EBA Engineering Consultants Ltd.

TRANSMITTAL SHEET

TO: Mr. Bud McAlpine, P.Eng.
Water Resources Division
Northern Affairs Program
345-300 Main Street
Whitehorse, Yukon
Y1A 2B5

DATE: December 17, 1999

FROM: Cord Hamilton, P.Eng.
Senior Project Engineer

PROJECT: Mount Nansen Dam Safety Assessment

FILE NO: 0201-99-14108

ENCLOSED: One draft copy – "Geotechnical Data Review Report"
One copy of November 1999 invoice

REMARKS:

Dear Bud,

Milos has already reviewed the first version of this report and I have incorporated some of his comments in this revision. I will available during the first week of January to provide revisions if that should be required. After January 7th I will be away until early February.

The November invoice is also enclosed for your approval. Note that a copy has been sent to Brett, as we understand he also needs to review and approve the invoice.

Regards,

☑ As Requested
☐ For Your Information
☐ For Your Comment
☐ For Your Approval
☐ Approved as Noted

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EBA Engineering Consultants Ltd.

GEOTECHNICAL DATA REVIEW REPORT
Mount Nansen Tailings Dam Safety Evaluation

Prepared by:

EBA ENGINEERING CONSULTANTS LTD.
Whitehorse, Yukon

Submitted To:

Water Resources Division
Department of Indian Affairs & Northern Development – Yukon Region
Whitehorse, Yukon

Project No. 0201-99-14108

December, 1999

Calcite Business Centre, Unit 6, 151 Industrial Road, Whitehorse, Yukon Y1A 2V3
Tel: (867) 668-3068 - Fax: (867) 668-4349 Internet: whitehorse@eba.ca - Web Site: http//www.eba.ca

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1.0 INTRODUCTION

As requested by Mr. Bud McAlpine of the Government of Canada (Water Resources Division – DIAND, Yukon Region), EBA Engineering Consultants Ltd. (EBA) have completed an initial review of the geotechnical data available from thermistors and piezometers installed by EBA at the Mount Nansen mine site, previously operated by B.Y.G. Natural Resources Inc.

This review has been completed by EBA as part of the Initial Dam Safety Assessment of Tailings Dam #1 being undertaken by EBA and Klohn Crippen Consultants Ltd. (Klohn). The dam safety assessment, of which this review is a limited part, is being completed under the terms of Standing Offer Number 98-6200 between EBA and the Government of Canada. The specific scope of work is defined under the terms of Call Up Number 98-6200-04 of that standing offer. Authorization to proceed with this review was received from Mr. Brett Hartshorne on August 27th, 1999.

The review of the data is contained in the following sections of this report and includes a summary of the instrumentation installed at the dams, a review of the data quality, and a discussion of the trends and observations resulting from the data. Specific plots of the obtained data are also presented as Figures in the Appendices following this report. General Conditions regarding the use of and limitations to this report are presented in Appendix A that forms part of this report.

2.0 DAM INSTRUMENTATION AND MONITORING

In March 1998, EBA was contracted by B.Y.G. Natural Resources Inc. (BYG) to install a series of geotechnical instruments into and adjacent to Tailings Dams #1 and #2 at the Mount Nansen Mine site. The instrumentation was required to replace existing instrumentation that had failed or had been destroyed since construction of the dams in 1996.

As reported in EBA's April 1998 Installation Report to BYG, a total of 10 boreholes were drilled on and around Dam #1 and Dam #2 to install thermistors, piezometers, and standpipes to facilitate monitoring of ground water levels and ground temperatures. For the main tailings dam, Dam #1, the program consist of:

- three instrumentation suites along the dam crest (Boreholes # 12861-01, -02 and –03);
- two along the crest of the downstream toe berm, (Boreholes # 12861-05 and –06);
- one at the toe of the dam (Borehole # 12861-08); and
- three on the north terrace downstream of the dam (Boreholes #12861-04, -07 and –09)

For Dam #2, the program included a single instrumentation suite at the centre of the dam crest (Borehole # 12861-10). The locations of the instrument suites are shown in Figure #1. Table #1 presents a summary of instruments contained in and the depths of each instrument in the suites. Complete details of the installation program were presented in EBA's April 1998 instrument installation report that is included as Appendix B of this report.

Following installation of the thermistor strings and piezometers, collection of the data from these instruments was undertaken by BYG until the winter of 1999 after which the mine receiver continued to record data. Most recently, personnel of Ketza Construction Corporation (Ketza) acting as the mine caretaker for the Department of Indian Affairs and Northern Development (DIAND) have collected the data. EBA has been supplied with all of the collected data, from these three sources, for use in this review.

Disregarding the initial data obtained during the installation program, most of the instruments have been monitored on a weekly basis since April 1998, although some equipment problems have resulted in occasional missed readings. The exception to this monitoring schedule was and still is the two standpipe installations on the north terrace. To EBA's knowledge, the two standpipes and the single bead thermistors installed with them have not been monitored. Overall, including data up to December 3rd, 1999 there have been 78 full or partial data sets recorded since April 8th, 1999.

Table 1: INSTRUMENTATION DETAILS

BH, Location & Collar Elevation	Thermistor Cable No./ Bead Elevation	Piezometer No. / Elevation
BH 12861-01 Top Of Dam # 1 el. 1151.4 m	Cable # 1178 1 / 1138.6 m 2 / 1136.6 m 3 / 1134.6 m	# 22715 / 1140.6 m # 22713 / 1136.6 m # 9377 / 1134.6 m
BH 12861-02 Top Of Dam # 1 el. 1151.4 m	Cable # 1179 1 / 1139.1 m 2 / 1136.6 m 3 / 1133.6 m 4 / 1131.6 m 5 / 1130.6 m 6 / 1129.6 m 7 / 1128.6 m 8 / 1126.1 m	# 7658 / 1136.6 m # 9362 / 1131.6 m # 7711 / 1129.6 m
BH 12861-03 Top Of Dam # 1 el. 1151.5 m	Cable # 1180 1 / 1151.5 m 2 / 1151.2 m 3 / 1147.2 m	# 19172 / 1135.3 m # 22592 / 1133.3 m # 22793 / 1129.3 m
BH 12861-04 Bank Above Pond # 2 el. 1147.3 m	Single Bead # 1 1 / 1136.6 m	50 mm Standpipe to 1136.6 m
BH 12861-05 Top Of Toe Berm el. 1139.7 m	Cable # 1181 1 / 1132.7 m 2 / 1130.7 m 3 / 1126.7 m	# 22720 / 1132.7 m # 22716 / 1130.7 m # 22714 / 1126.7 m
BH 12861-06 Top Of Toe Berm el. 1139.9 m	Cable # 1182 1 / 1135.4 m 2 / 1133.1 m 3 / 1131.1 m 4 / 1129.1 m 5 / 1128.1 m 6 / 1127.1 m 7 / 1126.1 m 8 / 1125.1 m 9 / 1123.1 m	
BH 12861-07 North Abutment near Toe Berm Crest el. 1143.3 m	Cable # 1183 1 / 1139.1 m 2 / 1137.1 m 3 / 1133.1 m	# 22721 / 1139.1 m # 22719 / 1137.1 m # 22718 / 1133.1 m
BH 12861-08 Toe Of Dam # 1 el. 1132.6 m	Cable # 1143 1 / 1131.9 m 2 / 1131.4 m 3 / 1130.4 m 4 / 1128.4 m 5 / 1124.4 m 6 / 1120.4 m 7 / 1117.4 m	
BH 12861-09 Bank Above Pond # 2 el. 1142.3 m	Single Bead # 2 1 / 1125.5 m	50 mm Standpipe to 1125.5 m
BH 12861-10 Top Of Dam # 2 el. 1130.7 m	Cable # 1144 1 / 1128.6 m 2 / 1128.1 m 3 / 1127.1 m 4 / 1125.1 m 5 / 1121.1 m 6 / 1117.1 m 7 / 1114.1 m	

3.0 INSTRUMENTATION DATA

3.1 Thermistor Data

As shown in Table #1, there were three main thermistor strings installed in Dam #1, one at the dam crest, one at the toe berm crest, and one near the dam toe. For Dam #2, there is a single thermistor string located roughly in the centre of the dam structure. All of these main thermistor installations are located above and within the former channel/floodplain of Dome Creek.

For Dam #1, additional thermistor strings were installed in association with the piezometers located in holes penetrating into the permafrost soils on the south and north abutment slopes that underlie the dam structure. These strings consisted of three thermistor beads that were typically coupled with the piezometers placed in the borehole. Both the thermistor beads and the associated piezometers were positioned with one above the permafrost level (at the time of installation) and two below the permafrost level.

Unfortunately, the abutment installations on the north side were not completely successful. At the crest hole above the north abutment (Borehole # 12861-03), the thermistor string could not be properly positioned at depth in the borehole. For this installation the thermistor beads are near surface and do not penetrate into the underlying permafrost. Moreover, they are not coupled with the piezometers that lie at greater depths within this borehole. The other north side thermistor string (Borehole # 12861-07) was located just off of the dam structure on the north side of the toe berm crest and was not ideally positioned to provide the most useful data from the north abutment. Fortunately the south side abutment installations were both successful in penetrating the permafrost table under the dam structure and in matching up with companion piezometers.

In order to evaluate the thermistor data retrieved from all of the thermistor installations, plots of the ground temperature versus time for each thermistor string installation have been prepared. In addition, for each thermistor string (main strings and three bead installations), a trumpet curve plot has also been prepared.

A trumpet curve shows the ground temperature profile from each installation by plotting select reading sets from critical periods of the year. For the plots provided in this report, the first reading sets from the months of April, July, October, and January have been used to show the seasonal ground temperature profiles.

The completed ground temperature versus time plots are presented as Figures A-1 to A-8 and the trumpet curve plots are shown as Figures A-1P to A-8P.

3.2 Piezometer Data

As shown in Table #1, five sets of three pneumatic piezometers are located within and adjacent to Dam #1. With each installation, the piezometers were positioned to have the top piezometer above the permafrost foundation soils and the lower two placed below the permafrost table. Where possible each piezometer has been coupled with a companion thermistor bead. This allows measurement of the temperature of the piezometers.

Measurement of the piezometers has been taken in pound-force per square inch units and converted into an elevation of the phreatic surface based on the measured pressure and the known elevation of the piezometer. For this conversion to elevation units the pressure head of water at 4°C has been used.

Plots of the resulting phreatic elevations versus time for each of the installation locations have been prepared as Figures B-1 to B-5. Where known, only the active (thawed) piezometers are shown on these plots. The variation of pond elevation with time has also been plotted on each of these figures to allow a comparison of between pond fluctuations and piezometer response.

3.3 Pond Level

During the period of monitoring, water level elevations within Pond #1 (Tailings Pond) have also been recorded at varying intervals by BYG, the receiver, and Ketza. The method of obtaining water level readings was typically by a survey staff gauge, although direct level shots onto the water surface were also made at various times. The recorded pond levels have been plotted on Figures B-1 to B-5 in order to allow comparison of pond levels to measured phreatic levels.

4.0 DATA EVALUATION

4.1 Data Quality

In terms of the general quality of the data, review of the data plots indicates that some erroneous data readings and sets have been recorded over the monitoring period. For the thermistor data, these erroneous readings are clearly seen as data spikes indicating rapid ground temperature changes above or below the general trend of the data. These spikes are believed to have resulted by personnel not fully allowing the data reading to equalize prior to recording its value. It is also possible that the thermistor readout box was malfunctioning or incorrectly connected during the readings. It is also important to note that BYG apparently used a variety of personnel to record the data and this has also likely been a cause of the data spikes visible in the records.

Overall, EBA believes that the thermistor beads are functioning properly and believes that the data sets minus the data spikes are reasonable, although some trends are difficult to interpret.

For the piezometric data, the same types of erroneous errors are also visible in the data records. The data spikes in the piezometric data are particularly visible earlier in the records and likely resulted from incorrect measurement procedures. Another cause of erroneous data for the piezometers is that in some cases individual piezometers are frozen and as such the obtained data is not of value.

In addition to piezometer data, EBA has also reviewed the pond level data. This data was obtained by measuring from a staff gauge established in Pond #1 by BYG. As there was some uncertainty regarding the accuracy of the staff gauge, EBA had the gauge resurveyed in October 1999. Comparison between the water elevation determined by the survey and the staff gauge was in the order of 6 cm, which is not considered significant.

Nevertheless, pond level readings completed during the winter months are considered to be misleading. This is because the measurement procedure was to record the water level around the staff gauge through a hole in the pond ice cover. The thickness and elevation of the ice cover was not recorded. Therefore, the overall amount of water (solid and liquid) within the pond during the winter months is not known. While this may not have an effect upon the piezometric levels within Dam#1, it does have implications in terms of water balance and storage within the pond. Certainly, conclusions regarding the available storage volume within the impoundment cannot be made without accounting for the volume of ice.

4.2 General Data Trends

The data and data plots, prepared for this report have been reviewed in order to determine trends in ground temperature, piezometric response, active layer thickness, etc. A detailed discussion of the data from each measurement point is presented in Section 4.3.

In terms of general ground temperature trends, most the boreholes have shown that a gradual warming trend exists in the permafrost soils and that some level of permanent and/or seasonal thawing of the permafrost has occurred. The greatest thaw has occurred on the north abutment terrace and the least near the toe of Dam #1. The south abutment slope indicated very little thaw at the dam centre line but a large amount of seasonal thaw at the toe berm crest. Dam #2 has a significant amount of seasonal thaw. The maximum depth of thaw and seasonal variations in the depth to the permafrost table (where known) are shown in Table #2.

Table #2: Thaw Depth and Seasonal Variation in Permafrost Depth

Borehole	Maximum Thaw depth[1]	Seasonal Variation in Permafrost Depth[2]
12861-01	0.75 m[3]	Above fill to 0.75 m
12861-02	1.5 m	1.15 m – 1.5 m
12861-03	3.6 m to 4.9 m[4]	Unknown
12861-05	4.5 m	Above fill to 4.5 m
12861-06	0.4 m	0.8 above the fill to 0.4 m below
12861-07	>6.7 m	Unknown
12861-08	0.6 m	Ground surface to 0.6 m[5]
12861-10	1.7 m	Ground surface to 1.7 m[5]

Notes:

[1] Thaw depth is measured from the fill/native soil interface.

[2] Measurements refer to depth below fill interface unless otherwise indicated.

[3] This thaw depth was from a single reading shortly after installation, only two data sets have indicated thawing below the fill interface, all other sets show freezing into the fill.

[4] Depth of thaw estimated from design drawings and drilling records.

[5] For both boreholes 12861-08 and 12861-10, the permafrost table joins with the active layer.

From the piezometric data, it is seen that the piezometers at the dam crest are sensitive to pond level changes and that piezometric levels appear to lag slightly behind the pond changes. In terms of the magnitude of changes, the pond level has had changes in the order of 1 m during the monitoring period whereas the crest piezometers have shown changes in the range of 2.0 m to 2.5 m.

One unusual aspect of the dam crest phreatic levels is that a distinct slope exists across the dam length. This slope shows a fall of around 3.0 m to 3.5 m in the phreatic level from the south side to the north side. Because of this slope and given the range in phreatic levels over the course of monitoring, the phreatic level has ranged from as little as 5.5 m below the crest elevation (south side) to over 10 m below the crest elevation (north side).

A significant observation is the last two series of readings from the crest piezometers have all indicated a drop in the phreatic level in response to the drawdown of the pond level that has occurred over the fall of 1999.

At the crest of the toe berm, the phreatic surface has remained quite high in respect to the dam surface level for the entire monitoring period. The phreatic level has ranged from 1.7 m to 0.7 m below the toe crest elevation. The response of the phreatic level at the crest of the toe berm to changes in pond elevation appears to be complex and more data will be necessary to better define the relationship. In terms of a cross fall at the toe berm crest, there is insufficient data to conclude that a cross fall is present. However, a cursory review of the most recent data from Borehole #12861-07 and Borehole # 12861-05 show these locations have phreatic levels within 0.5 m of each other with the highest level shown to be on the south side.

The piezometric levels at the toe of the dam have not been monitored; however, seepage is known to daylight at several locations across the dam toe throughout the year.

4.3 Detailed Data Review

A detailed discussion of the data trends and specific observations resulting from the data at each borehole is presented in the following sections.

4.3.1 Borehole 12861-01

Borehole # 12861-01 is located on the south side of the dam crest. Based on the original mapping of the dam site, the original ground elevation at the borehole location is estimated to be 1139 m ± 0.5 m. Drilling of the borehole indicated the fill/native ground interface was at a depth of 13.7 m (elevation 1137.7 m). This suggests the area was stripped on the order of 1.3 ± 0.5 m during construction. The low end of this range is more in keeping with the documented stripping depths indicated in Klohn's 1996 Construction Report.

Review of the thermistor data from this location, as shown in Figures A-1 and A-1P, indicates that the deeper two thermistor beads have been continuously frozen over the period of monitoring. Ignoring data spikes present in the records, it appears that the upper thermistor bead has generally been above 0°C, although it has been marginally frozen (warmer than –0.1°C) during the late summer and fall of 1998.

The trend of the upper thermistor is unusual in that it appears to the cool during the summer months and warm during the winter months. A possible explanation of this trend, provided by Mr. Bud McApline of DIAND, is that the warm pond water from the summer months arrives at the thermistor during the winter months and warms the thermistor. During the summer months, colder seepage that initiated during the winter months arrives and cools the thermistor location.

The trend in the two lower beads appears independent of seasonal variations, but does suggest a gradual warming over time (a positive slope). This gradual warming is present in both beads and is in the order of 0.1°C to 0.2°C over the course of monitoring.

The depth to the 0°C isotherm is estimated to be near the fill and native soil interface and has extended upward into the fill slightly at some times. Generally, the location does not seem to have experienced any significant thaw of native foundation soils.

Based on the thermistor results, it is concluded that only the upper piezometer has been active over the course of monitoring. The variation of phreatic levels at this location is shown in Figure B-1. Review of this figure indicates that there was a gradually decline in the phreatic level from 1145.0 m to 1144.0 m over the period of August 1998 to May 1999. From May 1999 to September 1999, the level rose sharply to a maximum of nearly 1146.0 m. Since September 1999, the level has dropped to below 1145.5 m.

Comparison of the phreatic level changes to the pond level changes is difficult due to the large data gaps in the pond level between August 1998 and April 1999. However, it is known that the pond level did drop over this period. After April 1999, the pond level is shown to rise in an irregular manner up to September 1999. It appears that the piezometric level fluctuated in a somewhat lagged manner behind the pond level fluctuations.

4.3.2 Borehole 12861-02

Borehole # 12861-02 is located on the dam crest roughly above the former channel of dome Creek. It contains a nine bead thermistor string and three pneumatic piezometers. Based on the original mapping of the dam site, the original ground elevation at the borehole location is estimated to be 1132.7 m ± 0.5 m. Drilling of the borehole indicated a fill/native ground interface at an elevation of 1132.2 m. This suggests the area was stripped on the order of 0.5 m ± 0.5 m during construction.

Review of the thermistor data from this location, as shown in Figures A-2 and A-2P, indicates that the three thermistor beads that were placed above the fill/native soil interface have remained well above 0°C over the period of monitoring. These three beads show a reverse trend to typical seasonal ground temperatures variations. The trend is for cooling in the summer and warming in the winter. The magnitude of this trend is seen to decrease with depth.

The first bead that lies within the native foundation soils was also seen to be unfrozen throughout the period of monitoring. This bead lies in organics soils 0.8 m below the fill interface. This bead also exhibits the reverse trend in seasonal variation although it is not of great magnitude.

The final four thermistor beads in this borehole are all located in the frozen native sand underneath the organic soil. These beads indicated that the foundation becomes colder with depth and that all three have remained frozen over the course of monitoring (excluding data spikes). The trend in these foundation beads is for a slight warming with time, similar in nature to that described for the foundation beads in Borehole # 12861-01.

Review of the data from this installation suggests that the 0°C isotherm typically lies between an elevation of 1131.0 m and 1130.7 m. Therefore up to 1.5 m of thaw has developed in the foundation soils underlying the dam fill. Recent trends suggest that the depth of thaw is still increasing.

The piezometric data from this location has been plotted in Figure B-2. Data from all three of the piezometers have been included in the plot even though the lowest of the piezometers (#7711) is believed to be frozen. Comparison of the three piezometers shows that the lower two provide very similar data while the higher piezometer provides values that are up to 1.0 m greater that the lower two instruments. It is felt that the upper piezometer is likely to be representative of the phreatic levels within the dam structure.

The variation of piezometric levels with time appears to match the general pattern previously described for Borehole #12861-01; however, the piezometric level is consistently lower than that of Borehole #12861-01.

For piezometer #7658 (upper piezometer) in Borehole #12861-02, the levels range from a low of 1140.0 m in the spring 1999 to a high of 1143.0 m in the fall of 1999. The levels drops after the fall high and is currently in the range of 1141.2 m.

4.3.3 Borehole 12861-03

Borehole #12861-03, located on the dam crest, was aligned to penetrate into the native soils that formed the south facing slope above Dome Creek channel. This borehole contains three pneumatic piezometers and three thermistor beads. The thermistor beads are not coupled to the piezometers.

The original mapping of the dam site suggested that the original ground elevation at this location would be approximately 1138.0 m ± 0.5 m. The depth of stripping below the original ground is not known but construction records suggest a range of 0.3 m to 0.6 m was typical for the dam foundation preparation. Therefore the fill/native soil interface was expected within a range of 1138.2 to 1136.9 m. Unfortunately, the drilling records from this borehole do not provide any evidence to locate the actual interface between the fill sand and the native foundation sand.

Ground temperature data from this borehole is presented on Figures A-3 and A-3P. As was discussed in Section 3.1, the three thermistor beads at this location are located near the crest of the dam and do not provide any information on the permafrost table position at this location. Nevertheless, the three shallow thermistor beads do provide some correlation between air temperatures and ground temperatures that may be useful for additional thermal modelling.

In terms of thawing of native soils at this location, the only known depth is derived from the drilling program where permafrost was encountered at an elevation of 1133.3 m. Given that the fill interface is estimated to be between an elevation of 1136.9 m to 1138.2 m, the depth of thaw was estimated to range between 4.9 m to 3.6 m at the time of the drilling program.

In terms of piezometric levels, this borehole has three piezometers, two of which were placed above the permafrost level at the time of installation. Review of the data from all three of the piezometers suggests that the lower piezometer has remained frozen. This conclusion is based on the fact that the data from the upper two piezometers follows the same general pattern as the unfrozen piezometers from the other dam crest boreholes. The phreatic level suggested by the two upper piezometers differs from each other in the order of 0.5 m with the upper piezometer consistently providing higher values.

Using the data from the highest piezometer, the phreatic level started around 1141.4 m in fall of 1998, dropped to 1140.4 m by the spring of 1999, and rose to a high of 1142.8 m in the fall of 1999. Since the high point in September 1999, the level has dropped to 1141.7 m.

4.3.4 Borehole 12861-04

Borehole # 12861-04 is located on the north abutment terrace 35 m downstream of the dam centreline and 90 m south the emergency spillway channel. This installation consists of a 50 mm standpipe and a single thermistor bead. It was located to provide a possible sampling location for seepage should thawing of this area develop and seepage flows be encountered. To EBA's knowledge this standpipe has not been sounded for water levels and the thermistor bead has not been read.

4.3.5 Borehole 12861-05

Borehole # 12861-05 is located on the south side of the toe berm. It was located to penetrate into the former north facing slope that lies above the Dome Creek channel and floodplain. The borehole contains three piezometers each coupled with a thermistor bead. The upper piezometer/thermistor lies just above the fill/native soil interface elevation and the lower two have been placed within the underlying native foundation sand.

Based on the original mapping of the dam site, the original ground elevation at the borehole location is estimated to be 1132.4 m ± 0.5 m. Construction records indicate stripping depths ranged from 0.3 m to 0.6 m. Drilling of the borehole had indicated the fill/native ground interface was at an elevation of 1132.4 m.

Review of the thermistor data from this location, as shown in Figures A-4 and A-4P, indicates that the upper two thermistor beads are affected by seasonal temperature changes within the surrounding soil. Generally these two beads have had a temperature of above 0°C, except for the period between April 1999 and September 1999 where they exhibited a temperature of between -0.1°C to –0.3°C.

It is interesting to note that in the first season of monitoring (1998) these two beads had maximum temperatures during October of between 1°C and 2.5°C, whereas during the second season (1999) they had temperature highs in October of only 0.4°C and 1.5°C. Moreover they were frozen for much of the summer of 1999 whereas they were thawed for the summer of 1998. It is possible that the difference between the 1998 season and the 1999 season was due to the initial thermal disturbance created during the 1998 installation program.

Unlike the thermistor data from the dam crest, the seasonal variation of ground temperatures indicated by the upper two thermistor beads follows the classical lagged pattern prevalent in permafrost areas. This typically results in the warmest ground temperatures (greatest depth of thaw) occurring the late fall and the coldest temperatures (deepest seasonal frost penetration) occurring the late spring or early summer. Hence, the ground temperature variations lag behind the ambient air temperature variations. At this installation, the highest ground temperatures were observed during late September to early October, while the coolest temperatures were in mid summer (July).

The third thermistor bead at this location lies below the permafrost table and has not been noticeably affected by seasonal temperature changes. It has maintained a temperature in the range of –0.4°C to –0.3°C; however, it does appear to be gradually warming.

The depth to the 0°C isotherm inferred by the thermistor data varies widely over the course of measurement. Even ignoring the data from the initial spring following installation, the range is from a depth of less than 7 m to over 11.8 m. Thus the permafrost table varies from some unknown height above the fill interface to as much as 4.5 m below the fill interface.

Detailed review of the thermistor records suggests that the 0°C isotherm is typically in the range of 2.5 m to 4.5 m below the fill interface during the fall and winter months (September to March). Over the course of the spring and summer months, the 0°C isotherm rises upward to and past the fill interface.

Based on the thermistor results, it is concluded that all of the piezometers are either frozen or are subject to seasonal freezing. The deepest of the three piezometers has been continuously frozen over the period of monitoring. Data from the remaining two piezometers is shown in Figure B-4.

Although each of the two plotted piezometers has been subjected to some periods where the seasonal temperature was below 0°C, they may or may not have frozen. It is possible that the ground water chemistry has depressed the freezing point below the -0.16°C temperature that was the coldest recorded temperature for these piezometers. Regardless, the shallowest piezometer (#22720) has likely been the least affected by the temperature variations and is most likely to represent the piezometric level within the dam fill.

Therefore, using the data from piezometer #22720, it can be seen that the level is quite erratic following the initial installation. By August 1998 the level has settled down to a value of approximately 1138.1 m and remained at that level until January 1999. After January 1999, the level increases to a maximum of nearly 1139 m by April 1999. After April 1999, the level begins to drop down and reaches a plateau value of around 1138.1 m by August 1999. From August 1999 until present, the level has remained in the range of 1138.1 m to 1138.3 m except for a significant drop indicated by the last data set (November 25th, 1999). EBA has reason to suspect the value of the last reading set, therefore it should be treated as suspect until further data confirms its value.

Some implications of the inferred phreatic levels are that they have risen to within 0.7 of the crest of the toe berm during the current calendar year and are still within 2 m of the toe berm crest at this time. Given that frost penetration through the toe berm crest is likely in excess of 0.7 m, it may be that the ground water table was actually confined by the frost level at some depth greater than 0.7 m below the crest (i.e. the flow was confined).

Another observation is that the pattern of piezometric changes at the toe berm crest is different from that found at the dam crest. Seepage through a homogenous medium would suggest that a lag or phase shift in the pattern would be expected, but a change in the pattern implies some change in the flow parameters between the dam crest and the toe berm. It is possible that the development of confined flow and a narrowing of the width of the flow path has lead to the alternation of the pattern of piezometric variations from the dam crest to the toe berm.

4.3.6 Borehole 12861-06

Borehole #12861-06 was installed on the top of the toe berm roughly over the centre of the former Dome Creek valley. It was advanced to install a nine bead thermistor string that extends down to a depth of 16.8 m. The original ground elevation at this location was estimated to have an elevation of 1130.7 m ±0.5 m. The fill/native ground interface was encountered at a depth of 10.0 m giving an interface elevation of 1129.9 m. Hence, the depth of stripping during construction is estimated to be in the order of 0.8 m ±0.5 m.

The recorded ground temperatures at this location are shown in Figures A-5 and A-5P. As can be seen in these plots, the three thermistor beads located in the fill soils have remained above 0°C throughout the monitoring period and show seasonal variations in temperature. Unlike the boreholes along the dam crest, the seasonal variation of ground temperature follows the more classical pattern of exhibiting a 3-4 month lag behind seasonal ambient air temperatures. Hence, the beads indicate a lagged warming during the summer and fall, and a lagged cooling during the winter and spring.

All of the thermistor beads below the fill soils have been continuously frozen over the monitoring period. These five beads have indicated that the ground temperatures becomes slightly colder with depth. Moreover, they all indicate a slight increase in temperature over the course of monitoring. The temperature increases are on the order of 0.1°C or less.

Excluding erroneous readings and readings taken soon after the installation was completed, the maximum depth of the 0°C isotherm is estimated to be about 10.3 m or to an elevation of 1129.6 m. This suggests that the maximum seasonal thawing of native soils underneath the fill level has been on the order of 0.3 m. The minimum depth of the permafrost table over the course of measurement was found to be 9.4 m indicating about 0.6 m of seasonal freezing into the fill.

4.3.7 Borehole 12861-07

Borehole #12861-07 is located just off of the north end of the toe berm crest on the north abutment terrace beside the Dam #1. This borehole contains three piezometers each coupled with a thermistor bead. The depths where the instruments have been placed are 4.0 m, 6.0 m and 10.0 m.

The original ground elevation at this location was estimated to be approximately 1142 m. As the present elevation is 1143.3 m it is concluded that some fill soils have been placed over this location. During the drilling program it was not possible to differentiate between fill soils and native soils, so the actual fill thickness (if any) cannot be confirmed.

Ground temperatures from this installation are shown on Figures A-6 and A-6P. These figures show that the ground temperatures at this installation have undergone complex changes over the period of monitoring. Up to September 1998, all three thermistor beads remained frozen. This is believed to have been the result of backfilling the dry borehole with cold sand and is not necessarily a reliable indication of the actual ground temperatures around the borehole.

Since September 1998 the upper two beads have followed a sinusoidal type pattern with peak temperatures in excess of 2.0°C, low temperatures in the order of –0.3°C, and a mean temperature of roughly 1.25°C. The peak temperatures have occurred in October and the low temperatures in June or July. The shallower of these two beads exhibits both the highest and lowest seasonal temperatures. Therefore it is likely that the seasonal temperature changes are the result of the penetration of seasonal frost as opposed to the seasonal variation of the underlying permafrost table. While a 6 m seasonal frost depth seems excessive for these soils, the installation is near a cleared access road and on a slope, and both of these could have the effect of increasing the apparent depth of frost penetration. It is also important to note that much of the sand is quite dry and there is no organic cover at this location. Both of these factors also lead to higher frost penetration depths.

The third and lowest thermistor was also frozen from April to August 1998. From August 1998 to August 1999, the bead has exhibited the same sinusoidal temperature pattern as the higher thermistor beads, although the temperature range has been roughly ±0.25°C with a mean temperature of roughly 0°C. After August 1999 this bead experienced a significant increase in temperature and rose to a temperature of 2.0°C by late November 1999.

Given the relatively great depth of this bead (10 m) it is unlikely that the seasonal variation is the result of the penetration of seasonal frost. The seasonal changes at a depth of 10 m are more likely related to seasonal fluctuations in the level of the permafrost table. The large increase in ground temperature after October 1999 may either be the result of inaccurate readings (operator error) or suggestive of the presence of warm seepage entering into the formerly dry area.

The possible depth of thaw at this location is difficult to determine due to the complexity of the thermistor data. During drilling, permafrost was encountered at a depth of roughly 8 m. Drilling by Klohn completed in 1995 suggested that the permafrost table would be encountered at depths above 2 m at similar locations along the north valley terrace. Therefore accounting for the possible placement of up to 1.3 m of fill, the depth of thaw indicated during drilling was in the order of 4.7 m.

Since April 1998 the thermistor bead at a depth of 10 m has indicated seasonal thawing behaviour; therefore, the permafrost table should be assumed to vary below 10 m. This suggests a depth of thaw now in excess of 6.7 m (based on the original ground and permafrost level).

While this depth of thaw seems excessive, it should be understood that this portion of the north terrace was highly disturbed during construction of the dam and during subsequent maintenance construction operations. It was also a formerly south facing location with relatively warm ground temperatures. Finally, the presence of the dam beside the former south facing slope has likely lead to lateral thawing as well as vertical thawing at the borehole location. Hence a large thawing depth would be expected at this location.

The piezometric data at this installation is also fairly complex and somewhat inconclusive. The response of the three piezometers is shown in Figure B-5. The piezometer at a depth of 4.0 m shows an essentially flat response having a piezometric reading of only 0.4 m to 0.5 m above its actual elevation. This flat response suggests that it is not truly reading a piezometric level. Therefore the readings should be discounted.

The next piezometer (located at a depth of 6 m) starts off with a flat response similar to the highest piezometer. This response, that indicates a piezometric level of around 1137.5 m (only 0.4 m to 0.5 m above the piezometers elevation), continues until the summer of 1999 where deviations initially below 1137.5 m and then above 1137.5 m start to occur.

After August 1999, the inferred piezometric level from this piezometer matches quite closely to that indicated by the deepest of the three piezometers.

The deepest piezometer, located at a depth of 10.0 m, reveals a response similar in pattern to the piezometers located along the dam crest. The level is initially around 4 m above the piezometer elevation indicating a piezometric level of 1137.4 m. The level drops gradually to a low point of 1136.6 m in May 1999 and then rises to a high of 1138.0 m in October 1999.

It is important to note that during drilling no water was encountered in this borehole, so the initial head level of around 4 m for this piezometer is suspect, even more so given that thermistor readings indicate that it was frozen until October 1998. The piezometer was also shown to be frozen during the period of April 1999 to October 1999 and this casts doubt on the piezometer values obtained during that time.

As can be seen, it is not possible to reach a definitive conclusion regarding the conflicting piezometric data that has been recorded from this borehole. The writer suggests that based on the thermistor data and knowledge that the borehole was dry upon drilling, the piezometric data from the piezometers at depths of 6 m and 10 m should be considered to be representative of the phreatic level after August 1999. Prior to August 1999, all of the piezometric data is considered to be unreliable.

This implies a current phreatic level of 1137.5 m that matches closely with the current level indicated in Borehole 12861-05 located on the opposite abutment of the dam at roughly the same offset from the tailings pond. In any case more data will be required in order to confirm these conclusions.

4.3.8 Borehole 12861-08

Borehole #12861-08, which contains a 7 bead thermistor string extending at a depth of 15.2 m, is located near the toe of Dam #1. The original ground elevation at the borehole location was estimated to be 1130.0 m ±0.5 m. The fill/native soil interface depth discovered during drilling was 3.3 m giving an interface elevation of 1129.3 m. Therefore stripping during construction was in the order of 0.7 m ±0.5 m.

Review of the ground temperature records from this installation, as plotted on Figure A-7 and A-7P, indicates that all beads in the thermistor string are either frozen or are subject to seasonal freezing. Hence the active layer at this location extends to the dam surface. In the active layer portion of the installation, the seasonal ground temperature changes follow the classical pattern of warming during the summer and fall months and cooling during the winter and spring months.

Below the active layer, the permafrost temperature was found to be in the order of –0.4°C in the zone of organic soils and –0.8°C in the underlying frozen sands. There is no distinct trend in the permafrost ground temperatures.

In terms of seasonal thawing, the greatest thaw depth occurred during the first season of monitoring (1998) and that extended to a depth of 3.9 m below the dam surface or 0.6 m below the fill/native ground interface. During the second season of monitoring (1999), the maximum thaw depth was 3.8 m or 0.5 m below the fill/native ground interface.

4.3.9 Borehole 12861-09

Borehole # 12861-09 is located on the north abutment terrace overlooking the seepage pond formed by Dam #2. This installation consists of a 50 mm standpipe and a single thermistor bead. It was located to provide a possible sampling location for seepage should thawing of this area develop and seepage flows be encountered. To EBA's knowledge this standpipe has not been sounded for water levels and the thermistor bead has not been read.

4.3.10 Borehole 12861-10

Borehole 12861-10 is the only borehole advanced through Tailings Dam #2. This borehole was completed to install a 7 bead thermistor string to a depth of 16.6 m below the dam crest. Prior to construction, the original ground in the vicinity of the borehole was estimated to be at an elevation of 1128.2 m ±0.5 m. During drilling the fill/native ground interface was encountered at an elevation of 1127.6 m indicated that stripping in the area was approximately 0.6 m ±0.5 m which is in agreement with the construction records from the site.

Review of the ground temperature records from this installation indicates that all beads in the thermistor string are either frozen or are subject to seasonal freezing. This implies that the active layer at this location extends to the ground surface (dam crest).

In the active layer portion of the installation, the seasonal ground temperature changes follow the classical pattern with the highest ground temperature being observed during the late fall. Below the active layer, the permafrost was found to decrease in temperature with depth. Moreover, all four beads below the permafrost table indicated a gradual warming trend over the period of measurement. The magnitude of warming ranges from 0.1°C to 0.2°C.

In terms of seasonal thawing, the greatest thaw depth occurred during the first season of monitoring (1998) and that extended to a depth of 4.8 m below the dam crest or 1.7 m below the fill/native ground interface. During the second season of monitoring (1999), the maximum thaw depth was only 4.2 m or 1.1 m below the fill/native ground interface.

5.0 LIMITATIONS

The contents of this report are based on the geotechnical instrumentation data provided to EBA by BYG and Ketza. The provided data, in the form of thermistor readings and pneumatic piezometer readings has been supplemented by EBA's direct observations of the site.

Accordingly, the information, plots and evaluations presented in this report are based on the supplied data. Actual conditions at the site may vary from those described by the data. Should different conditions be encountered during subsequent site activities, it is requested that EBA be notified so that the contents of this report can be reviewed to confirm that they are still appropriate.

This report and the recommendations contained in it are intended for the sole use of the Government of Canada and Klohn Crippen Consultants Ltd. EBA does not accept any responsibility for the accuracy of any of the data (except where verified by EBA) or for the analysis or the recommendations contained or referenced in the report when the report is used or relied upon by any party other than those indicated above. Any such unauthorized use of this report is at the sole risk of the user.

6.0 CLOSURE

EBA trusts that this report provides you with sufficient information at this time. Please forward all review comments and direct any questions regarding this report to the undersigned. This report will be finalized following receipt and discussion of all comments from both DIAND and Klohn.

Yours truly,
EBA Engineering Consultants Ltd.

Reviewed by:

Cord Hamilton, P.Eng.
Senior Project Engineer

J. Richard Trimble, P.Eng.
Project Director, Yukon Region

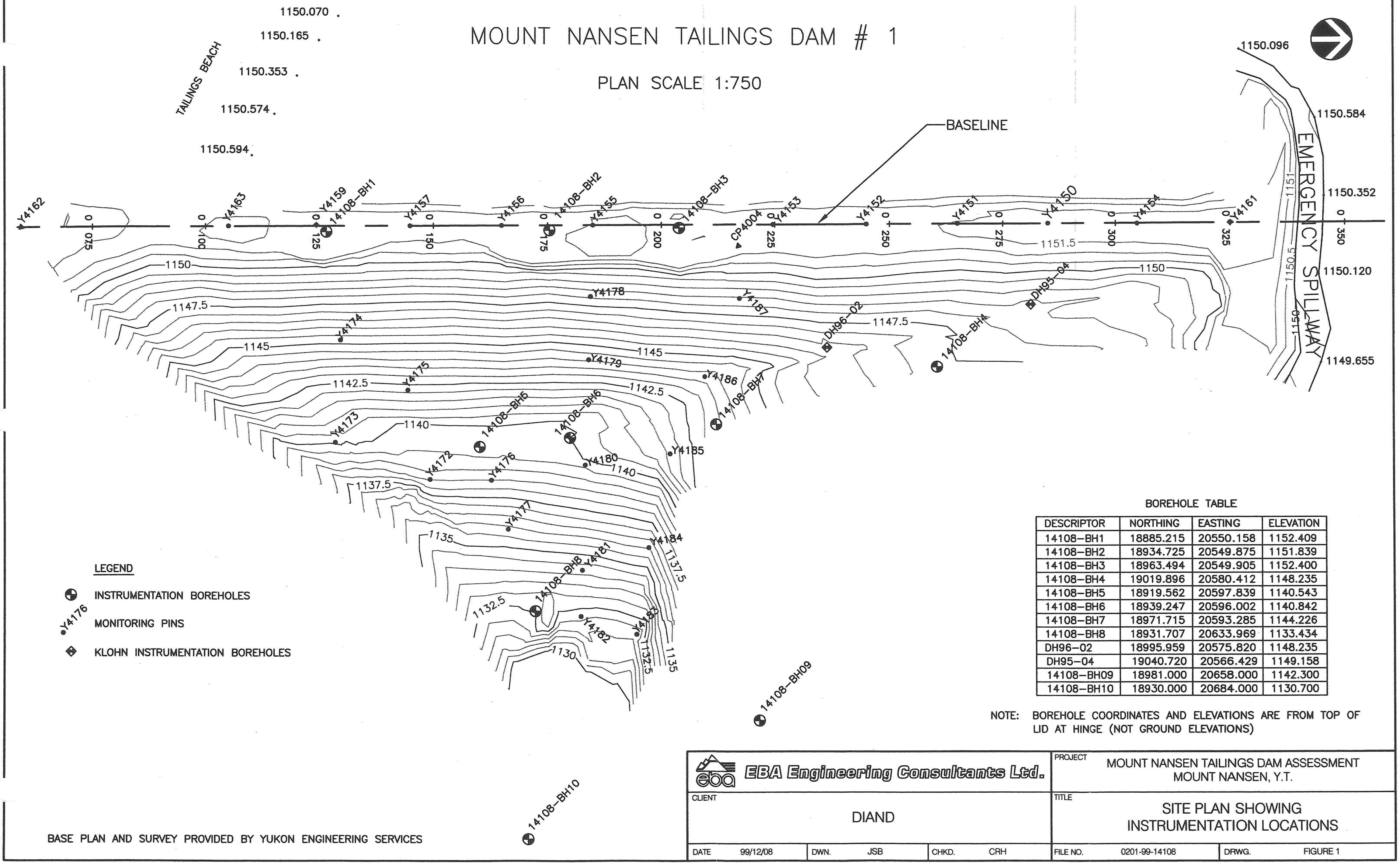
CRH/crh

R02-99-14108dataR2.doc

FIGURES

MOUNT NANSEN TAILINGS DAM # 1

PLAN SCALE 1:750



LEGEND

● INSTRUMENTATION BOREHOLES

Y4176 MONITORING PINS

◆ KLOHN INSTRUMENTATION BOREHOLES

BOREHOLE TABLE

DESCRIPTOR	NORTHING	EASTING	ELEVATION
14108–BH1	18885.215	20550.158	1152.409
14108–BH2	18934.725	20549.875	1151.839
14108–BH3	18963.494	20549.905	1152.400
14108–BH4	19019.896	20580.412	1148.235
14108–BH5	18919.562	20597.839	1140.543
14108–BH6	18939.247	20596.002	1140.842
14108–BH7	18971.715	20593.285	1144.226
14108–BH8	18931.707	20633.969	1133.434
DH96–02	18995.959	20575.820	1148.235
DH95–04	19040.720	20566.429	1149.158
14108–BH09	18981.000	20658.000	1142.300
14108–BH10	18930.000	20684.000	1130.700

NOTE: BOREHOLE COORDINATES AND ELEVATIONS ARE FROM TOP OF LID AT HINGE (NOT GROUND ELEVATIONS)

BASE PLAN AND SURVEY PROVIDED BY YUKON ENGINEERING SERVICES

EBA Engineering Consultants Ltd.

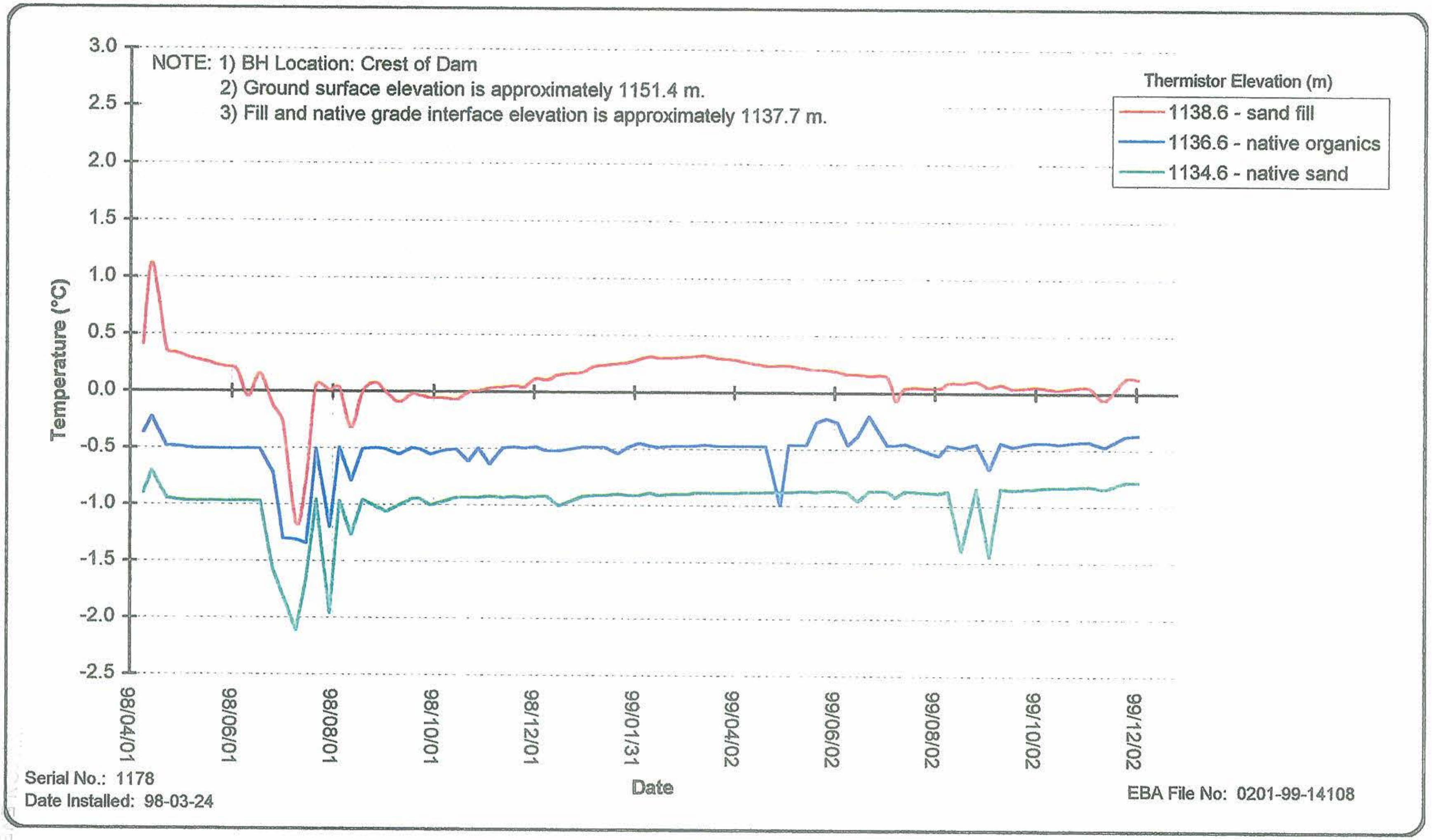
PROJECT
MOUNT NANSEN TAILINGS DAM ASSESSMENT
MOUNT NANSEN, Y.T.

CLIENT
DIAND

TITLE
SITE PLAN SHOWING
INSTRUMENTATION LOCATIONS

DATE 99/12/08
DWN. JSB
CHKD. CRH
FILE NO. 0201-99-14108
DRWG. FIGURE 1

Mt. Nansen - Tailings Dam
Ground Temperature History



NOTE: 1) BH Location: Crest of Dam
2) Ground surface elevation is approximately 1151.4 m.
3) Fill and native grade interface elevation is approximately 1137.7 m.

Serial No.: 1178
Date Installed: 98-03-24

EBA File No: 0201-99-14108

Figure A-1
Ground Temperature History
BH 12861-01

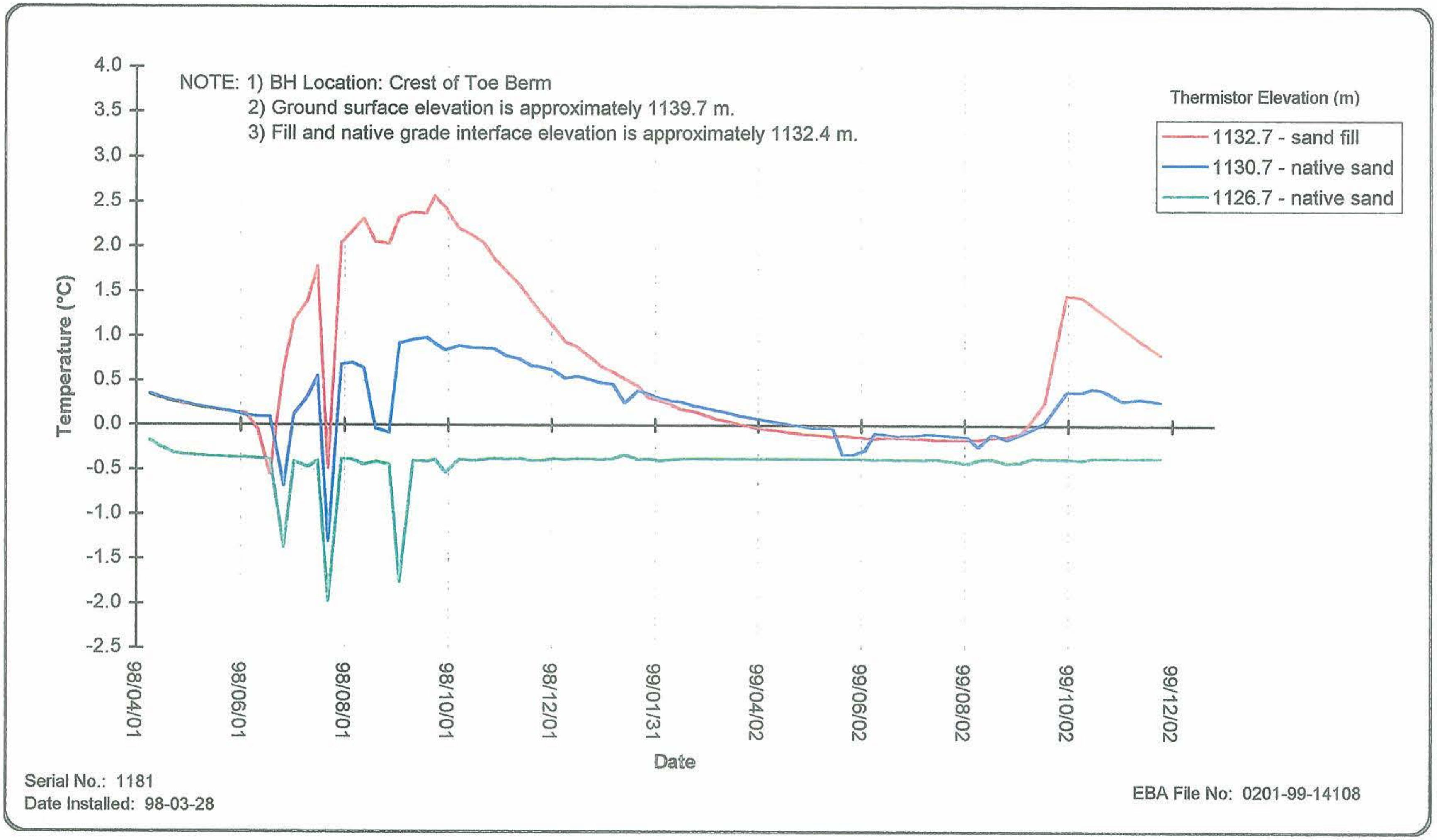
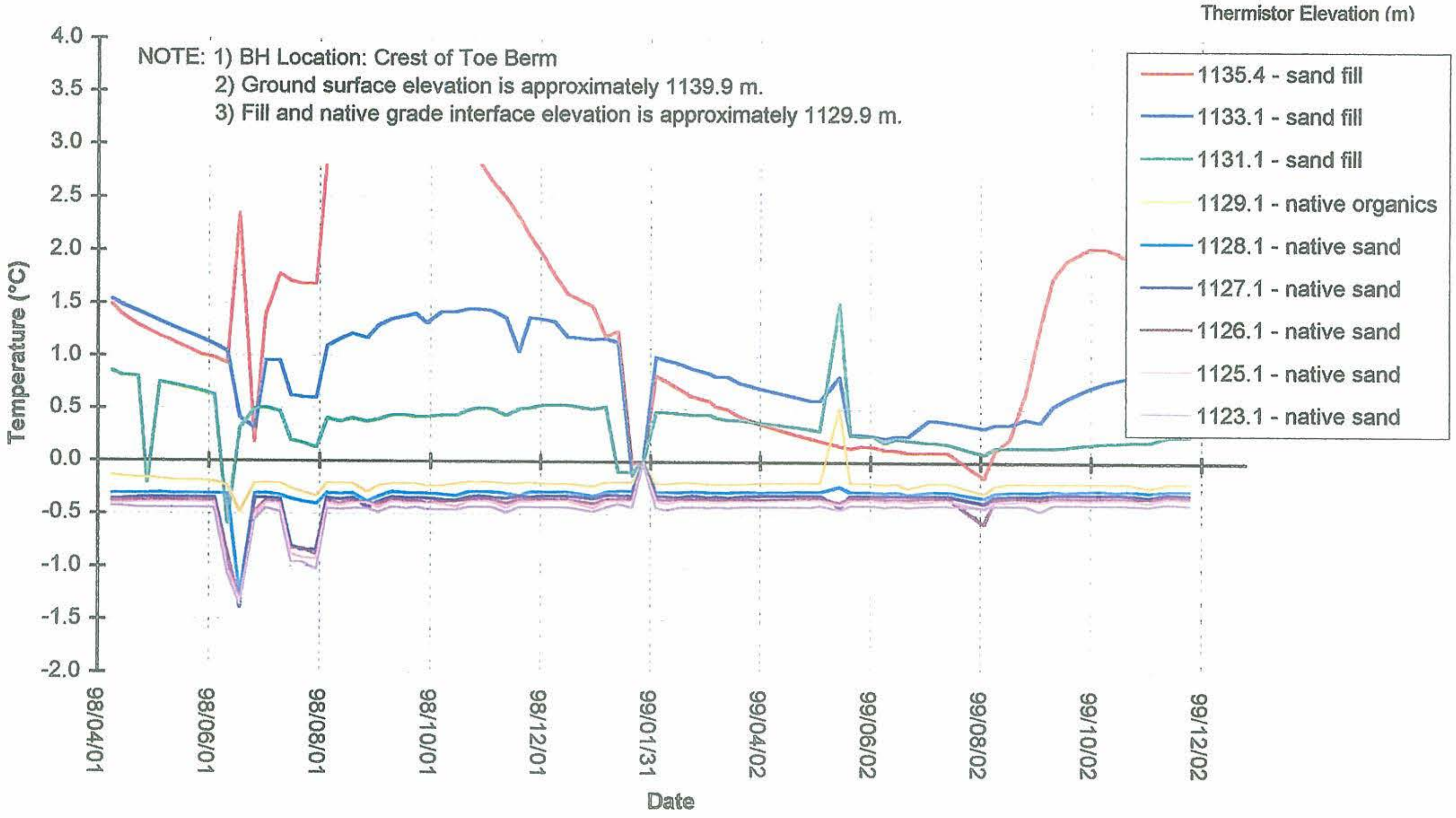


Figure A-4
Ground Temperature History
BH 12861-05

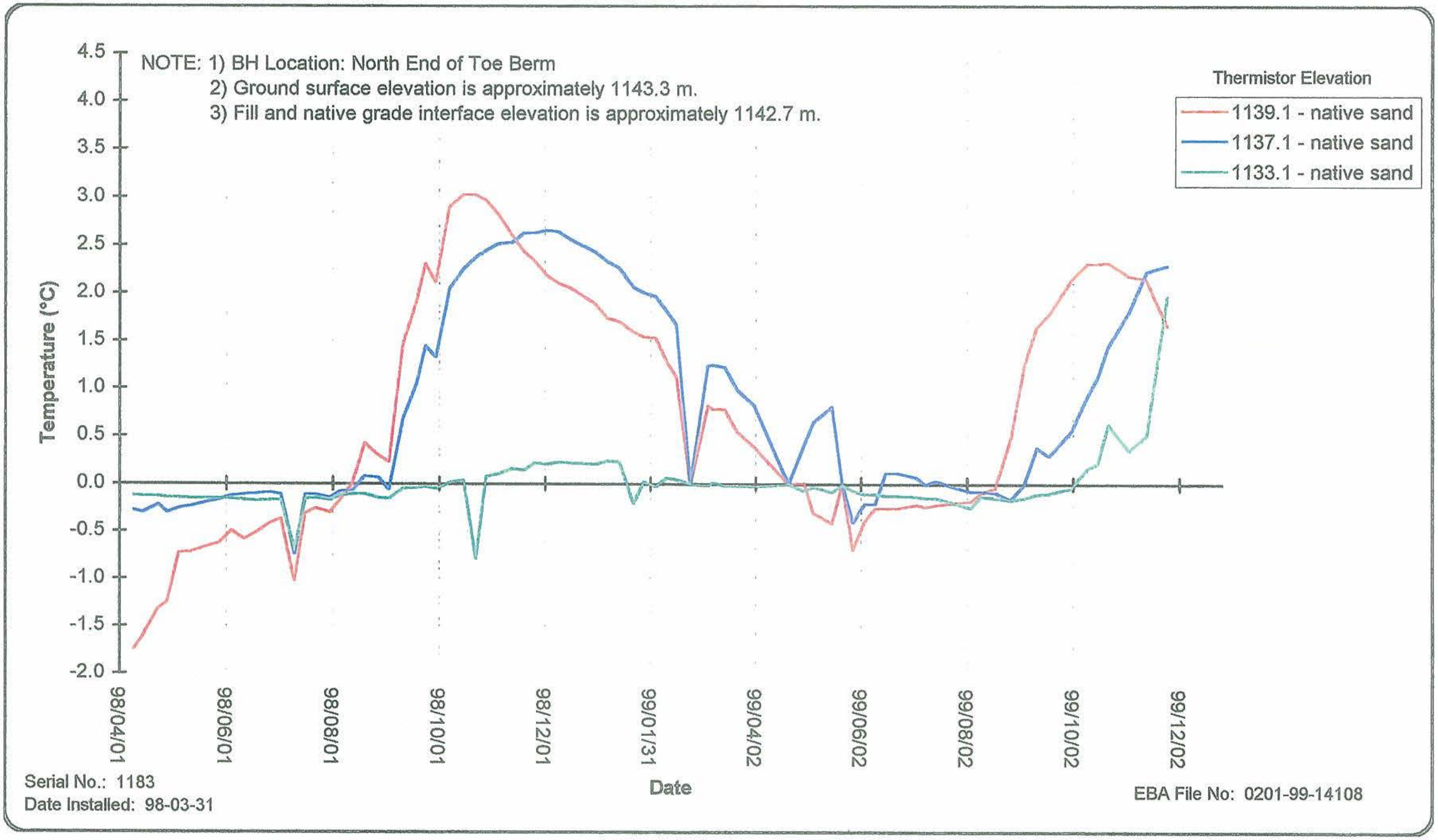


NOTE: 1) BH Location: Crest of Toe Berm
2) Ground surface elevation is approximately 1139.9 m.
3) Fill and native grade interface elevation is approximately 1129.9 m.

Serial No.: 1182
Date Installed: 98-03-30

EBA File No: 0201-99-14108

Figure A-5
Ground Temperature History
BH 12861-06

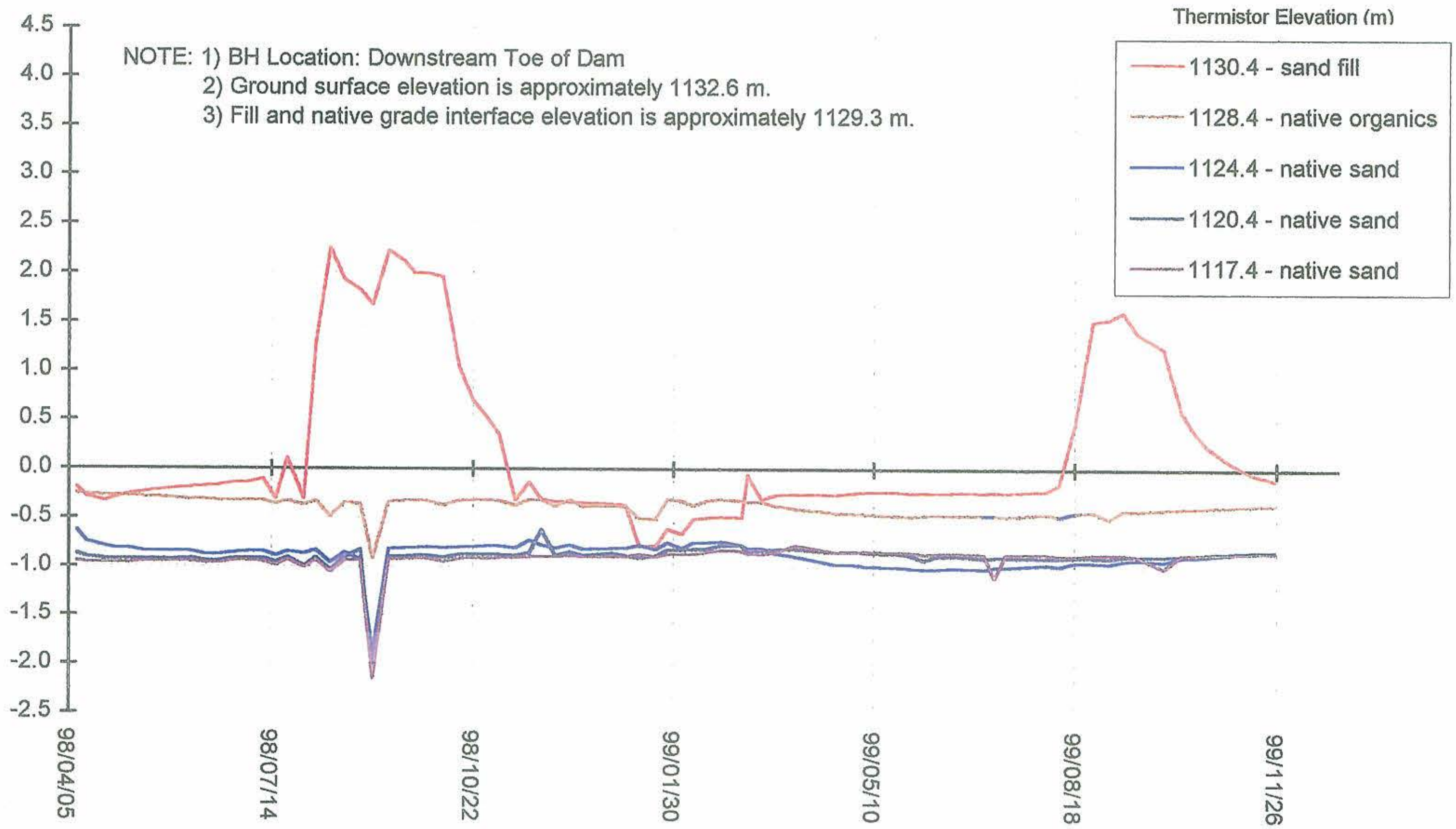


NOTE: 1) BH Location: North End of Toe Berm
2) Ground surface elevation is approximately 1143.3 m.
3) Fill and native grade interface elevation is approximately 1142.7 m.

Serial No.: 1183
Date Installed: 98-03-31

EBA File No: 0201-99-14108

Figure A-6
Ground Temperature History
BH 12861-07

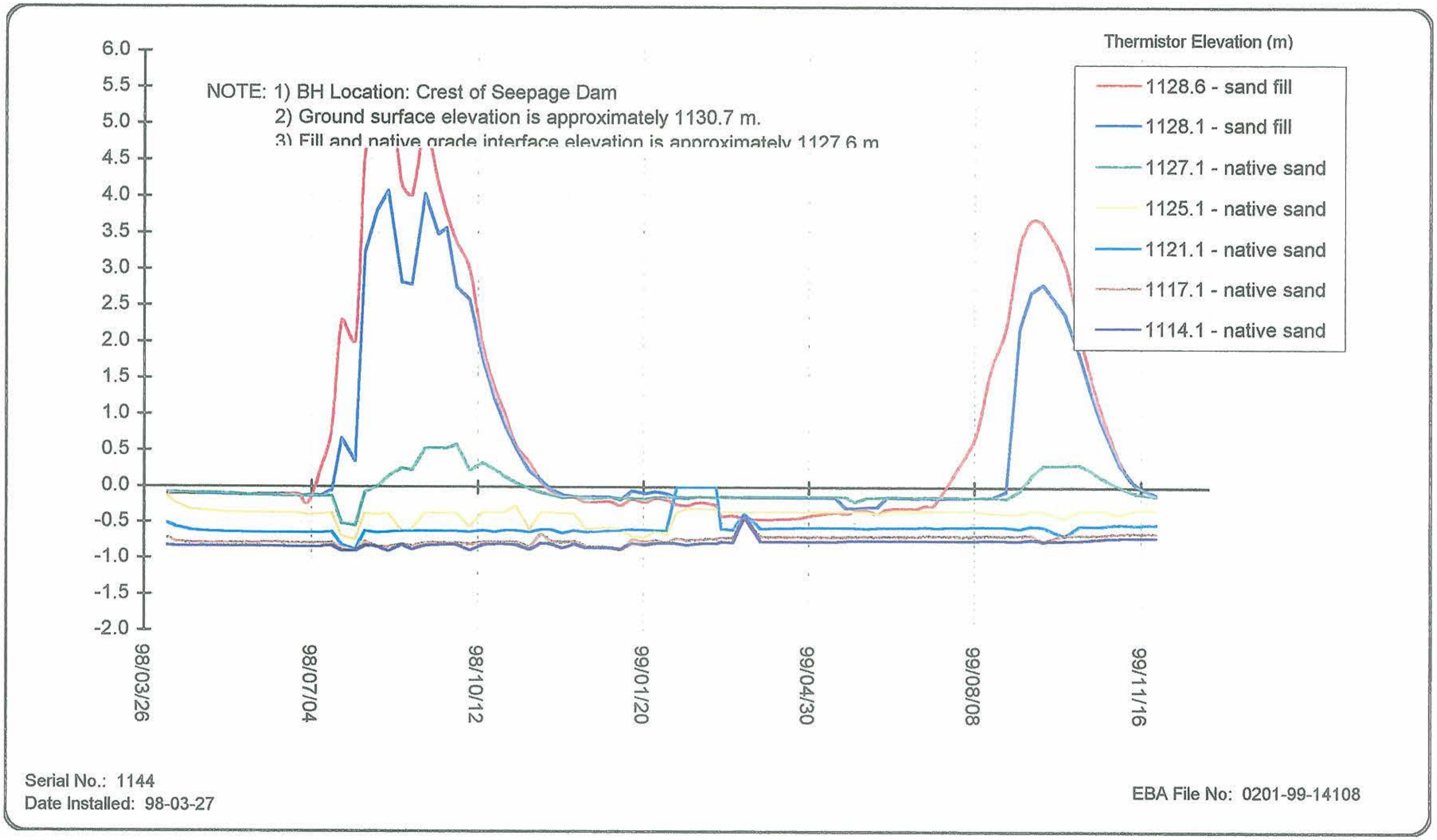


NOTE: 1) BH Location: Downstream Toe of Dam
2) Ground surface elevation is approximately 1132.6 m.
3) Fill and native grade interface elevation is approximately 1129.3 m.

Serial No.: 1143
Date Installed: 98-03-30

EBA File No: 0201-99-14108

Figure A-7
Ground Temperature History
BH 12861-08

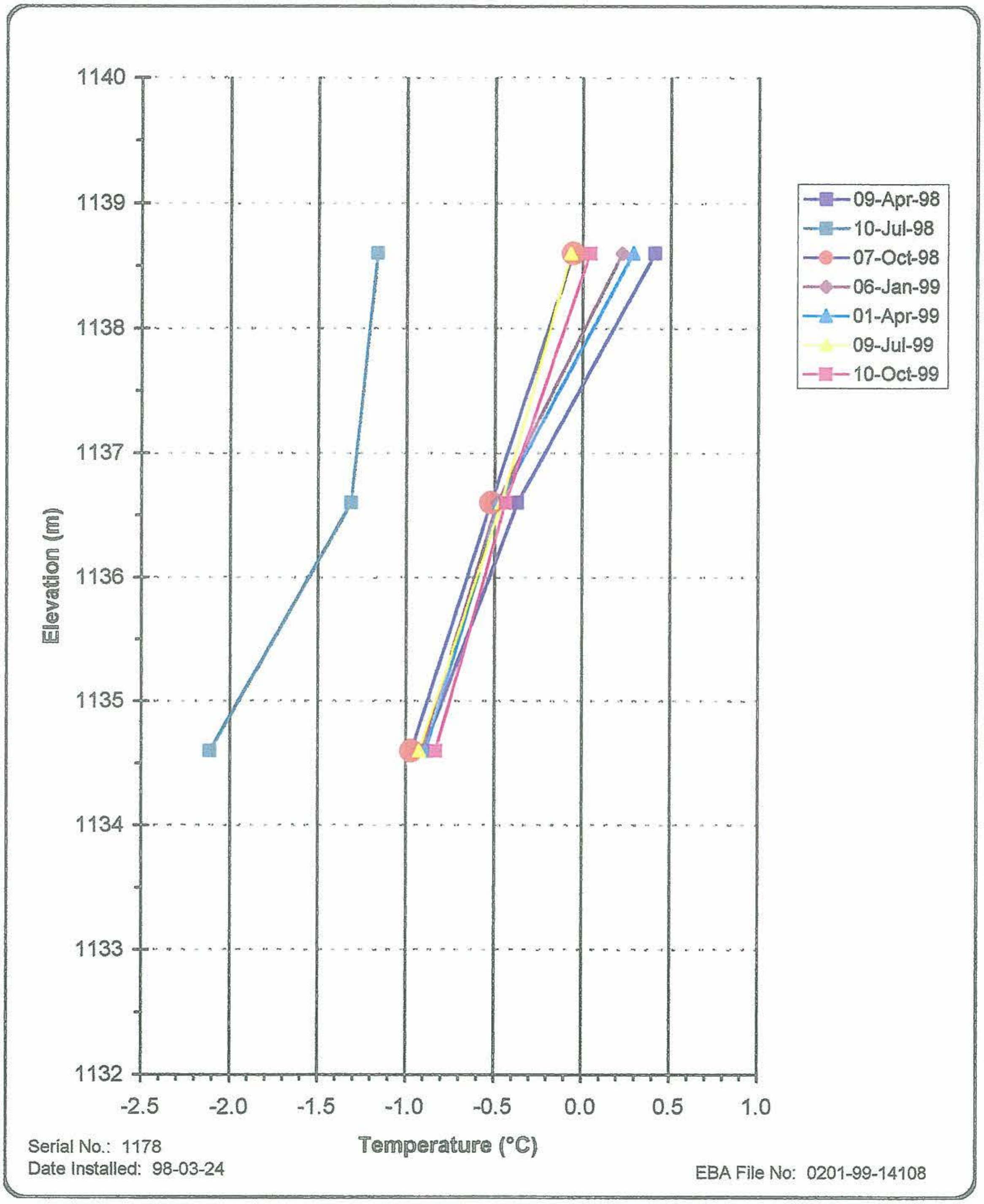


NOTE: 1) BH Location: Crest of Seepage Dam
2) Ground surface elevation is approximately 1130.7 m.
3) Fill and native grade interface elevation is approximately 1127.6 m

Serial No.: 1144
Date Installed: 98-03-27

EBA File No: 0201-99-14108

Figure A-8
Ground Temperature History
BH 12861-10



Serial No.: 1178
Date Installed: 98-03-24

EBA File No: 0201-99-14108

Figure A-1P
Ground Temperature Profile
BH 12861-01

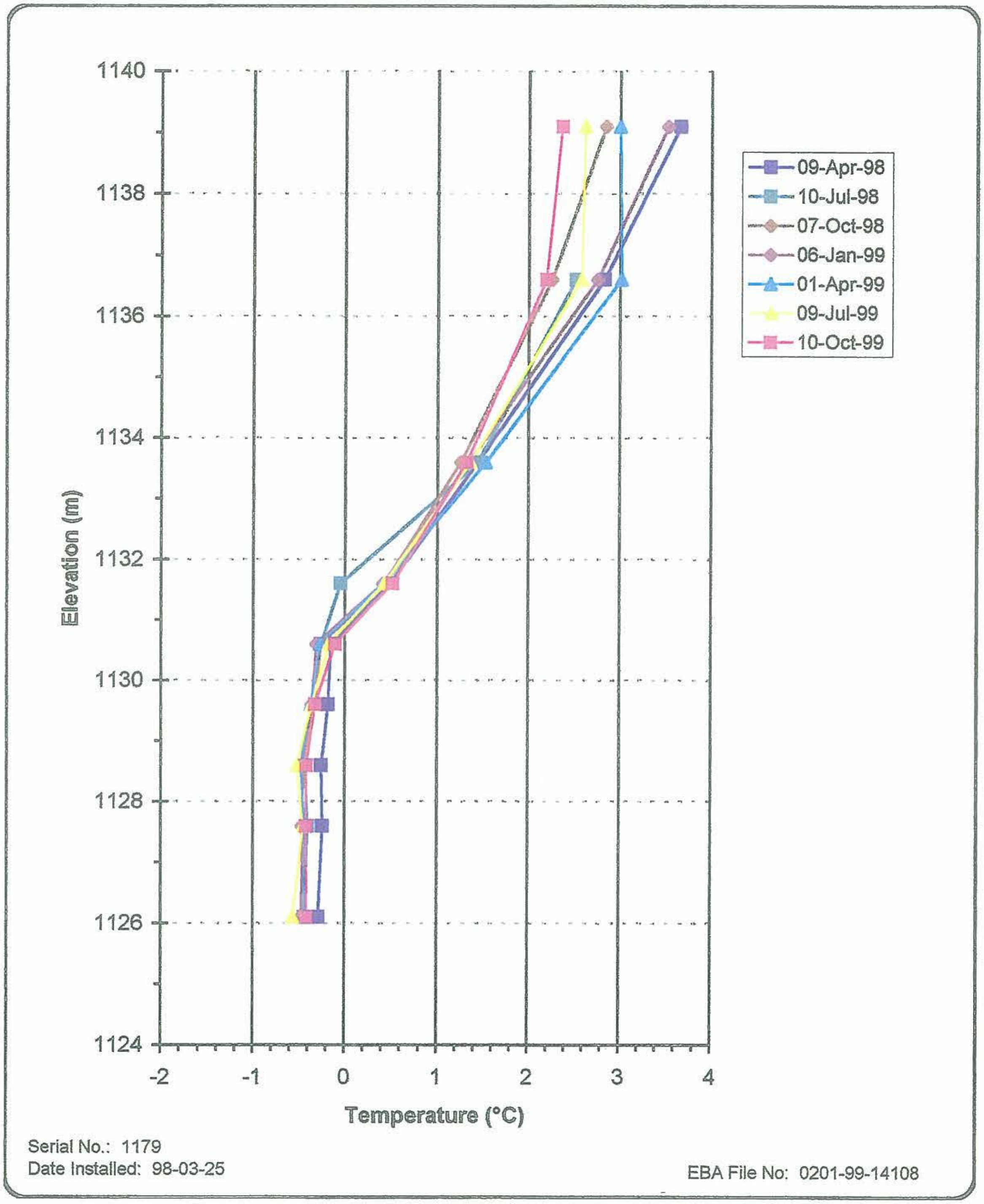
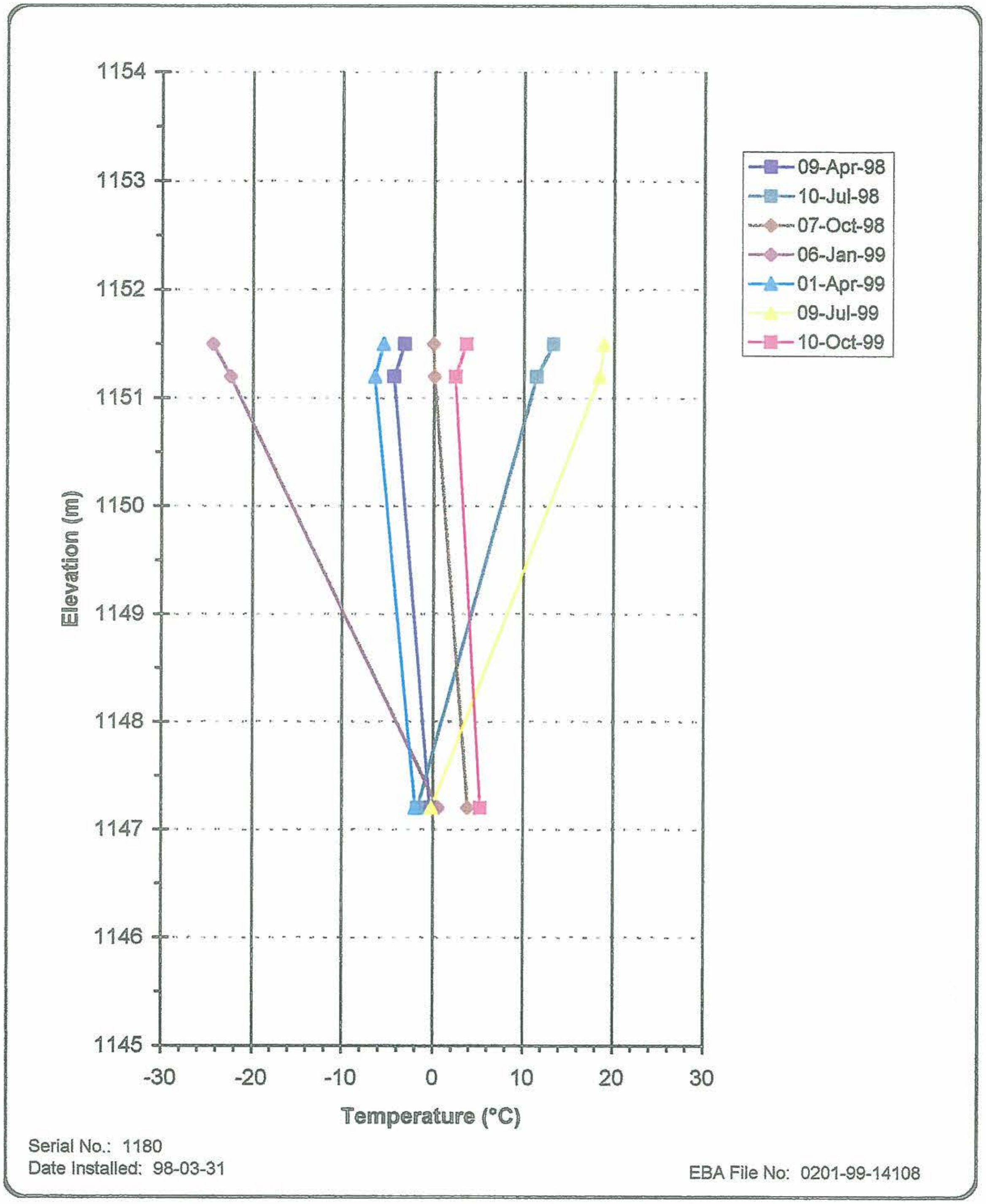


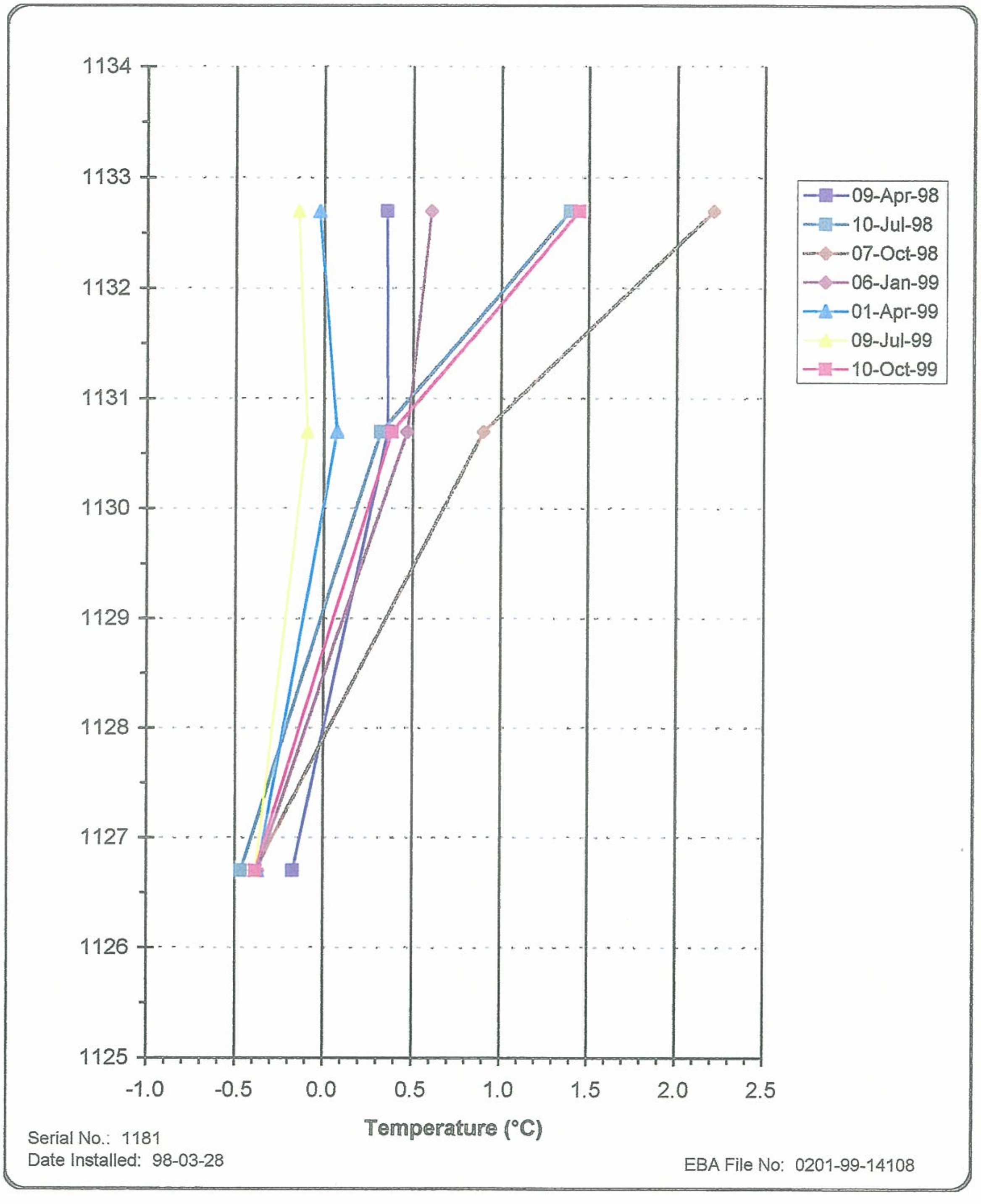
Figure A-2P
Ground Temperature Profile
BH 12861-02



Serial No.: 1180
Date Installed: 98-03-31

EBA File No: 0201-99-14108

Figure A-3P
Ground Temperature Profile
BH 12861-03



Serial No.: 1181
Date Installed: 98-03-28

EBA File No: 0201-99-14108

Figure A-4P
Ground Temperature Profile
BH 12861-05

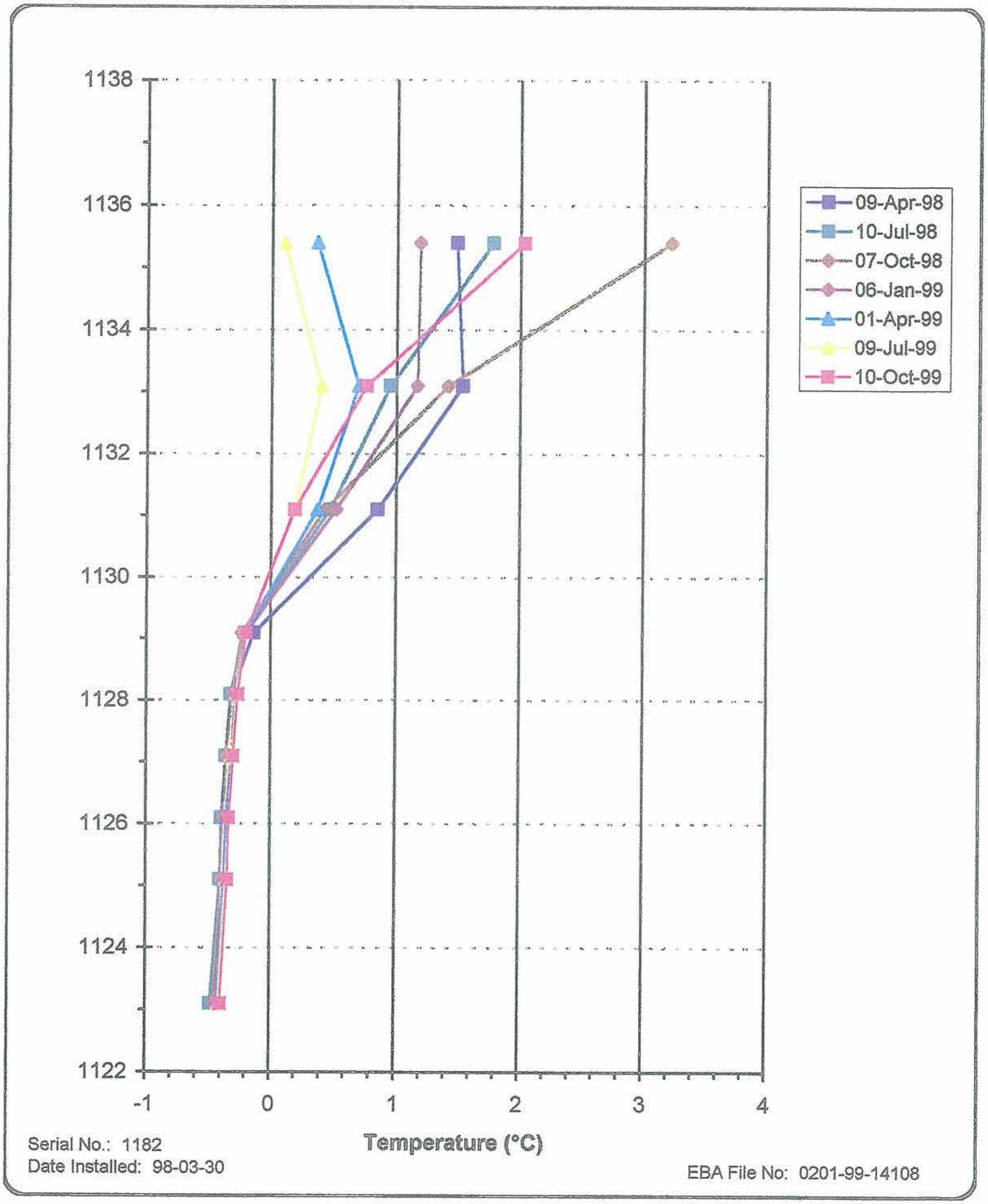
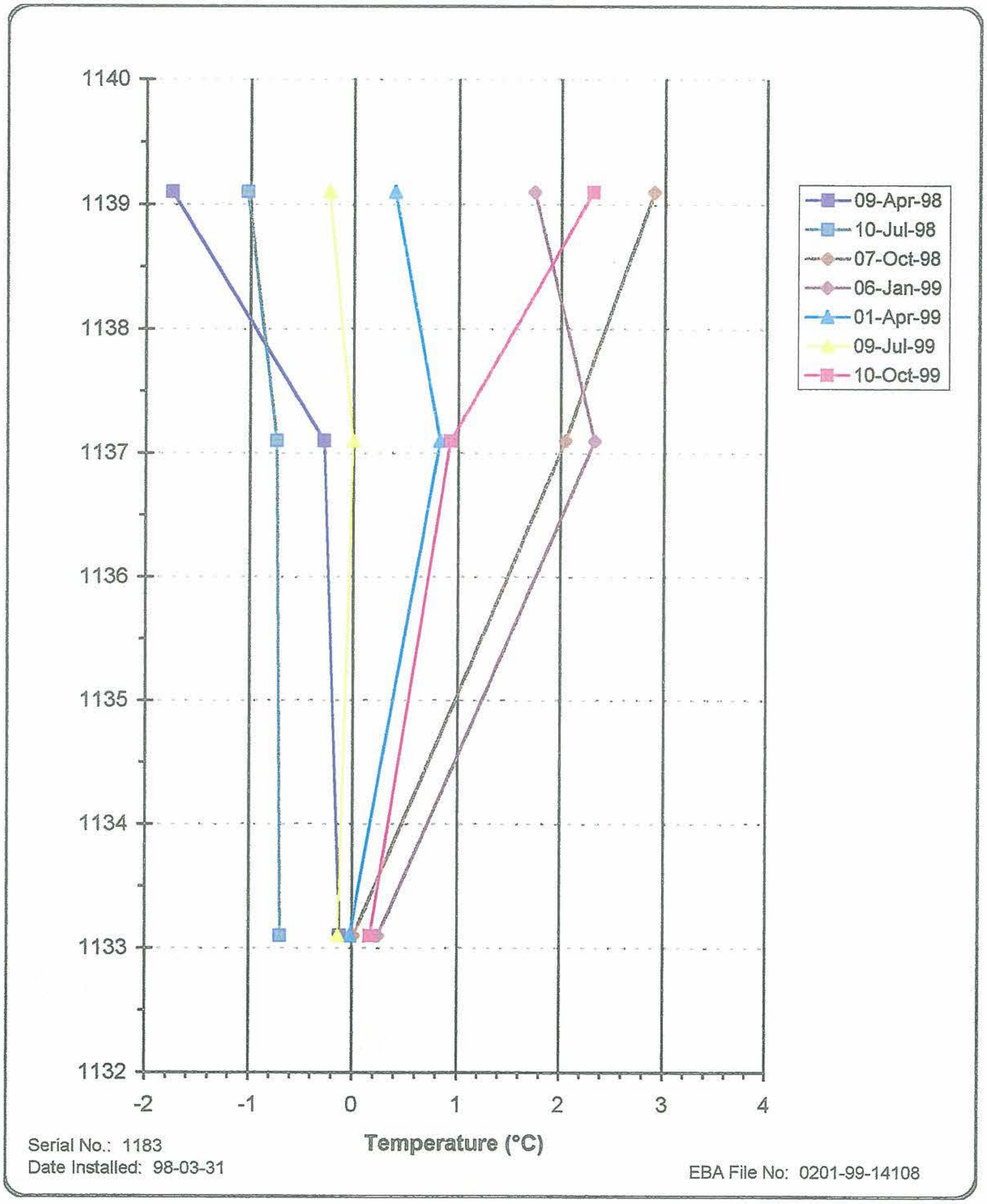


Figure A-5P
Ground Temperature Profile
BH 12861-06



Serial No.: 1183
Date Installed: 98-03-31

EBA File No: 0201-99-14108

Figure A-6P
Ground Temperature Profile
BH 12861-07

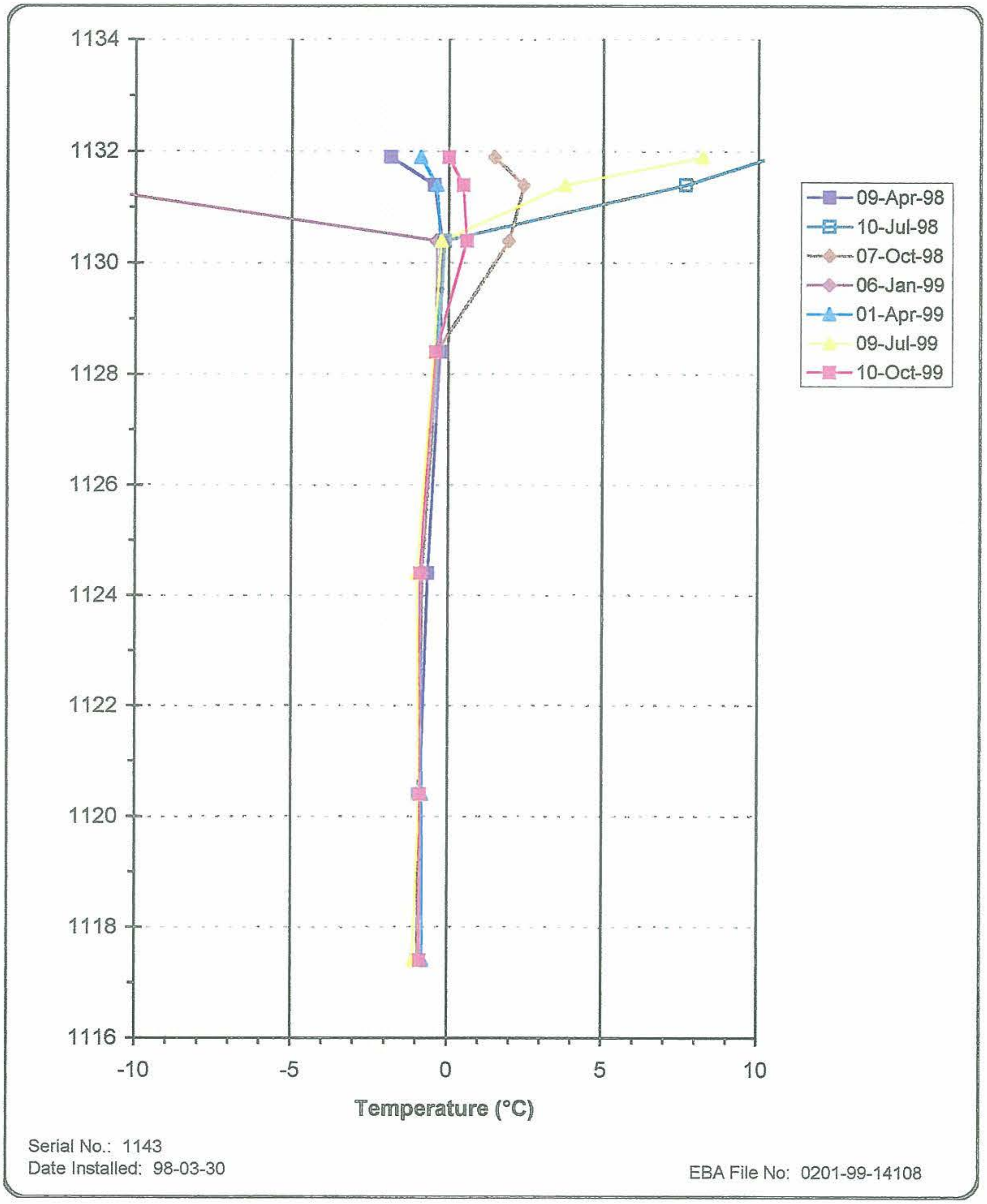


Figure A-7P
Ground Temperature Profile
BH 12861-08

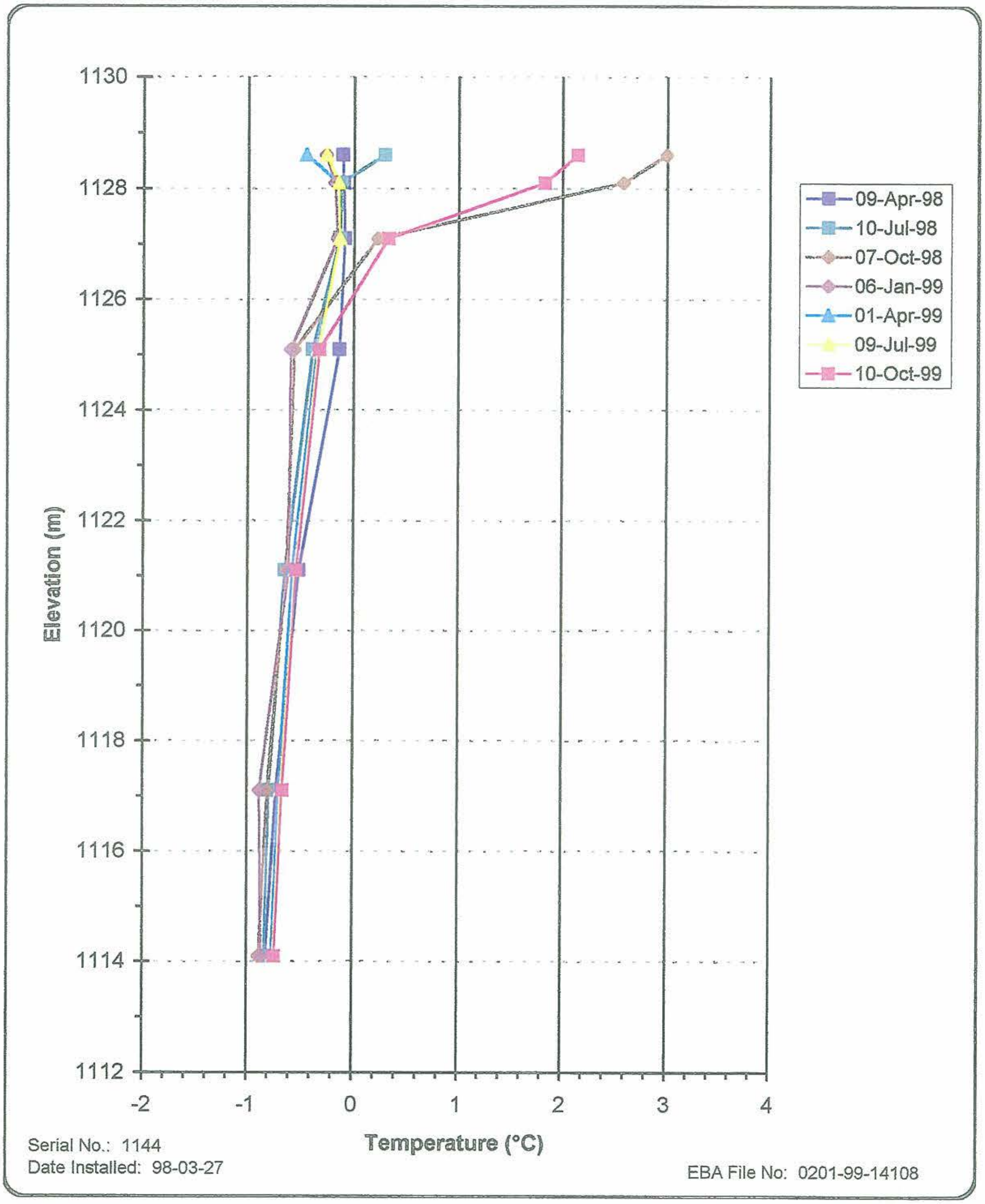
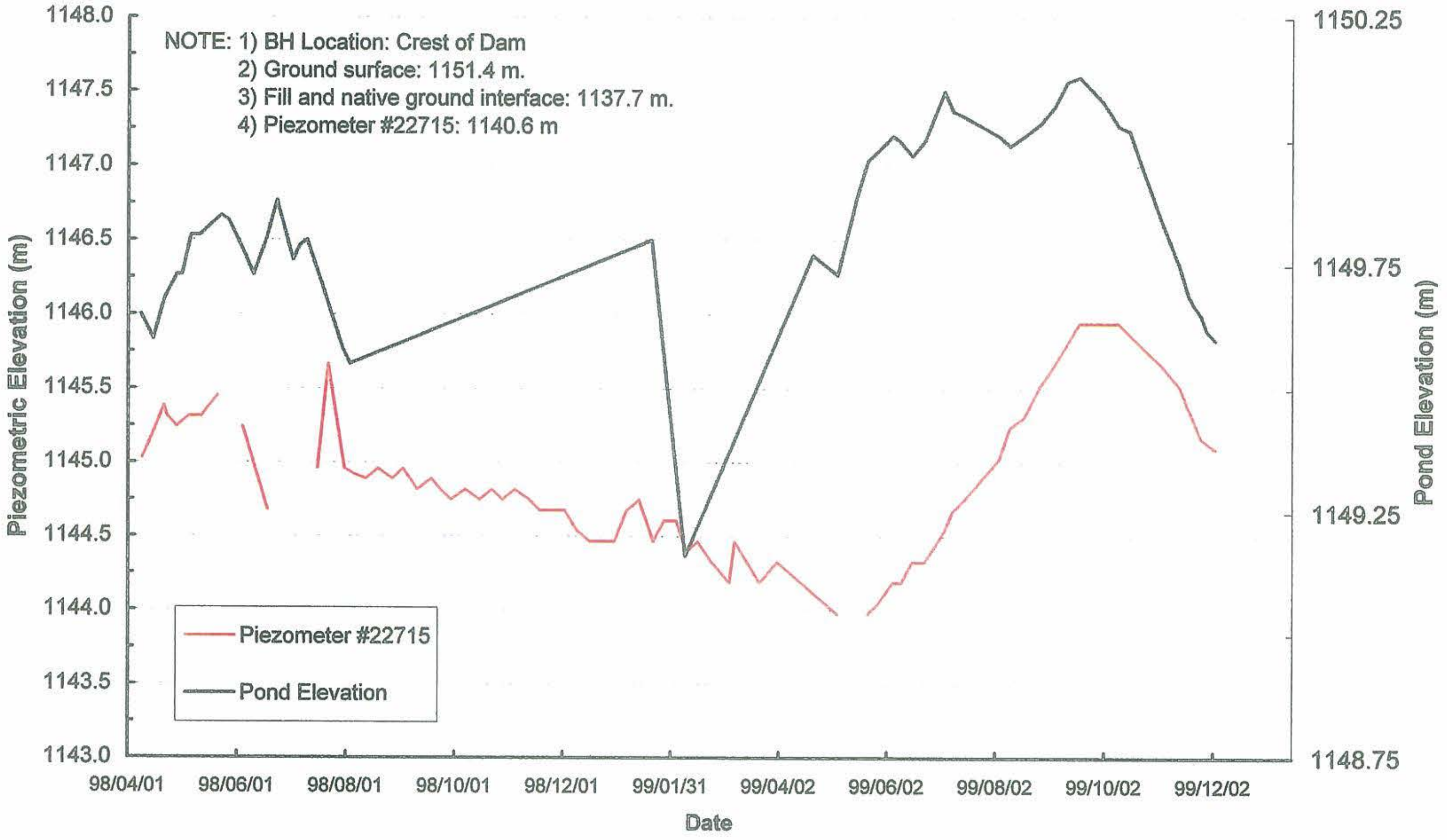


Figure A-8P
Ground Temperature Profile
BH 12861-10



NOTE: 1) BH Location: Crest of Dam
2) Ground surface: 1151.4 m.
3) Fill and native ground interface: 1137.7 m.
4) Piezometer #22715: 1140.6 m

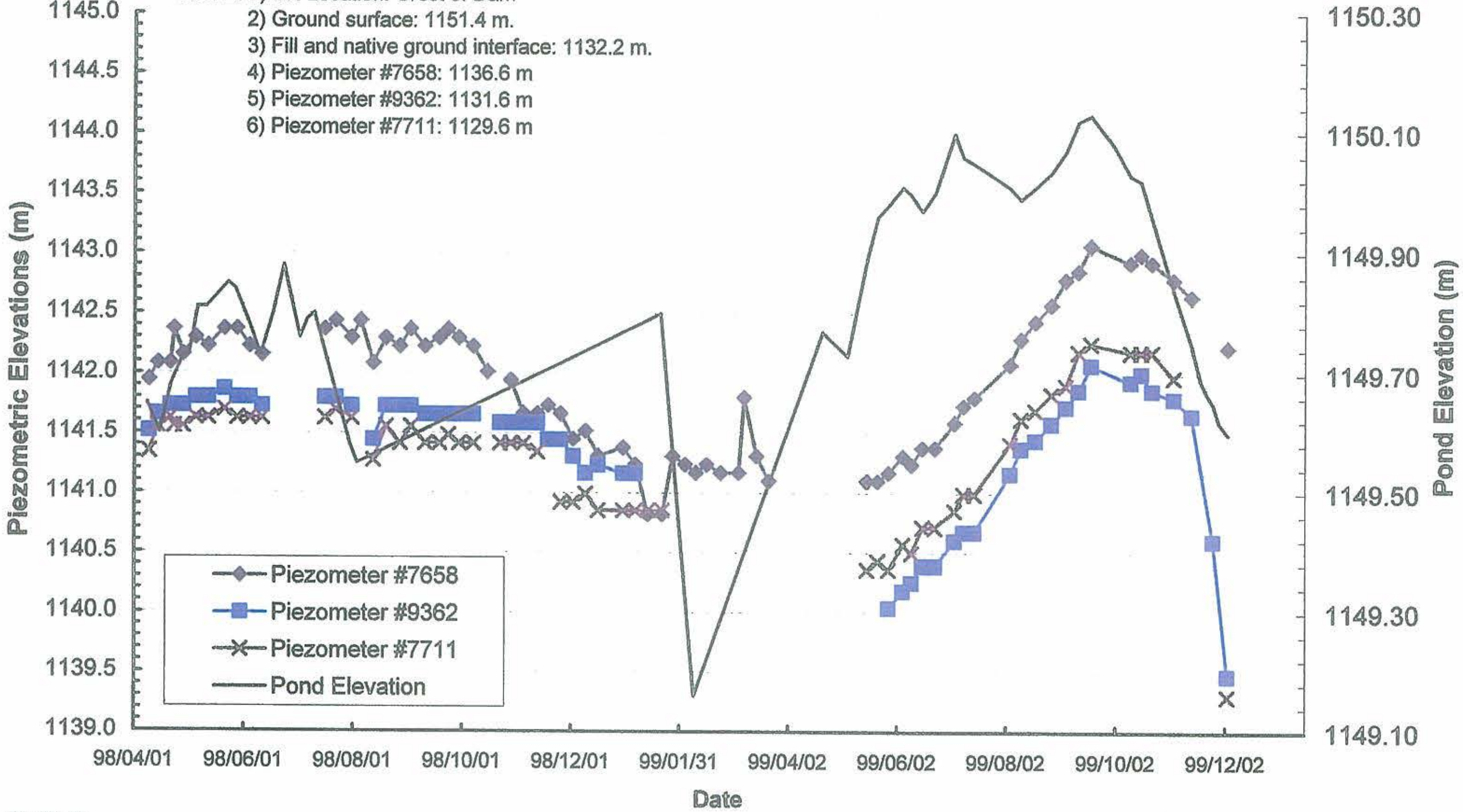
Date Installed: 98-03-24

EBA File No: 0201-99-14108

Figure B-1
Piezometric Elevations
BH 12861-01

Mt. Nansen - Tailings Dam
Piezometric Elevations

NOTE: 1) BH Location: Crest of Dam
2) Ground surface: 1151.4 m.
3) Fill and native ground interface: 1132.2 m.
4) Piezometer #7658: 1136.6 m
5) Piezometer #9362: 1131.6 m
6) Piezometer #7711: 1129.6 m



Date Installed: 98-03-25

EBA File No: 0201-99-14108

Figure B-2
Piezometric Elevations
BH 12861-02

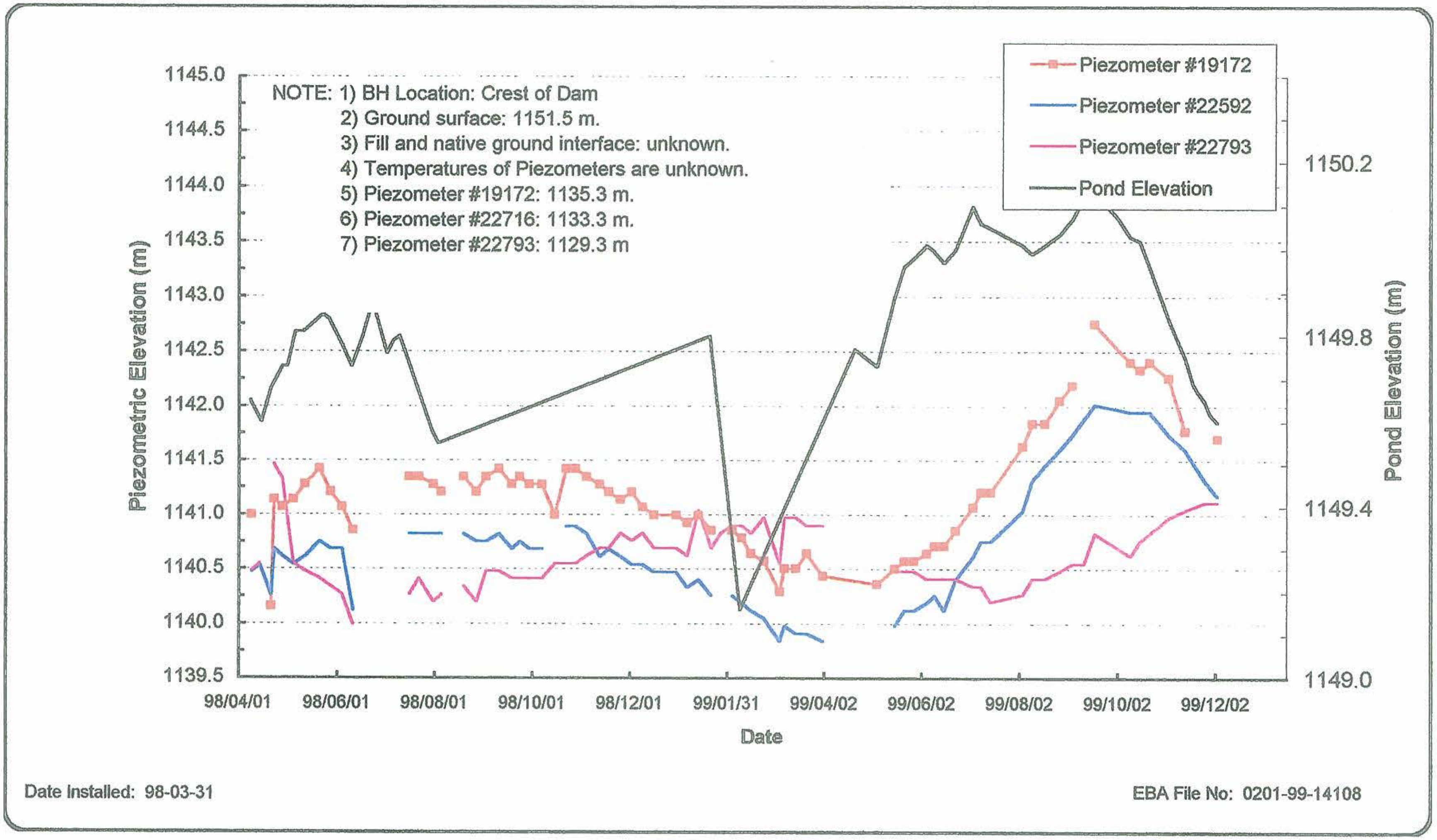
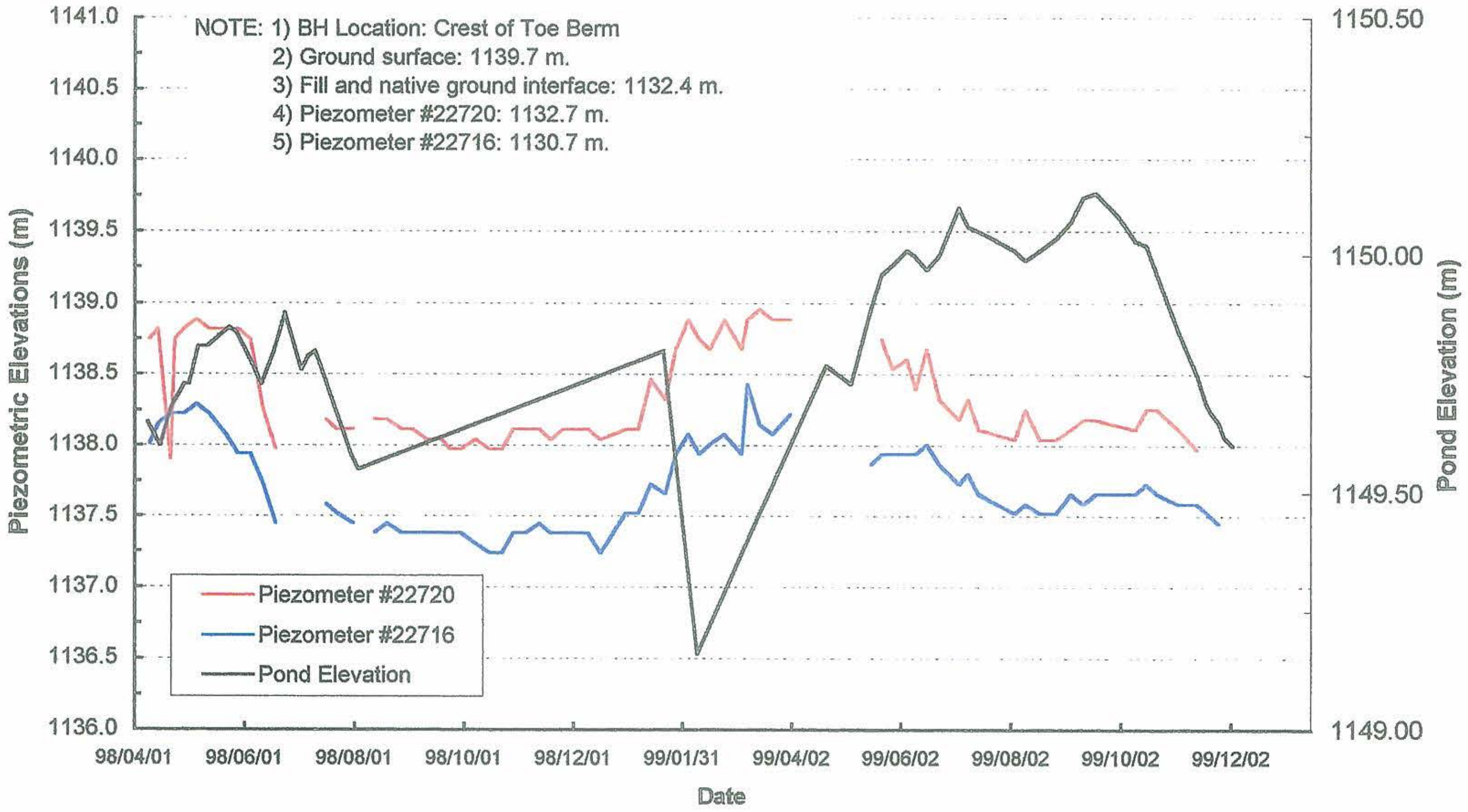


Figure B-3
Piezometric Elevations
BH 12861-03



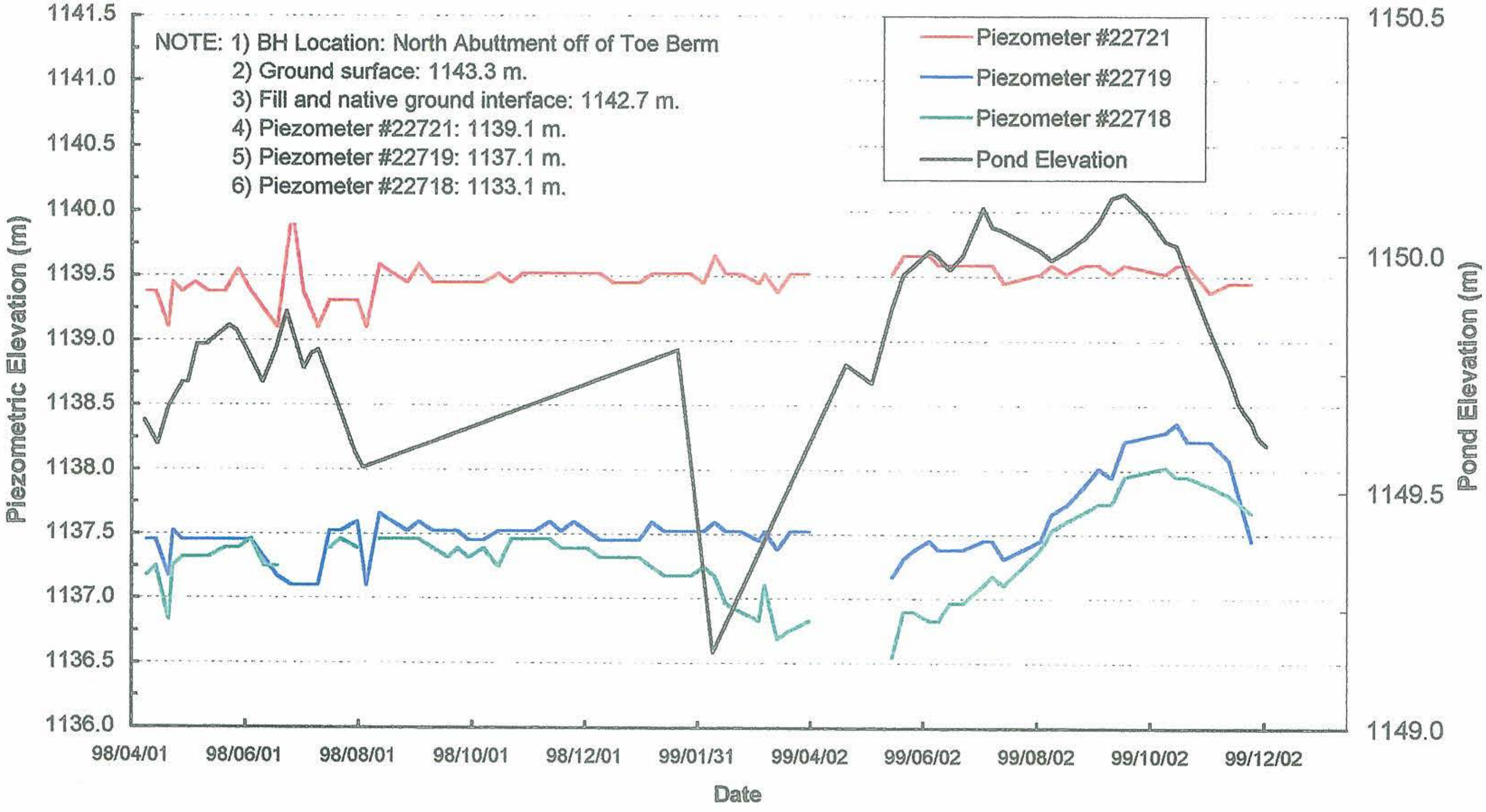
Date Installed: 98-03-28

EBA File No: 0201-99-14108

Figure B-4

Piezometric Elevations

BH 12861-05



NOTE: 1) BH Location: North Abuttment off of Toe Berm
2) Ground surface: 1143.3 m.
3) Fill and native ground interface: 1142.7 m.
4) Piezometer #22721: 1139.1 m.
5) Piezometer #22719: 1137.1 m.
6) Piezometer #22718: 1133.1 m.

Date Installed: 98-03-31

EBA File No: 0201-99-14108

Figure B-5
Piezometric Elevations
BH 12861-07

eba

Appendix A: General Conditions

EBA Engineering Consultants Ltd. (EBA)
GEOTECHNICAL REPORT - GENERAL CONDITIONS

This report incorporates and is subject to these "General Conditions"

A.1 USE OF REPORT AND OWNERSHIP

This geotechnical report pertains to a specific site, a specific development, and a specific scope of work. It is not applicable to any other sites nor should it be relied upon for types of development other than that to which it refers. Any variation from the site or development would necessitate a supplementary geotechnical assessment.

This report and the recommendations contained in it are intended for the sole use of EBA's client. EBA does not accept any responsibility for the accuracy of any of the data, the analyses or the recommendations contained or referenced in the report when the report is used or relied upon by any party other than EBA's client unless otherwise authorized in writing by EBA. Any unauthorized use of the report is at the sole risk of the user.

This report is subject to copyright and shall not be reproduced either wholly or in part without the prior, written permission of EBA. Additional copies of the report, if required, may be obtained upon request.

A.2 NATURE AND EXACTNESS OF SOIL AND ROCK DESCRIPTIONS

Classification and identification of soils and rocks are based upon commonly accepted systems and methods employed in professional geotechnical practice. This report contains descriptions of the systems and methods used. Where deviations from the system or method prevail, they are specifically mentioned.

Classification and identification of geological units are judgmental in nature as to both type and condition. EBA does not warrant conditions represented herein as exact, but infers accuracy only to the extent that is common in practice.

Where subsurface conditions encountered during development are different from those described in this report, qualified geotechnical personnel should revisit the site and review recommendations in light of the actual conditions encountered.

A.3 LOGS OF TEST HOLES

The test hole logs are a compilation of conditions and classification of soils and rocks as obtained from field observations and laboratory testing of selected samples. Soil and rock zones have been interpreted. Change from one geological zone to the other, indicated on the logs as a distinct line, can be, in fact, transitional. The extent of transition is interpretive. Any circumstance which requires precise definition of soil or rock zone transition elevations may require further investigation and review.

A.4 STRATIGRAPHIC AND GEOLOGICAL INFORMATION

The stratigraphic and geological information indicated on drawings contained in this report are inferred from logs of test holes and/or soil/rock exposures. Stratigraphy is known only at the locations of the test hole or exposure. Actual geology and stratigraphy between test holes and/or exposures may vary from that shown on these drawings. Natural variations in geological conditions are inherent and are a function of the historic environment. EBA does not represent the conditions illustrated as exact but recognizes that variations will exist. Where knowledge of more precise locations of geological units is necessary, additional investigation and review may be necessary.

A.5 SURFACE WATER AND GROUNDWATER CONDITIONS

Surface and groundwater conditions mentioned in this report are those observed at the times recorded in the report. These conditions vary with geological detail between observation sites; annual, seasonal and special meteorologic conditions; and with development activity. Interpretation of water conditions from observations and records is judgmental and constitutes an evaluation of circumstances as influenced by geology, meteorology and development activity. Deviations from these observations may occur during the course of development activities.

A.6 PROTECTION OF EXPOSED GROUND

Excavation and construction operations expose geological materials to climatic elements (freeze/thaw, wet/dry) and/or mechanical disturbance which can cause severe deterioration. Unless otherwise specifically indicated in this report, the walls and floors of excavations must be protected from the elements, particularly moisture, desiccation, frost action and construction traffic.

Appendix B: 1998 Installation Report

EBA Engineering Consultants Ltd.

April 24, 1998

B.Y.G. Natural Resources Inc.
General Delivery
Carmacks, YT
Y0B 1C0

EBA File No. 0201-97-12861

Attention: Mr. Graham Dickson
President

Dear Sir:

Subject: Instrumentation Installation
Mount Nansen Mine
North West of Carmacks

1.0 INTRODUCTION

EBA Engineering Consultants Ltd. (EBA) was retained by BYG Natural Resources Inc. (BYG) to install thermistor and piezometer instrumentation in Dams 1 & 2 at the Mt. Nansen Mine as well as in the north abutment/natural terrace between the two dams.

The locations of all boreholes were predetermined prior to drilling, as were the depths of the thermistors and piezometers installed. This allowed EBA to order instruments with appropriate lead lengths for each of the borehole locations. Upon notification of mobilization, BYG survey personnel staked each borehole location.

The following sections present a summary of work completed and conditions noted during the instrumentation installation program.

Authorization to proceed was received from Mr. Pascal Renardet on February 28, 1998.

Table 1
INSTRUMENTATION DETAILS

BH, Location & Collar Elevation	Thermistor Cable No./ Bead Elevation	Piezometer No. / Elevation
BH 12861-01	Cable # 1178	
Top Of Dam # 1	1 / 1138.6 m	# 22715 / 1140.6 m
el. 1151.4 m	2 / 1136.6 m	# 22713 / 1136.6 m
	3 / 1134.6 m	# 9377 / 1134.6 m
BH 12861-02	Cable # 1179	
Top Of Dam # 1	1 / 1139.1 m	
el. 1151.4 m	2 / 1136.6 m	# 7658 / 1136.6 m
	3 / 1133.6 m	
	4 / 1131.6 m	# 9362 / 1131.6 m
	5 / 1130.6 m	
	6 / 1129.6 m	# 7711 / 1129.6 m
	7 / 1128.6 m	
	8 / 1126.1 m	
BH 12861-03	Cable # 1180	
Top Of Dam # 1	1 / 1151.5 m	# 19172 / 1135.3 m
el. 1151.5 m	2 / 1151.2 m	# 22592 / 1133.3 m
	3 / 1147.2 m	# 22793 / 1129.3 m
BH 12861-04	Single Bead # 1	
Bank Above Pond # 2	1 / 1136.6 m	
el. 1147.3 m		
BH 12861-05	Cable # 1181	
Top Of Toe Berm	1 / 1132.7 m	# 22720 / 1132.7 m
el. 1139.7 m	2 / 1130.7 m	# 22716 / 1130.7 m
	3 / 1126.7 m	# 22714 / 1126.7 m
BH 12861-06	Cable # 1182	
Top Of Toe Berm	1 / 1135.4 m	
el. 1139.9 m	2 / 1133.1 m	
	3 / 1131.1 m	
	4 / 1129.1 m	
	5 / 1128.1 m	
	6 / 1127.1 m	
	7 / 1126.1 m	
	8 / 1125.1 m	
	9 / 1123.1 m	
BH 12861-07	Cable # 1183	
North End Of Toe Berm	1 / 1139.1 m	# 22721 / 1139.1 m
el. 1143.3 m	2 / 1137.1 m	# 22719 / 1137.1 m
	3 / 1133.1 m	# 22718 / 1133.1 m
BH 12861-08	Cable # 1143	
Toe Of Dam # 1	1 / 1131.9 m	
el. 1132.6 m	2 / 1131.4 m	
	3 / 1130.4 m	
	4 / 1128.4 m	
	5 / 1124.4 m	
	6 / 1120.4 m	
	7 / 1117.4 m	
BH 12861-09	Single Bead # 2	
Bank Above Pond # 2	1 / 1125.5 m	
el. 1142.3 m		
BH 12861-10	Cable # 1144	
Top Of Dam # 2	1 / 1128.6 m	
el. 1130.7 m	2 / 1128.1 m	
	3 / 1127.1 m	
	4 / 1125.1 m	
	5 / 1121.1 m	
	6 / 1117.1 m	
	7 / 1114.1 m	

The observations made during drilling, and the initial ground temperature readings enclosed, indicate that permafrost levels in the foundation soils beneath the tailings dam have not changed significantly since construction. In fact, some freezeback into the fill appears to have occurred, particularly in Boreholes 12861-01 and -05. Continued monitoring of all the thermistor cables and piezometers (readings to be taken at least monthly) will confirm that this is the case. It should be noted that the temperature readings enclosed may not accurately reflect the long term temperatures beneath the dam, as the readings at depth are still changing.

5.0 CLOSURE

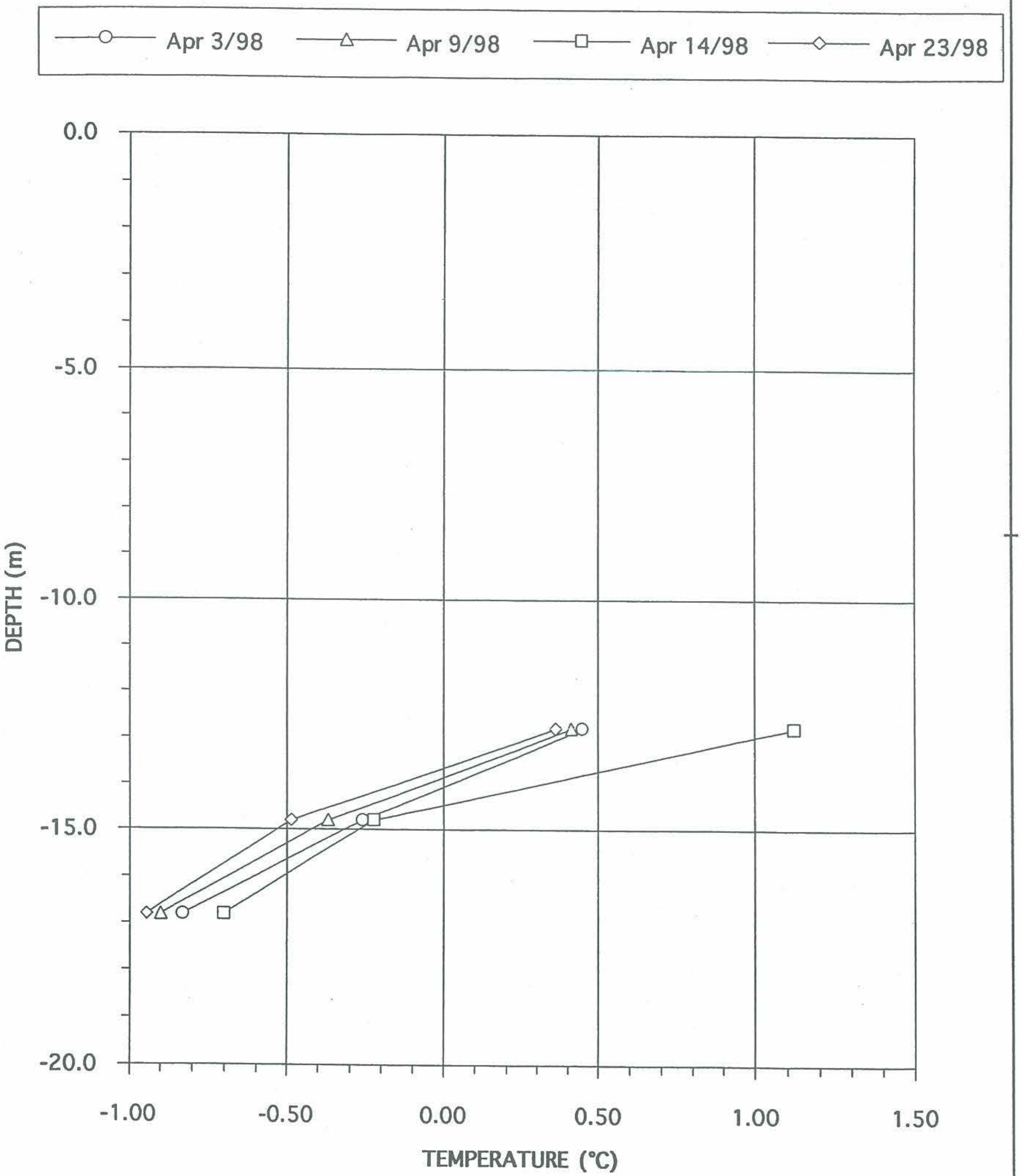
We trust that this report satisfies your present requirements, and we expect to be able to submit piezometer data to you in the near future. Please call if we can be of further assistance.

EBA Engineering Consultants Ltd.

Myles Plaunt, C.E.T.
Engineering Technologist

J. Richard Trimble, P.Eng.
Project Director, Yukon Region

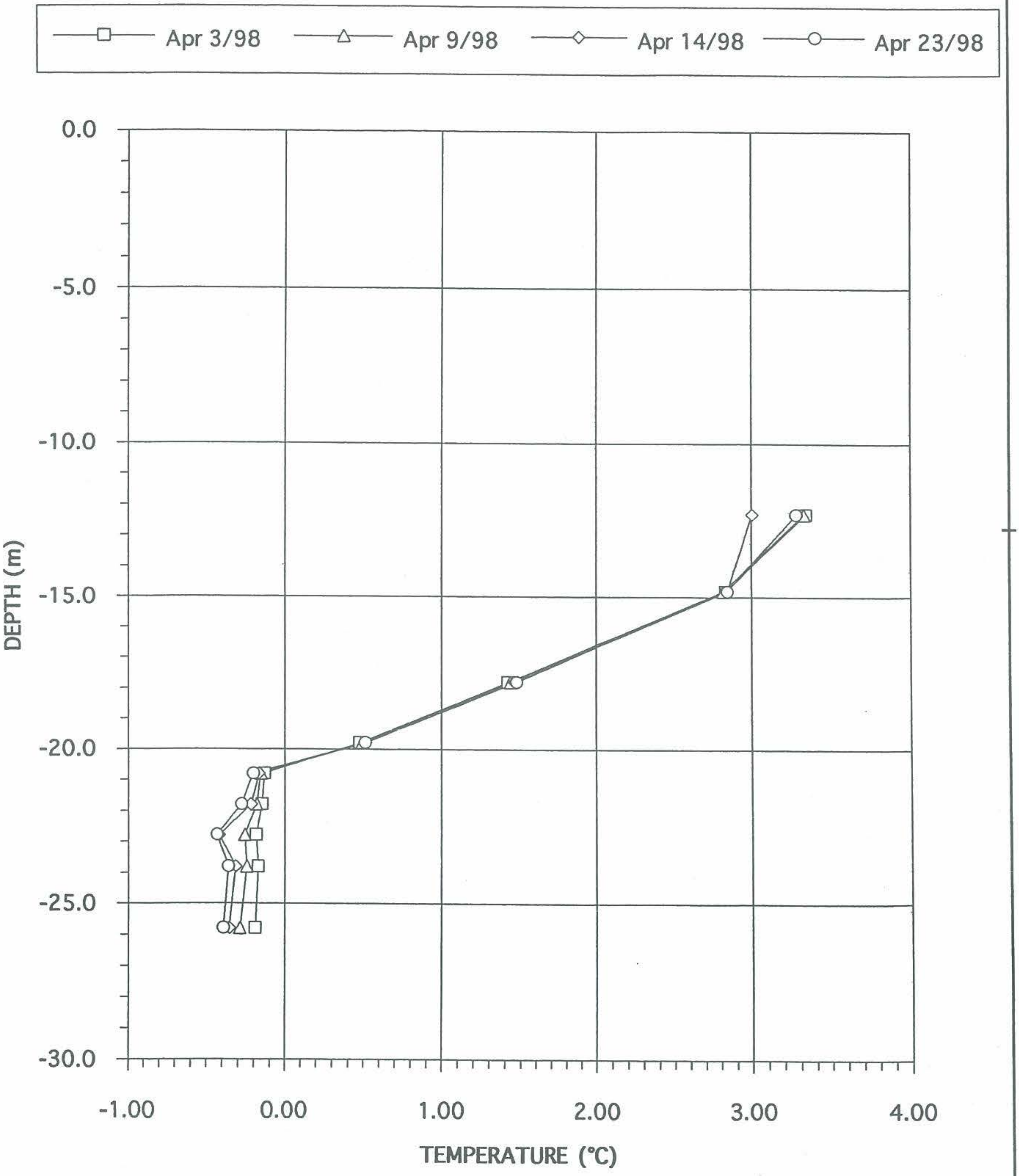
Thermistor No.: 1178
Date Installed: 98-03-24



GROUND TEMPERATURE PROFILE
MT. NANSEN - TAILINGS DAM
BOREHOLE 12861-01 (el. 1151.4)

eba

Thermistor No.: 1179
Date Installed: 98-03-25



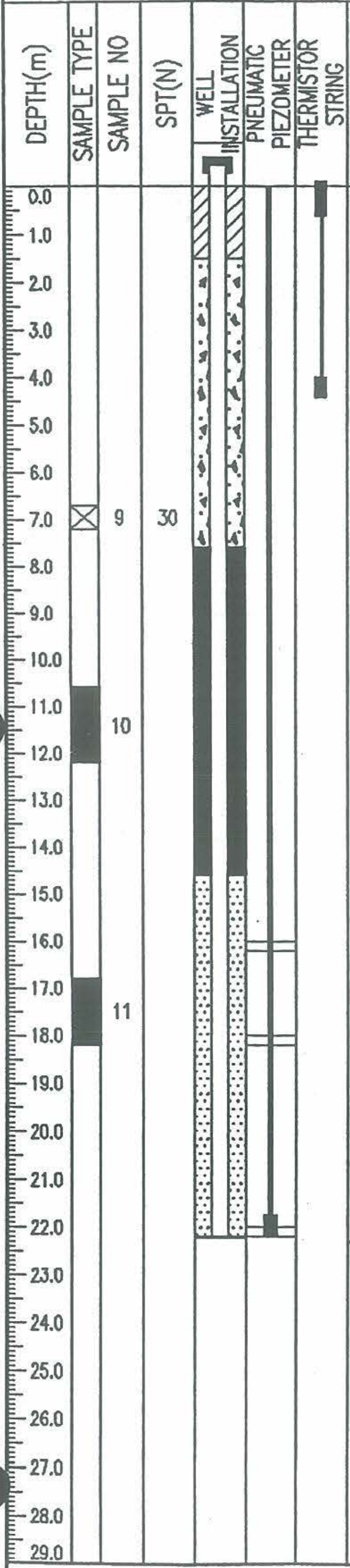
GROUND TEMPERATURE PROFILE
MT. NANSEN - TAILINGS DAM
BOREHOLE 12861-02 (el. 1151.4)

eba

INSTRUMENTATION INSTALLATION	BYG NATURAL RESOURCES	BOREHOLE NO: 12861-03
MT. NANSEN MINE	DRILL: SCHRAMM AIR ROTARY	PROJECT NO: 0201-97-12861
NW OF CARMACKS, YT	UTM ZONE: – N – E –	ELEVATION: 1151.5 m

SAMPLE TYPE ■ GRAB SAMPLE ▨ NO RECOVERY ☒ STANDARD PEN. ☰ 75 mm SPLIT SP. ▥ CRREL BARREL ▮ NW CORE

BACKFILL TYPE ■ BENTONITE ⁝ PEA GRAVEL ▥ SLOUGH ▨ GROUT ▨ DRILL CUTTINGS ⁝ SAND



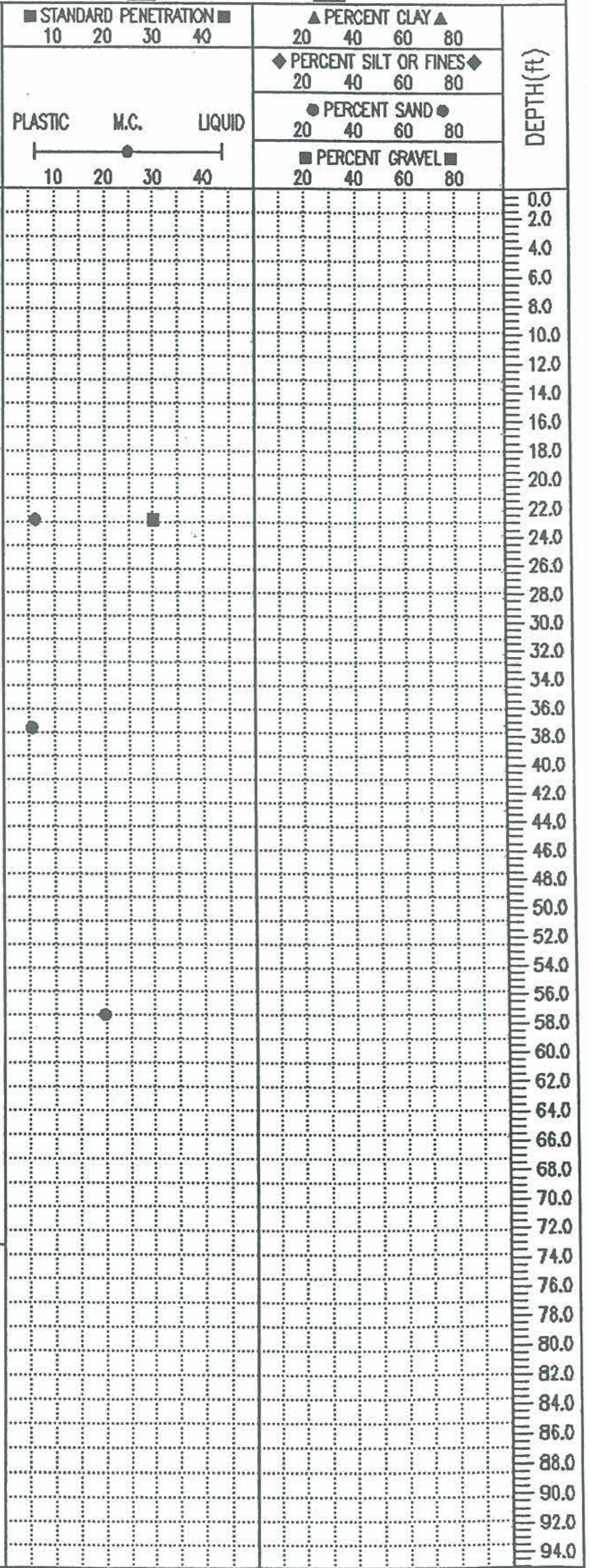
SOIL DESCRIPTION

SAND (FILL) – angular gravel, cobbles and boulders at surface, some silt, medium grained, seasonally frozen, medium brown

– wet to saturated below 10 m, drilling very easy

– frozen (Permafrost) by 18.2 m
– drilling with water below 18.5 m

END OF BOREHOLE @ 22.3 m
MINE COORDINATES
N 18964 E 20550
NOTE: First attempt at BH 3 on March 26/98 was aborted after losing all piezometers while pulling casing During second attempt on March 31/98, the PVC pipe became clogged, thermistor could only be installed to a depth of 4.3 m



EBA Engineering Consultants Ltd. Whitehorse, Yukon	LOGGED BY: MCP	COMPLETION DEPTH: 22.3 m
	REVIEWED BY: JRT	COMPLETE: 98/03/31
	Fig. No:	Page 1 of 1

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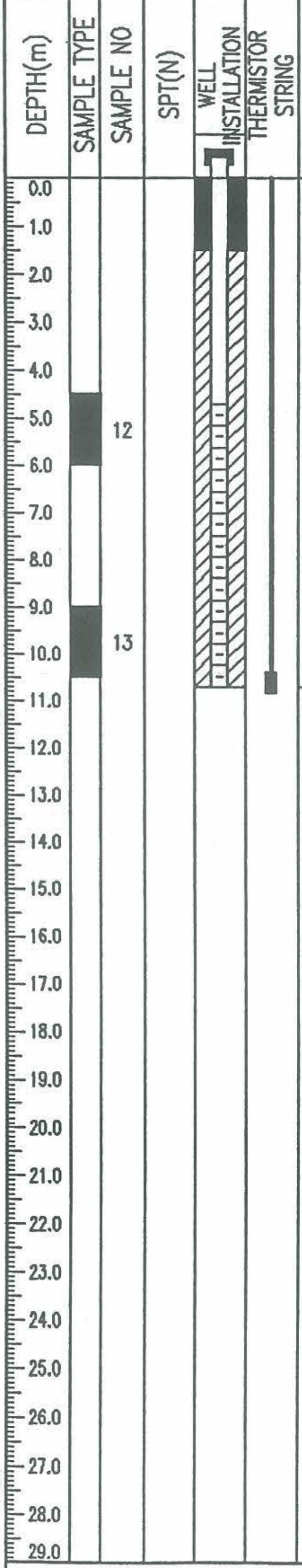
INSTRUMENTATION INSTALLATION	BYG NATURAL RESOURCES	BOREHOLE NO: 12861-04
MT. NANSEN MINE	DRILL: SCHRAMM AIR ROTARY	PROJECT NO: 0201-97-12861
NW OF CARMACKS, YT	UTM ZONE: – N – E –	ELEVATION: 1147.3 m

SAMPLE TYPE ■ GRAB SAMPLE ▨ NO RECOVERY ☒ STANDARD PEN. ▤ 75 mm SPLIT SP. ▥ CRREL BARREL ▮ NW CORE

BACKFILL TYPE ■ BENTONITE ▦ PEA GRAVEL ▥ SLOUGH ▦ GROUT ▨ DRILL CUTTINGS ▦ SAND



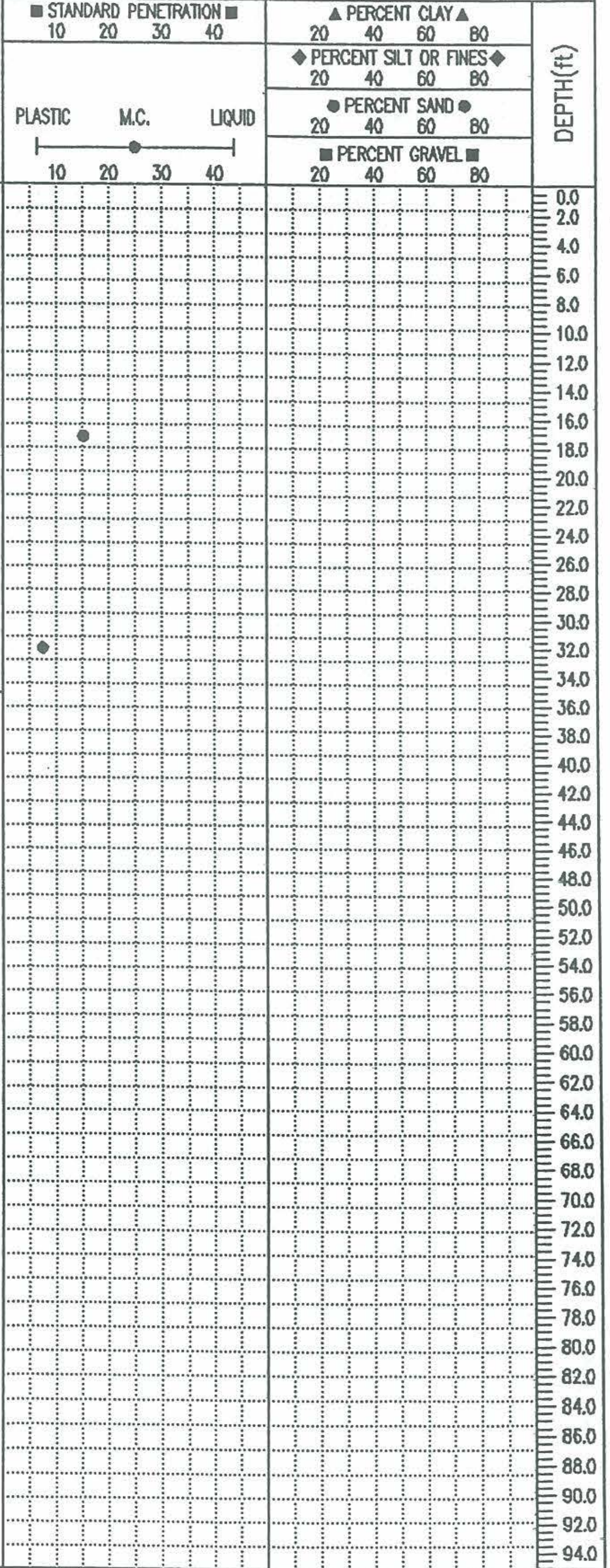
SOIL DESCRIPTION

SAND – some to trace of silt, some gravel and occassional cobbles and boulders at surface, seasonally frozen to 1.7 m, damp to moist below seasonal frost, medium brown

– frozen (permafrost, Nbn, Nbe) by 3.7 m
– fairly ice rich between 4.5 and 6.0 m

– drilled straight hole below 7.0 m (no casing)

END OF BOREHOLE @ 10.7 m
MINE COORDINATES
N 19020 E 20580
NOTE: Screened section wrapped in Geotextile



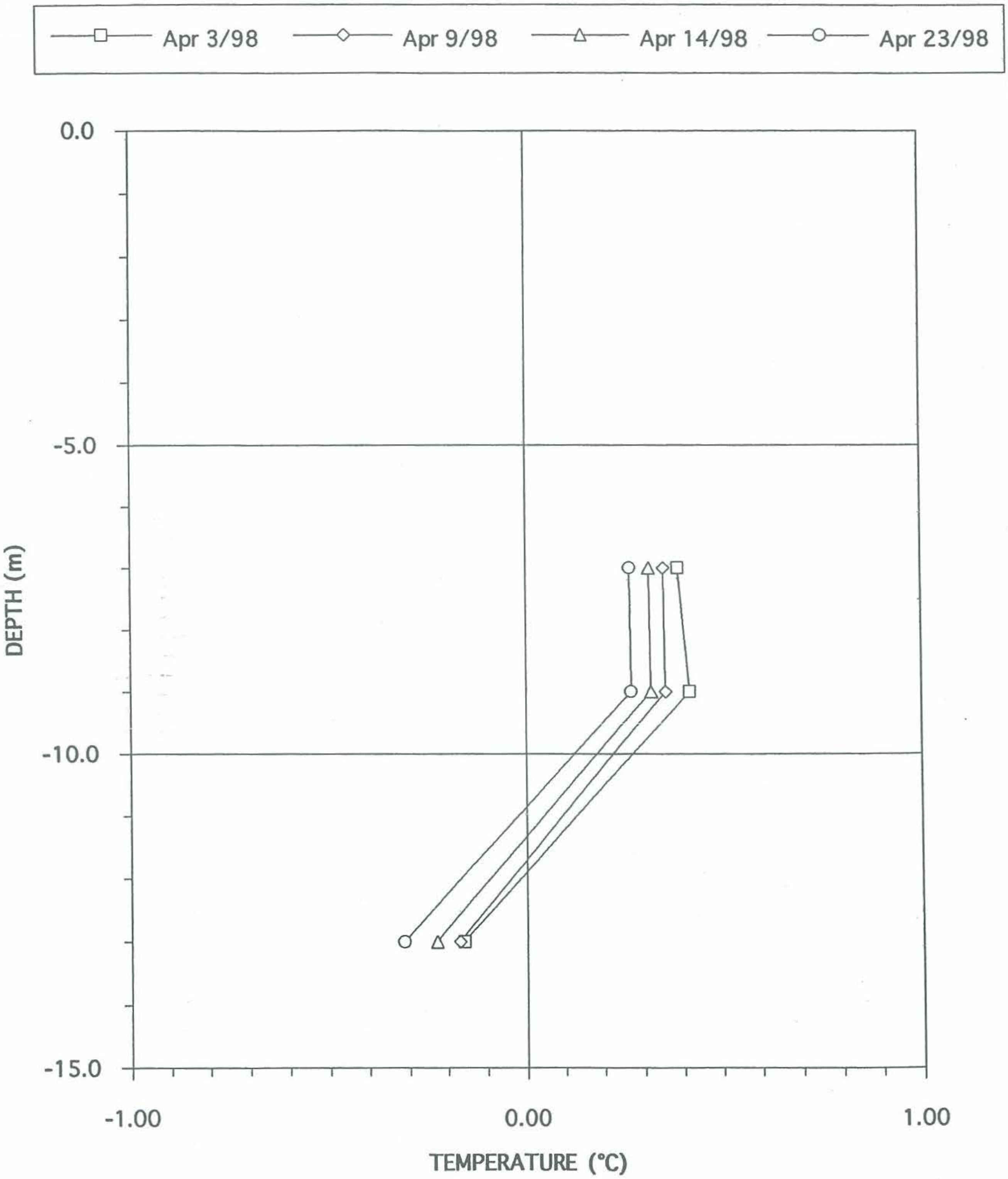
EBA Engineering Consultants Ltd.
Whitehorse, Yukon

LOGGED BY: MCP
REVIEWED BY: JRT
Fig. No:

COMPLETION DEPTH: 10.7 m
COMPLETE: 98/03/27

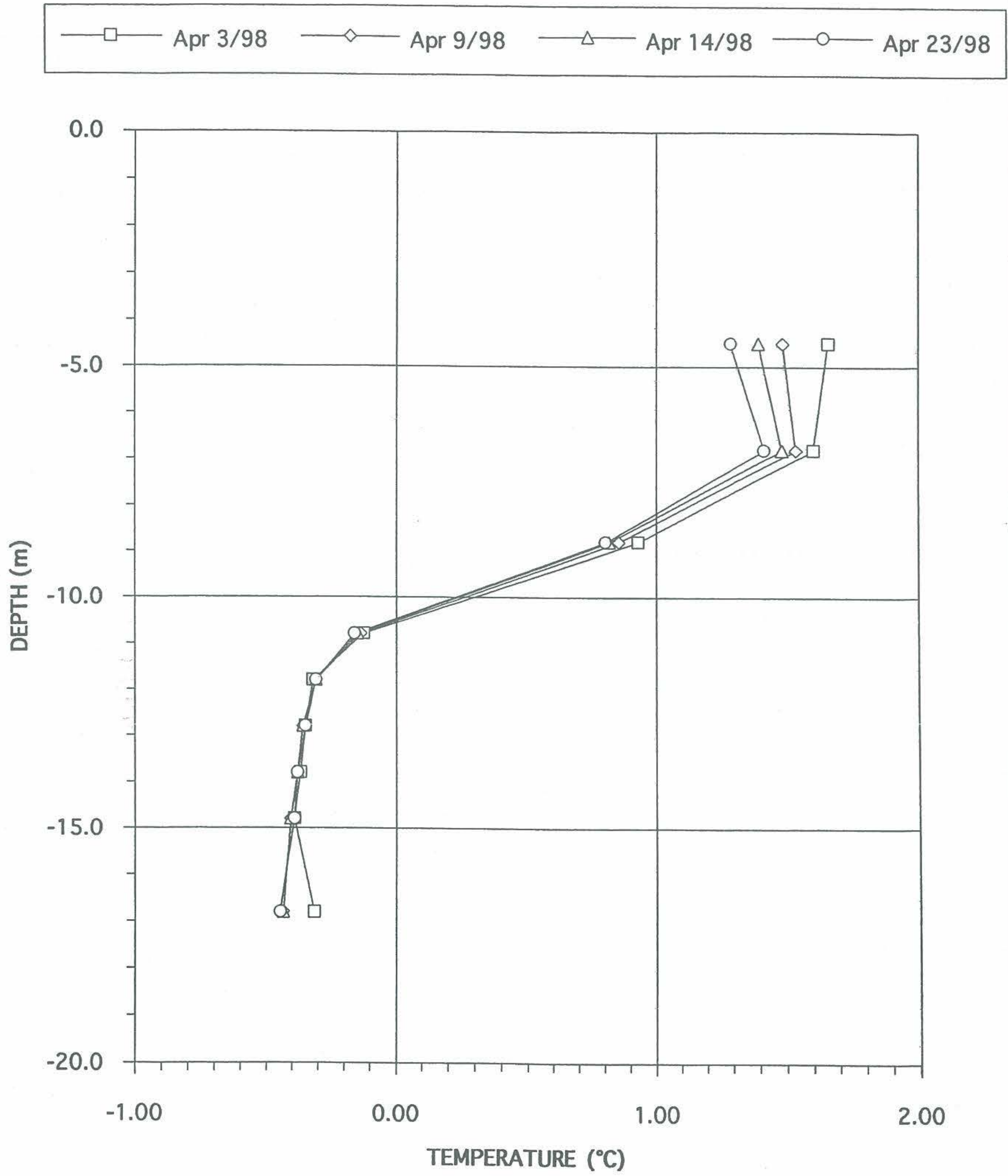
98/04/17 07:42AM (WELL28)

Thermistor No.: 1181
Date Installed: 98-03-28



GROUND TEMPERATURE PROFILE
MT. NANSEN - TAILINGS DAM TOE BERM
BOREHOLE 12861-05 (el. 1139.7)

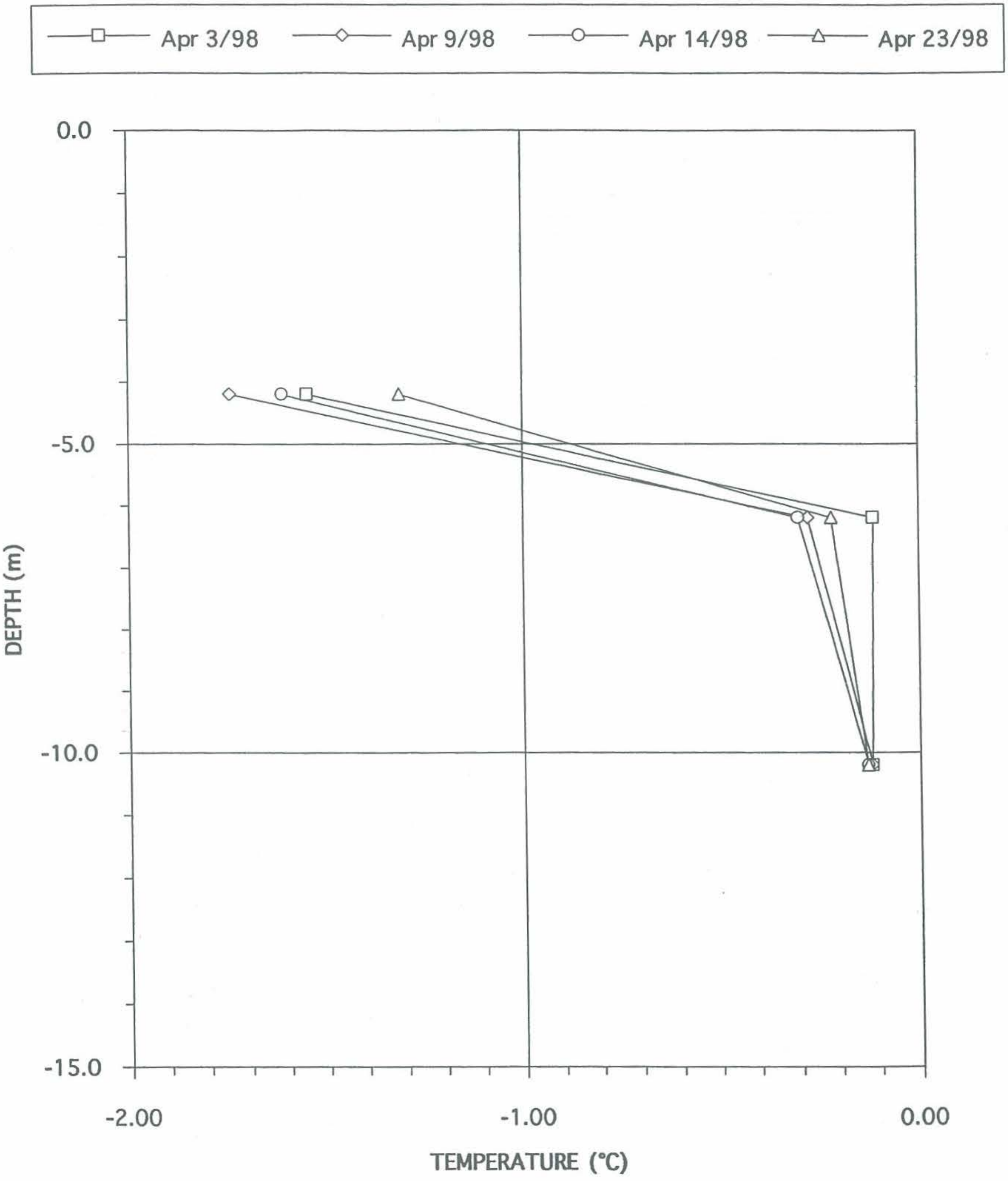
Thermistor No.: 1182
Date Installed: 98-03-30



GROUND TEMPERATURE PROFILE
MT. NANSEN - TAILINGS DAM TOE BERM
BOREHOLE 12861-06 (el. 1139.9)

eba

Thermistor No.: 1183
Date Installed: 98-03-31



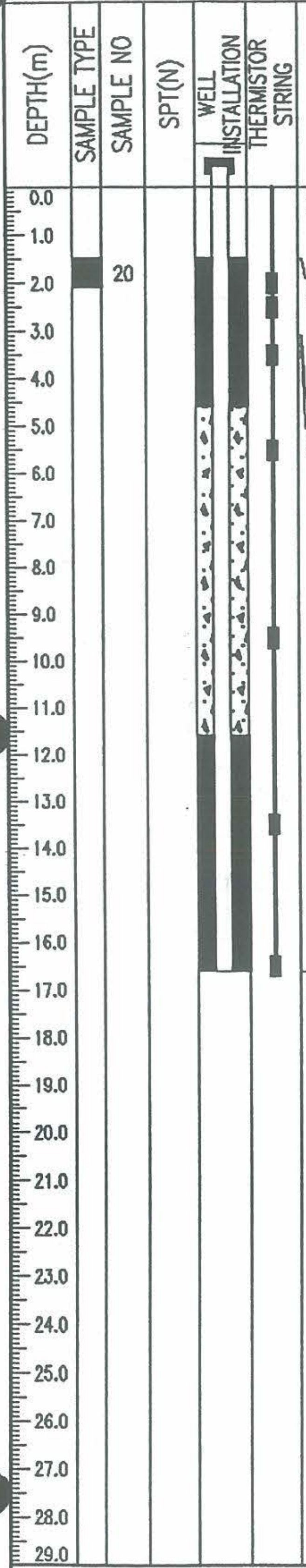
GROUND TEMPERATURE PROFILE
MT. NANSEN - TAILINGS DAM TOE BERM
BOREHOLE 12861-07 (el. 1143.3)

INSTRUMENTATION INSTALLATION	BYG NATURAL RESOURCES	BOREHOLE NO: 12861-10
MT. NANSEN MINE	DRILL: SCHRAMM AIR ROTARY	PROJECT NO: .901-97-12861
NW OF CARMACKS, YT	UTM ZONE: – N – E –	ELEVATION: 1130.7 m

SAMPLE TYPE ■ GRAB SAMPLE ▨ NO RECOVERY ☒ STANDARD PEN. ☰ 75 mm SPLIT SP. ▯ CRREL BARREL ▮ NW CORE

BACKFILL TYPE ■ BENTONITE ⁘ PEA GRAVEL ▥ SLOUGH ▨ GROUT ▨ DRILL CUTTINGS ⁘ SAND

DEPTH(m) | SAMPLE TYPE | SAMPLE NO | SPT(N) | WELL INSTALLATION | THERMISTOR STRING



SOIL DESCRIPTION

GRAVEL (FILL) – sandy, some silt, angular cobbles and boulders, seasonally frozen, medium brown

SAND (FILL) – some silt, some gravel, medium grained, moist to wet, dark olive brown
- saturated by 3.0 m

ORGANICS – frozen (permafrost), black

SAND – some silt, some gravel, medium to fine grained, medium brown

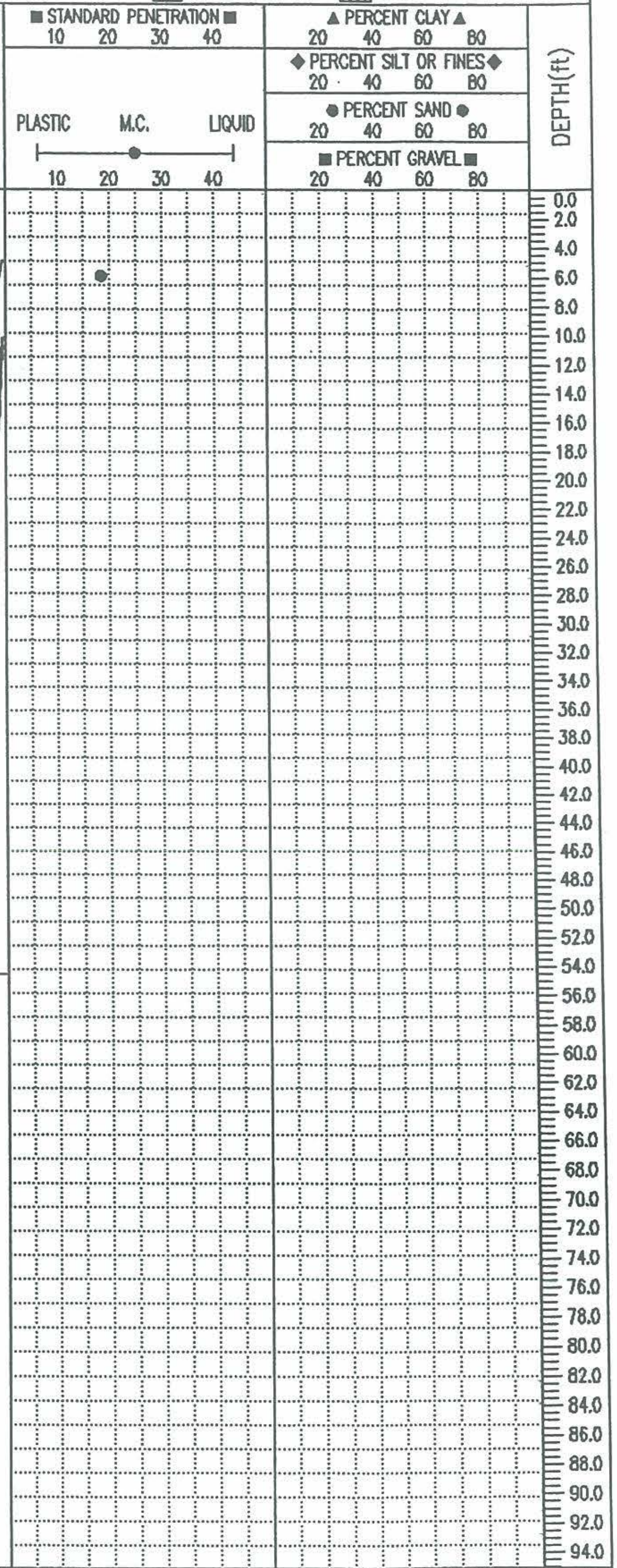
- may be drilling through the occassional boulder below 9.0 m
- lots of water in borehole during drilling

END OF BOREHOLE @ 16.6 m

MINE COORDINATES

N 18930 E 20684

NOTE: Fill above organics may have been frozen (to approx. 0.15 m above fill line) indicating possible freezeback



EBA Engineering Consultants Ltd. Whitehorse, Yukon	LOGGED BY: MCP	COMPLETION DEPTH: 16.6 m
	REVIEWED BY: JRT	COMPLETE: 98/03/27
	Fig. No:	Page 1 of 1

98/04/17 07:49AM (WELL28)