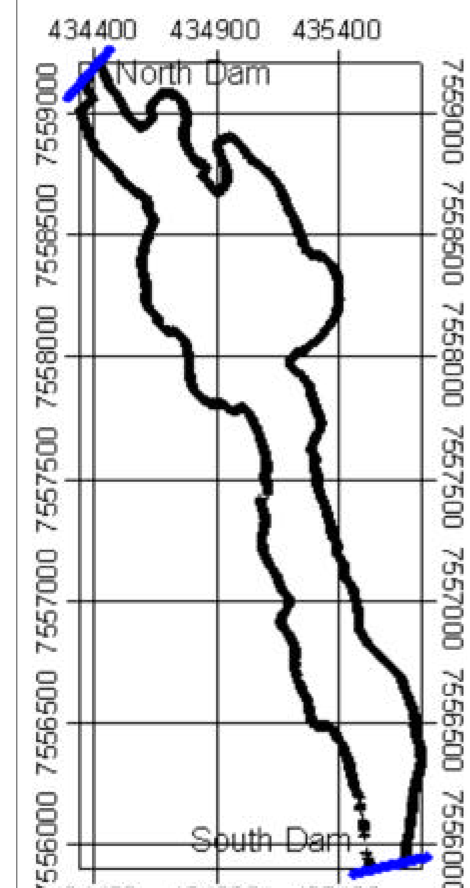
IMC
Associated Mining Consultants Ltd.

WEST

EAST







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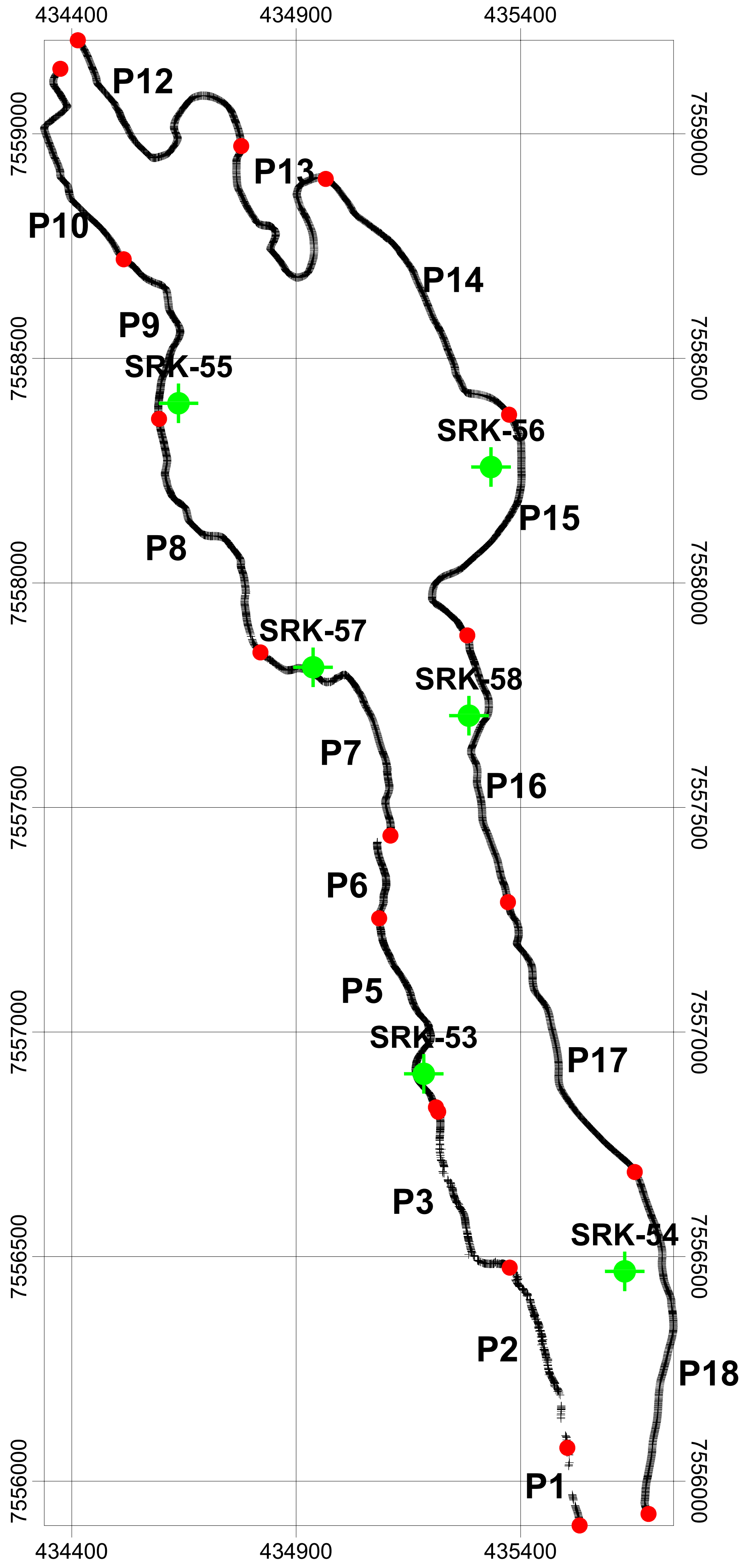
NORTH DAM
GPR CORRELATION

Figure 11
Project 06PW43
June 2006

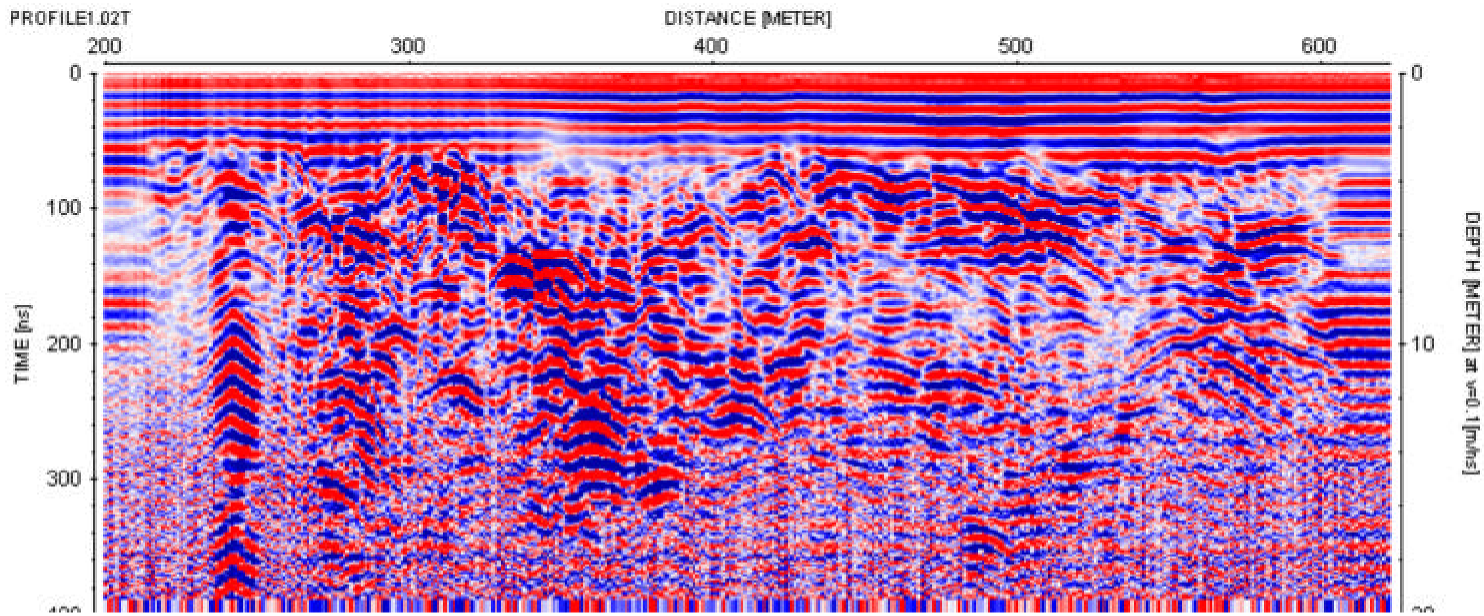
IMC
Associated Mining Consultants Ltd.

APPENDIX 1

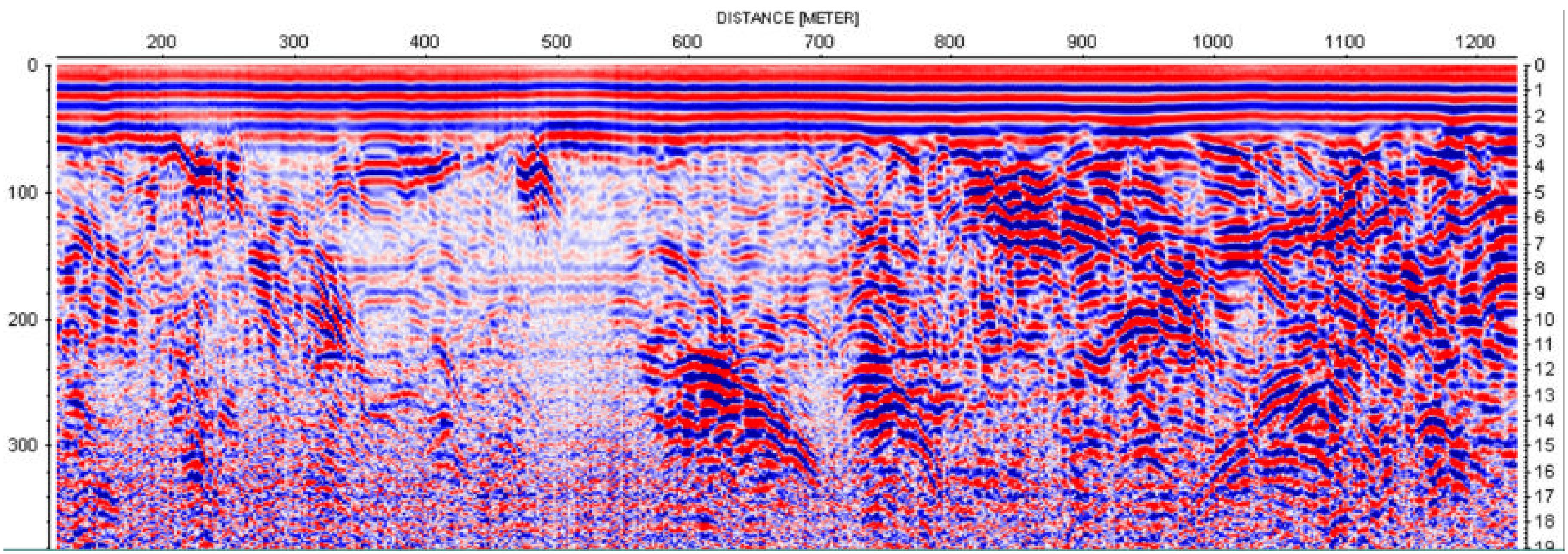
RESULTS



LOCATION OF GPR PROFILE AROUND THE LAKE


PROFILE1.02T
DISTANCE [METER]
200
300
400
500
600
TIME [ns]
0
100
200
300
DEPTH [METER] at v=0.1[m/ns]
0
10

P1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3
4
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6
7
8
9
10
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12
13
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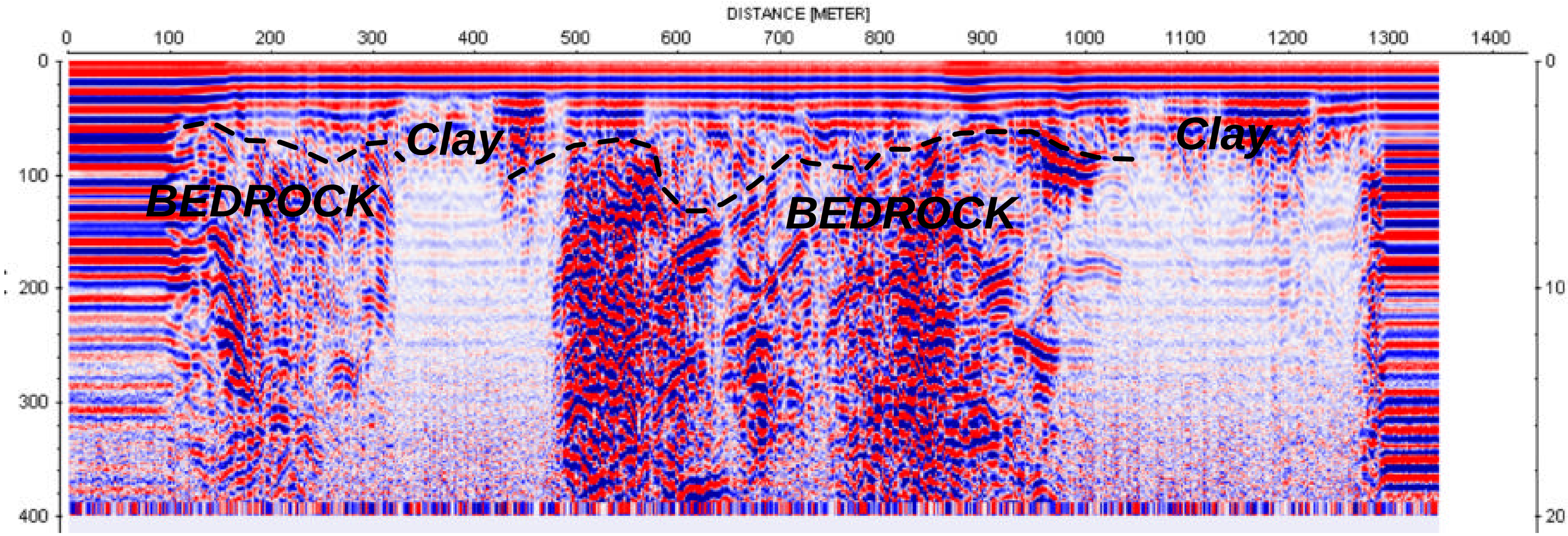
15
16
17
18

P2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100
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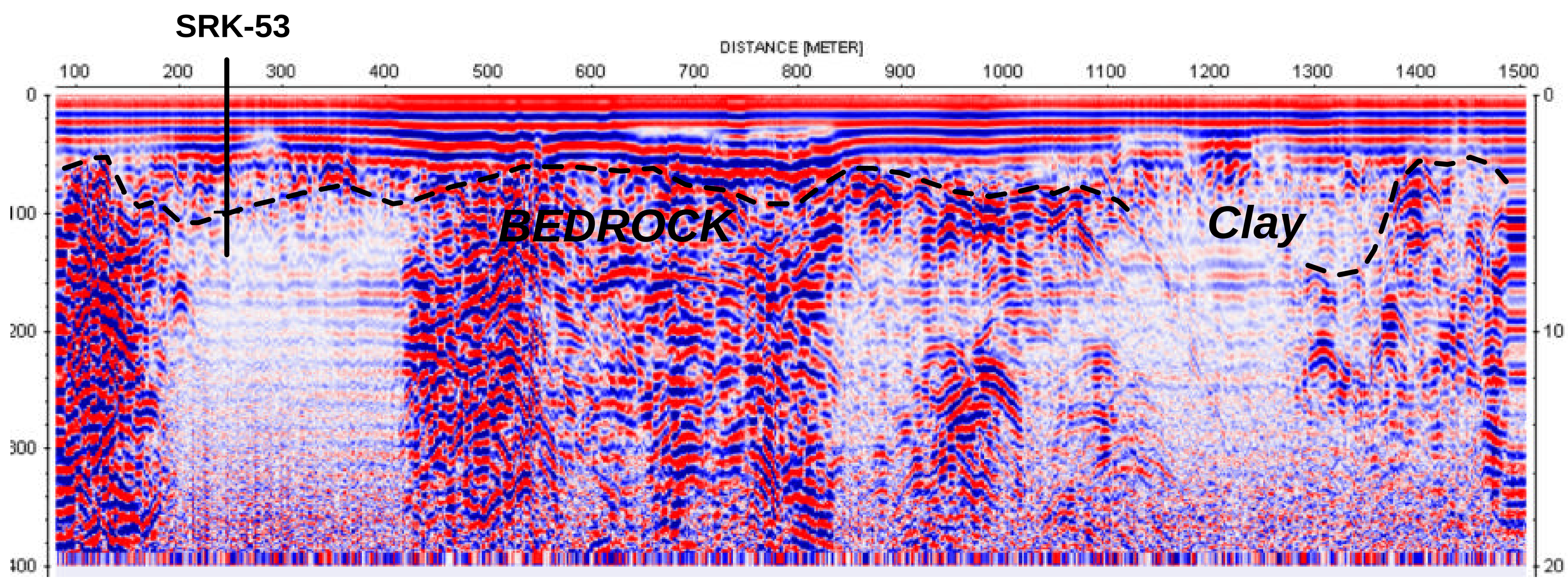
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
Clay
Clay
BEDROCK
BEDROCK
0
100
200
300
400
0
10
20

P3


SRK-53
DISTANCE [METER]
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400
500
600
700
800
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1000
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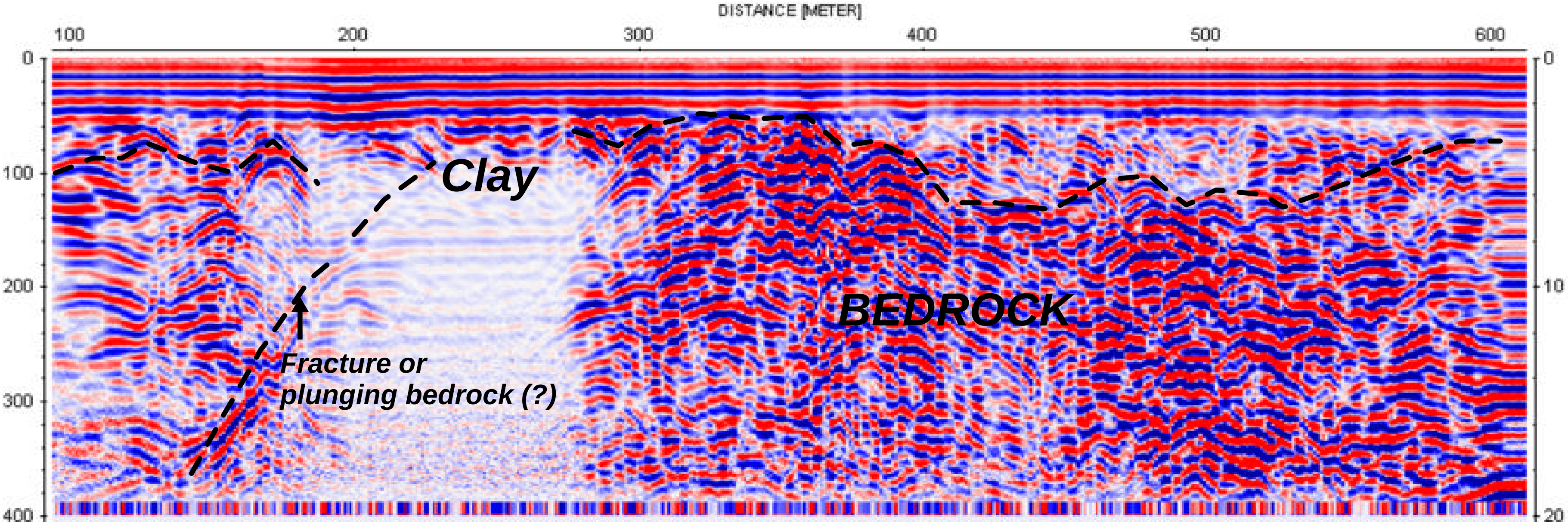
1200
1300
1400
1500
BEDROCK
Clay
0
100
200
300
400
0
10
20

P5


DISTANCE [METER]
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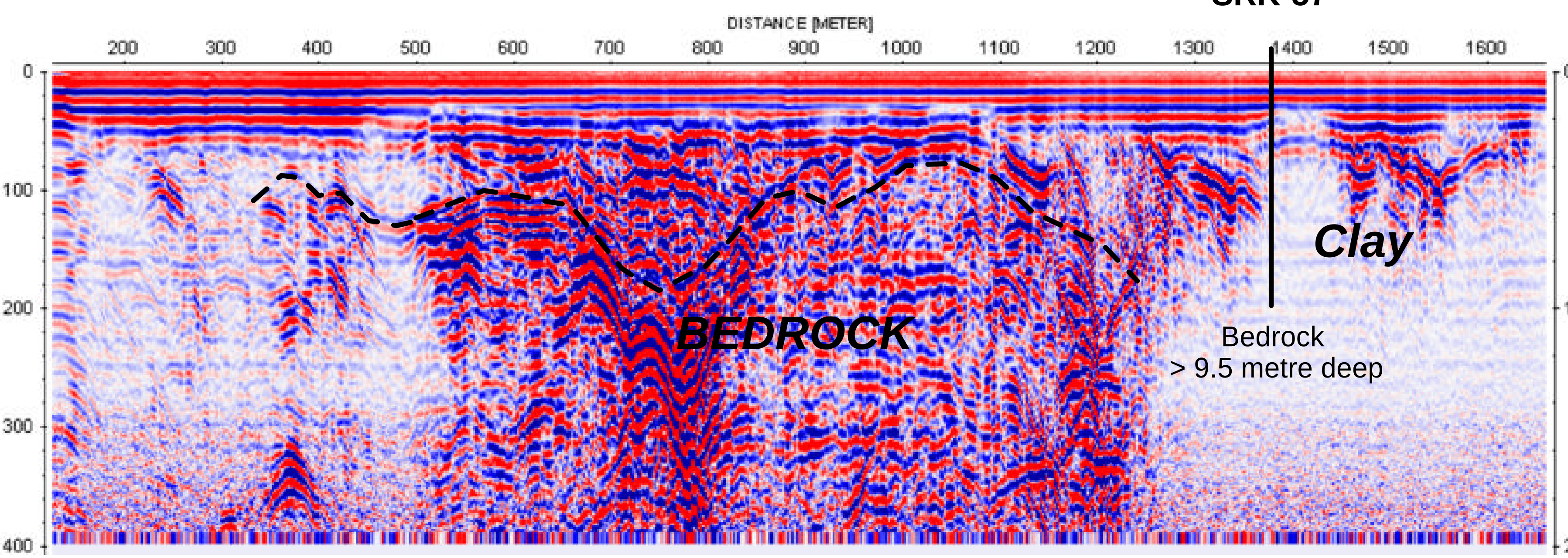
200
300
400
500
600
0
100
200
300
400
0
10
20
Clay
Fracture or
plunging bedrock (?)
BEDROCK

P6


SRK-57
DISTANCE [METER]
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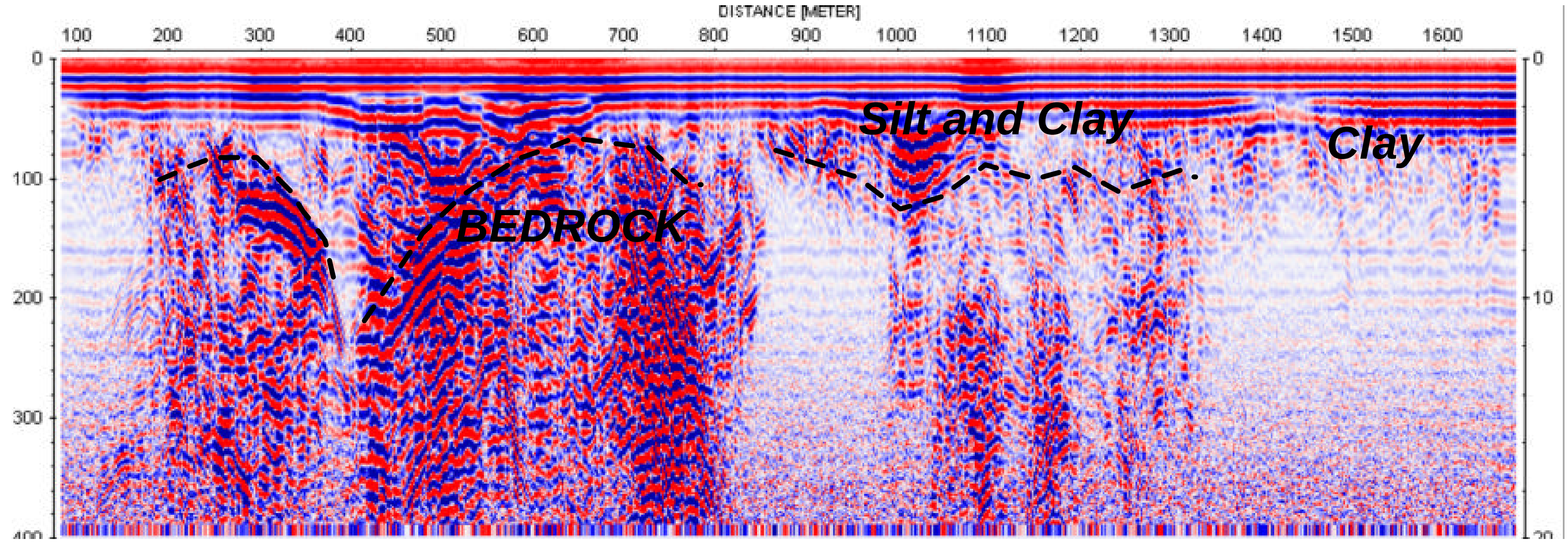
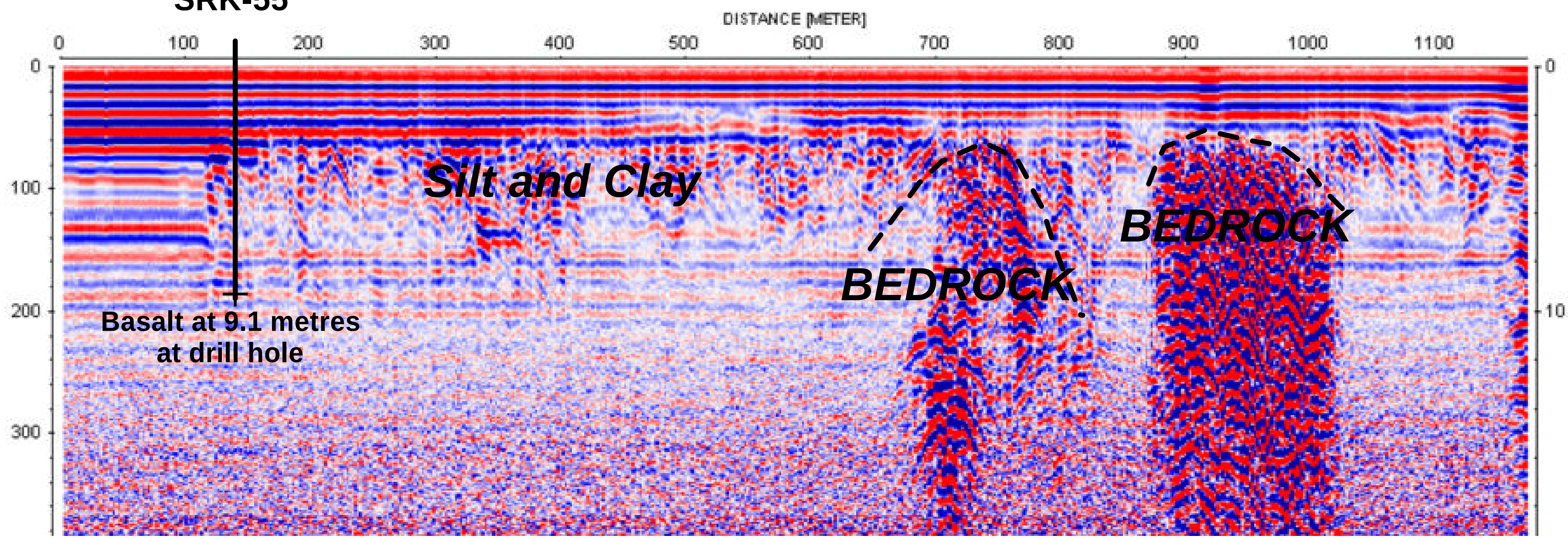
300
400
500
600
700
800
900
1000
1100
1200
1300
1400
1500
1600
0
100
200
300
400
0
10
20
BEDROCK
Clay
Bedrock
> 9.5 metre deep

P7

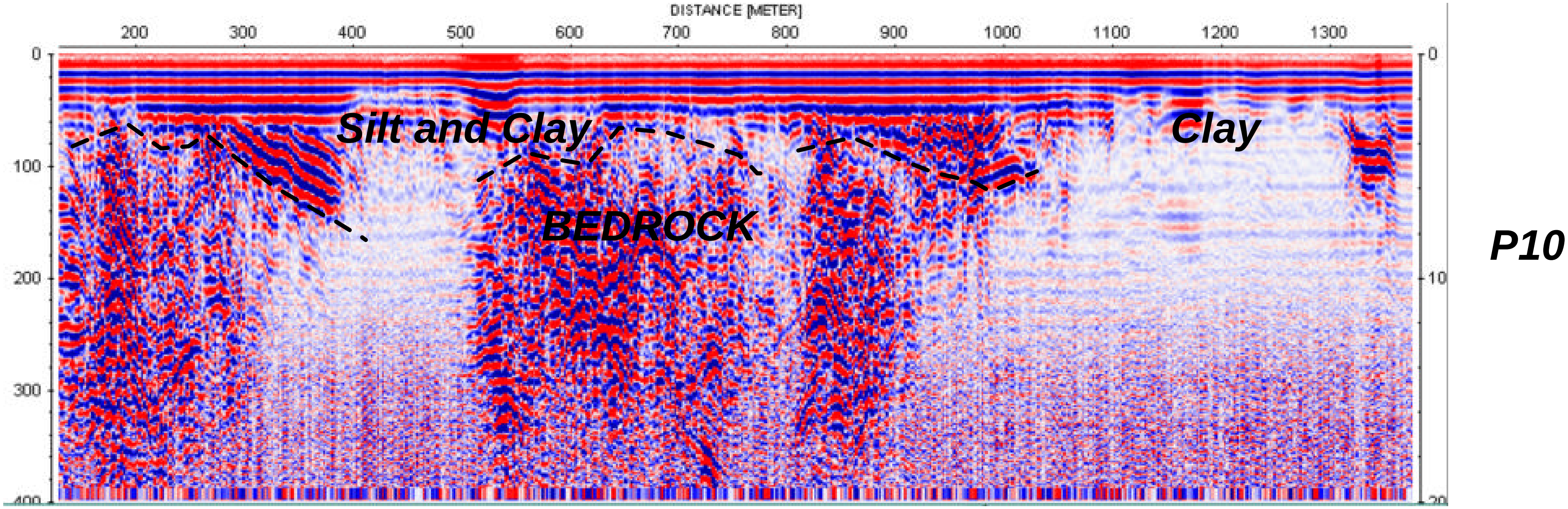

DISTANCE [METER]
Silt and Clay
Clay
BEDROCK

P8

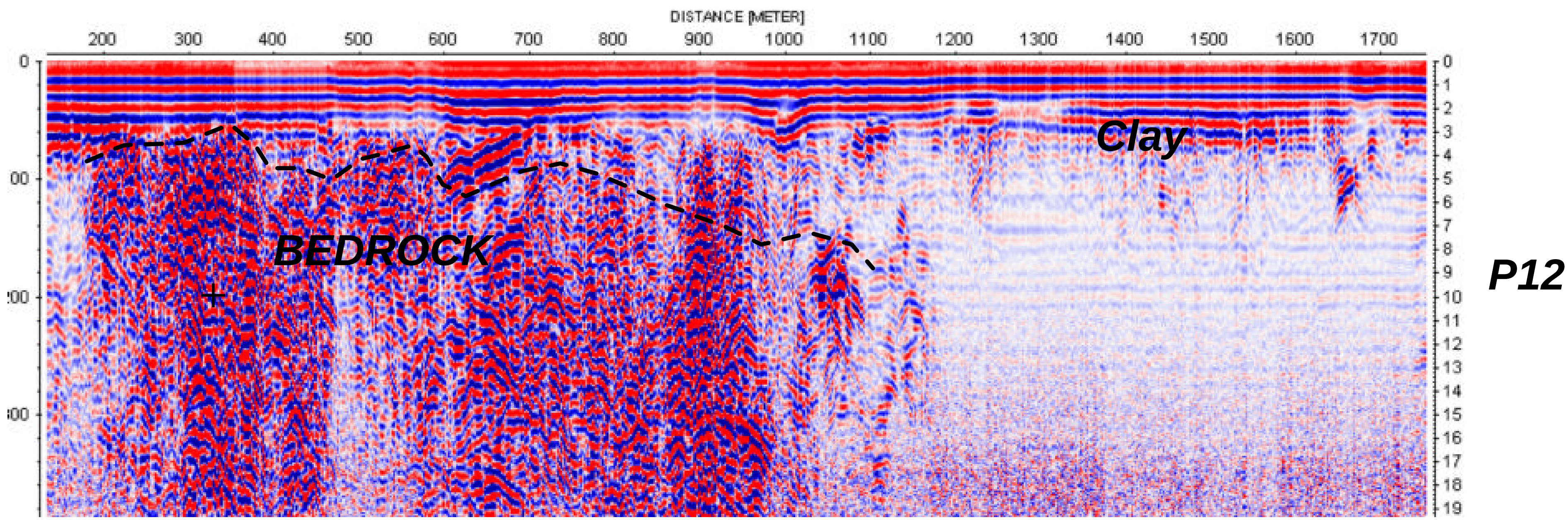
SRK-55

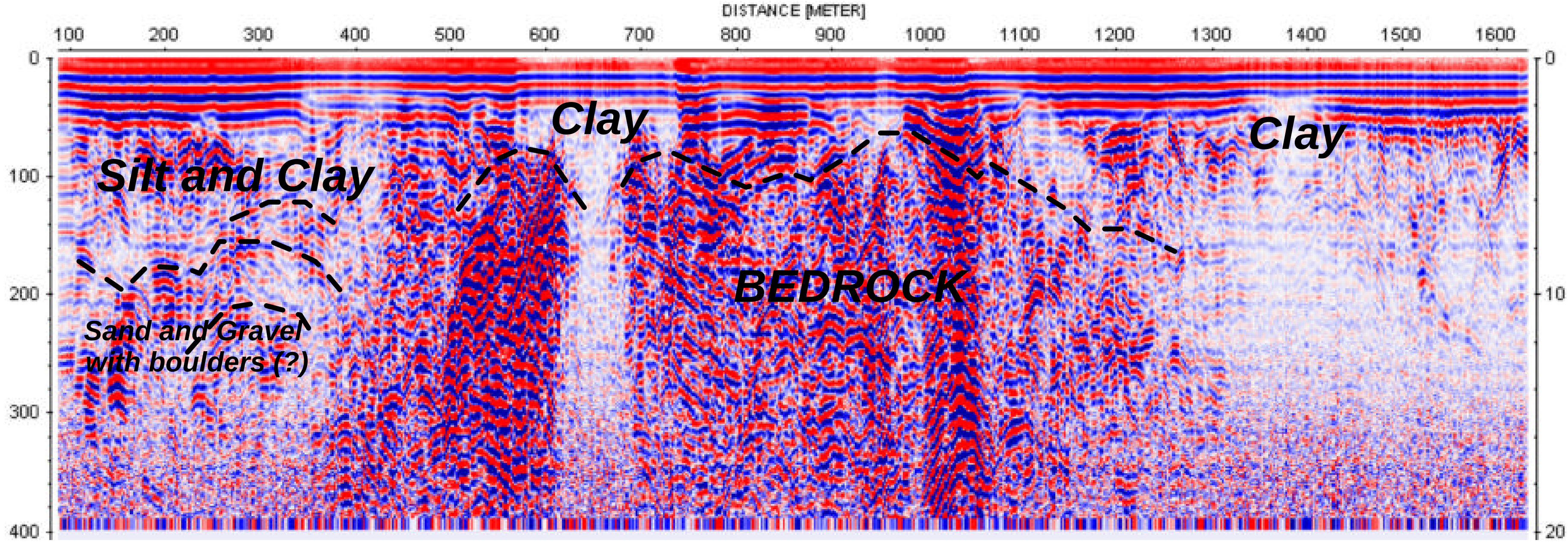

DISTANCE [METER]
Silt and Clay
BEDROCK
BEDROCK
Basalt at 9.1 metres
at drill hole

P9

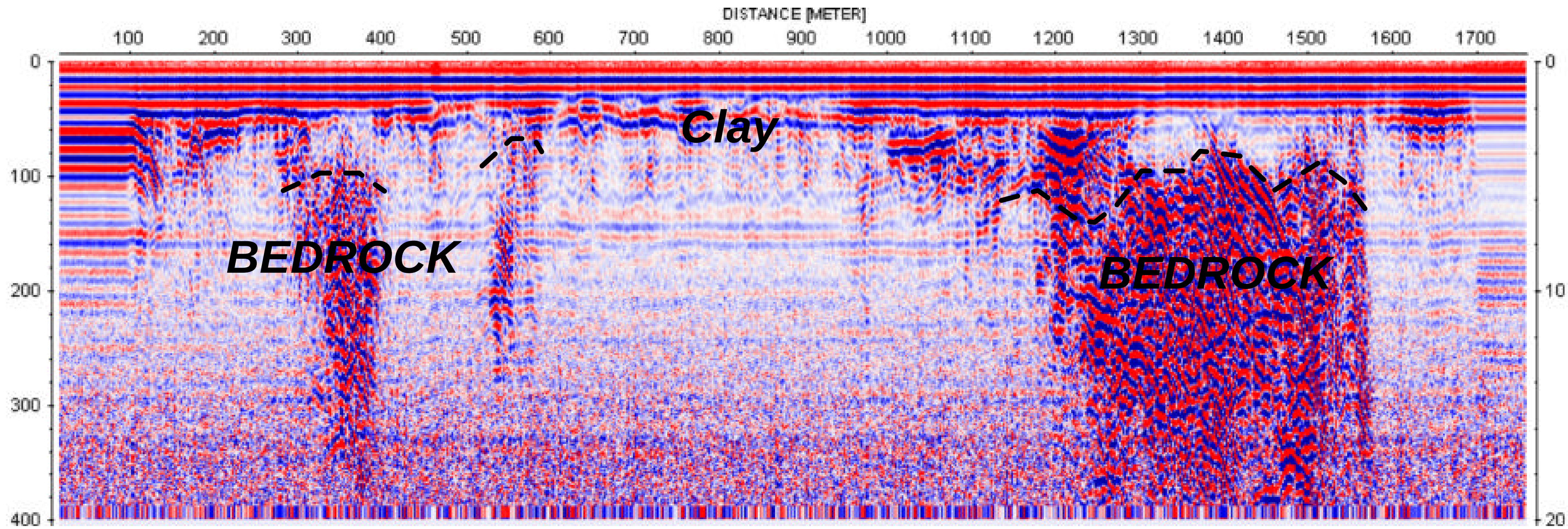


End of West Bank (above) - Beginning of East Bank (Below)




DISTANCE [METER]
100 200 300 400 500 600 700 800 900 1000 1100 1200 1300 1400 1500 1600
0 100 200 300 400
0 10 20
Clay
Silt and Clay
Clay
BEDROCK
Sand and Gravel
with boulders (?)

P13


DISTANCE [METER]
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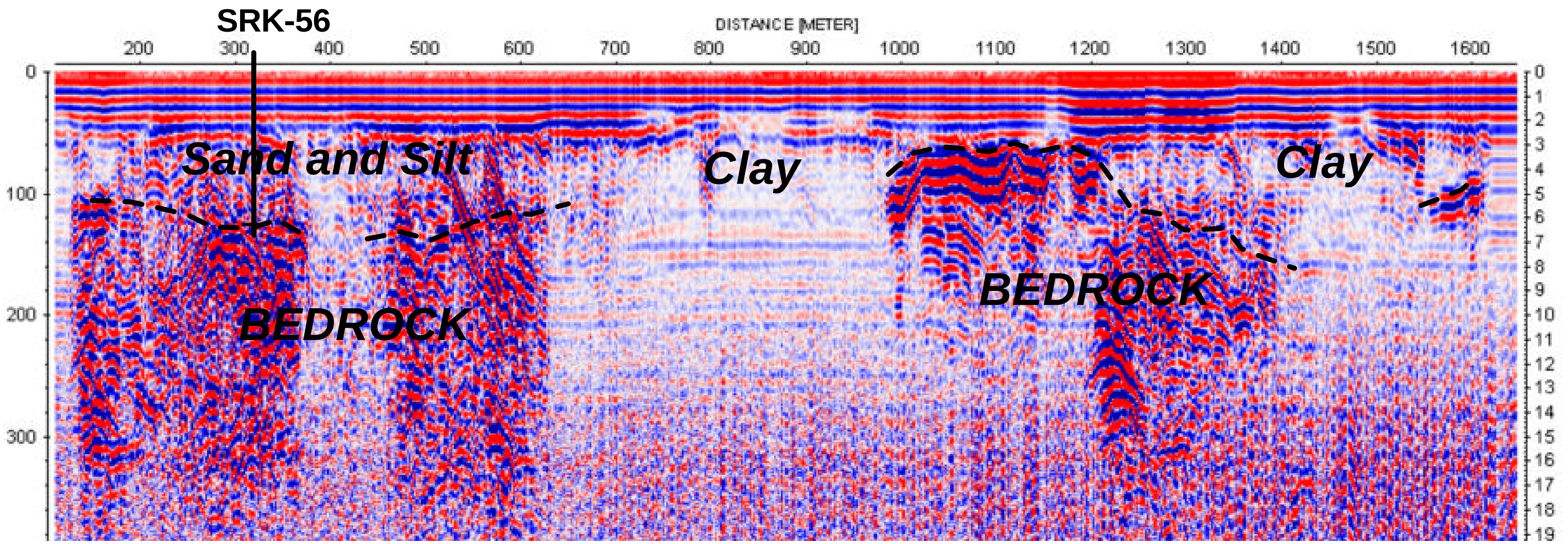
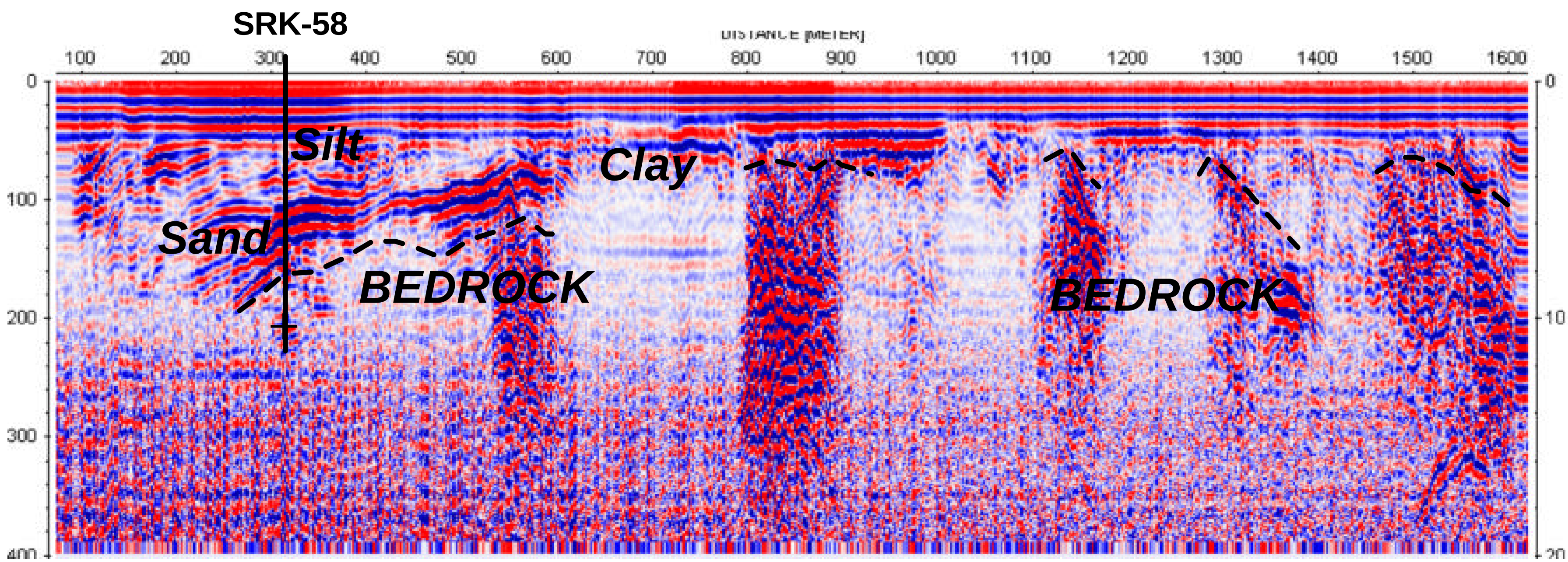
0 100 200 300 400
0 10 20
Clay
BEDROCK
BEDROCK

P14



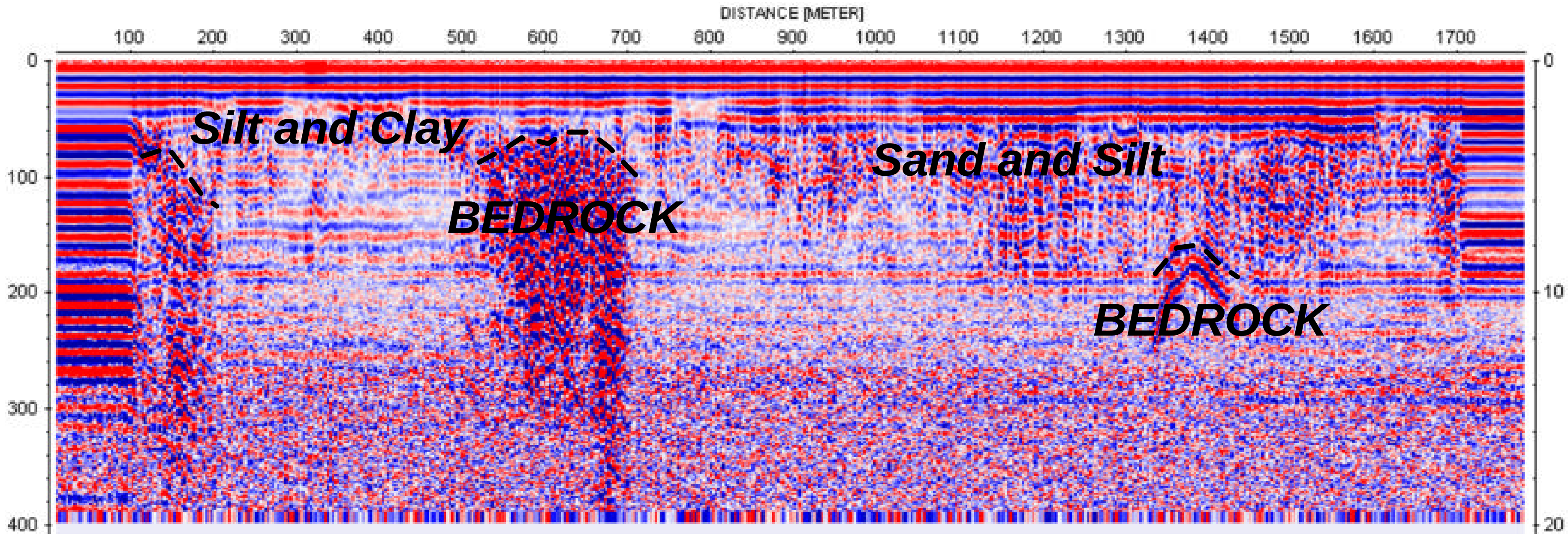
SRK-56
DISTANCE [METER]
Sand and Silt
Clay
Clay
BEDROCK
BEDROCK

P15

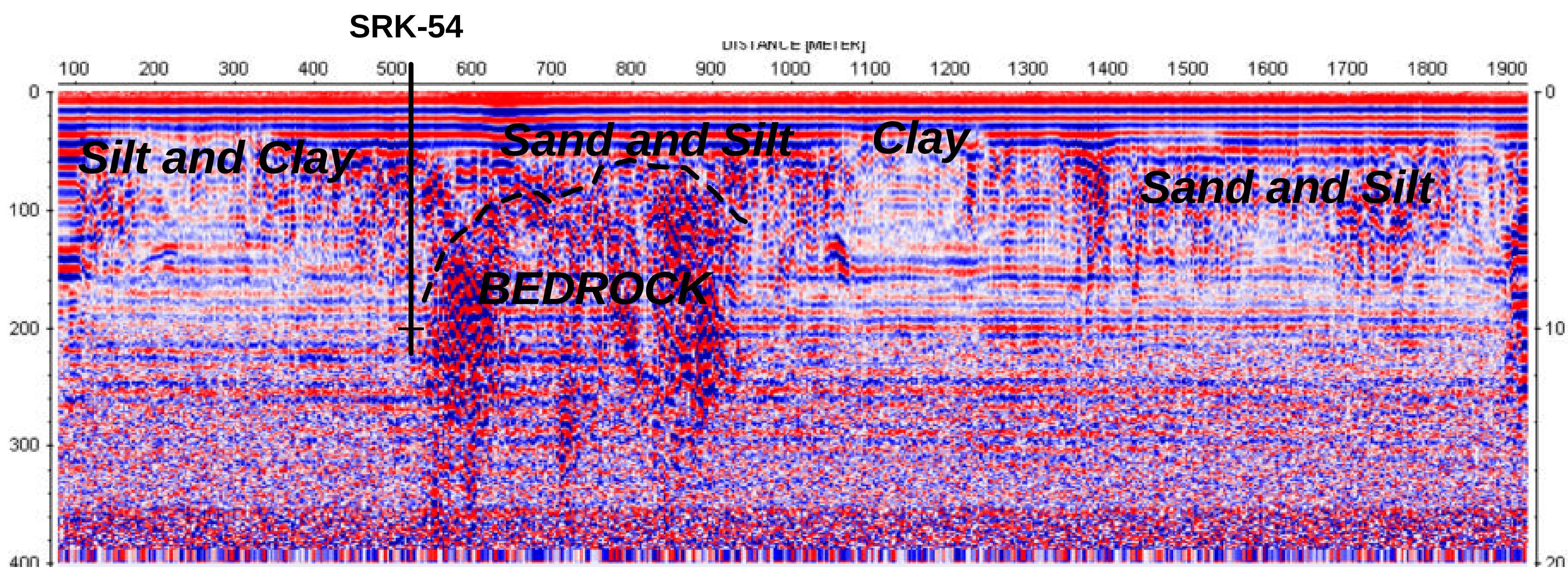


SRK-58
DISTANCE [METER]
Silt
Clay
Sand
BEDROCK
BEDROCK

P16


DISTANCE [METER]
Silt and Clay
Sand and Silt
BEDROCK
BEDROCK

P17


SRK-54
DISTANCE [METER]
Silt and Clay
Sand and Silt
Clay
Sand and Silt
BEDROCK

P18

Appendix E

SRK Technical Memorandum re: Wave Run-up Calculations

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Technical Memorandum

To:	Brian Labadie	**Date:**	September 6, 2005
cc:	Project File	**From:**	Lowell Wade, Maritz Rykaart
Subject:	Wave Run-up Calculation to Determine Hydraulic Freeboard for Doris North Project Tailings Dam	**Project #:**	1CM014.006

1 Introduction

This technical memorandum documents the wave run-up calculations that were used to determine the appropriate wave run-up portion of the hydraulic freeboard design height for the North Dam of the Doris North Project.

2 Previous Wave Run-up Calculation

A preliminary calculation of the wave run-up was documented in SRK (2005), and used empirical tables correlating wind speed, fetch and wave height (USDI 1987). Based on an arbitrary maximum wind speed of 160 km/hr, with a maximum fetch distance of 3,200 m (equal to the maximum distance between the North and South Dams); the resultant wave height would be 1.13 m, requiring a 1.7 m vertical freeboard height. Since this value is obviously too conservative, a more rigorous assessment of the wave run-up height was carried out as described in the following sections.

3 Wind Speed Determination

A long term database of site specific wind data is not available for the Doris North Project site. The data that is available includes two years of data from a weather station at Doris Lake, as well as approximately 5 years of data at the Boston site 60 km south of the Project (Golder 2005a, b; AMEC 2003). Golder (2005b) carried out a correlation between wind data at Roberts bay (4 km north of the site) with wind data from Cambridge Bay (160 km north of the site); however, this involved only a few days of data. Neither of these data sets is sufficient to estimate wind speeds required for wave run-up calculations.

SRK contracted Mr. Pat Bryan, P.Eng., an associate hydrologist to determine design wind speeds for any given recurrence interval that could be used at the Doris North site.

The estimation of extreme winds entailed a three step process. The first step was to extract an annual series of annual maximum hourly wind speed from the climate record of the Cambridge Bay Airport (see Table 1). This station has been measuring wind speed since 1953 and its record now spans 52 years. The largest event on record occurred on October 3, 1974 and attained an hourly average wind speed of 101 km/h.

The second step involved fitting the annual series of maximum wind speeds to three different frequency distributions to estimate extreme wind speeds for a variety of return periods. The results of the analysis are presented in Table 2. All three distributions provided reasonably similar estimates for all return periods from 2 to 500 years. The largest estimate of the 500-year event was generated by the Log-Pearson Type III distribution and is only 11% greater than the smallest estimate, which was generated by the Generalized Extreme Value distribution.

Table 1: Observed Annual Maximum Hourly Wind Speeds at Cambridge Bay.

Calendar Year	Annual Maximum Hourly Wind Speed (km/h)
1953	71
1954	80
1955	68
1956	71
1957	76
1958	80
1959	89
1960	69
1961	76
1962	71
1963	89
1964	69
1965	72
1966	68
1967	69
1968	72
1969	85
1970	84
1971	80
1972	89
1973	82
1974	101
1975	87
1976	97
1977	80
1978	93
1979	83
1980	89
1981	65
1982	67
1983	70
1984	69
1985	80
1986	80
1987	70
1988	69
1989	74
1990	83
1991	74
1992	74
1993	67
1994	70
1995	82
1996	76
1997	74
1998	83
1999	65
2000	74
2001	80
2002	65
2003	70
2004	65
Minimum	**65**
Average	**76.7**
Maximum	**101**

Table 2: Estimated Annual Maximum Hourly Wind Speeds (km/h) at Cambridge Bay for Various Return Periods.

Return Period (years)	Frequency Distribution Used to Predict Extreme Hourly Wind Speeds:		
	Generalized Extreme Value	3-Parameter Lognormal	Log-Pearson Type III
2	75	75	74
5	84	83	83
10	89	89	89
20	95	95	96
50	102	104	105
100	107	111	112
200	112	118	120
500	118	128	131

The third step entailed determining how representative the Cambridge Bay wind data are of the mine site. This was done by comparing annual extremes at the two mine site weather stations with the corresponding annual extremes at Cambridge Bay. Table 3 tabulates the annual maximum wind speeds at the three stations over the period 2000 to 2004. The annual peak hourly wind speeds at the Boston station tended to be about 17% smaller than the annual peaks measured at Cambridge Bay. The peaks at Doris North, on the other hand, were nearly identical to the peaks observed at Cambridge Bay. Accordingly, these data suggest the Cambridge Bay data are reasonably representative of the mine site conditions. The Boston site provided four annual peaks for the comparison while the Doris Site provided two.

Table 3: Comparison of Maximum Wind Speeds at Cambridge Bay and Mine site Meteorological Stations.

Year	Meteorological Station					
	Cambridge Bay Airport		Boston		Doris North	
	Completeness of Annual Record (%)	Annual Maximum Hourly Wind Speed (km/h)	Completeness of Annual Record (%)	Annual Maximum Hourly Wind Speed (km/h)	Completeness of Annual Record (%)	Annual Maximum Hourly Wind Speed (km/h)
2000	99.8	74	99.7	57		n/a
2001	99.9	80	81.5	65		n/a
2002	100	65	99.2	57		n/a
2003	100	70	70.0	60	49.3	71
2004	100	65		n/a	90.1	64

4 Fetch Length

The maximum fetch length for any waves that may connect with the North Dam, for any wind direction, when the full supply level of 33.5 m has been reached in Tail Lake, is 1,326 m (northwest direction). Similarly, the maximum fetch length impacting the South Dam is 3,012 m (north-northwest direction).

5 Wave Run-up Calculations

For the wave run-up calculations the extreme wind speeds calculated according to the Log Pearson Type III method (Table 2) was used. Calculations were carried out for a 1:100 year and 1:500 year recurrence interval, at fetch lengths of 1,326 and 3,102 m.

Table 4 list the results of the wave run-up calculations according to the method described in Sorenson (1997, Section 2.9).

Table 4: Summary of Wave Run-up Calculation Results.

Parameter	North Dam		South Dam	
Fetch	1,326 m		3,012 m	
Recurrence Interval	1:100	1:500	1:100	1:500
Wind Speed (km/hr)	112	131	112	131
Wind Speed (m/sec)	31.1	36.4	31.1	36.4
Significant Wave Height (m)	0.58	0.68	0.87	1.02
Peak Spectral Period (sec)	2.2	2.3	2.8	3.0
Wavelength (m)	7.2	8.1	12.5	13.9
Wave Run-up, Smooth Surface (m)	0.33	0.38	0.50	0.59
Wave Run-up, Rip-rap Surface (m)	0.16	0.19	0.25	0.29

6 Conclusion

Based on the wave run-up calculations documented in this technical memorandum, the maximum hydraulic freeboard required to prevent overtopping of the dams due to wave run-up is 0.29 m.

7 References

AMEC Earth & Environmental Ltd. 2003. *Meteorology and Hydrology Baseline, Doris North Project*. November.

Golder Associates Ltd. 2005a. *Doris North Project Air Quality Assessment Methods*. Report No. 05-1373-008, May.

Golder Associates Ltd. 2005b. *Potential Impacts on Shorelines Due to Construction of a Jetty at Roberts Bay, Miramar Doris North Project*. Report No. 04-1373-009.4100, May.

Sorenson, R.M., 1997. *Basic Coastal Engineering*. Chapman & Hall. ISBN: 041212341X. pp. 288.

SRK Consulting (Canada) Inc. 2005. *Revised Dam Design, Preliminary Engineering, Hope Bay Doris North Project, Nunavut, Canada*. Project No. 1CM014.04. May.

United States Department of the Interior, Bureau of Reclamation. 1987. *Design of Small Dams*. A Water Resources Technical Publication, Third Edition, 66. 860.

Appendix F

SRK Technical Memorandum re: Water Balance Calculation

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Technical Memorandum

To:	Larry Connell, MHBL	**Date:**	September 28, 2006
cc:	Project File	**From:**	Maritz Rykaart
Subject:	Doris North Project TCA Water Balance	**Project #:**	1CM014.008.150

1 Introduction

This Technical Memorandum describes the Doris North Project tailings containment area (TCA) water balance. This water balance has been used in conjunction with other relevant technical information to determine the design height of the TCA containment dams and water management strategy. This water balance also forms the basis for the water quality predictions in the Water Quality Model for the Project (SRK 2006).

2 Methodology

The water balance has been calculated using a custom, and site specific model developed for the Doris North TCA. This water balance model is build using an EXCELL spreadsheet calculation, and the resolution is based on monthly time steps, from the start of operations through to final closure and abandonment.

3 Primary Assumptions

Conservative, but reasonable engineering assumptions have been made to develop a realistic water balance for the TCA. These assumptions include;

- Tail Lake will be completely isolated with respect to surface and groundwater from the adjoining Doris Lake and Ogama Lake catchments by two water retaining dams.
- Tailings deposition will be sub-aqueous and will be managed such that the final tailings surface will be relatively horizontal.
- Tail Lake will not be pumped out prior to constructing the dams or starting deposition.
- The volume of Tail Lake at its normal full supply elevation of 28.3 m is ~ 2,196,000 m^3.
- Annual decant release from the TCA is planned; however, the TCA is designed as a zero discharge facility for the two-year mine life (at a constant production rate), plus an additional period of natural runoff after mining ceases.
- The impact of varying climate and hydrology on the water balance is illustrated with a sensitivity analysis.
- The water balance is calculated in monthly time steps. The water balance calculations use a year that starts in March and ends in February.

- All values in this water balance are expressed in terms of the dam FSL. It should be noted that at any time there will be a minimum 4 m freeboard height above the FSL, which serves as thermal and wave run-up protection.

4 Water Balance Calculation

The TCA has a total surface catchment area of 450 ha. A bathymetric survey of Tail Lake (Rescan 2001) and a topographical survey of the catchment were used to develop a stage curve for the TCA, as illustrated in Figure 1.

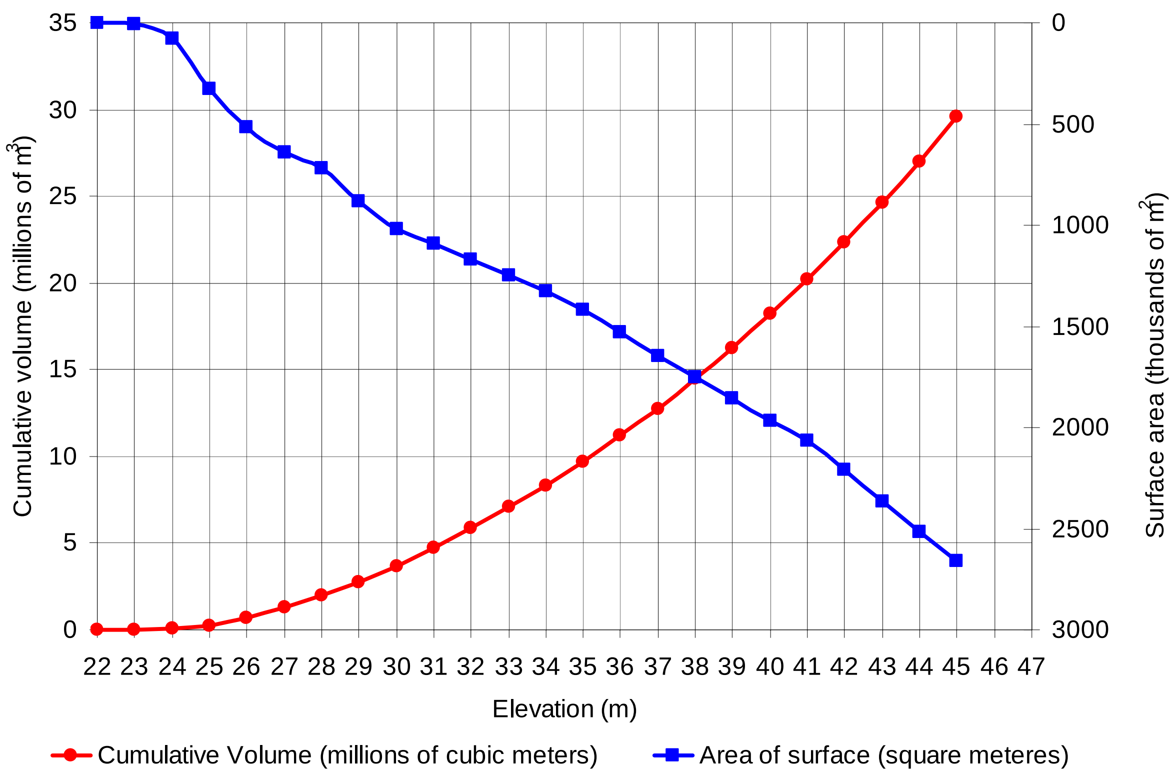

Figure 1: TCA Stage Curves.

The best-fit mathematical expressions for the TCA surface area and storage volume, expressed in terms of the lake water elevation are respectively given as:

$$V = -0.00020 \cdot h^3 + 0.07354 \cdot h^2 - 2.94811 \cdot h + 31.26314 \qquad \ldots(1)$$

$$A = 0.32656 \cdot h^6 - 67.95719 \cdot h^5 + 5829.42586 \cdot h^4 - 263467.30709 \cdot h^3 + 6607466.03356 \cdot h^2 - 86950808.77770 \cdot h + 467883520.90250 \qquad \ldots(2)$$

In addition an expression for the TCA water elevation, expressed in terms of the total storage volume is given as:

$$h = -1.18740 \times 10^{-42} \cdot V^6 + 1.13280 \times 10^{-34} \cdot V^5 - 4.17315 \times 10^{-27} \cdot V^4 + 7.47625 \times 10^{-20} \cdot V^3 - 6.83698 \times 10^{-13} \cdot V^2 + 3.72593 \times 10^{-6} \cdot V + 2.28955 \times 10^1 \qquad \ldots(3)$$

Where V = TCA pond storage volume (m^3),
A = TCA pond surface area (m^2), and
h = TCA pond elevation (m).

The TCA water balance is schematically illustrated in Figure 2. The water balance is calculated in monthly time steps using the following expression:

$$\Delta S = Q_1 - Q_2 + Q_3 + Q_4 - Q_5 - Q_6 \pm Q_7 + Q_8 + Q_9 \quad \ldots(4)$$

Where ΔS = change in TCA storage volume (m^3),
Q_1 = volume of direct precipitation falling onto TCA (m^3),
Q_2 = volume of potential evaporation from TCA (m^3),
Q_3 = volume runoff entering TCA (m^3),
Q_4 = volume of tailings feed pumped to TCA (m^3),
Q_5 = volume of reclaim water pumped back to mill (m^3),
Q_6 = volume of decant allowed from TCA (m^3),
Q_7 = volume of dam(s) seepage pumped back to TCA (m^3),
Q_8 = volume of sewage water sludge pumped to TCA (m^3), and
Q_9 = volume of underground mine water pumped to TCA (m^3).

The individual components Q_1, Q_2, and Q_3 are calculated as follows:

$$Q_1 = (A_{lake})P \quad \ldots(5)$$

$$Q_2 = (A_{lake})PE \quad \ldots(6)$$

$$Q_3 = (A_{catchment} - A_{lake})Y \quad \ldots(7)$$

Where A_{lake} = surface area of TCA (m^2),
$A_{catchment}$ = total area of TCA catchment (m^2),
P = total precipitation (m),
PE = potential evaporation (m), and
Y = water yield (m^3).

The total precipitation (P) is calculated as follows:

$$P = R + S \quad \ldots(8)$$

Where R = total rainfall (m), and
S = total snowfall water equivalent (m).

The tailings feed volume, Q_4, is calculated as follows:

$$Q_4 = Q_{10} + Q_{11} \quad \ldots(9)$$

$$Q_{10} = \frac{F}{\rho_d} \quad \ldots(2.10)$$

$$\rho_d = \frac{G_s}{(1+e)} \quad \ldots(2.11)$$

$$Q_{11} = \frac{F}{\omega} \cdot (100 - \omega) \quad \ldots(2.12)$$

Where Q_{10} = the volume of tailings solids (m^3),
Q_{11} = the volume of water entrained in the tailings slurry (m^3),
F = the tailings slurry feed (tonnes/day),
ρ_d = the tailings solids dry density (tonnes/m^3),
G_s = the tailings solids specific gravity,
e = the tailings void ratio for hydraulically placed tailings under water (-), and
ω = the tailings slurry feed solids (by weight) content (%).

The impoundment seepage Q_7 is calculated as follows:

$$Q_7 = Q_{12} + Q_{13} - Q_{14} \quad \ldots(2.13)$$

Where Q_{12} = volume of seepage pumped back from the North Dam (m^3),
Q_{13} = volume of seepage pumped back from the South Dam (m^3), and
Q_{14} = volume of seepage lost to deep deep recharge (m^3).

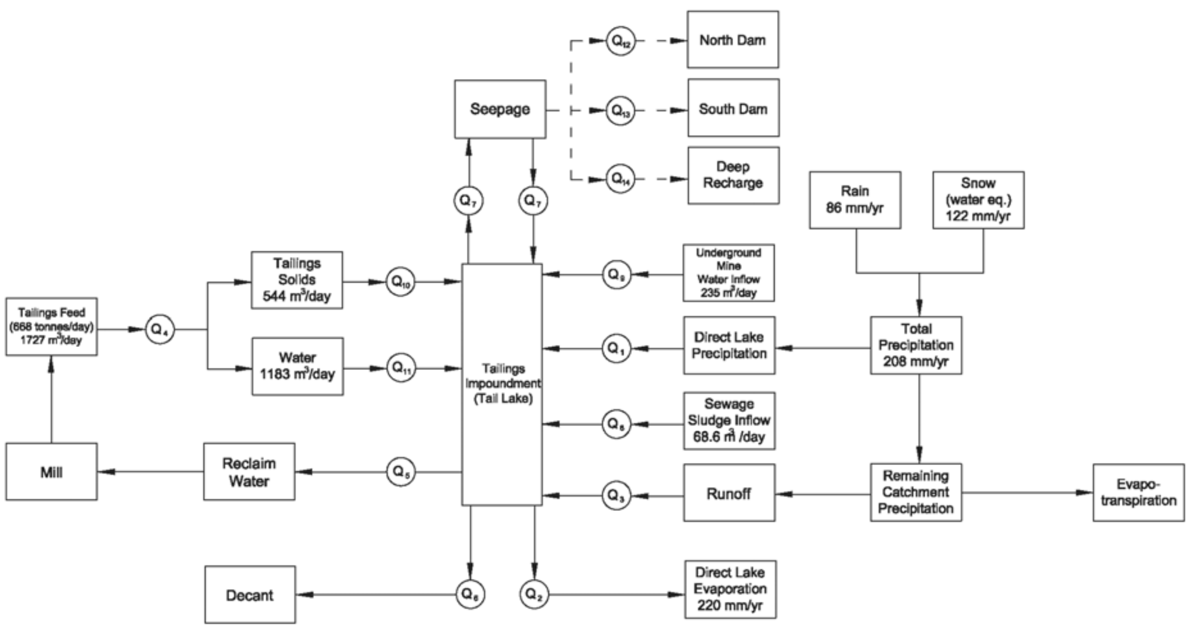

Figure 2: TCA Water Balance.

5 Water Balance Data Set

5.1 Total Precipitation

AMEC (2003) developed a detailed metrological and hydrological baseline for the Doris North Project, specifically targeting the Tail Lake and Doris Lake catchments. This document was used for the primary climatic data in the water balance. The mean monthly rainfall, snowfall (water equivalent) and total precipitation data extracted from AMEC (2003) is reproduced as Table 1.

Table 1: Mean monthly precipitation data

Month	Rainfall (mm)	Snowfall – Water Equivalent (mm)	Total Precipitation (mm)
January	0.0	8.0	8.0
February	0.0	8.4	8.4
March	0.0	10.8	10.8
April	0.1	11.8	11.9
May	3.2	12.5	15.7
June	13.7	3.6	17.3
July	24.2	0.2	24.4
August	29.0	1.9	30.9
September	14.4	12.5	26.9
October	1.2	25.8	27.0
November	0.0	14.4	14.4
December	0.0	11.6	11.6
Annual	85.8	121.5	207.3

Golder (2006) presents a detailed discussion of the meteorological and hydrology data with respect to possible variances from the baseline. That information will not be reproduced in this report; however, the impact of those variations had been thoroughly tested in a series of water balance sensitivity analysis.

With respect to mean annual precipitation (MAP), an increased value of 225 mm was suggested, and this value was subsequently used in the sensitivity analysis for the water balance.

In general the water balance is conducted using average climatic year data; however, it is recognized that extreme events can affect the outcome. The water balance sensitivity analysis therefore includes an evaluation of extreme wet and dry years. These extreme events are documented in Golder (2006).

5.2 Potential Lake Evaporation

AMEC (2003) did an extensive evaluation of the limited lake evaporation data for Doris North and developed the data set reproduced in Table 2, which was used in the water balance calculation to establish Q_3 in Equation 7. MHBL (2005) documents, that for sensitivity analysis, it would be appropriate to alter the evaporation to ±20% of this value, i.e. varying the evaporation between 176 and 264 mm.

Table 2: Monthly and annual lake evaporation data

Period	Days with Evaporation	Average Evaporation (mm)
June	15	35
July	31	95
August	31	77
September	30	13
Annual	105	220

5.3 Runoff/Water Yield

AMEC (2003) documents the annual outflow from Doris and Tail Lake. Based on this data they determined the annual water yield (runoff from the catchment) for Tail Lake to be 111 mm, and 134 mm for Doris Lake. Golder (2006) presents a detailed discussion on water yield, and concludes that the water yield could be as much as 180 mm/yr. For the purpose of the water balance presented in this report the base case water yield was conservatively assumed to be 180 mm, and the effect of the lower water yield was evaluated through sensitivity analysis.

5.4 Seepage

Seepage from the TCA can be via three primary routes; North Dam, South Dam and deep recharge through the lake basin. In reality, the North and South Dams will be frozen core dams, which should not have any seepage. Furthermore, in the event that seepage was to occur, MHBL would intercept this seepage and return it to Tail Lake.

It was however considered appropriate to estimate what this seepage may be, such that an evaluation could be made as the potential effect that it may have on the water balance. Since the seepage rates at any of these points cannot be physically measured at this time, first order seepage calculations were made using the D'arcy equation (Holtz and Kovacs 1981):

$$q = k \cdot i_{north/south} \cdot A = k \cdot \frac{\Delta h_{north/south}}{L_{north/south}} \cdot A \qquad \ldots(14)$$

$$A = d_{unfrozen} \times w_{unfrozen} \qquad \ldots(15)$$

$$\Delta h_{north/south} = h_{\max} - h_{north/south} \qquad \ldots(16)$$

$$L_{north/south} = d_{crest} \cdot \left(\Delta h_{north/south} \times S_u\right) \cdot \left(\Delta h_{north/south} \times S_d\right) \qquad \ldots(17)$$

Where q = seepage flow rate (m^3/s),
k = tailings permeability (m/s),
$i_{north/south}$ = hydraulic gradient for North or South dam respectively (-),
A = seepage area (m^2),
$\Delta h_{north/south}$ = change in headloss for North and South dam respectively (m),
$L_{north/south}$ = Length of seepage zone for North and South dam respectively (m).

Table 3 lists the assumed constants for the theoretical seepage calculations. The resultant seepage rates for each potential seep are listed in Table 4. The permeability used for these calculations are an average, maximum or minimum value to provide a range of seepage results. These permeability values are based on typical gold tailings data.

Table3: Constants used in the seepage calculations

Parameter	Symbol	Value
Maximum tailings impoundment water level	h_{max}	33.5m above sea level
North dam foundation elevation	h_{north}	26.5m above sea level
South dam foundation elevation	h_{south}	32.0m above sea level
Assumed thickness of "unfrozen" zone	$d_{unfrozen}$	15 m
Assumed width of "unfrozen" zone	$w_{unfrozen}$	35 m
Dam crest width	d_{crest}	10 m
Upstream Dam slope	$1:S_u$	6 (i.e. 1 vertical:6 horizontal)
Downstream Dam slope	$1:S_d$	4 (i.e. 1 vertical:4 horizontal)
Average tailings permeability	$k_{s(avg)}$	1 x 10^{-5} m/sec
Minimum tailings permeability	$k_{s(min)}$	1 x 10^{-6} m/sec
Maximum tailings permeability	$k_{s(max)}$	1 x 10^{-4} m/sec

Table 4: Estimated seepage rates through North and South Dams

Condition	North Dam (m^3/day)	South Dam (m^3/day)	Total (m^3/day)
Minimum	6	1	7
Average	61	13	74
Maximum	607	137	744

The deep recharge component refers to the potential for deep recharge via the foundation materials of the TCA, i.e. Tail Lake. The intact permeability of these foundation materials was measured by SRK using packer tests (SRK 2003). The average hydraulic conductivity was 9.9 x 10^{-12} m/sec. The reason for this low permeability was twofold; the ground was frozen, and the bedrock was not fractured.

In calculating the deep seepage an assumption has been made that the pool size is constant at 131 ha (the surface area covered by Tail Lake at FSL), the hydraulic gradient is constant at 1, and foundation permeabilities are as follows; average = 9.9 x 10^{-12} m/s; minimum = 9.9 x 10^{-13} m/s; maximum = 9.9 x 10^{-11} m/s. The resultant deep recharge rates are listed in Table 5.

Table 5: Estimated deep recharge rates for Tail Lake

Condition	Deep Recharge (m^3/day)
Minimum	0.1
Average	1.1
Maximum	11.1

The average condition theoretical seepage calculations described above have been used in the TCA water balance. It was however assumed that all seepage from the North and South Dams would be intercepted and pumped back to the TCA. The average deep seepage rate is so low that it has been omitted from any water balance calculations. Since the TCA is designed for full containment, this was deemed to be conservative.

5.5 Tailings Slurry Feed

The average constant tailings production rate will be 668 tonnes/day at a solids moisture content of 36.1%, a solids specific gravity of 2.7 and a submerged in-place tailings void ratio of 1.2. This will result in a daily slurry feed of 1,727 m^3 (544 m^3/day solids and 1,183 m^3/day water).

5.6 Reclaim Water

Tail Lake is relatively shallow, and it is possible that during the winter months increased turbidity may be experienced as a result of a reduced water volume in the lake created by the freezing conditions (lake-ice). Consequently, 100% recirculation water (1,183 m^3/day) is assumed for four months of the year only (June through September). During the remainder of the year fresh water make-up will be from Doris Lake.

5.7 Sewage Sludge Volume

The sewage treatment plant outflow and sludge will be pumped to the TCA as part of the tailings feed stream. This volume of sludge is dependant of the size of the camp. For the purpose of this water balance calculation we have assumed a 175-man camp, for a total sewage treatment plant load of ~ 68.6 m^3/day (value supplied by MHBL).

5.8 Underground Volume

Mining at the Doris North Project will exploit the Doris Hinge reserves, which are located north of Doris Lake. There is known permafrost in this region, and therefore it would be reasonable to assume that water make-up in the mine would be negligible.

SRK (2005) documents the results of a scoping level geohydrological model for a mining scenario where the Doris Connector and Doris Central sections are exploited. Under this scenario, mining will move underneath Doris Lake and it is conceivable that there could be an inflow of water into the mine. This inflow has been estimated to average 235 m^3/day.

Although the two-year Doris North project would in all likelihood not experience any mine water inflow (SRK 2005), a conservative assumption has been made that a mine inflow of 235m^3/day would occur for the life of the project. This water would be captured in the mine and pumped to Tail Lake.

5.9 Decant Rate

Baseline hydrology prepared by AMEC (2003) confirmed that flow from Tail and Doris Lakes only occurs during the period June through October. Any outflow from Tail Lake will flow into Doris Lake, immediately upstream from Doris Creek.

A tailings management strategy is proposed that would allow annual discharge from Tail Lake directly into Doris Creek, at a location immediately upstream of a 4.3 m high waterfall (SRK 2006a).

6 Water Balance Results

The primary purpose of the water balance was to determine an appropriate height for the containment dams, such that there would be sufficient storage capacity in Tail Lake. Therefore, the water balance was initially applied for an arbitrary period of 25 years. During this time the facility was kept as a full containment facility, and the height of containment dams to retain this volume was calculated. This 25 year period, includes two years of mining. The results of this analysis are presented in Table 6.

Table 6: Required FSL for full containment over 25 years

Scenario	MAP (mm)	Evap. (mm)	Water Yield (mm)	Extreme Events	Recycle (months)	Mine Water (m^3/day)	Required FSL (m)
Base Case (#1)	207	220	180	None	4	235	39.4
#2	225	220	180	None	4	235	39.7
#3	207	220	111	None	4	235	36.4
#4	207	176	180	None	4	235	40.1
#5	207	264	180	None	4	235	38.7
#6	207	220	180	Yr 1 = 1:500 Wet	4	235	39.7
#7	207	220	180	Yr 1 = 1:500 Wet; Yr 2 = 1:100 Wet	4	235	39.8
#8	207	220	180	Yr 1 = 1:100 Dry	4	235	39.3
#9	207	220	180	Yr 1 = 1:100 Dry; Yr 2 = 1:100 Dry	4	235	39.1
#10	207	220	180	None	0	235	39.5
#11	207	220	180	None	12	235	39.2
#12	207	220	180	None	4	0	39.3
#13	300	220	180	None	4	235	40.8
#14	207	233	111	None	4	235	36.1
#15	115	228	42	None	4	235	30.8
#16	158	228	84	None	4	235	33.8
#17	132	306	53	None	4	235	30.4

Table 7 list the required FSL in Tail Lake at different times, as calculated using the Base Case (Scenario #1) input parameters. Through an iterative procedure, and in consultation with MHBL, it was determined that an optimal design FSL in Tail Lake would be 33.5 m. Based on that water level, a sensitivity analysis was completed to illustrate the time to overflow. These results are presented in Table 8.

Table 7: Base Case (Scenario #1) required FSL at different time intervals

Time Interval	Required FSL (m)
25 years	39.4
20 years	38.1
15 years	36.4
10 years	34.1
5 years	32.5

Table 8: Calculated decant time based on a design FSL of 33.5 m (start date is March 2008)

Scenario	Decant Time (Date)	Decant Time (Years/Months from Start
Base Case (#1)	August 2015	7 years, 5 months
#2	July 2015	7 years, 4 months
#3	July 2020	12 years, 4 months
#4	December 2014	6 years, 9 months
#5	July 2016	8 years, 4 months
#6	July 2014	6 years, 4 months
#7	August 2013	5 years, 5 months
#8	July 2016	8 years, 4 months
#9	October 2016	8 years, 6 months
#10	May 2015	7 years, 2 months
#11	July 2016	8 years, 4 months
#12	January 2016	7 years, 10 months
#13	July 2014	6 years, 4 months
#14	July 2016	8 years, 4 months
#15	Never	Never
#16	May 2030	22 years, 2 months
#17	Never	Never

The effect of decanting water from Tail Lake on the water level in Tail Lake is illustrated in Table 9. As the volume of annual decant is increased the time until the FSL is reached is increased. At some point the discharge is greater than the annual inflow and the FSL will not be reached. If the annual discharge is greater than the annual inflow, the water level in Tail Lake would decrease over time.

Table 9: Effect of decant on the Base Case (Scenario #1)

Decant Scenario	Decant Time (Date)	Comment
100,000 m^3/year	June 2017	This is more than 9 years before FSL is reached
250,000 m^3/year	July 2021	This is more than 13 years before FSL is reached
500,000 m^3/year	Likely Never	Max. water level of 33.0m reached after 42 years
750,000 m^3/year	Likely Never	Max. water level of 29.9m reached June 2010; Water level drops to 28.3 by August 2019
1,000,000 m^3/year	Likely Never	Max. water level of 29.4m reached June 2010; Water level drops to 28.3 by September 2010

The water balance illustrated that an operating FSL of 33.5 m for Tail Lake would be appropriate. Under the most conservative water balance assumptions, Tail Lake can operate as a zero discharge facility for just under 5½ years before reaching FSL. Using more realistic water balance assumptions Tail Lake can operate as a zero discharge facility for at least 7½ years.

The water balance also clearly illustrates that, by allowing an annual discharge the time to reach FSL in Tail Lake is dramatically increased. Allowing as little as 100,000 m^3/year of discharge increases the time to FSL under the base case (Scenario #1) to just under 9½ years, which is a 27% increase in time. If the annual discharge is 500,000 m^3/year, FSL in Tail Lake will likely not be reached, since the decant rate will exceed the annual inflow.

7 References

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