Mount Nansen Summary Data Report
Department of Indian Affairs & Northern Development
Whitehorse, Yukon

Project No. 0201-00-14618

September 2002

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EXECUTIVE SUMMARY

EBA Engineering Consultants Ltd. (EBA) was retained by the Yukon Region of Indian and Northern Affairs Canada (DIAND) to complete a dam safety review for the tailings impoundment facility at the former B.Y.G. Natural Resources Inc. mine site, west of Carmarks, Yukon. The dam safety review was limited in scope to consideration of the physical condition and stability of the earthfill tailings dam, and of adequacy of both the spillway and the seepage control dyke associated with tailings dam.

During the course of this review, site characterization studies, and reviews of available geotechnical data were completed. Detailed reporting of these data acquisition and review activities is presented within this Data Summary report and within its associated appendices. Specifically including:

- Design and Construction reviews,
- Field assessments,
- Evaluations of thermistor and piezometric data from dam instrumentation,
- Evaluation of physical movement surveys,
- And tailings volume estimates.

The application of the data to the evaluation of the dam, dyke, and spillway is presented separately within the Dam Safety Review report also issued to DIAND.

Some upgrading activities completed as a result of this assessment have already been undertaken for the dyke and spillway. Reporting of these completed actions will be presented in a third report entitled: Seepage Dyke and Spillway Remediation that will be issued separately to DIAND.

1.0 INTRODUCTION

EBA Engineering Consultants Ltd. (EBA) was retained by Yukon Region of Indian and Northern Affairs Canada (Water Resources) to complete a dam safety assessment of the tailings impoundment facility at the former B.Y.G. Natural Resources Inc. mine site (Mount Nansen Mine Site), 60 km west of Carmacks, Yukon. The dam safety assessment was to utilize both existing and to be acquired data to consider the condition and physical stability of the earthfill tailings dam, and the adequacy of the dam's spillway and of the seepage control dyke that lies downstream of the tailings dam. The evaluation of these items was to consider both the current state of these facility elements, as well as a projected condition five years in the future. A longer time frame, such as would be required for a closure evaluation of the facility, was not within the scope of work of this assessment.

The dam safety assessment was initiated following a preliminary review completed by EBA, Klohn Crippen Consultants Ltd. (Klohn), and Water Resources in 1999/2000 wherein Project Data Review Reports were prepared and potential safety concerns, as well as data gaps (deficiencies) were identified. A full review and evaluation of all identified safety concerns was completed as part of EBA's dam safety assessment and is presented in a report entitled "Mount Nansen Dam Safety Assessment" issued in April 2002.

This Data Summary Report has been prepared to accompany the Dam Safety Assessment Report and includes updating of all data previously summarized in EBA's Geotechnical Data Review Report (December 1999), as well as reporting of additional field data that was obtained during the course of this assessment. Tasks completed for and reported in this Dam Summary Report include:

1. Reviews of summary documentation related to the Mount Nansen Tailings Impoundment.
2. Site visits and field characterization programs completed to gather additional data regarding the condition of the tailings dam, the seepage control dyke, and the spillway.
3. Compilation and assessment of all dam monitoring data including ground temperatures, piezometric levels, seepage rates, and tailings pond water elevation data.
4. Results of cadastral surveys of the dam completed to monitor settlement and movement.
5. Results of a tailings volume estimate completed based on topographic surveys of the tailings impoundment.

In order to deal with some significant environmental and safety deficiencies that were identified at the onset of this assessment some upgrading and repair programs were completed at the impoundment in 2000 and 2001. Reporting on these upgrading activities is presented in a third report volume entitled: 'Construction Report - Mount Nansen Seepage Dyke and Spillway Upgrading'.

The Dam Safety Assessment has been completed in accordance with generally accepted geotechnical practice and engineering judgement has been used in the development of conclusions and recommendations. For additional information regarding the use of this report or its companion reports, please refer to the General Conditions included as Appendix A that form a part of this report.

Authorization to proceed with this assessment was provided by Mr. Bud McAlpine, Water Rights Administrator, Yukon Region on July 28th, 2000.

2.0 DESIGN & CONSTRUCTION REVIEW

2.1 Documentation

Design and construction documentation available from the Mount Nansen project was reviewed as part of this Dam Safety Assessment. EBA and/or its subconsultant B.K. Hydrology Services (BKH) also reviewed documents and reports relating to the licensing, modification, and operation of the tailings facility. Collectively these documents included:

- Dam Design reports prepared by Klohn Crippen Consultants Ltd.
- Water Use application documents prepared by B.Y.G. Natural Resources Inc.
- Water Licence QZ94-004 issued by the Yukon Territorial Water Board.
- Tailings Dam Construction Report prepared by Klohn Crippen Consultants Ltd.
- Site Visit report prepared by Geo-Engineering Ltd.
- Instrumentation Installation Report and internal memorandums prepared by EBA.
- Spillway upgrading report prepared by Vista Engineering Ltd.
- and Project Data Review reports prepared by Klohn Crippen and EBA.

Full references to these documents are presented in the References following this report. Copies of these reports currently exist in Water Resources files and are not included in this report. Two exceptions to this are internal memorandums prepared for Klohn Crippen Ltd. by EBA regarding a review of the Klohn Dam Construction report and providing details regarding the 1997 construction of an emergency toe berm at the impoundment. For completeness these two documents are included in Appendix B of this report.

2.2 Design Criteria

Design criteria for the Mount Nansen Tailings impoundment have been reviewed by both EBA and by BKH. Specific criteria from the original construction and subsequent modifications, including design slopes, seepage rates, and design flows are presented in the following subsections and in Table 1 of this report.

2.2.1 Main Dam

2.2.1.1 General

The main dam was designed with a capacity to store 300 000 tonnes or 240 000 m^3 of tailings based on a settled tailings density of 1.25 tonnes/m^3. The dam crest was set at a width of 6 m and elevation 1151.5 m, 1.8 m above the invert level to pass the design 200 year flood flow and at least 50% of the Probable Maximum Flood (PMF). This elevation also accounted for settlement of at least 0.6 m. The settlement allowance provided sufficient freeboard only for any short term settlements which might occur in the proposed three year operating life. The upstream slope was set at 2.5H:1V with a 4 m thick toe berm and the downstream slope at 3.5H:1V with no toe berm.

2.2.1.2 Thermal Analysis

Principal objectives of the thermal analyses were to predict the depth and rate of thawing of the foundation soils, and to estimate the magnitude of the resulting settlements for determination of freeboard allowance and thaw-induced excess pore pressures for slope stability assessment.

It was predicted that the zone of thawing in the foundation soils would extend only one-third of the width of the tailings dam from the upstream toe. The thawing was to be confined to the upper 1 to 2 m of the foundation soils in the area underlying the upstream slope of the dam and up to 5 m under the pond. Thawing of the foundation soils beneath the downstream toe was not predicted.

It was also predicted that if the tailings pond operated for only three years, complete freeze back of the foundation soils beneath the dam would occur after approximately 25 years.

2.2.1.3 Slope Stability Analysis

Slope stability of the main dam embankment would initially be controlled by the presence of permafrost in the underlying foundation soils. The tailings dam overlying a frozen foundation was expected to behave more than adequately and stability was not an issue of concern. However, the design was to consider the long term possibility of the foundation thawing.

A minimum allowable factor of safety against failure for static conditions was taken to be 1.5.

2.2.1.4 Seepage Analysis

The design of the main tailings dam was intended to minimize seepage of the pond water downstream of the dam into Dome Creek. That would ensure release of water from the tailings pond was controlled through treatment facilities and/or the emergency spillway and would also ensure that piping and loss of material does not occur at the downstream toe of dam due to uncontrolled seepage pressures.

The quantities of seepage through the dam was expected to be at a maximum of 0.2 L/s for the case of a frozen foundation and unfrozen dam over a 200 m wide seepage zone. With about 16 m of thawed foundation, the maximum predicted seepage was estimated to increase to about 2.4 L/s assuming a 200 m wide seepage zone.

2.3 Identified Concerns

Both the preliminary assessment (completed by EBA and Klohn) and the further review conducted by EBA have revealed potential dam safety concerns that required further evaluation and assessment. These concerns were:

- The cause of settlement and deformation.
- Potential zones of poorly compacted fill soils.
- Higher than anticipated seepage rates.
- The seismic stability of the embankment.
- The static stability of the downstream slope.
- The condition and adequacy of the water diversion and spillway system.
- Seepage rates through the seepage control dyke.
- Predicted freeze back did not occur.

The dam safety concerns identified in the review process were tagged for further study and evaluation during the subsequent phases that include the gathering and evaluation of site data and the analytical and/or qualitative evaluations. Results of these evaluations are presented in the Dam Safety Assessment Report.

3.0 FIELD PROGRAMS

3.1 Site Visits

As part of the dam safety assessment, comprehensive site visits were completed by Mr. Cord Hamilton, P.Eng. of EBA, in August 2000 and July 2001, and by Mr. Bernie Kallenbach, P.Eng. of BKH in September 2000 and October 2001. Mr. Hamilton was also resident at the site for extended periods during the repair and upgrading programs completed in October 2000, and August 2001.

3.2 Field Programs

Specific data acquisition field programs completed over the course of this assessment have included testpitting and probe hole drilling, cone penetration testing, deformation/settlement surveys, and topographic surveys. These programs were in addition to regular monitoring of site instrumentation undertaken by the facility caretaker. Specific programs were completed in

August 2000, September 2000, and September 2001. Details regarding these field programs are presented in Sections 3.2.1 to 3.2.3.

In addition to these data acquisition programs, necessary reconstruction and upgrading programs were completed in October 2000, January 2001, and August 2001. The October 2000 program was undertaken to upgrade the emergency spillway and to replace the seepage control dyke. The January 2001 program was to install new instrumentation around the rebuilt seepage control dyke. The final upgrading program was completed in August 2001 and consisted of repairing a failed section of the emergency spillway, as well as continuing the general upgrading of the spillway that was only partially completed in October 2000. As indicated earlier, reporting on these upgrading activities is presented in EBA's Mount Nansen Seepage Dyke and Spillway Upgrading Construction Report.

3.2.1 August 2000

In August 2000, four concurrent field programs were undertaken at the impoundment site. These programs consisted of testpitting, probe hole drilling, cone penetration testing, and surveying.

The testpitting program was completed by EBA to examine the conditions around the seepage control dyke and within the area of subsidence along the south abutment of the tailings dam. In total four testpits were advanced downstream of the original seepage dyke and two testpits were advanced on the south abutment slope. The locations of the seepage dyke testpits are shown in Figure 1, which is based on the original seepage dyke prior to reconstruction in October 2000. The locations of the south abutment testpits are shown in Figure 2. All testpits were advanced using a Hitachi 220 excavator and were logged by Mr. Cord Hamilton of EBA's Whitehorse office. Completed logs from the testpits are presented in Appendix C.

The probe hole drilling program consisted of advancing 20 solid shaft auger drillholes down to the permafrost table. The drilling was completed at locations along the north terrace just downstream of the tailings dam, on the north terrace above the reclaim pond, and along the diversion spillway. The north terrace probe holes, Boreholes 00-BH01 to 00-BH05, are shown on Figure 2. The spillway boreholes (Borehole 00-BH06 to 00–BH20) are shown on Figure 3. The determined depths to permafrost ranged from as much as 11.6 m at Borehole 00-BH01 (intersection of the main embankment section of the dam with the lower dyke section that runs across the north terrace) to as little as 0.5 m near the base of the diversion spillway (Borehole

00-BH17). The typical depth to permafrost was found to range from 2.3 m to 3.3 m. Individual permafrost depths are presented in Appendix C.

Cone penetration testing (CPT) was completed at the dam site by Contec Investigations Ltd. (Contec) in conjunction with Midnight Sun Drilling Co. Ltd. (Midnight Sun). A total of nine CPT holes were completed on the dam crest, the toe berm crest and on the north terrace. The location of the CPT holes is shown on Figure 2. Contec's detailed report on the program, including logs of the CPT holes, is presented in Appendix C.

The surveying program was completed by Yukon Engineering Services Ltd. (YES) and consisted of a topographic survey of the downstream slope of the dam, as well as resurveying established monitoring pins and instrumentation casings that were installed in 1999. An additional task completed by YES consisted of establishing seven additional monitoring pins in the area of the south abutment subsidence. These pins were installed and baseline measurements established for future comparison. A movement survey report was prepared by YES based on this work and the report is presented in Appendix D. The topographic data gathered by YES has been incorporated into the site as-built plan that is shown in Figure 2 and Figure 3.

3.2.2 September 2000

In September 2000, Contec and Midnight Sun undertook a second CPT program. The program consisted of nine CPT's holes located on the dam and the north terrace as shown in Figure 2. Full details of the CPT program are presented in Contec's report presented in Appendix C.

3.2.3 September 2001

Field activities completed in September 2001 consisted of topographic surveys of the tailings beaches, and of the north terrace area located downstream of the tailings dam and between the reclaim pond and the spillway. In addition to the topographic surveys, a movement survey was completed for all of the monitoring pins and instrumentation casings in place at the tailings dam crest and downstream slope. The surveying work was undertaken by Yukon Engineering Services Ltd. A survey monitoring report prepared by YES is presented in Appendix E. The results of the topographic survey of the tailings beaches and the north terrace are shown in Figure 2.

4.0 INSTRUMENTATION RECORDS

The following section provides a summary of the instrumentation installed and data recorded. Detailed discussions of the data and data plots along with general trends and comments on ground temperatures, piezometric response, pond elevation and seepage records is presented in EBA's report 'Dam Instrumentation Data and Assessment' found in Appendix D.

4.1 Pre-1998

Instrumentation was present in various areas in the vicinity of the dam prior to 1998; however, the majority of these installations were destroyed.

4.2 Thermistor Strings

A total of ten boreholes (12861-01 to 12861-10) were installed by EBA with thermistor strings in March 1998. There were three main thermistor strings installed in the tailings dam, one at the dam crest, one at the toe berm crest, and one near the dam toe. For the seepage control dyke, there was a single thermistor string located roughly in the centre of the dyke structure. All of these main thermistor installations are located above and/or within the former channel/floodplain of Dome Creek.

For the tailings dam, 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.

Following installation of the thermistor strings, 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 between April 1998 to November 2001 from these three sources.

Disregarding the initial data obtained during the installation program, most of the thermistor strings have been monitored on a weekly basis from April 1998 to December 1999 and then biweekly to November 2001, although some equipment problems have resulted in occasional missed readings.

4.3 Piezometers

In conjunction with the installation of the thermistor strings, five sets of three pneumatic piezometers are located within and adjacent to the tailings dam. 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.

Data for the piezometers was collected at the same rate and by the same personnel as that of the thermistors.

4.4 Pond elevations

During the period of monitoring, water level elevations within the 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.

4.5 Seepage Records

Seepage records were developed by determining the volume of effluent pumped back to the tailings impoundment from the seepage collection pond formed by the seepage collection dyke downstream of the tailings dam.

The volume of effluent pumped back from the seepage provides only an estimate of the total seepage volume escaping from the tailings impoundment. It is only an estimate because the seepage pond neither captures all of the possible seepage that escapes the impoundment nor does it retain all of the seepage that is captured. Moreover, the seepage pond is also subject to inflows from sources other than the tailings impoundment seepage. Direct precipitation and runoff from the dam slope and the north and south abutment slopes all contribute to the volume of water contained in seepage pond at any time. Irrespective of these concerns, the pumped back volume of effluent is a strong indicator of the seepage performance of the impoundment and it can be compared to the design criteria that was developed for seepage passing through the dam structure and dam foundation.

From March 29 until November 2, 1999, the seepage flows were based on an intermittent daily record of the pumping rate and pumping duration as recorded by the mine operator, mine receiver, and/or Ketza. Starting on November 3, 1999 a flowmeter was installed at the end of the pump back line in order to improve the accuracy and completeness of the seepage records.

4.6 Movement Surveys

4.6.1 Pre-1999

Settlement of the dam crest was identified in the design process as a likely occurrence due to the thawing of permafrost foundation soils. The designer's settlement estimate for the first 3 years of the dam life was conservatively set at 0.6 m with this resulting from up to 4 m of permafrost thaw.

Monitoring of the predicted settlement was the responsibility of the mine operator and was to be based on surveying of monitoring pins across the crest of the dam. Unfortunately the mine operator did not complete these surveys as frequently as required, did not complete them accurately, and/or did not record the results in a proper manner. Therefore, there is a lack of data on the settlement of the dam crest and this has made the comparison of predicted and actual crest settlements impossible. However, the maximum crest settlement that could be inferred during the period of September 1996 to September 1999, based on the available data was 0.27 m as reported by Klohn in January 2000. This settlement amount was based on the simple assumption that the as-built crest elevation was uniformly at Elev 1151.50 m.

An internal memo presented in Appendix E presents a detailed review of the pre-1999 settlement data.

4.6.2 1999

Since the period ending September 1999, Water Resources has had three settlement/deformation surveys completed on the dam. The first survey, conducted in September 1999, was to install proper monitoring pins and to obtain baseline data for future settlement/deformation surveys. In total twenty-seven monitoring pins were established on the crest (11 pins) and downstream face of the dam (16 pins). In addition to these installed pins, nine borehole/instrumentation casings were also surveyed in 1999 for use in settlement/deformation monitoring. Three of the boreholes casings were located on the dam crest with the remainder being on the downstream face of the dam.

4.6.3 2000

The established pins and borehole casings were resurveyed in August 2000; however, damage to the control monuments which had been established in 1999 resulted in some uncertainty in the validity of horizontal movements that were determined from the comparison of 1999 and 2000 data. It was the conclusion of the surveying consultant that any horizontal movement identified by the comparison of the two surveys was either within the limits of precision of the survey or was the result of disturbance to the horizontal control utilized at the site. Therefore, it was deemed that no significant horizontal movement had occurred during this period, where significant is defined as greater than the precision of the survey. Vertical settlements determined during this period ranged up to 20 mm; however, the precision of the survey was considered to be ±20 mm. Therefore, the vertical movement was also not considered to be significant.

During the August 2000 survey, some additional monitoring pins were added to the monitoring system in order to provide a higher density of coverage in the area of the south abutment subsidence. In total seven additional pins were installed in this area.

4.6.4 2001

All of the monitoring pins and borehole casings were resurveyed in October 2001. The result of that survey showed both vertical and horizontal movement had occurred during the period of August 2000 and October 2001. The data indicated cumulative (1999 – 2001) dam crest settlements ranging from 8 mm to 61 mm. The most significant crest settlements were located over the south abutment side of the crest. Corresponding horizontal movements of the dam crest were not significant, as considered for the period of August 2000 to October 2001.

Cumulative settlements (1999 – 2001) on the downstream face of the dam were typically in the range of 10 mm to 40 mm. Horizontal movements during August 2000 to October 2001 on the downstream face varied from 6 mm to 64 mm with a typical range of 15 mm to 35 mm. The direction of horizontal displacement on the downstream face of the dam was primarily in a downslope direction (Mine Grid East), although some monitoring pins located near the north abutment showed movement in a southeast direction. Figure 4 presents the settlement/displacement data obtained from the completed surveys. The figure includes the cumulative settlement of each monitoring point (1999 – 2001), as well as the horizontal displacement and direction from the period of August 2000 to October 2001.

4.6.5 General Deformation Observations

In addition to the obtained survey data, visual evidence of deformation and cracking of the dam has also been observed. Subsidence and cracking of dam fill materials has been observed on the downstream face of the dam near the edge of the south abutment. The deformation consists of depressions ranging up to 1.2 m in depth and extensive cracking around and near the depressions. This area of deformation was not observed until after the construction of the emergency toe berm and crest access road in the summer and autumn of 1997.

Prior to July 1997, an erosion channel had developed along the interface between the south abutment and the dam fill materials. This channel varied in height and width; however, a steep face of embankment sand up to 1.2 m in height developed along some sections of the channel. Seepage was observed daylighting into this channel at elevations above 1135 m and this was creating sloughing and erosion of the exposed sand face.

In the autumn of 1997, the mine operator covered this trench and built an elevated access road over it leading from the south end of the toe berm up to the dam crest. The road over the channel area was built using a mixture of waste rock and excavated residual soils (gravel, sand, and cobbles with a trace of silt). The quality of construction, in terms of placement and compaction, during this operation is not known.

During the summer of 1998, the area downslope of the road and toe berm was observed to contain the depressions and cracks as already described. As far as can be determined by EBA, all of these features are located in areas that were subject to material placement in the fall and summer of 1997 and all are downslope of the downstream edge of the toe berm crest and the crest access road. Observation of the highest extent of tension cracks has not shown any observable change in the period of 1998 to 2001 even though surveying of monitoring pins in this area has indicated both vertical and downslope horizontal movement is occurring in this area.

EBA completed two testpits in this deformation area, one was located in a small depression near the edge of the dam (south downslope face) and the other was located immediately downslope of the crest of the toe berm at its southern end. The testpit at the edge of the dam revealed that the thawing underneath the fill soils near the edge was minimal (0.5 m). The other testpit, located further in from the edge of the dam, could not be safely excavated to permafrost without greatly disturbing the downstream slope of the dam.

Both testpits revealed residual soil fill that contained boulders and cobbles. This residual soil/waste rock fill varied in thickness (thinner at the dam edge) and did contain observable voids associated with the cobbles and boulders in the matrix of the fill. The testpit at the edge had these materials overlying a non-woven geotextile. Underneath the geotextile, native organic rich sand was in place.

The testpit located further in from the dam edge had 1.0 m to 1.2 m of fill sand underlying the residual sand, gravel and cobbles. The embankment sand was saturated and was found to easily quicken when disturbed. Underneath the embankment sand, organic rich native sand was observed.

Overall the magnitude of the settlement of the dam to date cannot be conclusively determined; however, it seems that the settlement may be less than was anticipated by the Designer. In addition, deformation of the downstream slope of the dam is occurring particularly on the south abutment area that is known to have high phreatic levels.

5.0 TAILINGS THICKNESS AND VOLUME ESTIMATE

Yukon Engineering Services Ltd. (YES) prepared an estimate of the volume of tailings contained at the Mount Nansen site in November 2001 which is presented in Appendix F. The tailings quantity was determined by utilizing the original ground model available from the mine operator's digital files, as-built dam and tailings beach surveys completed by YES in 2000 and 2001, and a bathometric survey completed by Labarge Environmental Services in 1999.

Using the YES site surveys and the bathometry a single existing surface model was developed by YES. The developed as-built surface model is shown in Figure 2. Comparison of the existing surface model to the original ground surface model allowed for the calculation of the quantity of tailings within the impoundment limits. This volume was found to be 280 000 m^3

±10% (roughly ±30 000 m^3). This estimate includes both the subaqueous tailings within the impoundment as well as the beached tailings present beside Dam 1 and at the west end of the impoundment.

The accuracy of the estimate is limited by the 1 m contour intervals provide within the original surface model, and the unknown deviations from this model created by borrowing sand materials from within the limit of the impoundment during dam construction in 1996. Moreover, the calculated volume also includes the upstream toe berm of the tailings dam, as well as, any dam fills that existing within the limits of the impoundment. The inclusion of the dam fill materials is believed to be a reasonable action as this material is expected to be contaminated due to seepage of tailings pore water.

As a check on the accuracy of the model, YES has compared the thickness of tailings projected by the two surface models with known thickness determined by Labarge Environmental Services (Labarge) during a tailings sampling program completed in autumn 2001. The results of the comparison are shown in the appended figure, which is an isopach drawing of the tailings impoundment detailing the projected thickness of tails. The location of the sampling boreholes advanced by Labarge are shown in the figure as is a table detailing the projected tailings thickness based on the YES model and the actual thickness (where known) based on the Labarge sampling program.

6.0 CLOSURE

EBA trusts that this report meets with your approval. Please do not hesitate to contact the undersigned should you have any questions or comments.

Yours truly,
EBA Engineering Consultants Ltd.

Reviewed by:

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Oct 28/03

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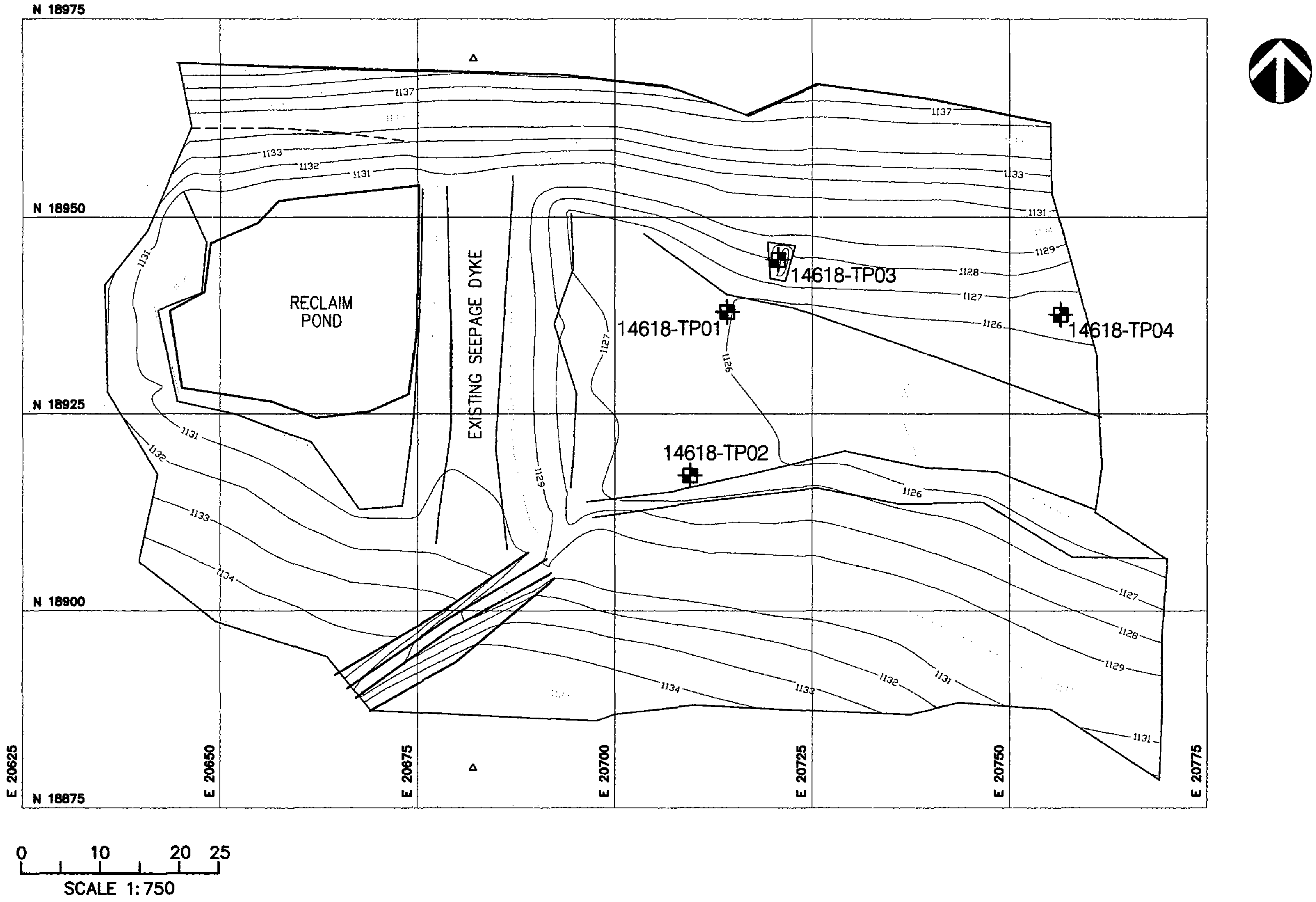
FIGURES



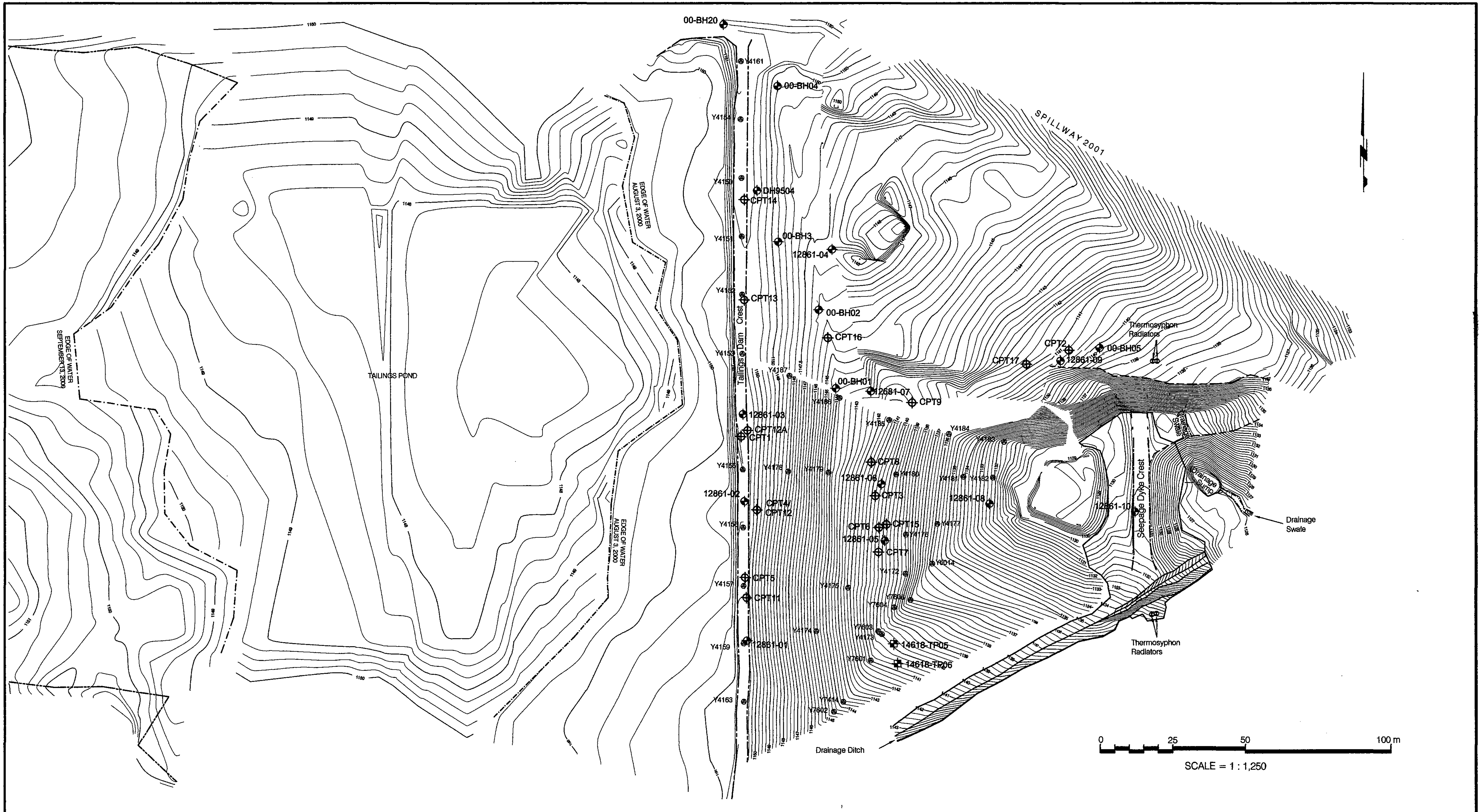
EBA Engineering Consultants Ltd.

PROJECT
MT. NANSEN
DAM SAFETY ASSESSMENT

CLIENT
DIAND

TITLE
SITE PLAN SHOWING
TESTPIT LOCATIONS (AUGUST 2000)

DATE	SEPTEMBER 2002	DWN.	JSB	CHKD.	JRT	FILE NO.	0201-00-14618	DRWG.	FIGURE 1



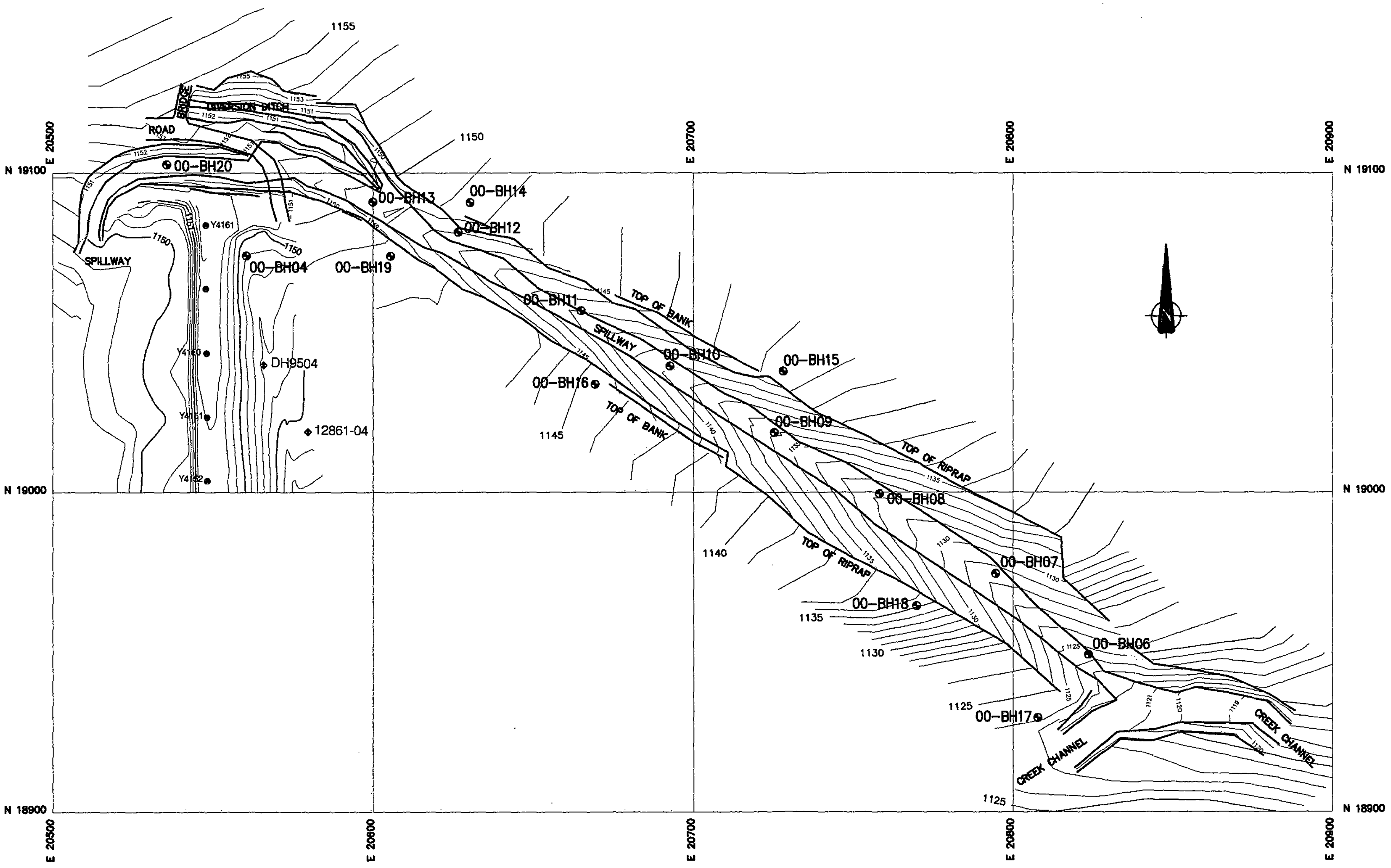
EBA Engineering Consultants Ltd.

CLIENT
DIAND

PROJECT
MT. NANSEN
DAM SAFETY ASSESSMENT

TITLE
SITE PLAN SHOWING
TESTHOLE LOCATIONS

DATE	SEPTEMBER 2002	DWN.	JSB	CHKD.	JRT	FILE NO.	0201-00-14618	DRWG.	FIGURE 2



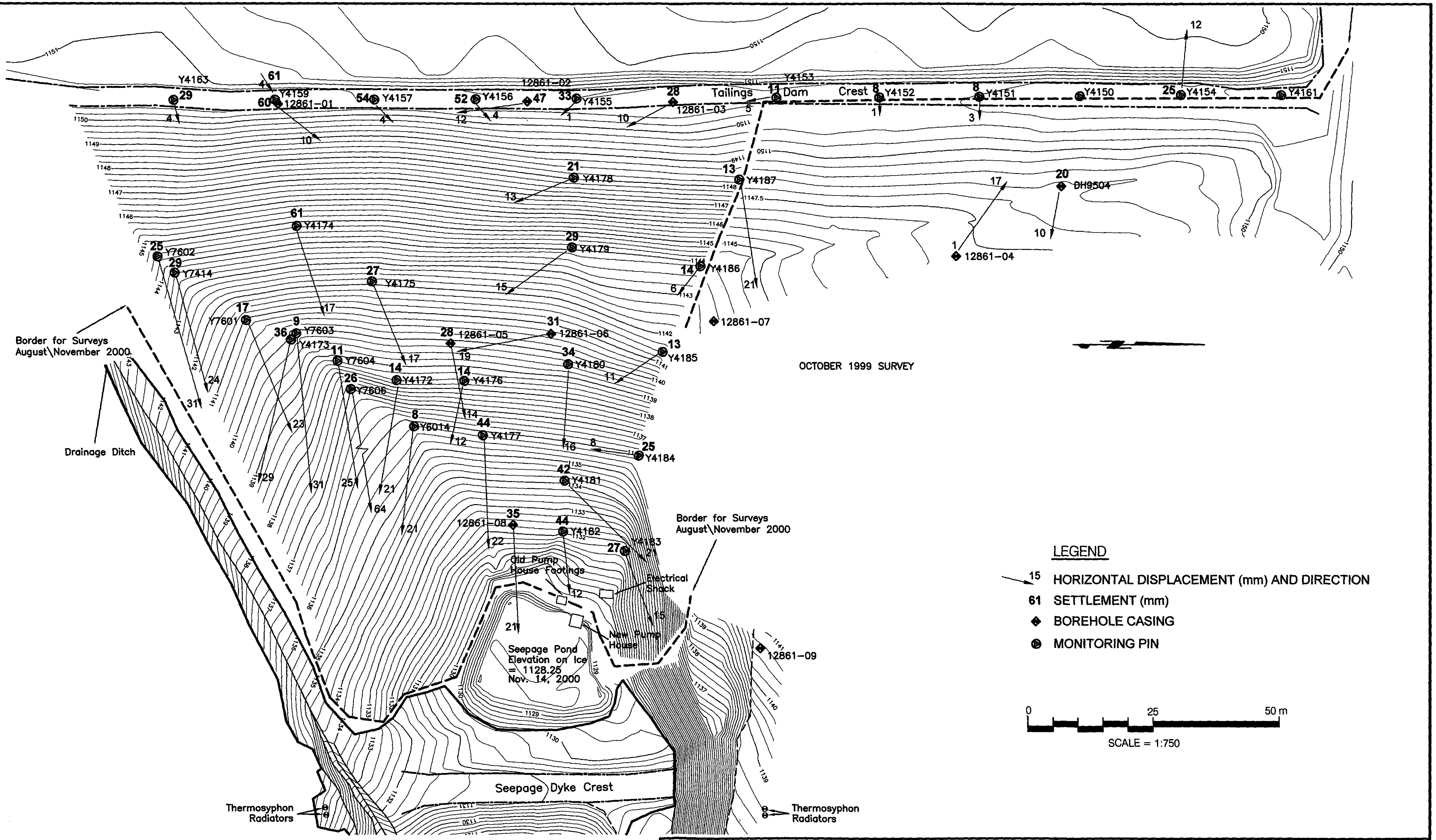
NOTES:
1. ELEVATION CONTOURS IN METRES.
2. GRID IS LOCAL MINE GRID.
3. CONTOURS BASED ON AUGUST, 2000 SURVEY, BY YUKON ENGINEERING SERVICES.

0 25 50

SCALE 1:2000

EBA Engineering Consultants Ltd.

CLIENT	DIAND
PROJECT	MT. NANSEN TAILINGS DAM ASSESSMENT
TITLE	SPILLWAY PLAN SHOWING TESTHOLE LOCATIONS
DATE	September 2002
DWN.	JPB
CHKD.	JRT
FILE NO.	0201-00-14618
DRWG.	FIGURE 3



EBA Engineering Consultants Ltd.

PROJECT	MT. NANSEN DAM SAFETY ASSESSMENT
CLIENT	DIAND
TITLE	DAM MOVEMENT SURVEY RESULTS (1999 - 2001)

DATE SEPTEMBER 2002 | DWN. JSB | CHKD. JRT | FILE NO. 0201-00-14618 | DRWG. FIGURE 4

APPENDIX A

Geotechnical Evaluation – 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.

A.7 SUPPORT OF ADJACENT GROUND AND STRUCTURES

Unless otherwise specifically advised, support of ground and structures adjacent to the anticipated construction and preservation of adjacent ground and structures from the adverse impact of construction activity is required.

A.8 INFLUENCE OF CONSTRUCTION ACTIVITY

There is a direct correlation between construction activity and structural performance of adjacent buildings and other installations. The influence of all anticipated construction activities should be considered by the contractor, owner, architect and prime engineer in consultation with a geotechnical engineer when the final design and construction techniques are known.

A.9 OBSERVATIONS DURING CONSTRUCTION

Because of the nature of geological deposits, the judgmental nature of geotechnical engineering, as well the potential of adverse circumstances arising from construction activity, observations during site preparation, excavation and construction should be carried out by a geotechnical engineer. These observations may then serve as the basis for confirmation and/or alteration of geotechnical recommendations or design guidelines presented herein.

A.10 DRAINAGE SYSTEMS

Where temporary or permanent drainage systems are installed within or around a structure, the systems which will be installed must protect the structure from loss of ground due to internal erosion and must be designed so as to assure continued performance of the drains. Specific design detail of such systems should be developed or reviewed by the geotechnical engineer. Unless otherwise specified, it is a condition of this report that effective temporary and permanent drainage systems are required and that they must be considered in relation to project purpose and function.

A.11 BEARING CAPACITY

Design bearing capacities, loads and allowable stresses quoted in this report relate to a specific soil or rock type and condition. Construction activity and environmental circumstances can materially change the condition of soil or rock. The elevation at which a soil or rock type occurs is variable. It is a requirement of this report that structural elements be founded in and/or upon geological materials of the type and in the condition assumed. Sufficient observations should be made by qualified geotechnical personnel during construction to assure that the soil and/or rock conditions assumed in this report in fact exist at the site.

A.12 SAMPLES

EBA will retain all soil and rock samples for 30 days after this report is issued. Further storage or transfer of samples can be made at the client□s expense upon written request, otherwise samples will be discarded.

A.13 STANDARD OF CARE

Services performed by EBA for this report have been conducted in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practising under similar conditions in the jurisdiction in which the services are provided. Engineering judgement has been applied in developing the conclusions and/or recommendations provided in this report. No warranty or guarantee, express or implied, is made concerning the test results, comments, recommendations, or any other portion of this report.

A.14 ENVIRONMENTAL AND REGULATORY ISSUES

Unless stipulated in the report, EBA has not been retained to investigate, address or consider and has not investigated, addressed or considered any environmental or regulatory issues associated with development on the subject site.

APPENDIX B

Design and Construction Review

MEMORANDUM

TO:	Dr. Robert Lo, P.Eng. Klohn Crippen Consultants	**DATE:**	December 23rd, 1999
FROM:	Cord Hamilton	**FILE:**	0201-99-14097

SUBJECT: **Review of 1996 Construction Report Mount Nansen Tailings Dam**

As part of the preliminary dam safety assessment being completed jointly by EBA and Klohn, I have reviewed the 1996 Construction report from the construction of the Mount Nansen tailings dams, diversion ditches, and spillway. The purpose of the review was specifically to determine if any issues exist regarding the quality of construction of the tailings dam and whether design criteria were achieved.

Review of this report revealed several potential issues regarding the overall quality of the tailings dams. Two primary concerns exist: the success of foundation stripping operations and the quality of placed embankment fills.

For the stripping issue it is clear that the contractor was not able to entirely remove the frozen organic materials that underlie the dam site. Therefore, the removal of organics was a design assumption that was not achieved in construction. Drilling at the dam site by EBA has indicated that the organic layers were not completely removed in 5 of 7 boreholes drilled in 1998 to install new dam instrumentation. The impact of this layer may need to be accounted for in future analysis of the dam.

The other major issue was the occasional difficulties in having the contractor follow the minimum fill placement standards. Specific issues revolved around lack of moisture conditioning, applying overly thick lifts, inadequate compaction, and ramping materials onto the dam from the north abutment. It is significant to note that only 26 compaction tests were reported on a project where over 100 000 m^3 of fill was placed. Of those 26 tests, several were failed tests that were not later re-tested to confirm the under compaction had been rectified. Moreover, no acceptable compaction tests were reported between an elevation of 1136 m and 1148 m.

The text of the construction report, including daily and weekly reports during construction, does suggest that the compaction was generally adequate but it was also clear that at certain times the contractor was not following the required placement standards. Whenever this was discovered the Klohn field representative enacted mitigative actions to correct the observed substandard work; however, it was not clear that such efforts were fully successful. As a result there is a reasonable risk that some fill within the dam may not have met the required design standards.

A particular concern that may explain some of the manifest behaviour of the dam was the ramping of dry fill from the north abutment onto the dam structure. Several daily reports, construction memorandum, and weekly reports indicated that the contractor pushed stockpiled fill from the north abutment onto the dam structure without keying in the fill layers. This procedure may have lead to poorly compacted wedges of dry fill being established at the north abutment interface. While some daily reports indicated that the ramping problem was being corrected, it was not clear that these wedges of fill were completely removed and replaced.

As you are aware instrumentation within the dam has indicated that the north abutment has a much lower phreatic level than that of the south abutment. A possible contributing cause of this situation is that the north abutment fills may have a higher permeability (lower in situ density) as compared to the south abutment. This could be the result of the ramped fills being under compacted on the north abutment.

MEMORANDUM

TO: Dr. Robert Lo, P.Eng.
Klohn Crippen Consultants

DATE: December 16th, 1999

FROM: Cord Hamilton

FILE: 0201-99-14108

SUBJECT: **Summary of 1997 Toe Berm Construction**
Mount Nansen Tailings Dam

1.0 INTRODUCTION

EBA has completed a review of internal project files in regards to the 1997 construction of a "temporary" toe berm downstream of Tailings Dam #1 at the Mount Nansen mine site. As you may be aware the toe berm was constructed by BYG after the condition of the dam was found to questionable due to heavy seepage flows and the development of sand boils near the dam toe in July 1997.

It is important to note that the toe berm was field designed in order to provide filtration, drainage, and short term support for the dam - no formal analyses were ever completed by EBA to support the field design. The toe berm was considered an emergency modification of the dam structure that was constructed to reduce the potential for piping failure and instability of the dam. A formal design review and analyses were to be completed after construction of the berm; however, that work was never commissioned by BYG.

Another important issue is that BYG directly supervised some aspects of the toe berm construction in the absence of EBA. No documentation of such activities was ever supplied by BYG. Although EBA was lead to believe that photographs and videotapes of the construction activities were made. Mr. Robert Stroshein of Ketza Corporation completed a search for these materials during this past fall but no documentation was located.

The conceptual design of the toe berm was shown in Vista Engineering Drawing No. 290-04-01 that was approved by EBA and submitted to Water Resources on July 30th, 1997. The drawing was based upon EBA's field directed activities and EBA's concept sketch dated July 29th, 1997. A copy of the concept sketch is shown in Appendix A. Based on this drawing the pertinent design features of the toe berm were:

- A sand bedding layer to cover the existing dam surface;
- a geotextile liner to overlie the bedding sand;
- a drainage blanket of clean placer gravel to overlie the geotextile;
- the body of berm to be a rockfill or "shale" fill;
- the toe berm was to be at least 6 m in width (horizontally);
- the berm slope to be 4:1 (horizontal: vertical);
- the berm toe to incorporated a shale filled cut-off trench;
- and the toe to contain a toe drain of placer gravel.

2.1 CONSTRUCTION

The toe berm and associated north terrace buttress was constructed in at least four phases that are known to EBA. The first phase saw the placement of bedding materials, geotextile, and drainage materials as well as the construction of an anchor trench at the toe of the dam. The second phase included the addition of more drainage materials and geotextile, and the western half of the north terrace buttress. Some waste rock fill was also placed at this time. The third phase consisted of adding coarse waste rock and residual gravel and sand soils to build the bulk of the toe berm volume. The north terrace buttress was extended towards Dam #2 at that time. The final phase consisted of filling the south abutment erosion channel from the top of the toe berm to the dam crest.

Of the four phases of construction, EBA was only on site to witness the first two phases. The final two phases were completed by BYG without EBA's presence and EBA has no documentation of the construction techniques and materials used.

Details of the construction for each phase are presented in the following sections.

2.1 Phase I

The first phase of construction occurred from July 22nd to July 24th 1997. The construction was initiated by the discovery of a sand boil near the toe of dam #1. Heavy seepage exiting the toe of the dam and from an instrumentation suite located above the toe, and the soft, saturated condition of much of the lower dam slope also lead to the decision to begin construction of the toe berm. Another factor was the presence and increasing severity of sloughing along the north abutment terrace where it intersected the toe of the dam. Seepage exiting the terrace was creating the sloughing.

Testing of the various seeps exiting through the dam, the north terrace and within a well developed erosion channel along the south abutment of the dam all indicated that the seepage was originating from within the tailings impoundment.

On July 22nd, 1997, EBA arrived at the site and developed provisional plans to begin the toe berm construction. BYG mobilized a local contractor to improve the access to the lower slope of the dam in advance of the toe berm construction.

At 1500 hrs on this date, a meeting was held between EBA, BYG, and Water Resources to review the proposed emergency toe berm design and construction. Minutes of that meeting are attached as Appendix A. The result of the meeting was that EBA and BYG would proceed with placing a filter medium and a drainage layer over the toe of the dam. Full details of the toe berm design would be submitted to Water Resources for review in the ensuing days.

With the approval of Water Resources, the toe berm construction began in the evening of July 22nd, 1997. The initial activities were to construct a dumping ramp off of the north terrace and to load, haul, and dump sand from the north terrace onto the dam face. From the dumping ramp the sand was spread using a CAT D3C dozer and a CAT 225 excavator. The sand was spread in a thickness of 0.1 m to 0.8 m depending upon the condition of the subgrade. Typically the sand layer became thicker near the toe of the dam.

During the spreading of the sand, the existing "shale" surfacing on the dam slope was left inplace. The instrumentation suite located in the centre of the lower dam downstream slope was dismantled and all instrumentation lines were moved up the dam slope to a higher point where they would be feed through a vertically placed culvert that would extend up through the toe berm. Many of the instrumentation lines were cut for later re-splicing, as they were not sufficiently long to reach the projected toe berm surface.

The bedding sand surface was shaped by the CAT 225 excavator at the toe and in the south channel in order to provide a smooth surface for the placement of the geotextile fabric.

After the sand layer was in place (July 23rd) the next step was to construct a containment berm across the toe of the dam. This berm consisted of roughly 1.0 to 1.2 m of residual gravel and sand soils ("shale" fill) placed over firm sand fill or eroded sand that formed the toe of the dam. Due to the softness of the lower dam slope, particularly in the central area (around the former instrumentation suite), the shale was transported to the toe by being pushed down along the edge of the northern abutment. From there the excavator carried it across the toe of the dam, building the containment berm as it went. The containment berm was roughly 3 m in width and acted to contain the sand bedding layer and to provide a traffic corridor along the toe for excavator.

At the northern corner of the toe, the shale was used to displace the saturated slough from the failure of the north terrace. Some the slough was excavated; however, as this created further sloughing, the displacement technique was used to push the sloughed material downslope into the seepage pond.

The next step was to excavate another trench immediately downstream of the shale berm. This trench was excavated to act as a cut off trench into the native soils and an anchor trench for the geotextile fabric that was to be placed over the sand bedding. The anchor trench was roughly 1.5 m in depth as measured from the top of the anchor berm and 0.6 m in depth measured from the downstream surface (seepage pond base).

The trench was excavated into frozen organic soils, except near the north terrace where the displaced slough and the presence of heavy seepage made it difficult to keep the trench excavation clean of slough. Spoil from the trench excavation was thrown forward into the seepage pond area.

With the anchor trench in place, the geotextile fabric was laid out in vertical strips approximately 25 m in length. Each strip was overlapped at least 0.3 m with the adjacent strips. The geotextile used was a Terrafix 600R fabric that was left over from the spillway construction in 1996. After placement of the geotextile the anchor trench was backfilled with shale.

Because the northern edge of the dam slope had been used to haul down the shale material, it could not be covered with geotextile on July 23rd. This area was smoothed out and then covered with additional sand bedding so that the geotextile could be placed over the area on July 24th.

On July 24th, the remaining area near the north abutment was covered with geotextile and additional sections of geotextile where added to bring up the fabric up to an elevation of roughly 1139 m to 1140.0 m. The geotextile used for this was identified as an Armtec 200 (non-woven). A final area of geotextile placement included sections of the slope erosion channel. For the erosion channel a Nilex 1635 non-woven geotextile was used. As this was a lighter weight fabric, it was placed doubled over. Along the south erosion channel the geotextile was extended to lie over the natural tundra vegetation on the south side of the channel.

Also on the July 24th, the instrumentation lines were feed through a 1.8 m long culvert that was stood up in a small sand pile. The exterior of the culvert and the sand pile were lapped with geotextile. The outside of the culvert was encased with four bags of bentonite underneath the geotextile layers to form a collar.

During the final placement of the geotextile, the contractor was able to start placing and spreading a layer of placer gravel and sand over the geotextile covered areas. The placer gravel was the remainder of erosion control materials hauled to the site in 1996 for lining the spillway.

This material was placed in a thickness of between 0.3 m and 0.6 m over the geotextile. Placement of the placer gravel extended over the containment berm and anchor trench at the toe of the dam.

No further action was taken after placement of the placer gravel, as no rock fill material was available to continue the toe berm construction.

Note that no compaction effort was used on any of the placed materials, other than that created by passage of the construction equipment. Compaction was not considered feasible due to the condition of the underlying embankment sand and due to the need for rapid construction.

2.2 PHASE II

On August 1st, 1997 EBA returned to the site as BYG had indicated that good quality rockfill was now available to complete the toe berm construction. On the first day of activities additional preparation details were undertaken. These included adding additional geotextile to the south side of the erosion channel. This was done to extend the geotextile further onto undisturbed native ground. This was followed by placing additional placer gravel in the south channel in order to fill the channel flush to the adjacent dam surface.

Another activity was to excavate another toe trench (in front of the placer gravel covered trench that was constructed in July 1997). This trench was excavated into native soils and lined with a geotextile that extended back over the placer gravel that covered the previous toe trench. The trench was then backfilled with placer gravel.

This new trench was keyed into the north terrace slope, but the key was not of good quality and would have to be reworked when the north buttress was extended into the seepage pond. The new toe trench was completed on August 2nd, 1997.

The culvert used to contain the relocated instrumentation suite was filled with bentonite powder to complete that installation.

The final preparation activity was to construct the north terrace buttress from the top of the toe berm to the edge of the seepage pond. The sequence to construct the buttress was to fall and remove the existing standing vegetation and to then cover the slope with sand pushed over from the top of the terrace.

The root mat and ground vegetation cover on the slope was not removed. After the sand layer was inplace, a geotextile was staked up over the slope. The geotextile was then covered with a layer of placer gravel.

After all of the placer gravel had been placed, the toe berm area was surveyed by BYG in order to provide as-built information. All available placer gravel at the site had now been placed on the dam toe. BYG was pursuing regulatory approval to begin hauling in additional placer gravel to the site. As with the first phase of construction, no specific compaction of placed materials was undertaken.

The final activity completed during this phase was the spreading of some waste rock over the placer gravel. Waste rock was brought down to the dam and spread over the northern third of the toe berm area; however, the rock was of poor quality and contained excessive amounts of sand and silt. EBA recommended that it not be used and so placement was stopped. BYG believed that a better quality rock would be available after the next blast cycle in the pit, so construction was stopped at this time to await the better rock. The rock that was placed on August 2nd did not extend to the toe of the berm, as EBA wanted this area to be filled with clean placer gravel.

EBA left a field memorandum with BYG to provide some direction for when construction resumed. This is included in Appendix A.

2.3 PHASE III

On September 12th 1997 EBA returned to the site to view the toe berm. BYG had completed construction of the toe berm and the buttress along the north terrace in the ensuing period from August 2nd, 1997. EBA was not informed until after the work was done.

The berm was observed to be surfaced with "shale", except for the southern toe and the southern edge of the erosion channel. At those locations coarse rock fill was visible. It is likely that coarse rockfill was used over the majority of the toe berm and that this was then surfaced with shale; however this has not been confirmed.

The north terrace buttress was inplace and had been extended to near Dam #2. The buttress appeared to consist of a blanket of shale in the order of 0.3 m to 0.6 m in thickness. Details of the construction of the toe berm and buttress are unknown.

It was observed that the culvert containing the instrumentation suite was not visible on the toe berm – it had apparently been destroyed in the placement of the toe berm fill.

It was observed that the south erosion channel was still open from the toe berm crest to the dam crest. Portions of this channel were observed to have a steep face of sand fill on the its north side (dam side). Erosion and sloughing of the fill face was evident and seepage was observed to be exiting the face. EBA left a field memo with directions as to how this channel should be filled using a geotextile liner, placer gravel, and rock fill.

2.2 PHASE IV

The final phase of construction was completed by BYG during the fall of 1997. EBA is not aware of the specific timing for this work. This final phase of work consisted of filling in the south side erosion channel from the toe berm crest to the dam crest. The methods and materials used are not known to EBA. Observations made during the next site visit completed by EBA

(July 30th, 1998) suggests that the south channel was infilled with coarse waste rock and covered with shale.

M08-99-14108toeberm.doc

Appendix A: Referenced Field Documents

MEETING MINUTES
MOUNT NANSEN MINE TAILINGS FACILITY

Date:	July 22, 1997, 15:00
Agenda:	Meeting between DIAND Water Resources, BYG and BYG engineering consultants to review proposed emergency improvements to tailings dam to reduce rate of seepage.
Location:	Mount Nansen Mine engineering office
Present:	Bud McAlpine, DIAND Water Resources (BM) Tony Polyck, DIAND Water Resources (TP) Jerry Whitely, DIAND Water Resources, arrived at 15:30 (JW) Wayne Kettley, DIAND Water Resources, arrived at 15:30 (WK) Logan Hind, BYG Natural Resources Inc. (LH) Fred Green, BYG Natural Resources Inc. (FG) Richard Trimble, EBA Engineering Consultants Ltd. (RT) Cord Hamilton, EBA Engineering Consultants Ltd. (CH) Victor Menkal, Vista Engineering (VM)
Distribution:	All above John Slack, BYG Natural Resources Inc.
Recorded By:	Victor Menkal, Vista Engineering

CH advised that EBA felt that the seepage conditions observed on-site warranted immediate action as the potential for failure of dam was high. The proposed remedial works would include a toe berm at the downstream base of Dam no.1 with associated drainage works to reduce the phreatic surface in the dam.

CH noted that BYG Natural Resources agreed with this analysis and asked if DIAND supported the decision to undertake the remedial works. BM requested that a plan for the proposed works be provided to them.

CH provided an overview of the proposed emergency improvements to the tailings dam which would include the placement of a toe berm at dam 1. The berm would extend approximately 3m vertically above the existing seepage elevation and extend to the toe of the dam for a total vertical height of approximately 8m.

The toe berm would include a geotextile place over a layer of sand bedding material, followed by approx 0.6m of "Johnson" rock to provide a drainage layer followed by an additional layer of approximately 5.4m of well draining armour rock to provide physical stability.

The top of the berm would be 6m wide, with a back slope of approximately 2:1. The existing dam slope is approximately 3.5:1 which would result in the toe berm width narrowing to the base. (*Recorders note: the actual downstream slope of the dam no. 1 is 3:1*)

CH noted that it was also intended to provide some type of drainage system where the toe berm met the original dam to draw down the phreatic surface.

The toe-berm is intended to be a temporary emergency measure only to reduce the possibility of dam failure. A full detailed design and permanent remedial works will be required to ensure stability of the dam in the long term.

BM noted that some type of cutoff would be required at the toe of the berm. CH advised that whatever could be reasonably installed under existing field conditions would be included in the berm.

BM noted the draw down wells could not be used in the winter. CH advised that the structure was only temporary in nature and that a long term design would need to be developed as soon as this structure was in place. VM noted that the pond level would be drawn down before the winter with the treatment plant.

BM noted that there was sloughing noted on the left (north) abutment and that he was concerned about the stability of this slope. CH advised that the toe berm would help to buttress this slope as well.

BM felt that the back slope of the proposed toe berm was too steep and was worried about the stability of the base of the berm. CH explained that he did not want to in-fill the secondary containment pond as this would be required over the summer. VM noted that even if the back slope of the toe berm was increased to 3.5:1, would only lose 6m of the upper slope of the pond and that this would not reduce the storage volume appreciably.

CH agreed that the back slope would be constructed as close to 3.5:1 as possible but the actual slope would depend on the foundation conditions encountered in storage pond itself.

BM reiterated that Water Resources three primary concerns were:

1. Geotextile be extended to toe of berm and cutoff trench be installed
2. Berm slope match existing dam slope
3. Stabilization for north abutment

There was some discussion on methods for keying in to north abutment with toe berm. It was decided to clear as much vegetation as possible without excavating into bank itself.

LH noted that initial lift at base of dam was shale before any sand was placed which would help drain the toe berm.

BM noted that a plan for the proposed work should be submitted to Water Resources as soon as possible and that a detailed report including photos would be required when work was complete.

There was further discussion on the instability of the north abutment and bank. JW provided results from samples indicating seepage on north abutment had cyanide concentrations much higher than any of the other seepage locations - 30 to 35 mg/L. LH will move tailings line to north end of dam to deposit tailings beach at the north end of the dam.

BM noted that test pits dug at the toe of dam one through the sand accumulation were one to two feet until frozen soil encountered. There was some discussion on the source of the sand. Generally agreed source was the erosion channel on the south abutment.

BM requested that drawings be submitted to Water Resources. Once Water Resources and BYG had agreed on proposed work, the final drawings to be submitted to the Water Board as part of a an emergency amendment request.

CH noted that if there was any signs of imminent failure that he would have to proceed with placement of material as quickly as possible even if review not complete. BM requested that if this happened that Water Resources be notified.

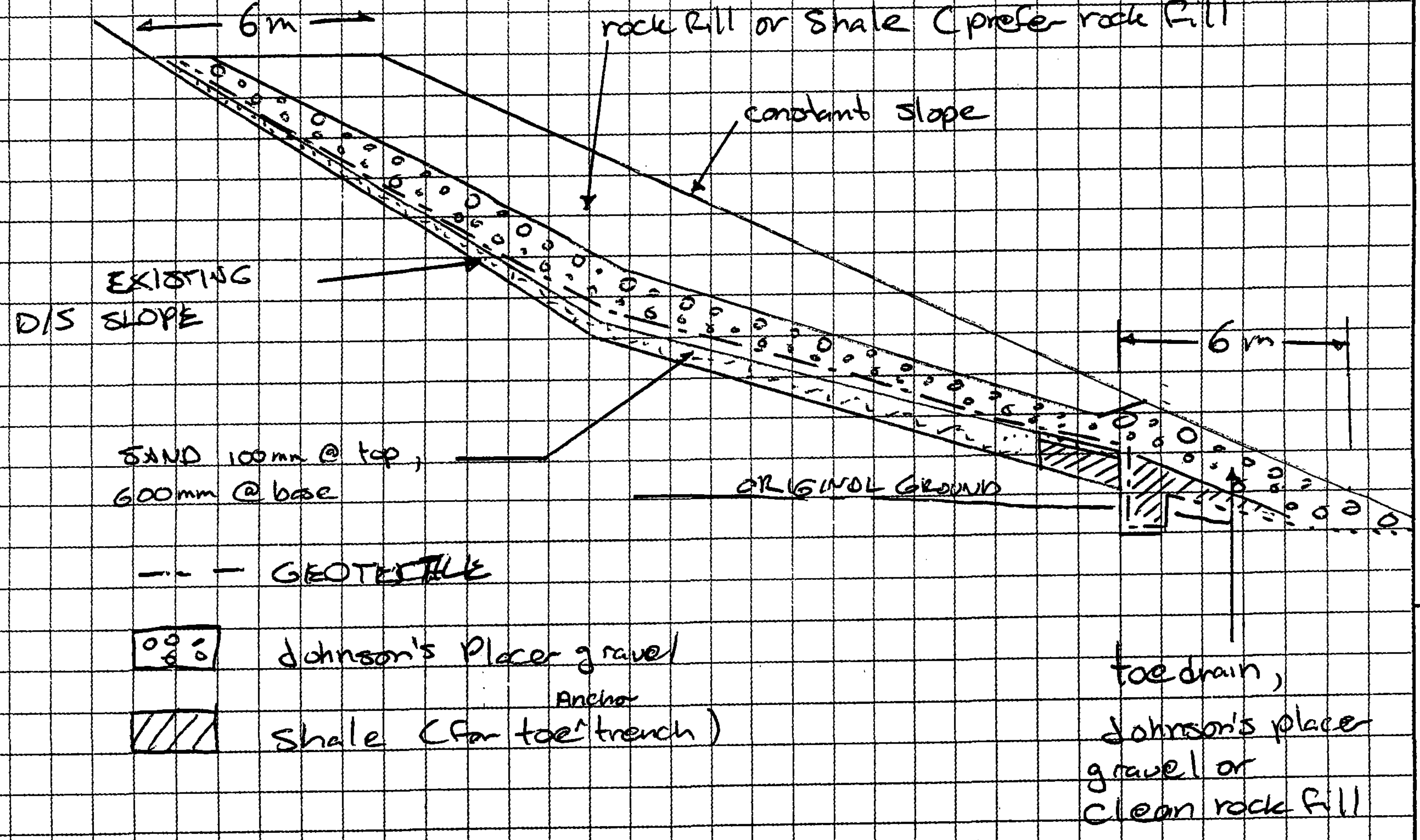
BM and TP were provided with draft copy of EBA geotechnical review of tailings facility. They are to be provided with final copies complete with photos as soon as complete. Will try to submit drawings and final report to Water Resources on Thursday.

The meeting finished at approximately 16:00.

If there should be any errors or omissions in the above, please contact the undersigned at Vista Engineering at 393-3458 by July 27, 1997.

Victor Menkal, P.Eng.

TOE BERM CONCEPT SKETCH



IMPERIAL

Project Number: 0201-97-12861 Page: 1 of 1

Date: 970729 By: Checked:

EBA Engineering Consultants Ltd.

~~INSPECTION REPORT~~

Project: MT. NANSEN TAILINGS DAM

Date: 97 08 02

Location: MT. NANSEN, YT.

General Contractor: KETZA

Contractor's Representative:

Job Number: 0201-12861

EBA Representative: CKH

ATTN: MR. LOGAN HIND

RE: TOE BERM CONSTRUCTION, DAM #1

PLACEMENT OF JOHNSON'S ROCK & GEOTEXTILE WAS COMPLETED @ 1030 hrs; BYG SURVEYORS HAVE PICKED UP THIS LAYER

WASTE ROCK HAULING HAS STARTED (1120hrs) WITH ONE TRUCK, SWITCHING TO TWO TRUCKS AFTER LUNCH

WASTE ROCK ~~IS~~ CONTAINS SIGNIFICANT AMOUNTS OF FINES & IS NOT RECOMMENDED FOR USE @ END OF TOE BERM (TOE DRAIN - SEE DRW); IT IS SUITABLE FOR AREAS DESIGNATED FOR ROCK FILL OR SHALE BUT NOT FOR "FREE DRAINING ROCK FILL".

AS A RESULT, ADDITION QUANTITIES OF JOHNSON'S PLACER GRAVEL WILL BE NEEDED FOR TOE DRAIN & FOR NORTH TERRACE BUTTRESS & FOR SOUTH ABUTMENT EROSION CHANNEL

Hours Worked:

EBA Engineering Consultants Ltd.

~~INSPECTION~~ REPORT

Project: BYG - TAILINGS DAM

Date: 970802

Location: MOUNT NANSEN, YT.

General Contractor: —

Contractor's Representative: —

Job Number: 0201-12861

EBA Representative: CKH

ACTION. ITEMS FOR BYG

① CONTINUE MONITORING OF INSTRUMENTATION INCL, DAILY PIEZOMETER READINGS, BI-WEEKLY THERMISTOR READINGS; ISSUE READINGS TO EBA, PLEASE COMMENT ON POND ELEVATION (IF AVAILABLE)

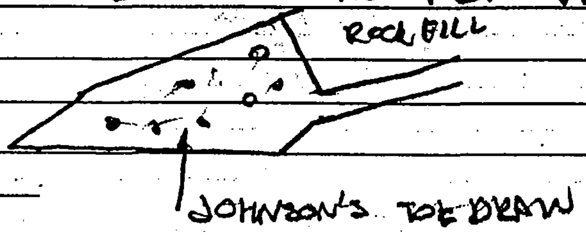
② PLACE SURVEY STAKES FOR TOE BERM CONSTRUCTION (SLOPE/FILL STAKES REQUIRED ON ALL SIDES AND TOE)

③ MONITOR TOE BERM CONSTRUCTION WITH DAILY PICTURES OF FILL

④ OBTAIN JOHNSON'S PLACER GRAVEL FOR TOE DRAIN, NORTH SLOPE BUTTRESS, AND SOUTH ABUTMENT EROSION CHANNEL (VOLUME TO BE DETERMINED BY VISTA/BYG)

⑤ MOVE PUMP BACK LINE FURTHER SOUTH TO ALLOW FILL TO EXTEND OVER TUNDRA AS PER VISTA DRAWING

⑥ CONSTRUCT TOE DRAIN AS PER VISTA DRAWING



Hours Worked:

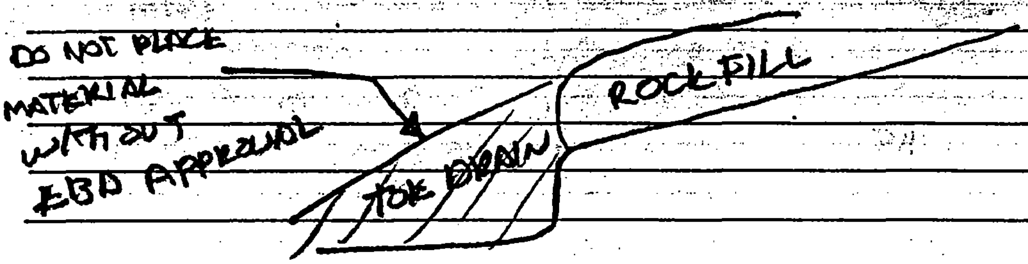
EBA Engineering Consultants Ltd.

~~INSPECTION~~ REPORT

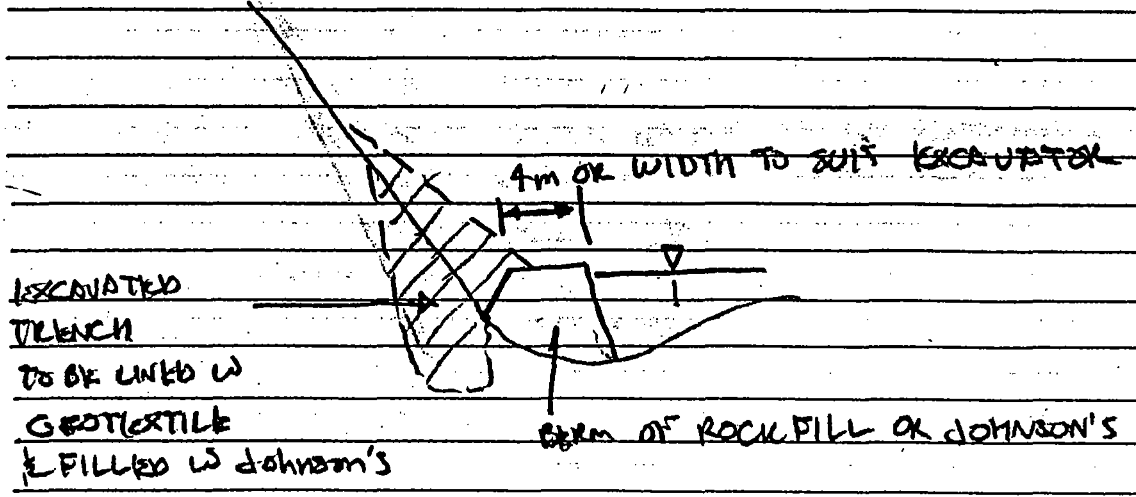
Project: BYG- TAILINGS DAM
Date: 97 08 02
Location: MOUNT HANSEN, YT.
General Contractor: /
Contractor's Representative:
Job Number: 0201-97-12861
EBA Representative: CRH

⑥ (CONTINUED) EBA SHOULD BE PRESENT TO WITNESS PART OF TOE DRAIN CONSTRUCTION

⑦ DO NOT ALLOW POOR QUALITY ROCKFILL TO BE PLACED IN AREA OF TOE DRAIN



⑧ NORTH SLOPE BUTTRESS TO BE CONSTRUCTED AS FOLLOWS



Hours Worked:

Page 3 of 4

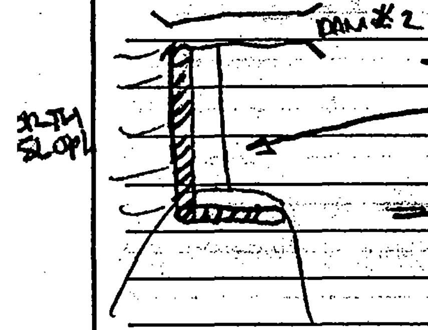
EBA Engineering Consultants Ltd.

eba

INSPECTION REPORT

Project: BYG - TAILINGS DAM
Date: 97 08 02
Location: MOUNT HANSEN
General Contractor: /
Contractor's Representative:
Job Number: 0201-97-12861
EBA Representative: CRH

⑧ (CONTINUED) - DEPTH OF TRENCH @ NORTH SLOPE TO BE FIELD DETERMINED BY EBA



- TRENCH & BERM TO INTERSECT TOE DRAIN & ANCHOR TRENCH OF MAIN DAM TOE BERM

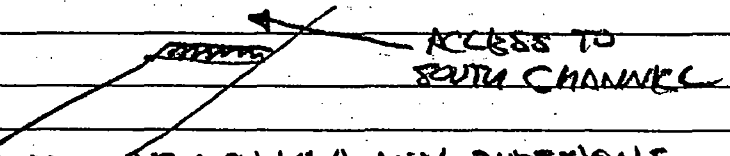
- EBA PERSONNEL TO BE PRESENT DURING BERM CONSTRUCTION

- AREA @ NORTH CORNER OF MAIN TOE BERM TO BE LEFT OPEN UNTIL NORTH BUTTRESS CONSTRUCTION

⑨ GEOTEXTILE @ END OF TOE BERM TO BE EXTENDED IF ULTIMATE TOE IS BEYOND CURRENT END OF GEOTEXTILE

- I.E. KEEP SEVERAL FEET OF GEOTEXTILE VISIBLE

⑩ SOUTH EROSION CHANNEL SHOULD BE REPAIRED AS SOON AS POSSIBLE; ACCESS FROM TOE OF BERM SHOULD BE ESTABLISHED FOR MOVING MATERIALS



Logan please call RICHARD IF YOU HAVE ANY QUESTIONS.

Hours Worked:

Page 4 of 4

eba

INSPECTION REPORT

Project: BYG - TAILINGS DAM
Date: 970912
Location: MT. NANSEN, YT
General Contractor:
Contractor's Representative:
Job Number: 0201-97-12861
EBA Representative: CKH

- CKH SITE VISIT TO MT. NANSEN MINE SITE

- CKH @ SITE @ 0735hrs

OBSERVATIONS

- TOE BERM @ DAM #1 IS ESSENTIALLY COMPLETE; FINAL FILL USED WAS "SHALE" EXCEPT FOR TOE & SOUTH SIDE (EROSION DITCH) WHICH HAVE BEEN FILLED W COARSE ROCK

- NORTH TERRACE SLOPE HAS BEEN COVERED BY SHALE BLANKET 0.3-0.6 m IN THICKNESS; BLANKET EXTENDS UP 1/2-2/3 OF SLOPE AND RUNS TO NEAR DAM #2

- A ROAD HAS BEEN BUILT AT BASE OF NORTH SLOPE INTO SEEPAGE POND TO PROVIDE ACCESS TO PUMP STATION

- SEEPAGE @ TOE OF BERM SEEMS LESS THAN PREVIOUSLY OBSERVED

- TAILINGS BEACH HAS BEEN BUILT ALONG NORTH THIRD OF DAM (U/S SIDE); A SMALL BEACH IS PRESENT @ MIDDLE & CURRENT DEPOSIT IS BEING DIRECTED TO NEAR SOUTH ABUTMENT

Hours Worked:

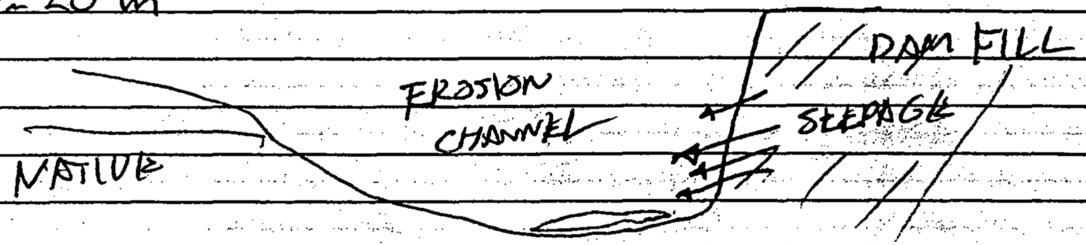
Page 1 of 4

eba

INSPECTION REPORT

Project:
Date: 97 09 12
Location:
General Contractor:
Contractor's Representative:
Job Number: 020-97-12861
EBA Representative: CRH

- SEEPAGE FROM SOUTH ABUTMENT EROSION CHANNEL IS STILL PRESENT; SOME SEEPAGE APPEARS TO BE COMING OUT OF EMBANKMENT FILL INTO THIS CHANNEL, JUST ABOVE END OF TOE BERM FOR ≈20 m



- INSTRUMENTATION SUITE PREVIOUSLY LOCATION IN D/S TOE BERM HAS BEEN WIPED OUT

CONCERNS

- EBA IS CONCERNED ABOUT SEEPAGE FROM THE EMBANKMENT FILL INTO THE SOUTH ABUTMENT EROSION CHANNEL & LACK OF INSTRUMENTATION

ACTIONS

- BYG SHOULD SAMPLE SEEPAGE FROM EMBANKMENT FILL ON SOUTH ABUTMENT TO DETERMINE WATER SOURCE
- ADDITIONAL INSTRUMENTATION SHOULD BE INSTALLED AS PLANNED

Hours Worked:

EBA Engineering Consultants Ltd.

eba

INSPECTION REPORT

Project: BYG - TAILINGS DAM

Date: 97 09 12

Location: MT. NANSEN

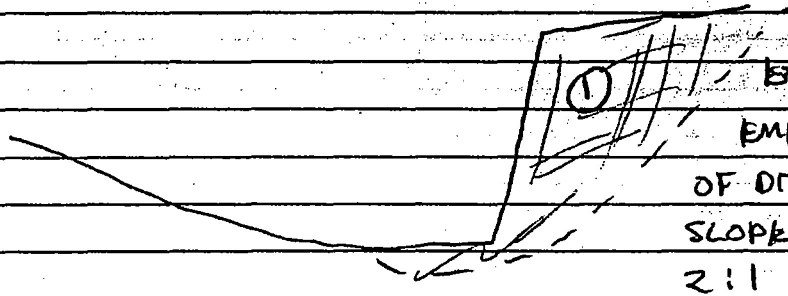
General Contractor:

Contractor's Representative:

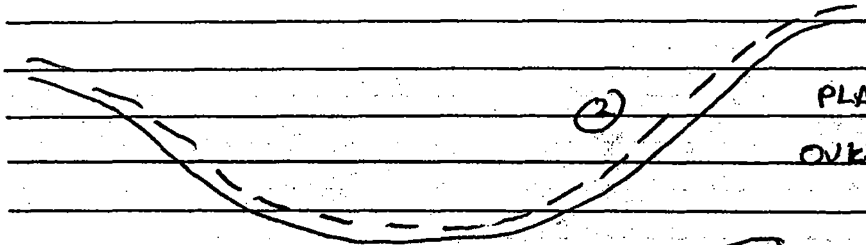
Job Number: 0201-97-12861

EBA Representative: CKH

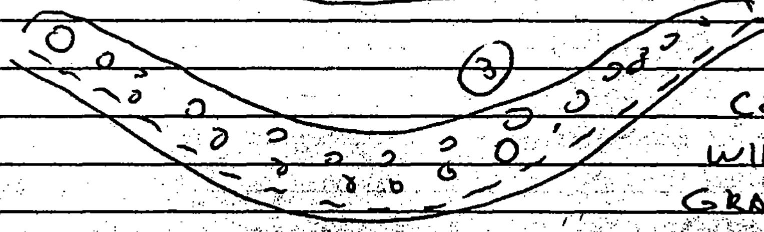
- SOUTH EROSION DITCH SHOULD BE FILLED IN AS FOLLOWS:



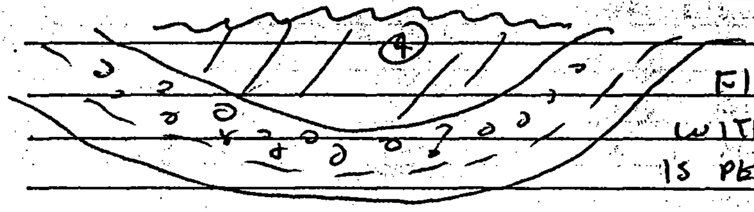
EXCAVATE EMBANKMENT SIDE OF DITCH TO SMOOTH SLOPE to AT LEAST 2:1



PLACE APPROVED GEOTEXTILE OVER SURFACE



COVER GEOTEXTILE WITH FREE DRAINING GRAVEL (Johnson's), USE AT LEAST 0.45 m (thickness) OR FILL IN ENTIRE DITCH



FILL IN REMAINING DITCH WITH MINE WASTE, ROCKFILL IS PREFERABLE

Hours Worked:

INSPECTION REPORT

Project: BYG - MOUNT NANSEN

Date: 970912

Location: MOUNT NANSEN

General Contractor:

Contractor's Representative:

Job Number: 0201-97-1286[illegible]

EBA Representative: CRH

ACTIONS (CONTINUED):

- CONTINUE BUILDING TAILINGS BEACH ALONG U/S FACE ~~SOUTH SIDE OF U/S SLOPE~~ FROM SOUTH ABUTMENT WORKING TOWARDS DAM CENTRE

REQUEST FOR INFORMATION

- EBA WOULD LIKE TO OBTAIN AND/OR REVIEW AS BUILT DRAWINGS OF TOE BERM
- EBA WOULD LIKE TO OBTAIN AND/OR REVIEW PHOTOGRAPHS & VIDEO'S OF TOE BERM CONSTRUCTION
- EBA WOULD LIKE A RECORD OF PAST TAILINGS POND WATER ELEVATIONS TO COMPARE TO HISTORICAL PIEZOMETER READINGS

Hours Worked:

Page 4 of 4

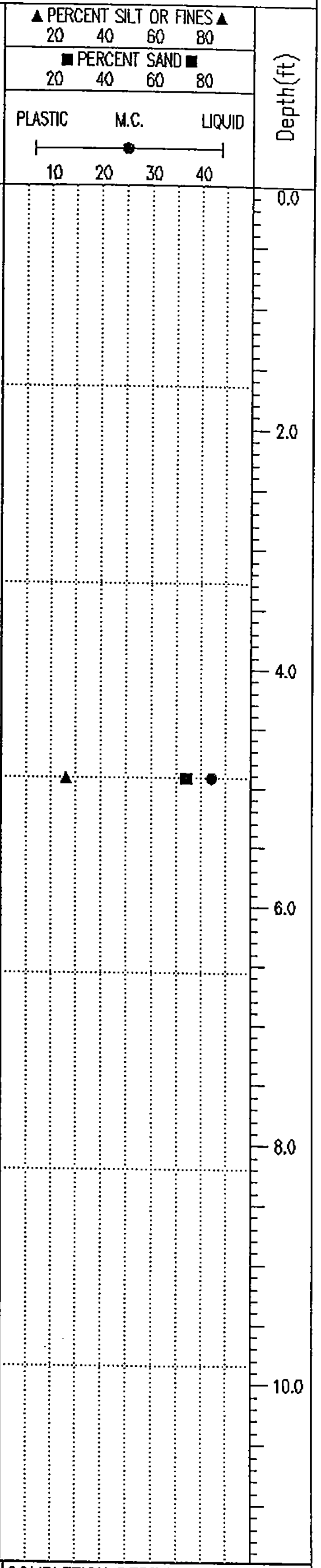
APPENDIX C

Field Assessments

Mount Nansen Dam Safety Assessment	CLIENT: DIAND – Yukon Region	TEST PIT NO: 14618-TP01
Mount Nansen Mine Site,	DRILL: Hitachi 220 Excavator	PROJECT NO: 0201-00-14618
Carmacks, YT	UTM ZONE: 8 N6881500 E388500	ELEVATION:

SAMPLE TYPE ■ GRAB SAMPLE ▨ NO RECOVERY ☒ STANDARD PEN. ▤ 75 mm SPOON ▥ CRREL BARREL

Depth(m)	SAMPLE TYPE	RUN NO	SPT(N)	USC	SOIL SYMBOL	SOIL DESCRIPTION	GROUND ICE DESCRIPTION
0.0						ORGANICS AND SAND – trace to some silt; rootlets; saturated; brown to dark brown	UNFROZEN
1.0							
	■					– becomes finer grained	FROZEN @ 1.6 m
						END OF TESTPIT @ 1.6 m – testpit filled with water to a depth of 0.5 m	
2.0						Mine Coordinates N 18934 E 20713	
3.0							

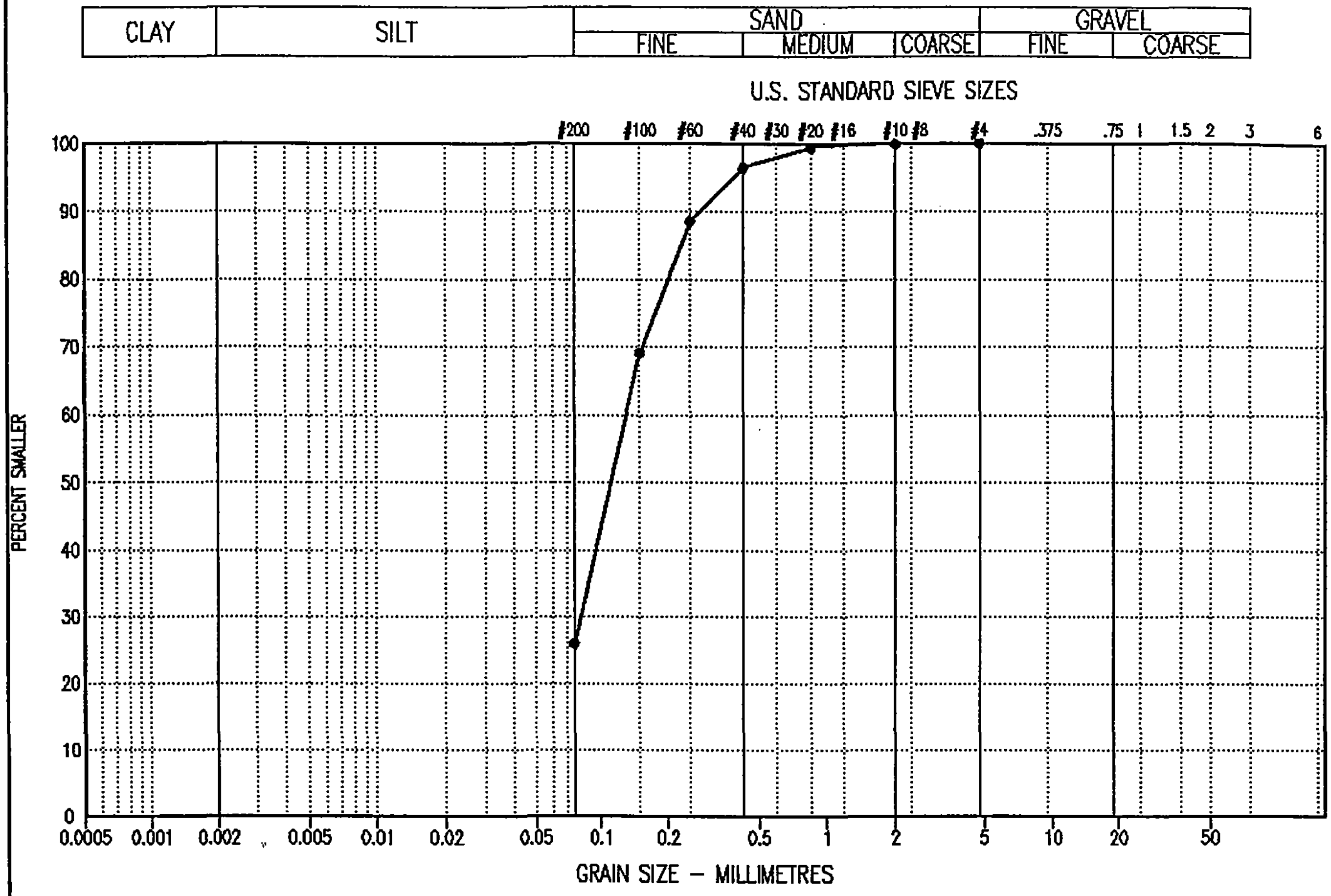


EBA Engineering Consultants Ltd.
Whitehorse, Yukon

LOGGED BY: CRH	COMPLETION DEPTH: 1.6 m
REVIEWED BY: JRT	COMPLETE: 01/08/00
	Page 1 of 1

02/09/18 08:18AM (YUKON-P3)

PARTICLE SIZE – ANALYSIS OF SOILS



SYMBOL	BOREHOLE NUMBER	DEPTH (m)	DESCRIPTION			Cu	Cc	U.S.C
			CLAY & SILT %	SAND %	GRAVEL %			
●—●	14618-TP01	1.40 – 1.60	26	74	0	2.8	1.1	SM

Project: 0201-00-14618

Date Tested: 00/08/11

BY: MS

Tested in accordance with ASTM D422 unless otherwise noted.

Mount Nansen Dam Safety Assessment	CLIENT: DIAND – Yukon Region	TEST PIT NO: 14618-TP02
Mount Nansen Mine Site,	DRILL: Hitachi 220 Excavator	PROJECT NO: 0201-00-14618
Carmacks, YT	UTM ZONE: 8 N6881500 E388500	ELEVATION:

SAMPLE TYPE ■ GRAB SAMPLE ◺ NO RECOVERY ☒ STANDARD PEN. ▤ 75 mm SPOON ▥ CRREL BARREL

Depth(m)	SAMPLE TYPE	RUN NO	SPT(N)	USC	SOIL SYMBOL	SOIL DESCRIPTION	GROUND ICE DESCRIPTION	▲PERCENT SILT OR FINES▲ 20 40 60 80 ■PERCENT SAND■ 20 40 60 80 PLASTIC M.C. LIQUID 10 20 30 40	Depth(ft)
0.0						SAND (FILL) – (tailings), trace to some silt; fine to medium grained sand; wet; brown	UNFROZEN		0.0
									2.0
1.0									
						ORGANICS AND SAND – trace to some silt; rootlets; saturated; brown to dark brown			4.0
						END OF TESTPIT @ 1.8 m – testpit filled with water to a depth of 1.6 m	FROZEN @ 1.8 m		6.0
2.0						Mine Coordinates N 18915 E 20708			
									8.0
3.0									10.0

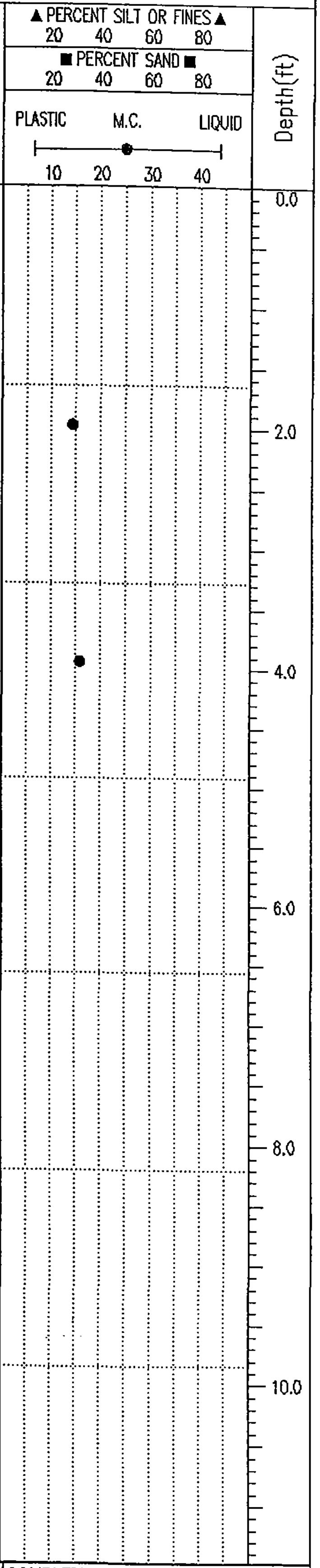
EBA Engineering Consultants Ltd. Whitehorse, Yukon	LOGGED BY: CRH	COMPLETION DEPTH: 1.8 m
	REVIEWED BY: JRT	COMPLETE: 01/08/00
		Page 1 of 1

02/09/18 08:19AM (YUKON-P3)

Mount Nansen Dam Safety Assessment	CLIENT: DIAND – Yukon Region	TEST PIT NO: 14618-TP03
Mount Nansen Mine Site,	DRILL: Hitachi 220 Excavator	PROJECT NO: 0201-00-14618
Carmacks, YT	UTM ZONE: 8 N6881500 E388500	ELEVATION:

SAMPLE TYPE ■ GRAB SAMPLE ◿ NO RECOVERY ☒ STANDARD PEN. ☰ 75 mm SPOON ‖ CRREL BARREL

Depth(m)	SAMPLE TYPE	RUN NO	SPT(N)	USC	SOIL SYMBOL	SOIL DESCRIPTION	GROUND ICE DESCRIPTION
0.0						ORGANICS – root mat	UNFROZEN
						SAND – some silt, some gravel and cobbles; fine to medium grained sand; angular; brown	
	■					– gravel and cobbles more frequent in upper 0.5 m	
1.0							
	■					– becomes wet to saturated; grey	
						– becomes silty	FROZEN @ 1.5 m
						END OF TESTPIT @ 1.5 m	
2.0						Mine Coordinates N 18940 E 20718	
3.0							



EBA Engineering Consultants Ltd. Whitehorse, Yukon	LOGGED BY: CRH	COMPLETION DEPTH: 1.5 m
	REVIEWED BY: JRT	COMPLETE: 01/08/00

Mount Nansen Dam Safety Assessment	CLIENT: DIAND – Yukon Region	TEST PIT NO: 14618-TP04
Mount Nansen Mine Site,	DRILL: Hitachi 220 Excavator	PROJECT NO: 0201-00-14618
Carmacks, YT	UTM ZONE: 8 N6881500 E388500	ELEVATION:

SAMPLE TYPE ■ GRAB SAMPLE ▨ NO RECOVERY ☒ STANDARD PEN. ▤ 75 mm SPOON ▥ CRREL BARREL

Depth(m)	SAMPLE TYPE	RUN NO	SPT(N)	USC	SOIL SYMBOL	SOIL DESCRIPTION	GROUND ICE DESCRIPTION	▲ PERCENT SILT OR FINES ▲ 20 40 60 80 ■ PERCENT SAND ■ 20 40 60 80 PLASTIC M.C. LIQUID 10 20 30 40	Depth(ft)
0.0						ORGANICS – root mat	UNFROZEN		0.0
						SAND – trace to some gravel, trace to some silt; fine to medium grained sand; wet to saturated; grey			2.0
1.0									4.0
							FROZEN @ 1.5 m		
						END OF TESTPIT @ 1.5 m			6.0
2.0									8.0
3.0									10.0

EBA Engineering Consultants Ltd. Whitehorse, Yukon	LOGGED BY: CRH	COMPLETION DEPTH: 1.5 m
	REVIEWED BY: JRT	COMPLETE: 01/08/00
		Page 1 of 1

Mount Nansen Dam Safety Assessment	CLIENT: DIAND – Yukon Region	TEST PIT NO: 14618-TP05
Mount Nansen Mine Site,	DRILL: Hitachi 220 Excavator	PROJECT NO: 0201-00-14618
Carmacks, YT	UTM ZONE: 8 N6881500 E388500	ELEVATION:

SAMPLE TYPE ■ GRAB ▨ NO RECOVERY

Depth(m)	SAMPLE TYPE	RUN NO	USC	SOIL SYMBOL	SOIL DESCRIPTION	■ STANDARD PENETRATION ■ 10 20 30 40 ◆ TEMPERATURE ◆ -1 3 7 11 PLASTIC M.C. LIQUID 10 20 30 40	■ PERCENT GRAVEL ■ 20 40 60 80 ● PERCENT SAND ● 20 40 60 80 ▲ PERCENT SILT OR FINES ▲ 20 40 60 80 ◆ PERCENT CLAY ◆ 20 40 60 80	Depth(ft)
0.0					SAND AND GRAVEL (FILL) – (residual soil), some cobbles and boulders, maximum aggregate size 450 mm; well graded; brown			0.0
								2.0
1.0					SAND (FILL) – (tailings) trace to some silt; fine to medium grained; wet to saturated; brown – liquifies if lightly vibrated			
								4.0
					ORGANICS – root mat			6.0
2.0					END OF TESTPIT @ 2.0 m – seepage in bottom of testpit Mine Coordinates N 18884 E 20601			
								8.0

EBA Engineering Consultants Ltd.
Whitehorse, Yukon

LOGGED BY: CRH	COMPLETION DEPTH: 2 m
REVIEWED BY: JRT	COMPLETE: 01/08/00
	Page 1 of 1

Mount Nansen Dam Safety Assessment	CLIENT: DIAND – Yukon Region	TEST PIT NO: 14618-TP06
Mount Nansen Mine Site,	DRILL: Hitachi 220 Excavator	PROJECT NO: 0201-00-14618
Carmacks, YT	UTM ZONE: 8 N6881500 E388500	ELEVATION:

SAMPLE TYPE ■ GRAB SAMPLE ▨ NO RECOVERY ☒ STANDARD PEN. ☰ 75 mm SPOON ◫ CRREL BARREL

Depth(m)	SAMPLE TYPE	RUN NO	SPT(N)	USC	SOIL SYMBOL	SOIL DESCRIPTION	GROUND ICE DESCRIPTION	▲ PERCENT SILT OR FINES ▲ 20 40 60 80 ■ PERCENT SAND ■ 20 40 60 80 PLASTIC M.C. LIQUID 10 20 30 40	Depth(ft)
0.0						SAND AND GRAVEL (FILL) – some cobbles and boulders, maximum aggregate size 450 mm, residual soil; well graded; brown	UNFROZEN		0.0
									2.0
						GEOTEXTILE			
						SAND (FILL) – (tailings), trace of some silt; fine to medium grained; saturated; brown – seepage			
1.0									
						ORGANICS AND SAND – trace to some silt; rootlets			
									4.0
							FROZEN @ 1.5 m		
						END OF TESTPIT @ 1.5 m			
									6.0
2.0									
						Mine Coordinates N 18877 E 20602			
									8.0
3.0									
									10.0

EBA Engineering Consultants Ltd. Whitehorse, Yukon	LOGGED BY: CRH	COMPLETION DEPTH: 1.5 m
	REVIEWED BY: JRT	COMPLETE: 01/08/00
		Page 1 of 1

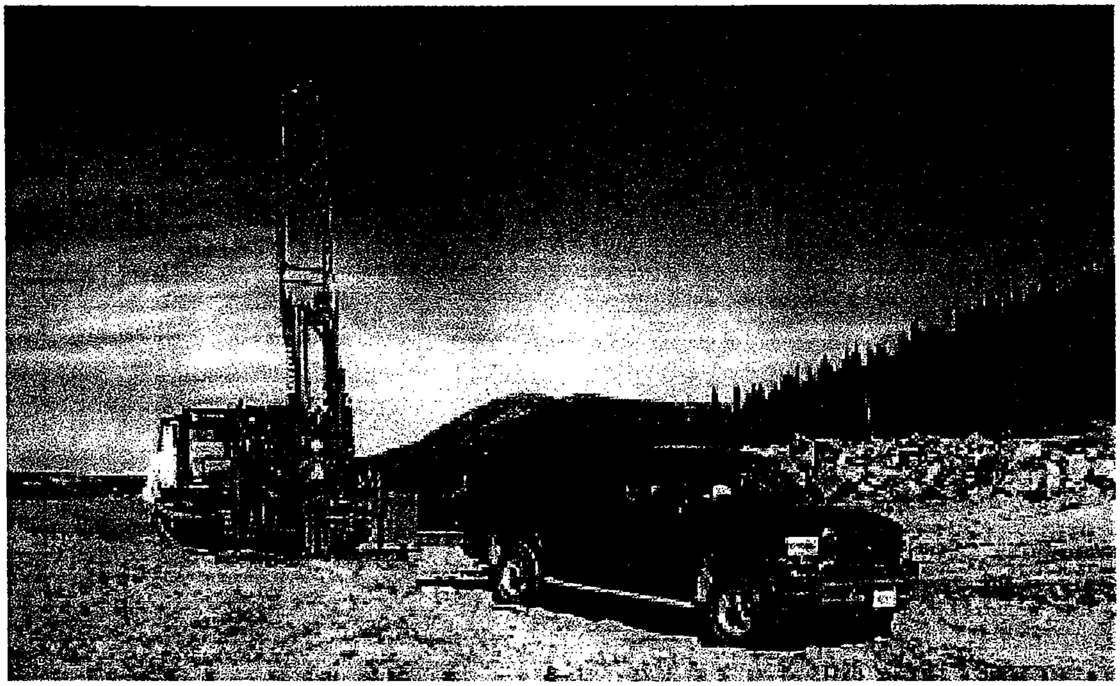
02/09/18 08:24AM (YUKON-P3)

PROBE HOLE DRILLING PROGRAM
Permafrost Depths

Borehole No.	Approximate Current Ground Elevation (m)	Approximate Original Ground Elevation (m)	Depth of Permafrost (Elevation) (m)
00-BH 01	1144.4	1142.5	11.6 (1132.8)
00-BH 02	1146.4	N/A	3.7 (1142.7)
00-BH 03	1147.7	N/A	2.6 (1145.1)
00-BH 04	1149.5	N/A	2.4 (1147.1)
00-BH 05	1143.0	N/A	3.0 (1140.0)
00-BH 06	1124.5	1126.0	2.9 (1121.6)
00-BH 07	1128.5	1135.0	3.2 (1125.3)
00-BH 08	1132.2	1138.0	3.0 (1129.2)
00-BH 09	1136.2	1141.0	3.5 (1132.7)
00-BH 10	1140.2	1144.0	2.9 (1137.3)
00-BH 11	1143.0	1146.0	2.9 (1140.1)
00-BH 12	1147.0	1148.2	2.2 (1144.8)
00-BH 13	1148.5	1149.7	2.4 (1146.1)
00-BH 14	1148.5	N/A	3.4 (1145.2)
00-BH 15	1142.5	N/A	2.6 (1139.9)
00-BH 16	1144.7	N/A	3.0 (1141.7)
00-BH 17	1124.1	N/A	0.5 (1123.6)
00-BH 18	1135.0	N/A	2.4 (1132.6)
00-BH 19	1148.7	N/A	2.4 (1146.3)
00-BH 20	1150.8	N/A	2.0 (1148.8)

Presentation of Cone Penetration Test Data,
BYG Tailings Dam

Carmacks, Yukon



Prepared for:

EBA Engineering
Whitehorse, Yukon

Prepared by:

CONETEC INVESTIGATIONS LTD.

August 10, 2000

Table Of Contents

1.0 INTRODUCTION

This report presents the results of a seismic cone penetration testing (SCPT) program carried out at the BYG tailings dam. The program entailed a total of 9 CPT's, 5 of which were SCPT holes. The tests were performed between July 31 and August 5,2000.

2.0 FIELD EQUIPMENT AND PROCEDURES

2.1 CPT Procedures

The cone penetration tests (CPT's) were carried out by **ConeTec Investigations Ltd.** of Vancouver, B.C. using an integrated electronic cone system. A 20 ton compression type cone was used for all of the soundings. The 20 ton cone has a tip area of 15 cm^2 and a friction sleeve area of $225cm^2$. A 6mm thick piezometer element is located immediately behind the cone tip. Pore pressure elements were saturated in glycerin under vacuum pressure prior to penetration. Pore pressure dissipations were recorded at 5 second intervals during all pauses in penetration. The cone system used during the program recorded the following parameters at 2.5 cm depth increments:

- Tip Resistance (Q_c) in bars
- Sleeve Friction (F_s) in bars
- Dynamic Pore pressure (U_t) in metres of water

The above parameters were printed simultaneously on a printer and stored on digital media for future analysis and reference

A complete set of baselines were taken prior to and at the end of each sounding to determine if any zero load offsets had occurred due to a temperature change in the probe. Establishing the presence and magnitude of temperature and load shifts allows the operator to make corrections to the cone data if necessary. These corrections can be important, especially where load conditions are relatively low. Temperature shifts are generally the single largest source of error effecting the accuracy of cone data. The probes used by ConeTec are temperature compensated, and only require correction in the presence of extreme temperature shifts. For this project the operating range of the cone was kept within the dynamic range of the temperature compensators. Zero load shifts did not present a problem.

The cone was pushed using a track mounted drill rig provided by Midnight Sun Drilling, of Whitehorse, Yukon. To provide the necessary reaction force the drill was anchored with a single auger anchor, depth of the anchor varied from 15 –

20 feet. Due to the cohesiveless nature of the soil it was found that the auger anchor alone was not sufficient, so reaction mass was added to the drill rig. Figure 1 outlines the pushing set-up. With the added reaction mass penetration depths of up to 13.4m were achieved.

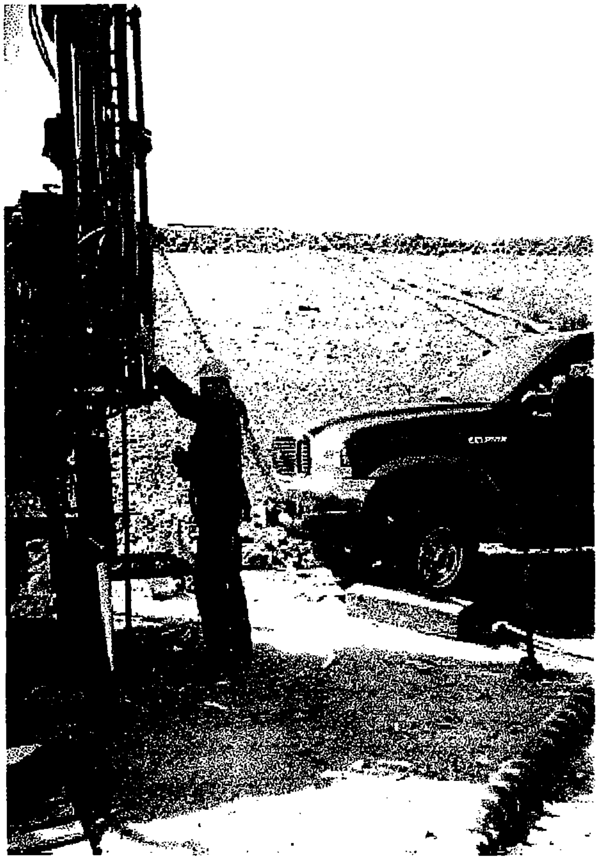


Figure 1 – Pushing Setup

The following is a list of the CPT names, test depths and estimated water tables.

CPT File	CPT Test Name	Depth (m)	Water Table (m)
195CP01	00-195 CPT-01	12.02	12
195CP02	00-195 CPT-02	2.22	5
195CP03	00-195 CPT-03	13.40	1.5
195CP04	00-195 CPT-04	4.47	12
195CP05	00-195 CPT-05	3.60	12
195CP06	00-195 CPT-06	7.43	1.5
195CP07	00-195 CPT-07	8.40	1.5
195CP08	00-195 CPT-08	7.43	1.5
195CP09	00-195 CPT-09	8.15	5.1

2.2 *Seismic CPT Test Procedures*

The equipment and procedures used for determining shear wave velocities were generally the same as those reported by Robertson et al, 1993. The procedure was incorporated within the CPT testing and conducted when the penetration was stopped to add additional push rods. With in the first few metres (depending on the ground conditions) the initial shear wave velocity measurements were made, subsequent measurements were made at one metre intervals until refusal. Before taking shear wave measurements the rods were decoupled from the drill rig, this serves to minimize the background noise that occurs during measurements.

The shear waves were generated by using a 15lb sledge hammer to strike a steel beam that sat under the stabilizers of the drillrig. This source method sets up an excellent shear wave, while creating a very weak P-wave pulse vastly improving data quality. The length and offset of the beam were taken into account during calculation of the shear wave velocities.

At each measurement location two to three hits were recorded for each end of the beam. This serves two purposes: the operator can check the consistency of the waveforms; secondly stacking of the wave forms improves the signal to noise ratio of the data. An electrical contact trigger between the hammer and the beam produced accurate triggering times and allowed for accurate timing of S wave markers.

The shear wave receiver used was a horizontally active geophone located in the body of the piezocone. The geophone is located 0.2 metres behind the cone tip. This offset is accounted for in all calculations. Data was sampled at a frequency of 20kHz (ie: 20,000 samples per second) with a total of 5000 points being recorded per wave trace. Shear wave signal experience significant attenuation in soils, therefore input sensitivity (gain) of the receiver was increased with depth to maintain acceptable signal resolution.

3.0 CONE PENETRATION TEST DATA

3.1 CPT Data

The cone penetration test data is presented in graphical format in Appendices A and B following the text of the report. The data is also stored as ACSII text in the accompanying data disk. The depth measurements for each test are referenced to the adjacent ground at the time of testing. Appendix A contains the standard CPT plots, these are plots of tip resistance, friction sleeve resistance, friction ratio, pore pressure and Soil behavior type. Appendix B contains advanced plots the show equivalent N(60) blow counts and N1(60) blow counts. The stratigraphic interpretation (SBT) included in both plot sets is based on a chart developed by Robertson et al, 1986. The charts relates cone tip resistance and sleeve friction to determine a soil behavior type. A detailed tabular interpretation to the CPT data is included in Appendix C.

3.2 Pore Pressure Dissipation Test Results

Pore pressure dissipations were automatically recorded during pauses in penetration. The pore pressure data was recorded at 5 second intervals. The pore pressure dissipation data for each CPT is included on the data disk. Plots of times for 50% pore pressure (and some to equilibrium) are presented in Appendix D along with tabular data identifying U_{50} times and U_{equil} times. These plots were only done for CPT-03, CPT-06 and CPT-09, as they were the only holes to yield valuable dissipation information.

3.3 Shear Wave Velocity Test Results

Plots of Shear wave velocity versus depth and tabular results for all the tests are presented in Appendix E. The velocity profiles show the shear wave velocity plotted at a depth midway between the one metre test interval.

The velocities measured are generally high, reflecting the high degree of compaction of the material. Most of the velocities fall within the 200 – 300 m/s range. At the bottom of CPT-03 the velocity is 1394 m/s indicating that the final interval is in frozen ground.

We trust that the information presented in this report is sufficient for your purposes. If you have any questions regarding the contents of this report, please do nor hesitate to contact our office.

Yours truly,

ConeTec Investigations Ltd.

Per

Adam Pidlisecky

Appendix A

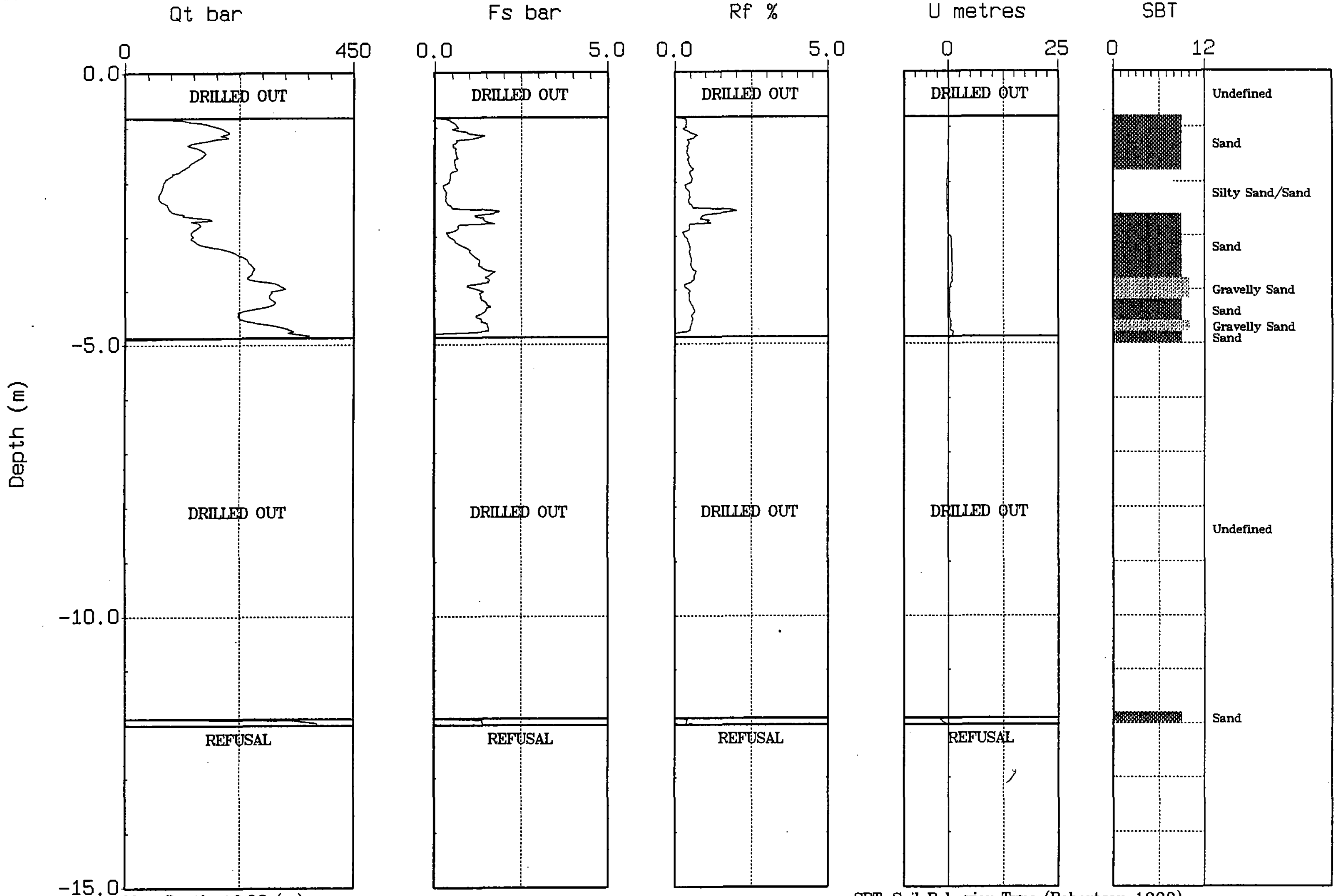
Standard CPT Plots

CONETEC

EBA ENGINEERING

Site: 00-195 CPT-01
Location: BYG DAM

Cone: 20 TON A 094
Date: 08:01:00 09:08



Max. Depth: 12.02 (m)

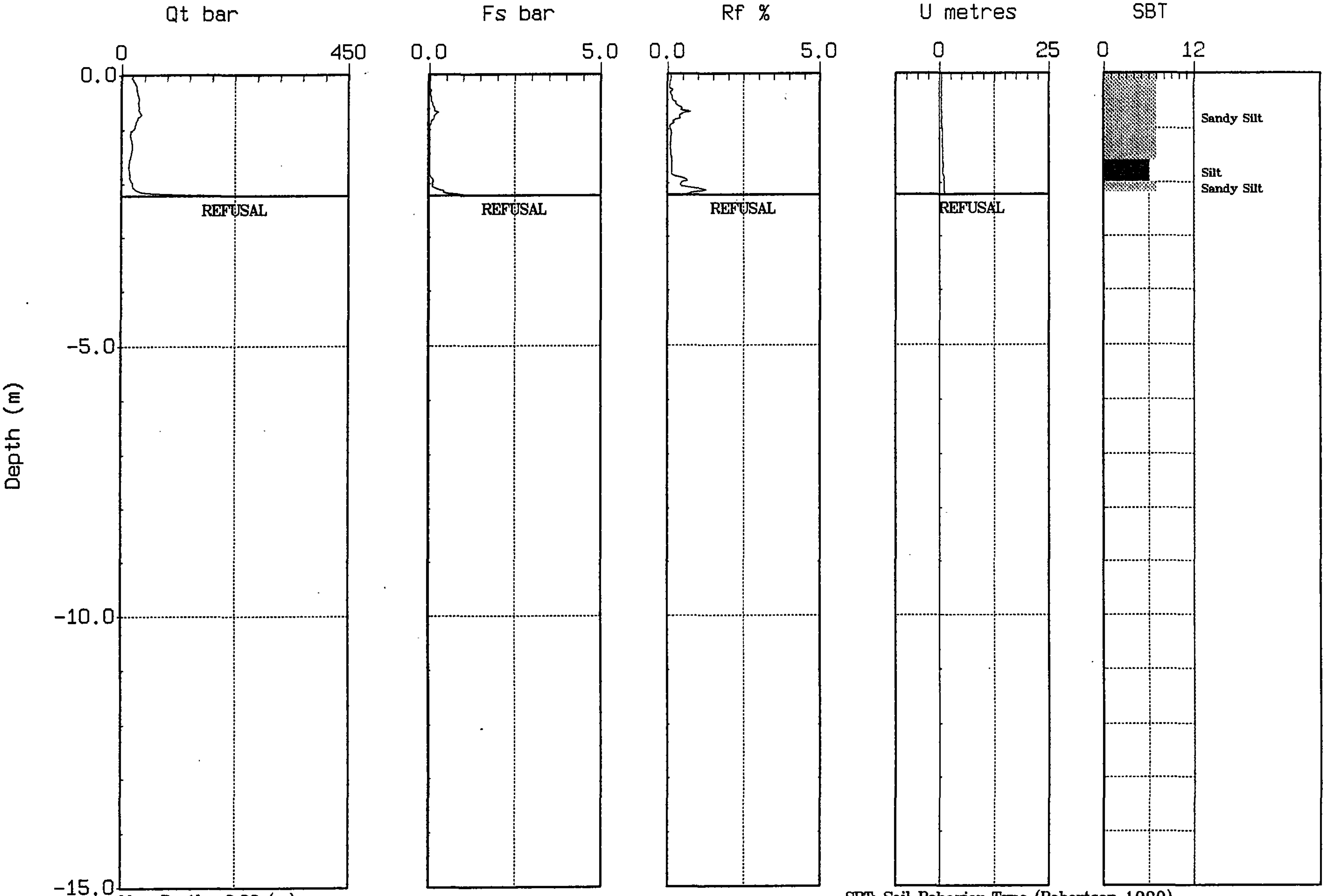
Depth Inc.: 0.025 (m)

SBT: Soil Behavior Type (Robertson 1990)

EBA ENGINEERING

Site: 00-195 CPT-02
Location: BYG DAM

Cone: 20 TON A 094
Date: 08:02:00 11:38



Max. Depth: 2.22 (m)

Depth Inc.: 0.025 (m)

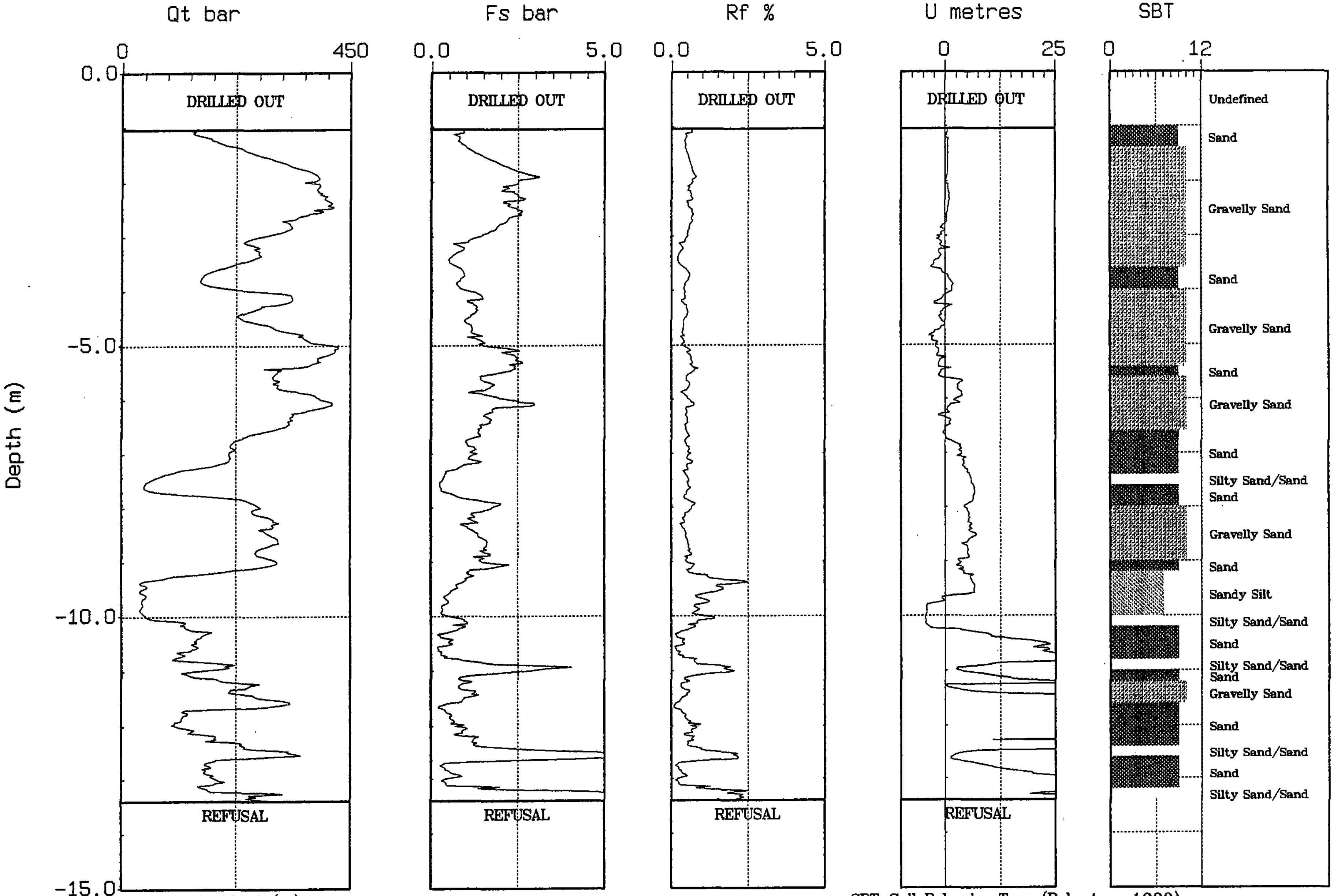
SBT: Soil Behavior Type (Robertson 1990)

CONETEC

EBA ENGINEERING

Site: 00-195 CPT-03
Location: BYG DAM

Cone: 20 TON A 094
Date: 08:02:00 13:39



Max. Depth: 13.40 (m)

Depth Inc.: 0.025 (m)

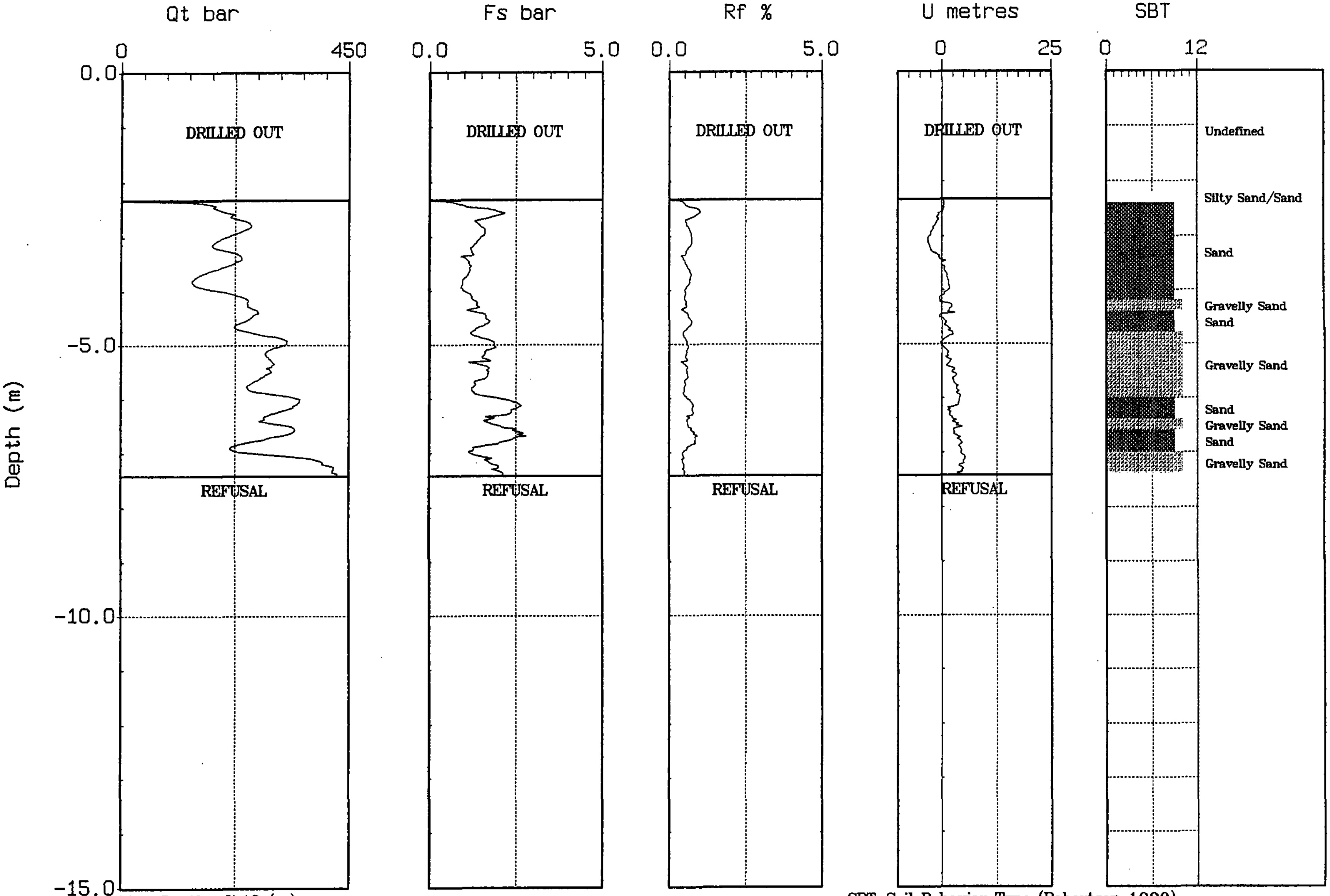
SBT: Soil Behavior Type (Robertson 1990)

CONETEC

EBA ENGINEERING

Site: 00-195 CPT-06
Location: BYG DAM

Cone: 20 TON A 094
Date: 08:04:00 09:10



Max. Depth: 7.43 (m)

Depth Inc.: 0.025 (m)

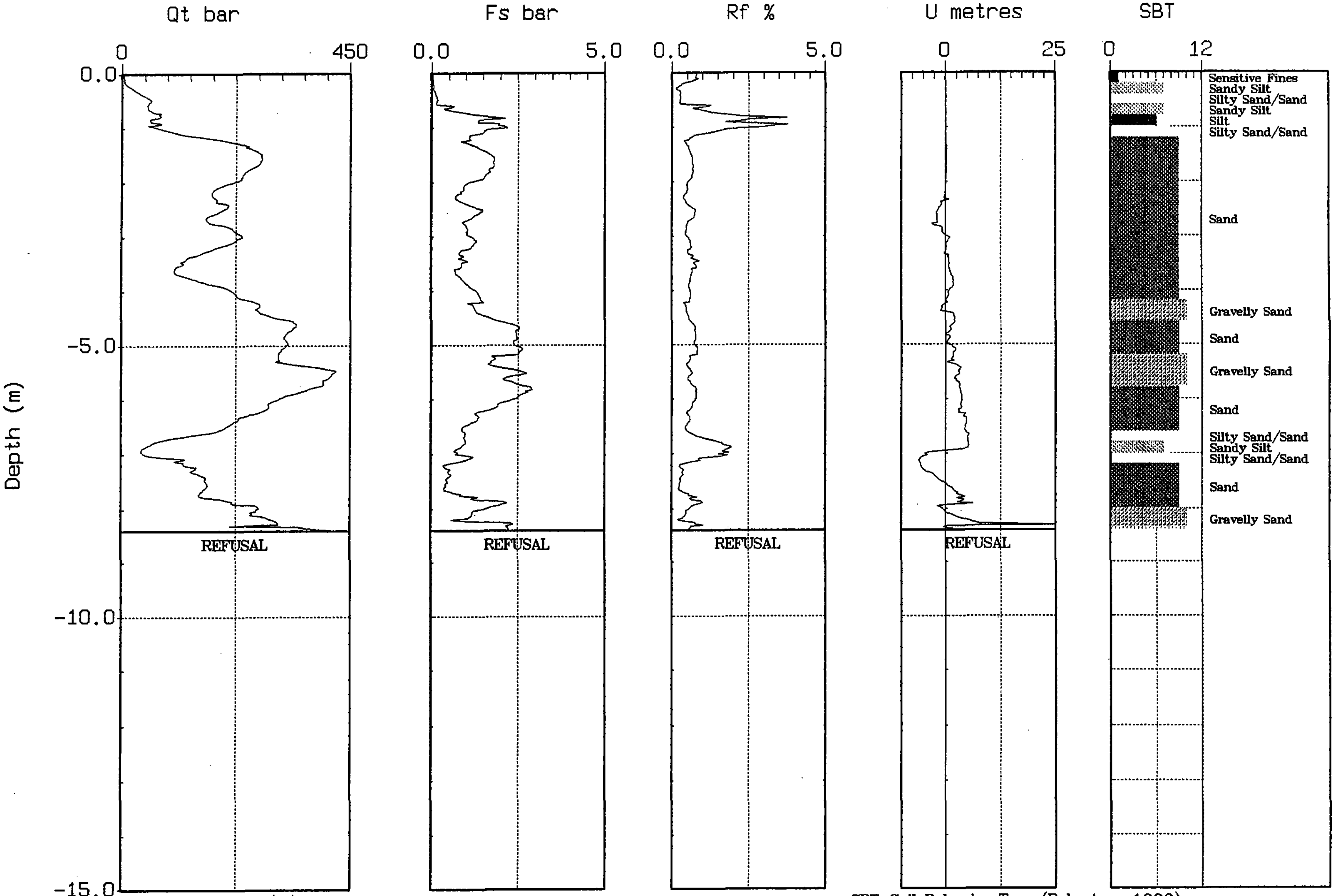
SBT: Soil Behavior Type (Robertson 1990)

CONETEC

EBA ENGINEERING

Site: 00-195 CPT-07
Location: BYG DAM

Cone: 20 TON A 094
Date: 08:04:00 13:22



Max. Depth: 8.40 (m)

Depth Inc.: 0.025 (m)

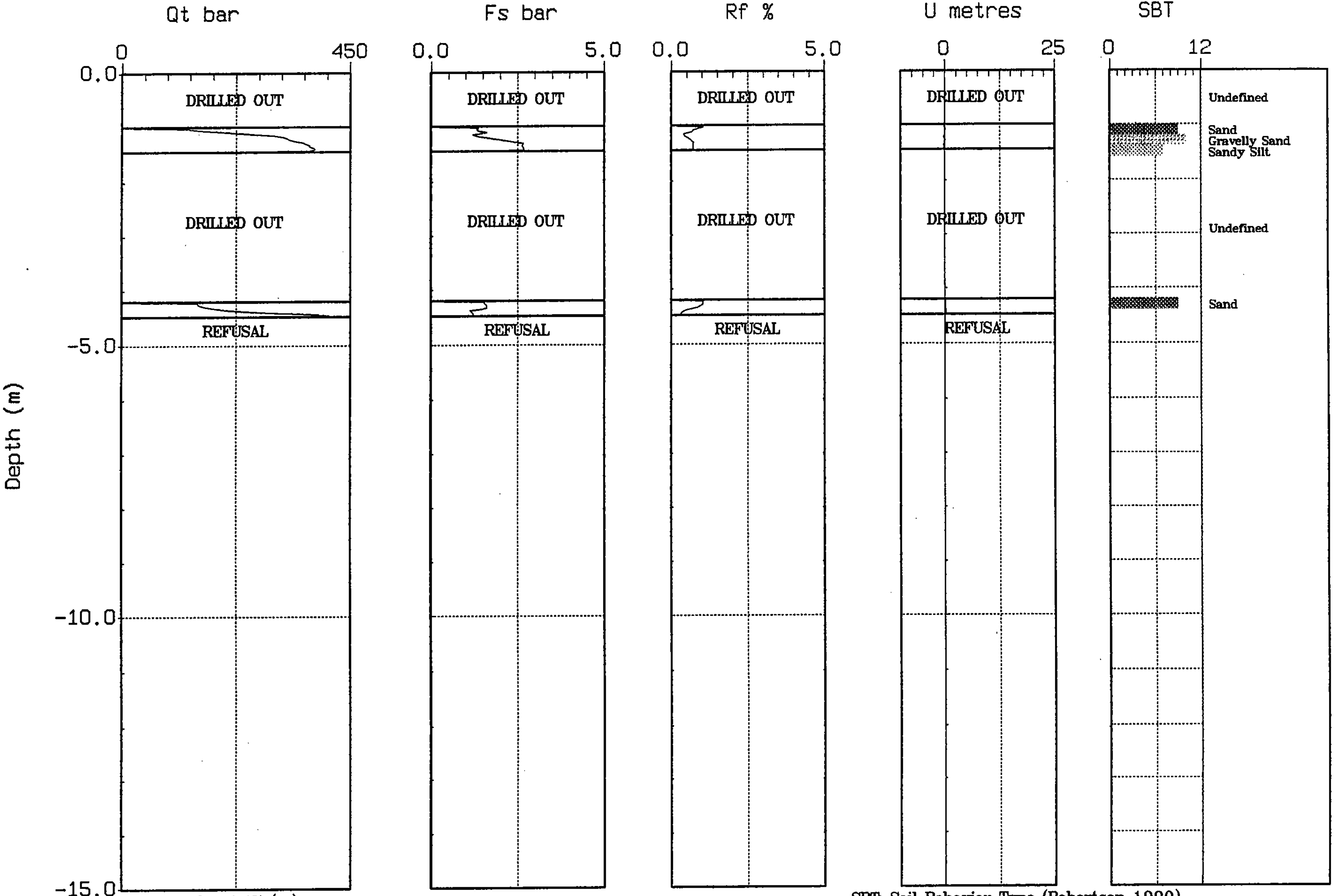
SBT: Soil Behavior Type (Robertson 1990)

CONETEC

EBA ENGINEERING

Site: 00-195 CPT-04
Location: BYG DAM

Cone: 20 TON A 094
Date: 08:03:00 07:45



Max. Depth: 4.47 (m)

Depth Inc.: 0.025 (m)

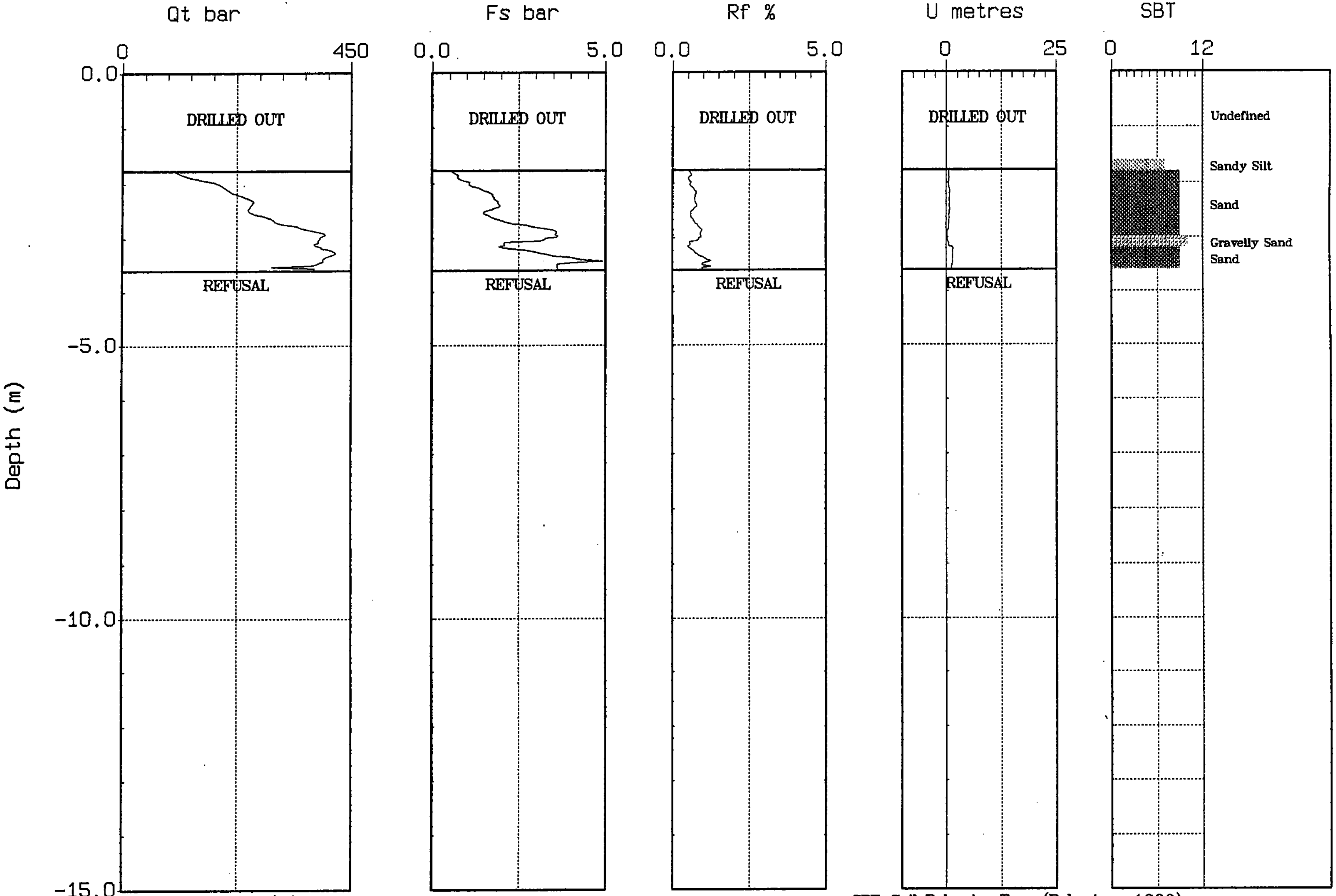
SBT: Soil Behavior Type (Robertson 1990)

CONETEC

EBA ENGINEERING

Site: 00-195 CPT-05
Location: BYG DAM

Cone: 20 TON A 094
Date: 08:03:00 11:15



Max. Depth: 3.60 (m)

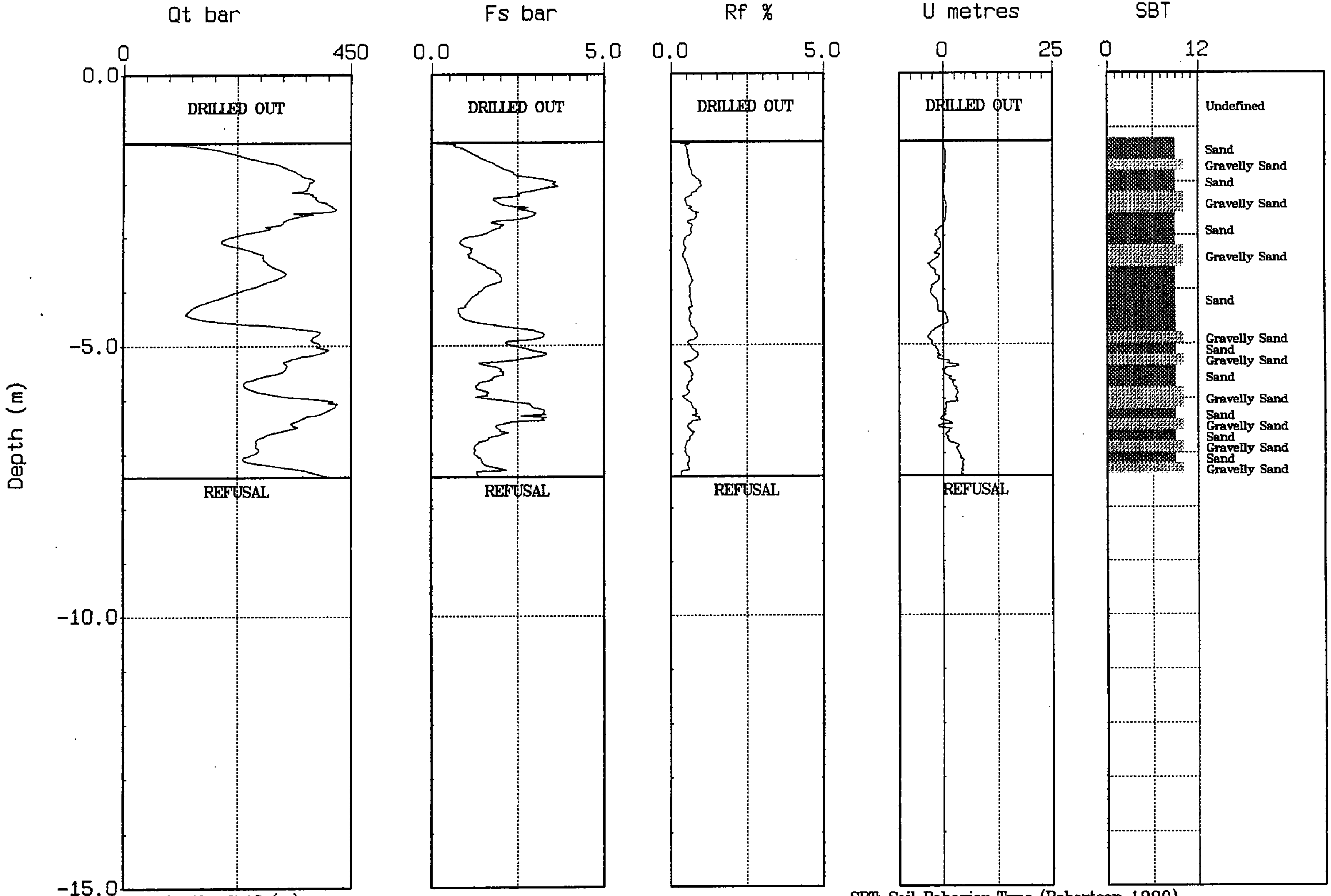
Depth Inc.: 0.025 (m)

SBT: Soil Behavior Type (Robertson 1990)

EBA ENGINEERING

Site: 00-195 CPT-08
Location: BYG DAM

Cone: 20 TON A 094
Date: 08:04:00 15:47



Max. Depth: 7.43 (m)

Depth Inc.: 0.025 (m)

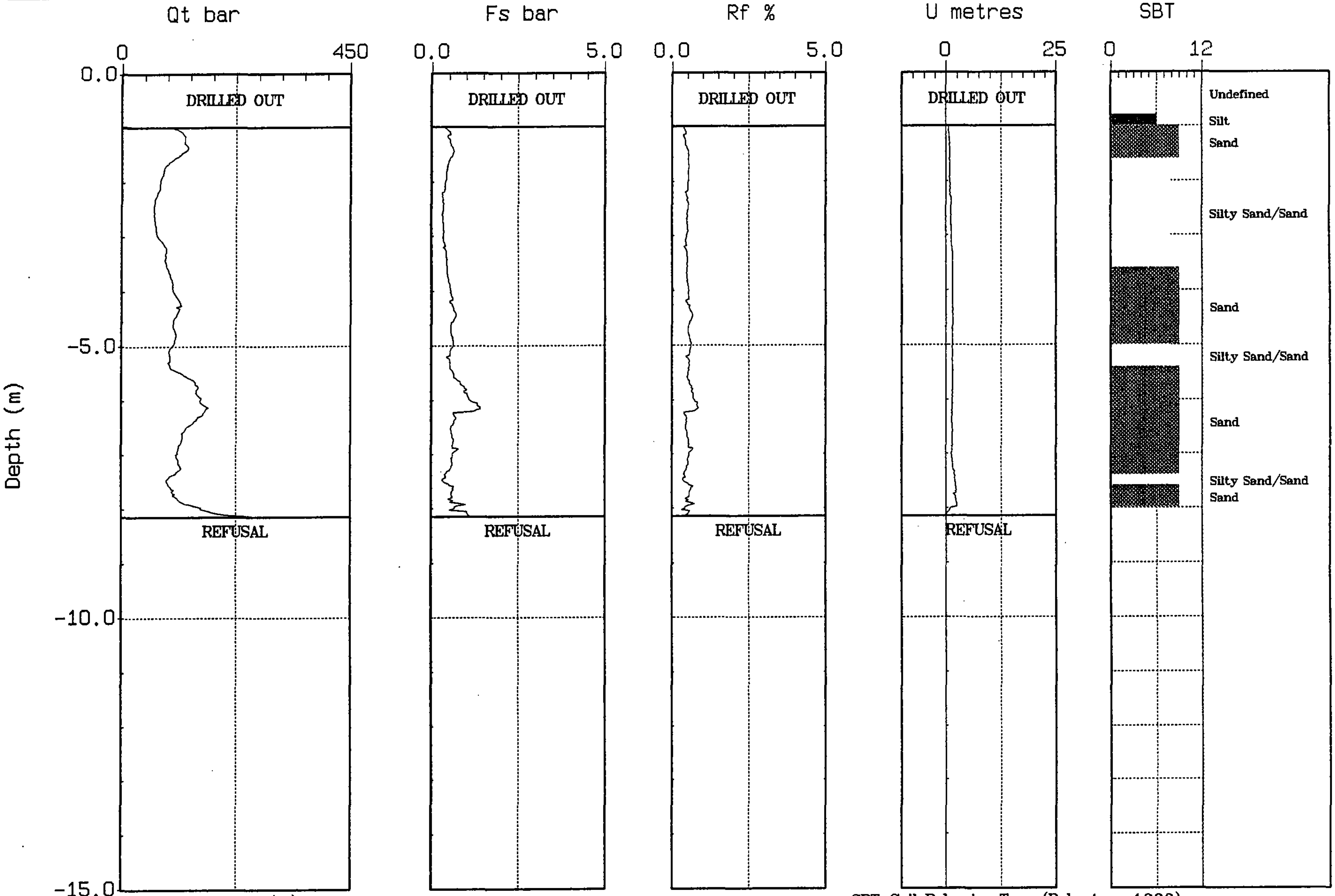
SBT: Soil Behavior Type (Robertson 1990)

CONETEC

EBA ENGINEERING

Site: 0-195 CPT-09
Location: BYG DAM

Cone: 20 TON A 094 0
Date: 08:04:00 17:49



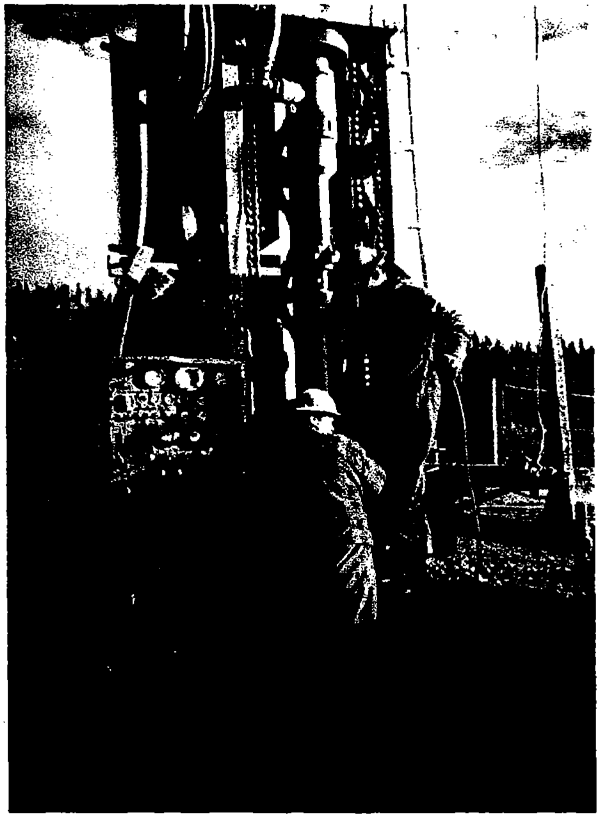
Max. Depth: 8.15 (m)

Depth Inc.: 0.025 (m)

SBT: Soil Behavior Type (Robertson 1990)

Presentation of Cone Penetration Test Data,
Phase II
BYG Tailings Dam

Carmacks, Yukon



Prepared for:

EBA Engineering
Whitehorse, Yukon

Prepared by:

CONETEC INVESTIGATIONS LTD.

September 29, 2000

Table Of Contents

1.0 INTRODUCTION

This report presents the results of a seismic cone penetration testing (SCPT) program carried out at the BYG tailings dam. The program was a follow up to an initial SCPT investigation that was undertaken between July 31 and August 5,2000. The second phase of testing involved 9 CPT's, 6 of which were SCPT holes. The second phase tests were. conducted on September 14 and 15,2000.

2.0 FIELD EQUIPMENT AND PROCEDURES

2.1 CPT Procedures

The cone penetration tests (CPT's) were carried out by **ConeTec Investigations Ltd.** of Vancouver, B.C. using an integrated electronic cone system. A 20 ton compression type cone was used for all of the soundings. The 20 ton cone has a tip area of 15 cm^2 and a friction sleeve area of $225cm^2$. A 6mm thick piezometer element is located immediately behind the cone tip. Pore pressure elements were saturated in glycerin under vacuum pressure prior to penetration. Pore pressure dissipations were recorded at 5 second intervals during all pauses in penetration. The cone system used during the program recorded the following parameters at 2.5 cm depth increments:

- Tip Resistance (Q_c) in bars
- Sleeve Friction (F_s) in bars
- Dynamic Pore pressure (U_t) in metres of water

The above parameters were printed simultaneously on a printer and stored on digital media for future analysis and reference

A complete set of baselines was taken prior to and at the end of each sounding to determine if any zero load offsets had occurred due to a temperature change in the probe. Establishing the presence and magnitude of temperature and load shifts allows the operator to make corrections to the cone data if necessary. These corrections can be important, especially where load conditions are relatively low. Temperature shifts are generally the single largest source of error effecting the accuracy of cone data. The probes used by ConeTec are temperature compensated, and only require correction in the presence of extreme temperature shifts. For this project the operating range of the cone was kept within the dynamic range of the temperature compensators. Zero load shifts did not present a problem.

The cone was pushed using a SCHRAMM Reverse Circulation drill rig provided by Midnight Sun Drilling, of Whitehorse, Yukon. The drill rig has a dead weight of

90,000lbs, this weight provided more than adequate reaction force to push the cone. The SCHRAMM drill has a maximum thrust of 20tons. The rig was able to achieve penetration depths of up to 17m and tip resistances of up to 700bar. Figure 1 shows the pushing setup and the deflection of the rods at refusal.

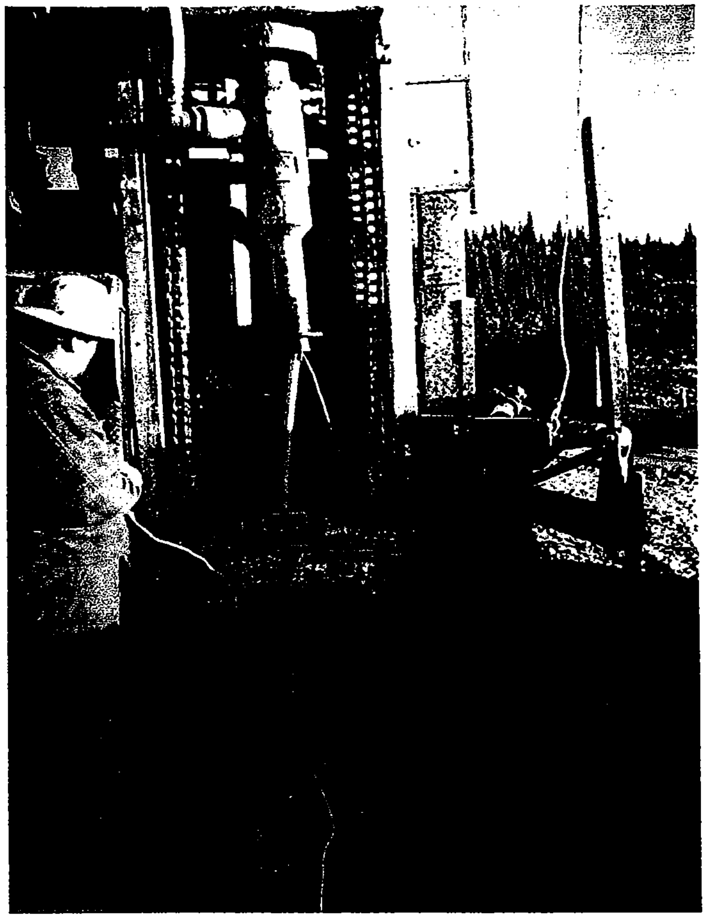


Figure 1 – Pushing Setup

The following is a list of the CPT test names, test depths and locations.

CPT File	CPT Test Name	Depth (m)	Location
195CP10	00-195 CPT-10	12.62	5.7m **S**, 2.5m **E** of Y4159
195CP11	00-195 CPT-11	17.00	4.3m **S**, 1.2m **E** of Y4157
195CP12	00-195 CPT-12	10.85	6.4m **N**, 4.5m **E** of Y4156
195CP12A	00-195 CPT-12A	13.55	4.9m **S**, 2.7m **E** of BH3

195CP13	00-195 CPT-13	12.60	1.9m **E** of Y4152
195CP14	00-195 CPT-14	5.88	6.5m **S**, 1.8m **E** of Y4150
195CP15	00-195 CPT-15	10.75	6.7m **N** of BH5
195CP16	00-195 CPT-16	5.35	20m **NNW** of Y4186
195CP17	00-195 CPT-17	8.38	12.5m **W** of BH9

2.2 *Seismic CPT Test Procedures*

The equipment and procedures used for determining shear wave velocities were generally the same as those reported by Robertson et al, 1983. The procedure was incorporated within the CPT testing and conducted when the penetration was stopped to add additional push rods. With in the first few metres (depending on the ground conditions) the initial shear wave velocity measurements were made, subsequent measurements were made at one metre intervals until refusal. Before taking shear wave measurements the rods were decoupled from the drill rig, this serves to minimize the background noise that occurs during measurements.

The shear waves were generated by using a 15lb sledge hammer to strike a steel beam that sat under the stabilizers of the drill rig. This source method sets up an excellent shear wave, while creating a very weak P-wave pulse vastly improving data quality. The length and offset of the beam were taken into account during calculation of the shear wave velocities.

At each measurement location two to three hits were recorded for each end of the beam. This serves two purposes: the operator can check the consistency of the waveforms; secondly stacking of the wave forms improves the signal to noise ratio of the data. An electrical contact trigger between the hammer and the beam produced accurate triggering times and allowed for accurate timing of S wave markers.

The shear wave receiver used was a horizontally active geophone located in the body of the piezocone. The geophone is located 0.2 metres behind the cone tip. This offset is accounted for in all calculations. Data was sampled at a frequency of 20kHz (ie: 20,000 samples per second) with a total of 5000 points being recorded per wave trace. The shear wave signal experienced significant attenuation in the soils, therefore input sensitivity (gain) of the receiver was increased with depth to maintain acceptable signal resolution.

3.0 CONE PENETRATION TEST DATA

3.1 CPT Data

The cone penetration test data is presented in graphical format in Appendices A and B following the text of the report. The data is also stored as ACSII text in the accompanying data disk. The depth measurements for each test are referenced to the adjacent ground surface at the time of testing. Appendix A contains the standard CPT plots. These plots illustrate the variation in tip resistance, friction sleeve resistance, friction ratio, pore pressure and Soil behavior type with depth. Appendix B contains advanced plots that show equivalent N(60) blow counts and N1(60) blow counts. The stratigraphic interpretation (SBT) included in both plot sets is based on a chart developed by Robertson et al, 1986. The charts relate cone tip resistance and friction ratio to determine a soil behavior type. A detailed tabular interpretation of the CPT data is included in Appendix C.

With the exception of tests 12 and 12A, all holes reached the permafrost boundary. The permafrost boundary can be identified by the a jump in pore pressure. Tests 12 and 12A fell short of this boundary, reaching 10.85m and 13.55m respectively. Upon inspection of the cone at the conclusion of test 12, it was noted that there was damage to the end of the cone that was indicative of coarse granular materials. It was not known whether the damage was a result of near surface fill, or due to the presence of fill at the refusal depth.

3.2 Shear Wave Velocity Test Results

Plots of Shear wave velocity versus depth and tabular results for all the tests are presented in Appendix D. The velocity profiles show the shear wave velocity plotted at a depth midway between the one metre test interval.

The velocities measured are generally high, reflecting the high degree of compaction of the material. Most of the velocities fall within the 200 – 350 m/s range. Velocities measured at the permafrost boundary were above 400m/s. A seismic test was attempted on test number 17, but due to the loose state of the material, very poor beam coupling was achieved yielding poor data quality. This data was therefore discarded.

We trust that the information presented in this report is sufficient for your purposes. If you have any questions regarding the contents of this report, please do not hesitate to contact our office.

Yours truly,

ConeTec Investigations Ltd.

Per

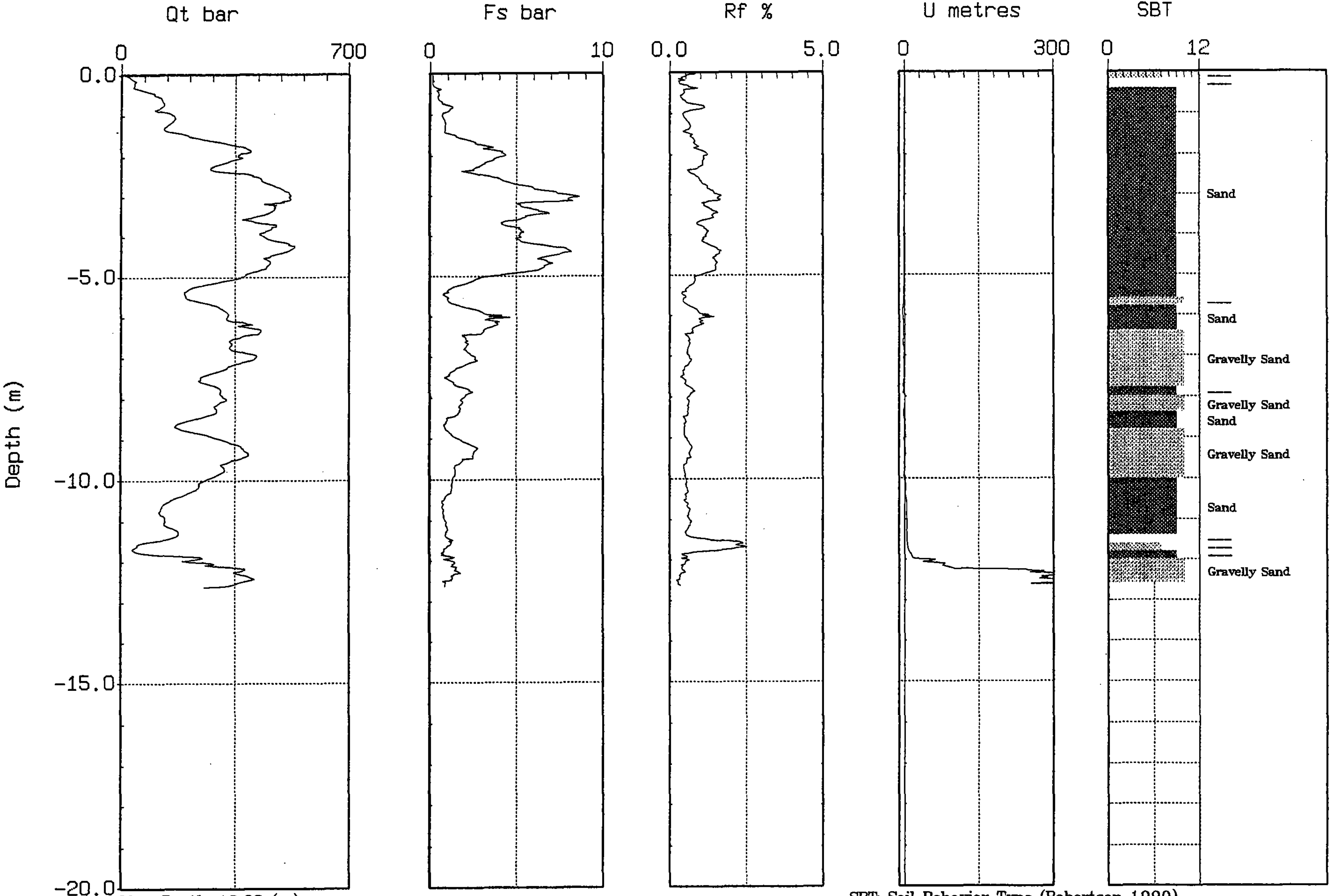
Adam Pidlisecky

CONETEC

EBA ENGINEERING

Site: 00-195 CPT-10
Location: BYG DAM

Cone: 20 TON A 095
Date: 09:14:00 11:21



Max. Depth: 12.62 (m)

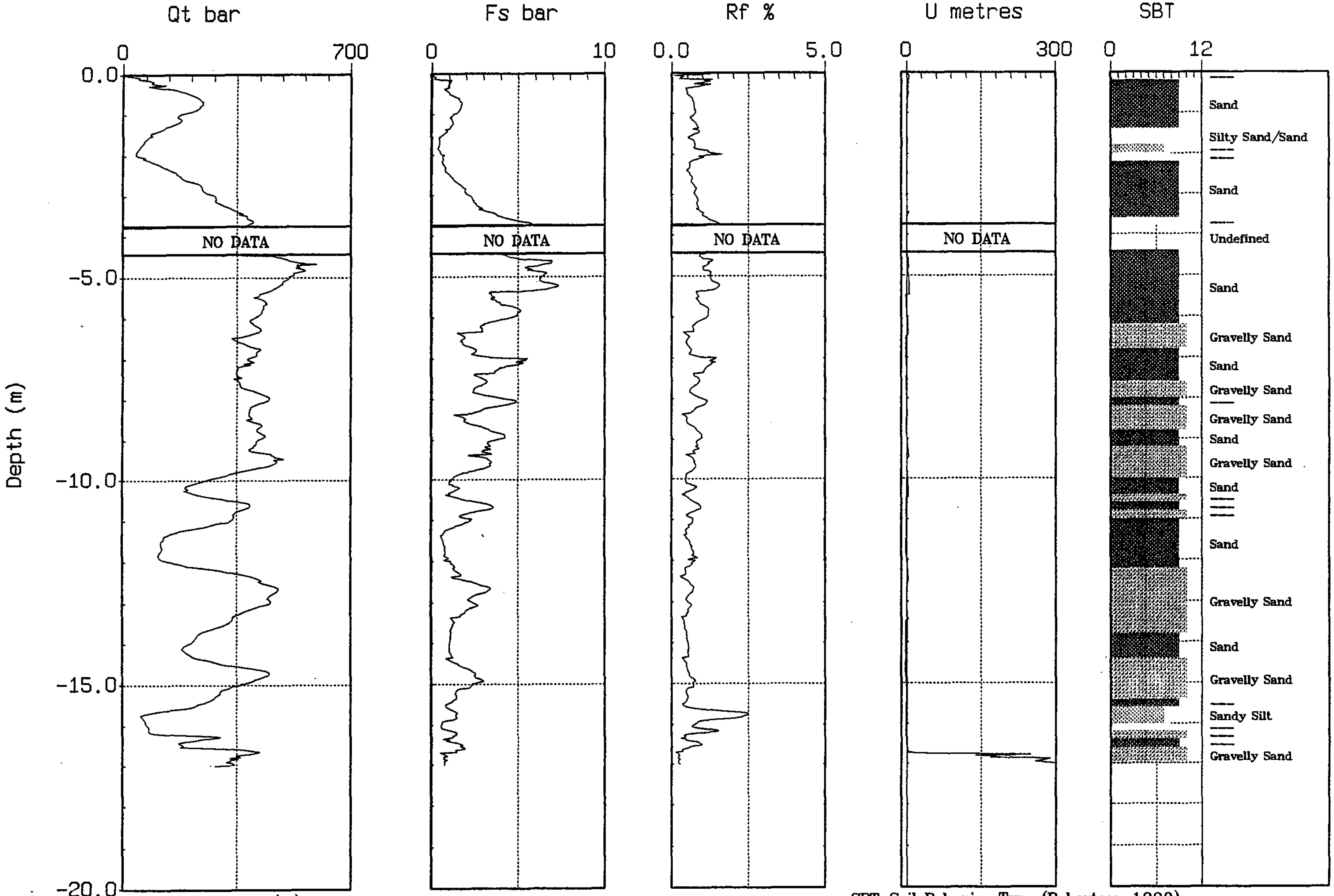
Depth Inc.: 0.025 (m)

SBT: Soil Behavior Type (Robertson 1990)

EBA ENGINEERING

Site: 00-195 CPT-11
Location: BYG DAM

Cone: 20 TON A 095
Date: 09:14:00 13:19



Max. Depth: 17.00 (m)

Depth Inc.: 0.025 (m)

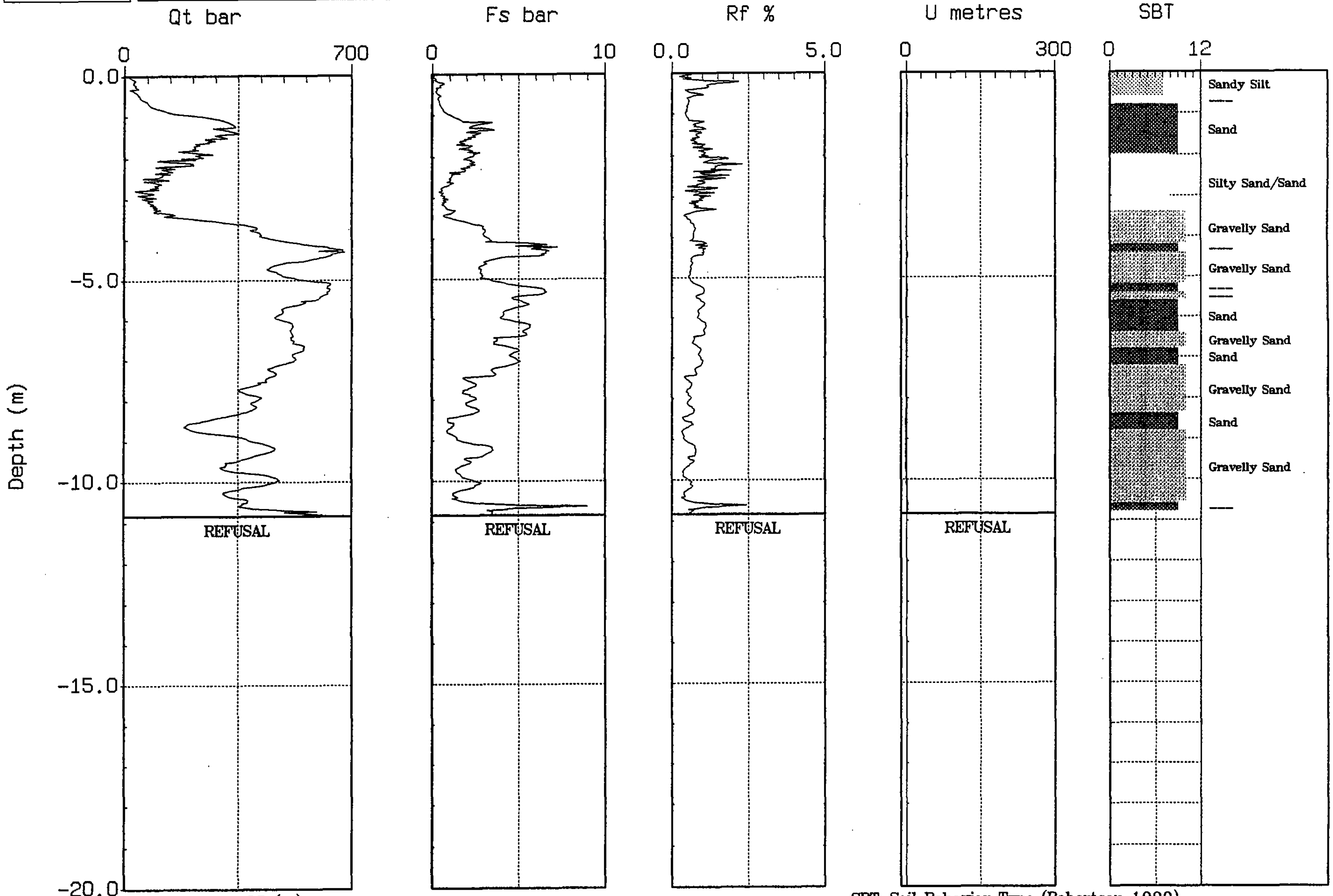
SBT: Soil Behavior Type (Robertson 1990)

CONETEC

EBA ENGINEERING

Site: 00-195 CPT-12
Location: BYG DAM

Cone: 20 TON A 097
Date: 09:14:00 15:23



Max. Depth: 10.85 (m)

Depth Inc.: 0.025 (m)

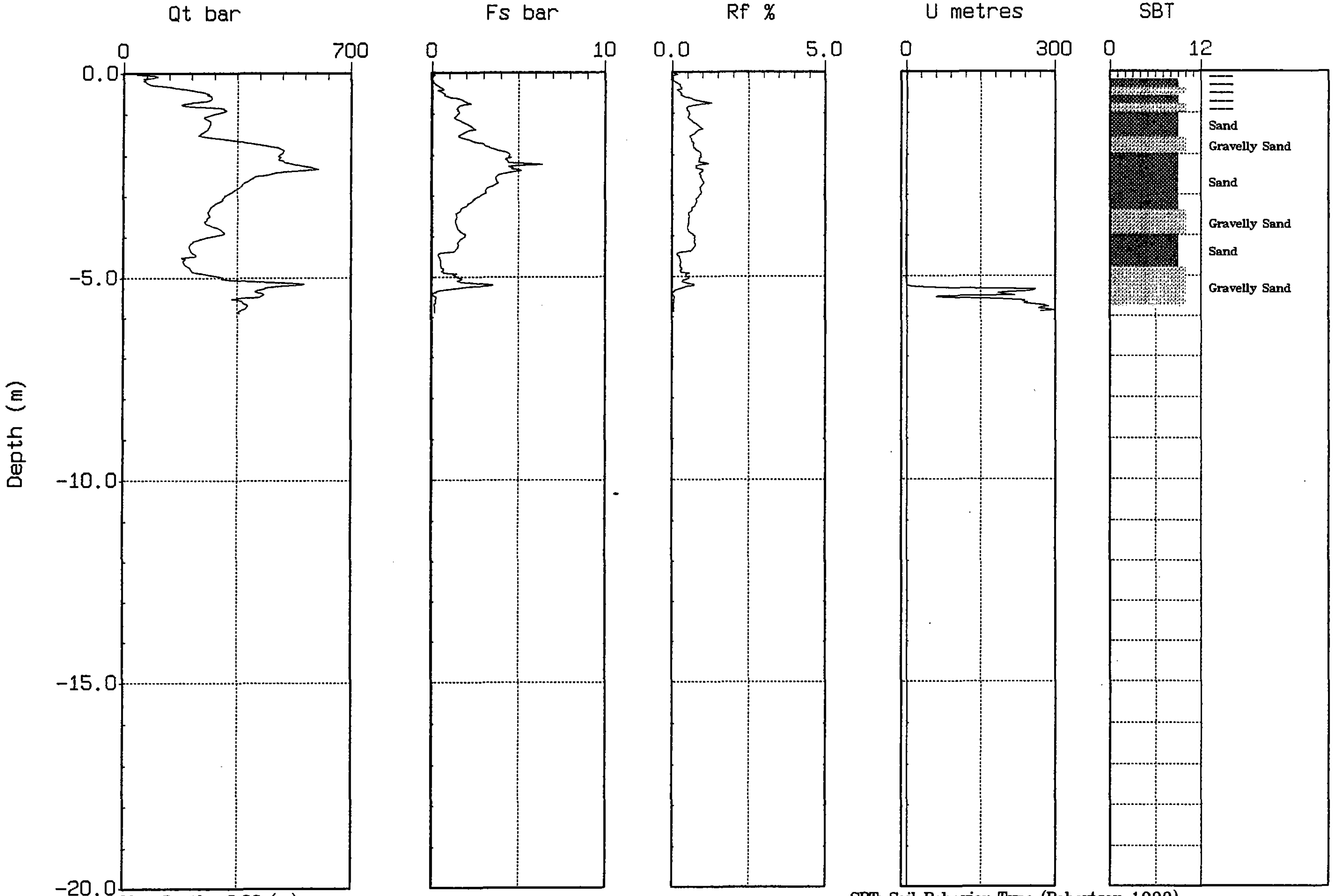
SBT: Soil Behavior Type (Robertson 1990)

CONETEC

EBA ENGINEERING

Site: 00-195 CPT-14
Location: BYG DAM

Cone: 20 TON A 097
Date: 09:15:00 09:55



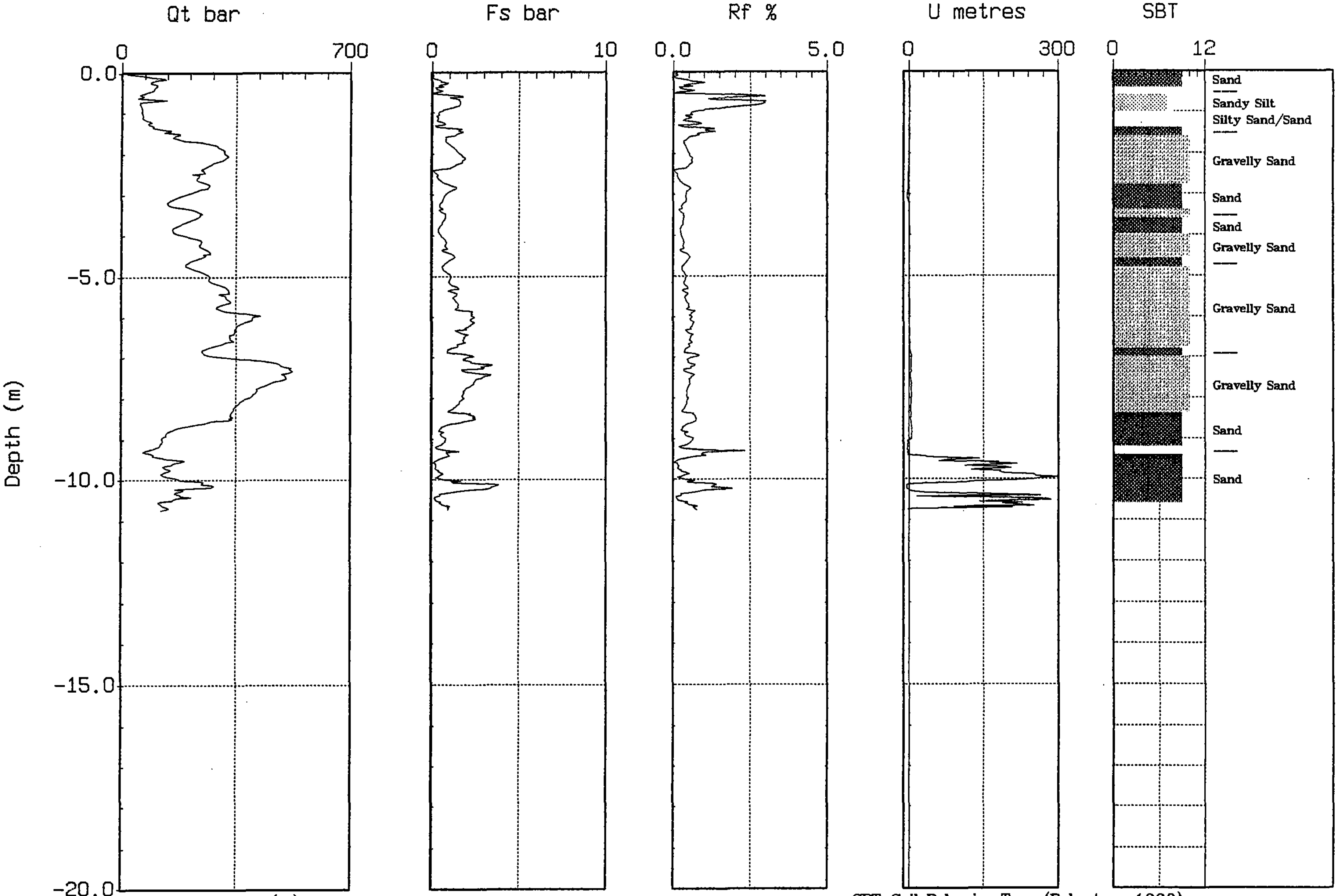
Max. Depth: 5.88 (m)
Depth Inc.: 0.025 (m)

SBT: Soil Behavior Type (Robertson 1990)

EBA ENGINEERING

Site: 00-195 CPT-15
Location: BYG DAM

Cone: 20 TON A 097
Date: 09:15:00 10:45



Max. Depth: 10.75 (m)

Depth Inc.: 0.025 (m)

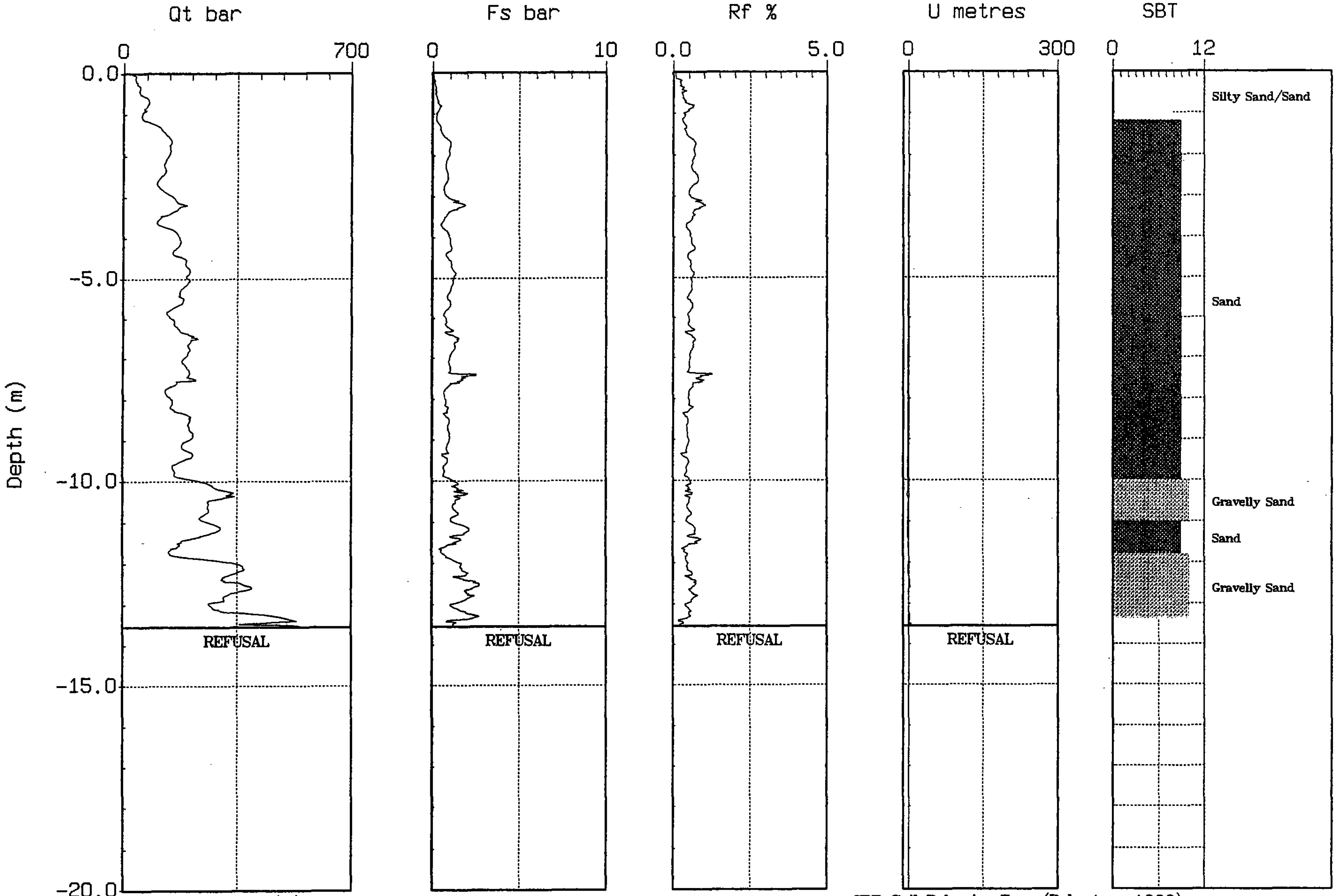
SBT: Soil Behavior Type (Robertson 1990)

CONETEC

EBA ENGINEERING

Site: 00-195 CPT-12A
Location: BYG DAM

Cone: 10 TON A 097
Date: 09:14:00 17:57



Max. Depth: 13.55 (m)
Depth Inc.: 0.025 (m)

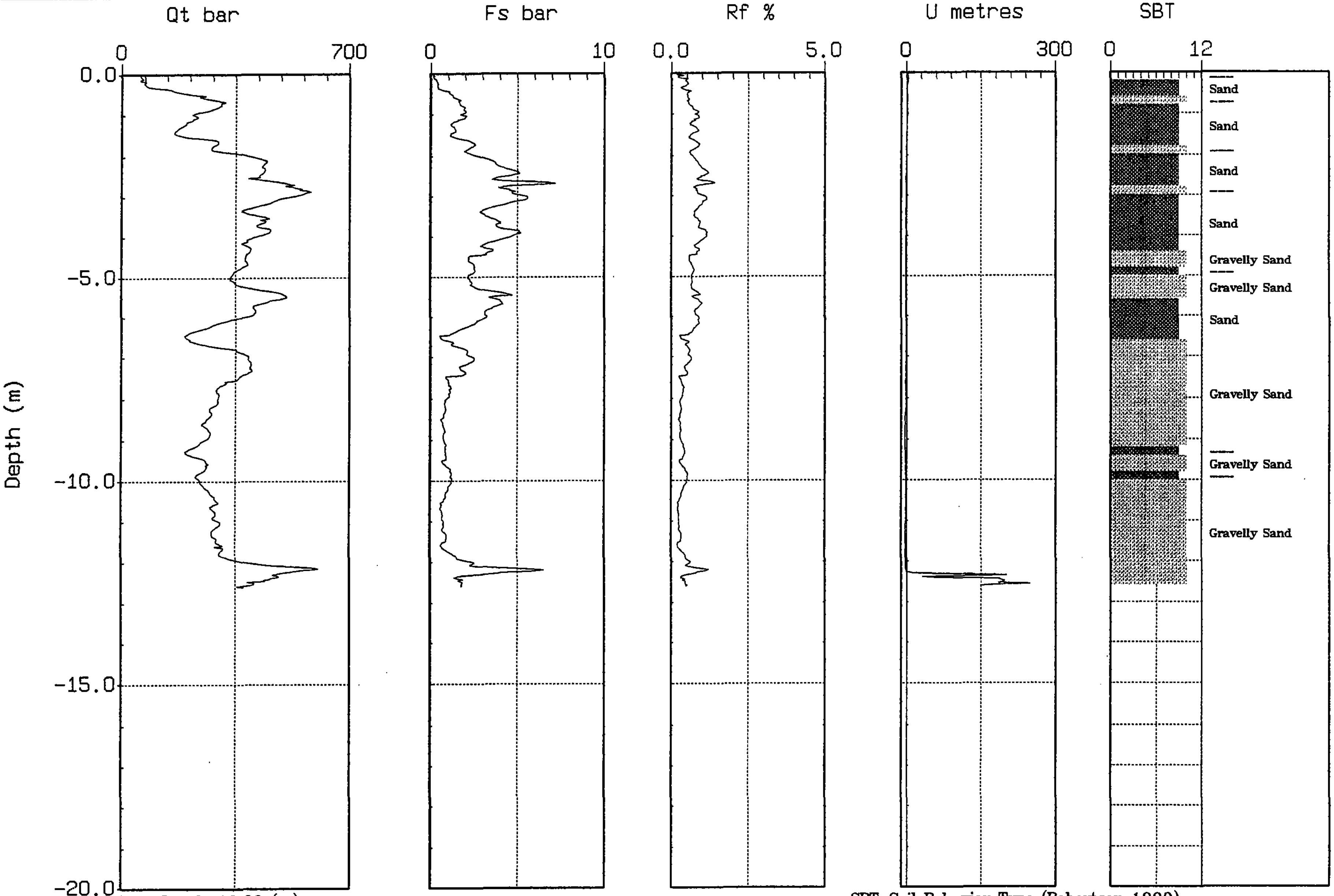
SBT: Soil Behavior Type (Robertson 1990)

CONETEC

EBA ENGINEERING

Site: 00-195 CPT-13
Location: BYG DAM

Cone: 20 TON A 097
Date: 09:15:00 08:31



Max. Depth: 12.60 (m)

Depth Inc.: 0.025 (m)

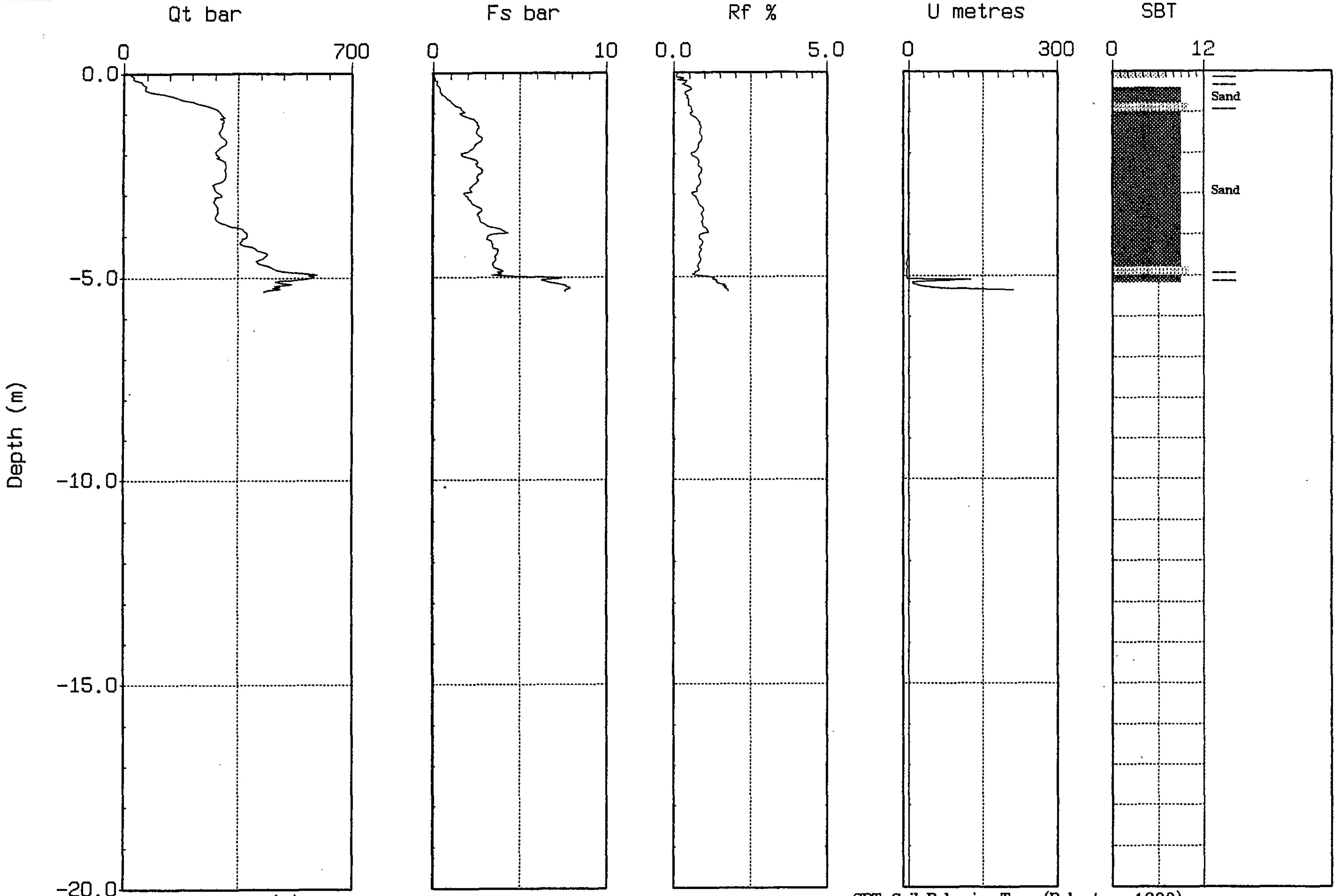
SBT: Soil Behavior Type (Robertson 1990)

CONETEC

EBA ENGINEERING

Site: 00-195 CPT-16
Location: BYG DAM

Cone: 20 TON A 097
Date: 09:15:00 12:35



Max. Depth: 5.35 (m)

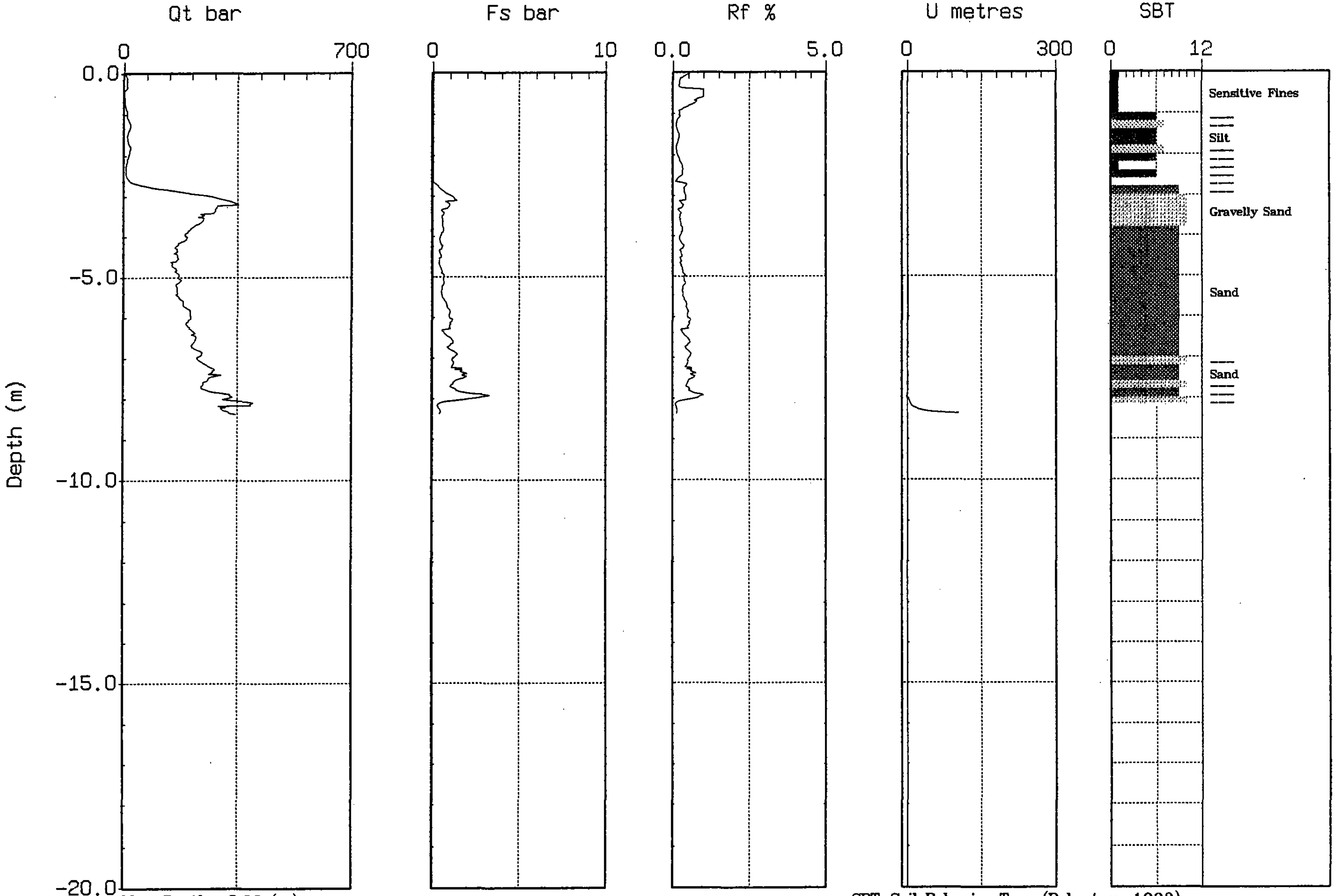
Depth Inc.: 0.025 (m)

SBT: Soil Behavior Type (Robertson 1990)

EBA ENGINEERING

Site: 00-195 CPT-17
Location: BYG DAM

Cone: 20 TON A 097
Date: 09:15:00 13:24



Max. Depth: 8.38 (m)
Depth Inc.: 0.025 (m)

SBT: Soil Behavior Type (Robertson 1990)

APPENDIX D

Dam Instrumentation Data & Assessment

MEMORANDUM

TO:	Dr. Robert Lo, P.Eng. Klohn Crippen Consultants	**DATE:**	December 13, 1999
FROM:	Cord Hamilton	**FILE:**	0201-99-14097

SUBJECT: **Review of Seepage Records**
Mount Nansen Tailings Dam

EBA has reviewed the available seepage records supplied by Mr. Robert Stroshein of Ketza Construction Corporation (Ketza) from the Mount Nansen mine site. The seepage records were developed by determining the volume of effluent pumped back to the tailings impoundment from the seepage pond that lies below the impoundment at the Mount Nansen mine site.

It is noted that the volume of effluent pumped back from the seepage provides only an estimate of the total seepage volume escaping from the tailings impoundment. It is only an estimate because the seepage pond neither captures all of the possible seepage that escapes the impoundment nor does it retain all of the seepage that is captured. Moreover, the seepage pond is also subject to inflows from sources other than the tailings impoundment seepage. Direct precipitation and runoff from the dam slope and the north and south abutment slopes can all contribute to the volume of water contained in seepage pond at any time. Irrespective of these concerns, the pumped back volume of effluent is a strong indicator of the seepage performance of the impoundment and it can be compared to the design criteria that was developed for seepage passing through the dam structure and dam foundation.

The seepage records were developed during 1999 using two different methods to determined seepage flows. From March 29th, 1999 until November 2nd, 1999, the seepage flows have been based on an intermittent daily record of the pumping rate and pumping duration as recorded by the mine operator, mine receiver, and/or Ketza.

Starting on November 3rd, 1999 a flowmeter was installed at the end of the pump back line in order to improve the accuracy and completeness of the seepage records.

Prior to the flowmeter being installed, a total of 95 individual days of pumping records were made over a period of 219 days. The data from these days, including pumping rates, and pumping duration are attached to this memorandum. For days where data was not recorded, there was either no pumping conducted or the personnel neglected to record the rate and/or duration of pumping activities completed.

Because many days of data were not recorded, the process of averaging and calculating seepage rates has been impacted. In addition, the procedure of recording the data was subject to quality control problems. It was described to EBA that in some cases the pumping rate was altered during pumping to decrease the time for drawdown of the pond. In other cases, it was found that the pump had completely drawndown the pond but the time required to do this was not known with certainty (duration of pumping). Another issue is that during some days, an unknown proportion of flow was re-circulated directly back to the seepage pond in order to maintain a constant depth or constant rate of flow. Other issues that may impact the seepage calculations are the method of determining the pumping rate and whether the pond was pumped to a constant minimum depth.

Given all of these issues, the data recorded prior to the installation of the flowmeter is apparently subject to various inaccuracies and uncertainties. On a daily level its usefulness is suspect. On average, it may be of greater value but is still subject to uncertainty and inaccuracies as described. Regardless the data has been used to determine both daily and cumulative seepage rates. Daily rates were determined based on the pumped volume over a 24 hour period. Cumulative seepage rates were determined from averaging pumped volumes over the number of days of record (excluding days where no data was recorded). The determined daily and cumulative seepage rates are shown on the attached spreadsheet.

In addition to the daily and cumulative seepage rates, a monthly seepage rate (monthly average) was also determined and these values are displayed in Table #1, below.

Table #1: Month Average Seepage Rates

Month	Days of Record	Average Seepage Rate (l/s)
March 1999	3	5.2
April 1999	19	4.4
May 1999	30	2.9
June 1999	19	2.4
July 1999	5	3.7
August 1999	0	Unknown
September 1999	2	1.6
October 1999	13	2.8
November 1999	2	2.6
November 1999[1]	28	2.6
December 1999[2]	12	2.8

Notes:

1 Seepage based on flowmeter data.

2 Seepage based on flowmeter data up to December 12th, 1999.

The seepage rate after November 2nd, 1999 has been determined by using flowmeter data. The flowmeter was installed near the discharge end of the pump back line and is therefore not subject to re-circulation issues. The flowmeter data is also not subject to issues created by a variable pumping rate. It is understood that the pump has be set up to operate continuously; therefore, if readings are made at the same daily time, then the readings should accurately represent daily pumped volume. Changes in the daily minimum elevation of the pond will have some impact on the determined seepage rate but the cumulative rate should adjust for this issue. The average seepage rates for the months of November and December 1999 based on the flowmeter data are shown in Table #1. Daily and cumulative data values are shown in the attached spreadsheet.

As can be seen the monthly rates in Table #1 show good agreement between the flowmeter based rates and pumped back based rates except for the months of March, April, July, and September.

For March, April and July, the pumped back method results in much higher rates than the flowmeter method indicated for November and December 1999. For September the pumped back rate is much lower.

Comparison of these rates shows that the months of March and September are each based on only two days of data and are likely not reasonable as a result. For April, the pumped back rate may be reasonable but it is possibly effected by snowmelt into the seepage pond. The July rate is higher than the November flowmeter rate but not greatly so. It may have be reasonable and simply higher due to rainstorms during that month. It should also be noted that it was based on only five days of data.

Considering all of the data it is reasonable to state that the seepage rate into the seepage pond is on the order of 2.6 l/s to 2.9 l/s when not significantly effected by snowmelt or precipitation. In comparison, the seepage analysis for the facility had predicted that a seepage rate in this range would require on the order of 16 m of foundation thawing to occur. It is known that this level of thawing has not occurred at this time.

EBA Engineering Consultants Ltd.

DAM INSTRUMENTATION DATA AND ASSESSMENT
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. 0201-00-14618

September 2002

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FIGURES

TABLES

APPENDICES

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 review of the geotechnical data available for Tailings Dam #1 (main tailings dam) and #2 (seepage dyke) at the Mount Nansen Mine site, previously operated by B.Y.G. Natural Resources Inc. The available data consists of thermistors and piezometers installed by EBA; a thermistor installed by Klohn, Cone Penetration Testing (CPT), and permafrost probe hole results.

This review has been completed by EBA as part of the Dam Safety Assessment of Tailings Dam #1 undertaken by EBA. The dam safety assessment, of which this review is a limited part, was completed under the terms of Standing Offer Number 98-6200-05 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. Bud M^{c}Alpine on July 27th, 2000.

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.

One Klonn thermistor string has also been incorporated in the review. This string, DH 95-04, was installed in June 1995 as a part of the initial instrumentation system installed to monitor the tailings dam performance both during and after mine operations. The location of the string is shown in Figure #1 and a summary of the instruments contained in and the depths of each instrument in the suites are presented in Table #1. The borehole log is presented in Appendix B.

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 EBA 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 November 1, 2001 which was the last record, there have been 129 full or partial data sets recorded since April 8th, 1998. The Klonn thermistor string was monitored on a regular basis between May and October 1996 and 1997. Following October 1997, the bead was only read twice, in January 1998 and December 1999, until consistent monitoring started up in February 2000 at which time the string was monitored on weekly basis in along with the EBA instrumentation.

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	50 mm Standpipe to 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 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 to1125.5 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	
DH 95-04 Terrace of Dam #1 El. 1149.2 m	1 / 1148.2 2 / 1147.2 3 / 1146.2 4 / 1144.2 5 / 1141.7 6 / 1139.2 7 / 1138.7 8 / 1134.2 9 / 1133.7 10 / 1129.2	

3.0 INSTRUMENTATION DATA

3.1 Thermistor Data

As shown in Table #1, there were three main EBA 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.

To aid in the evaluation of the terrace of Dam #1, data from DH 95-04 was utilized. This cable was installed prior to the construction of the dam. The lead was spliced and relocated to the toe of the dam during construction for future monitoring.

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.

The completed ground temperature versus time plots are presented as Figures A-1 to A-9.

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.

3.4 Seepage Data

Seepage records were developed by determining the volume of effluent pumped back to the tailings impoundment from the seepage pond that lies below the impoundment at the Mount Nansen mine site.

The volume of effluent pumped back from the seepage provides only an estimate of the total seepage volume escaping from the tailings impoundment. It is only an estimate because the seepage pond neither captures all of the possible seepage that escapes the impoundment nor does it retain all of the seepage that is captured. Moreover, the seepage pond is also subject to inflows from sources other than the tailings impoundment seepage. Direct precipitation and runoff from the dam slope and the north and south abutment slopes can all contribute to the volume of water contained in seepage pond at any time. Irrespective of these concerns, the pumped back volume of effluent is a strong indicator of the seepage performance of the impoundment and it can be compared to the design criteria that was developed for seepage passing through the dam structure and dam foundation.

From March 29 until November 2, 1999, the seepage flows were based on an intermittent daily record of the pumping rate and pumping duration as recorded by the mine operator, mine receiver, and/or Ketza. Starting on November 3, 1999 a flowmeter was installed at the end of the pump back line in order to improve the accuracy and completeness of the seepage records.

Prior to the flowmeter being installed, a total of 95 individual days of pumping records were made over a period of 219 days. For days where data was not recorded, there was either no pumping conducted or the personnel neglected to record the rate and/or duration of pumping activities completed.

Because many days of data were not recorded, the process of averaging and calculating seepage rates has been impacted. In addition, the procedure of recording the data was subject to quality control problems. It was described to EBA that in some cases the pumping rate was altered during pumping to decrease the time for drawdown of the pond. In other cases, it was found that the pump had completely drawndown the pond but the time required to do this was not known with certainty (duration of pumping). Another issue is that during some days, an unknown proportion of flow was re-circulated directly back to the seepage pond in order to maintain a constant depth or constant rate of flow. Other issues that may impact the seepage calculations are the method of determining the pumping rate and whether the pond was pumped to a constant minimum depth.

Given all of these issues, the data recorded prior to the installation of the flowmeter is apparently subject to various inaccuracies and uncertainties. On a daily level its usefulness is suspect. On average, it may be of greater value but is still subject to uncertainty and inaccuracies as described. Regardless the data has been used to determine both daily and cumulative seepage rates. Daily rates were determined based on the pumped volume over a 24 hour period. Cumulative seepage rates were determined from averaging pumped volumes over the number of days of record (excluding days where no data was recorded).

The seepage rate after November 2, 1999 has been determined by using flowmeter data. The flowmeter was installed near the discharge end of the pump back line and is therefore not subject to re-circulation issues. The flowmeter data is also not subject to issues created by a variable pumping rate. It is understood that the pump has be set up to operate continuously; therefore, if readings are made at the same daily time, then the readings should accurately represent daily pumped volume. Changes in the daily minimum elevation of the pond will have some impact on the determined seepage rate but the cumulative rate should adjust for this issue. Daily readings were recorded from installation to present with the exception of a few periods of equipment malfunction, etc.

4.0 DATA EVALUATION

4.1 Instrumentation 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.

4.1.1 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. The majority of data spikes have been eliminated from the presented plots.

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 the water level from a staff gauge. Throughout the reporting period the

staff gauge has been resurveyed to insure its accuracy. If required, corrective measures were taken; therefore, the elevation of the staff gauge is considered to be accurate.
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.

4.1.2 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, 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 and 2001.

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 various 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 phreatic level increases throughout the months of May to September and then gradually declines from October to April. The differential between the measured phreatic levels between October and April 1999, 2000 and 2001 is approximately 0.8, 2.4 and 2.5 m, respectively.

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, December 1999 to June 2000 and October 2000 to April 2001. However, it is known that the pond level did drop over these periods. It appears that the piezometric level fluctuated in a somewhat lagged manner behind the pond level fluctuations.

4.1.3 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, 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 between April 1998 and July 1999 and March 2000 and November 2001. The trend is for cooling in the summer and warming in the winter. The magnitude of this trend is seen to decrease with depth. Between October 1999 and March 2000, the beads gradually decrease in temperature, which is typical for that period of the year.

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 organic soils 0.8 m below the fill interface. This bead also exhibits the reverse trend in seasonal variation between April 1998 and October 1999 although it is not of great magnitude. From October 1999 to October 2000, the bead gradually declined in temperature then levelled out at approximately a constant temperature till July 2001 at which time temperatures decline to the end of the reporting period.

The final five thermistor beads in this borehole are all located in the frozen native sand underneath the organic soil. These beads indicate that the foundation becomes colder with depth to 1128.6 m where to ground temperature appears to level off and does not decrease further (shown in the three deepest beads). All five beads have remained frozen over the course of monitoring. The first two beads located in the native sand appear to warm slightly from April 1998 to October 1999 and then cool towards the remaining beads which are constant at approximately - 0.4 °C.

Review of the data from this installation suggests that the 0°C isotherm typically lies between an elevation of 1131.2 m and 1130.8 m throughout the last year. Therefore up to 1.4 m of thaw has developed in the foundation soils underlying the dam fill.

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 1141.0 m in the spring 1999 and 2000 to a high of 1143.0 m in the fall of 1999 and 1142.4 m in the fall of 2000. The level drops after the fall high within the range of 1140.3 m in April 2001 at which time the level increases to 1141.7 m.

4.1.4 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. 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 in 1998 where permafrost was encountered at an elevation of 1133.3 m. Given that the fill interface is estimated to be between an elevation of 1138.2 m to 1136.9 m, the depth of thaw was estimated to range between 3.6 m to 4.9 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. The level decreased to 1139.7 m during the spring of 2000 and increased to 1141.8 m by the fall. The phreatic surface is presently ranged from 1139.3 m to 1140.9 m in 2001. The large decrease shown in the fall of 2001 is believed to be erroneous.

4.1.5 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 only been sounded for water levels once, August 2000 at 2.72 m, and the thermistor bead has not been read.

4.1.6 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, 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 and September in 1999, 2000 and 2001 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, 1132.7 and 1130.7, had maximum temperatures during October of between 1°C and 2.5°C, respectively, whereas during the second, third and fourth season (1999, 2000, and 2001) they had temperature highs in October of only 0.4, 0.48, and 0.58°C and 1.5, 1.73, and 2.43 °C, respectively. Moreover they were frozen for much of the summer of 1999, 2000, and 2001 whereas they were thawed for the summer of 1998. It is possible that the difference between the 1998 season and the 1999 and 2000 seasons 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 and has remained constant throughout the last year.

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 -0.32°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.

Throughout the summer of 1998 piezometer #22720 shows the phreatic level relatively constant at 1138.1 m with the level increasing throughout the winter to 1139.0 m before dissipating in the spring and levelling out around 1138.2 m for the summer. The level decrease during the winter of 2000 to 1137.0 m and rose as high as 1138.0 m during that summer levelling out around 1137.6 m during the fall. The level again decreased through the winter of 2001 to a low of 1136.0 m then increased to 1137.9 and decreased to 1137.4 by the fall.

Some implications of the inferred phreatic levels are that they have risen to within 0.7 m of the crest of the toe berm during 1999 to 1.8 m during 2001. 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 1.8 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.

4.1.7 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. As can be seen in this plot, 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 over the course of monitoring. The readings are relatively constant throughout the reporting period.

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 10.0 m or to an elevation of 1129.9 m. This suggests that the maximum seasonal thawing of native soils underneath the fill level is negligible. The minimum depth of the permafrost table over the course of measurement was found to be 9.1 m indicating about 0.9 m of seasonal freezing into the fill.

4.1.8 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. This figure shows 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 2.5°C, low temperatures in the order of –0.3°C, and a mean temperature of roughly 0.8°C. The peak temperatures have occurred in September and 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 followed the profile of the top two beads more closely, approximately 1.5 °C degrees colder during the warmer periods and consistent with the top two during the colder periods.

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 between the month of June to November. Between December and April 2001, the level of the second piezometer is around 1.0 m higher than that of the third.

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. The level decreased to 1136.0 m throughout the winter of 2000 then rises to 1137.7 m during the summer and fall decreasing again during the winter of 2001. The phreatic level then increased to 1137.2 m by the end of the reporting period.

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 to October 1999 and April to September 2000 and this casts doubt on the piezometer values obtained during that time.

During the CPT 9 testing, it was noted that the water level was 5.1 m in depth. The ground elevation for CPT 9 is unknown; however, it will likely be between 1140.0 and 1142.5 m. Therefore, the corresponding water level would be between 1134.9 and 1137.4 m. During the same time period the deepest piezometer shows the phreatic level at 1137.5 m.

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. EBA 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 the phreatic level of Borehole #12861-07 corresponds with the level indicated in Borehole 12861-05 located on the opposite abutment of the dam at roughly the same offset from the tailings pond.

*4.1.9 **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, 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. The first two beads, at 1131.9 and 1131.4, were not plotted on Figure A-7 since they are at depths that are greatly affected by the ambient temperature.

Below the active layer, the permafrost temperature was found to range between –0.5 and –0.3 °C in the zone of organic soils. The warmer periods occur during the winter while the colder during the summer. The remaining three beads located in the native sands basically have been gradually warming since July 1999. From July 1999 to April 2001 the temperature has increased by 0.2 °C

In terms of seasonal thawing, the greatest thaw depth occurred during the fall of 2000 and that extended to a depth of 4.0 m below the dam surface or 0.7 m below the fill/native ground interface.

4.1.10 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.

This installation was destroyed in October 2000 during the reconstruction of the seepage control dyke.

4.1.11 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, as plotted on Figure A-8, 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 fall of 2000 and that extended to a depth of 5.3 m below the dam crest or 2.2 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. The four remaining beads located in the native sand have generally had a slight upward warming trend in the range of 0.2 °C since inception.

The Borehole #12681-10 thermistor string was destroyed during the reconstruction of Dam #2 in October of 2000.

4.1.12 ***Borehole DH 95-04***

Borehole DH 95-04, which contains a 10 bead thermistor string extending at a depth of 20.0 m, is located on the north terrace of Dam #1. The original ground elevation at the borehole location was 1149.23 m. The construction of the dam brought the existing ground surface to an elevation of approximately 1150.6 m.

Review of the ground temperature records from this installation, as plotted on Figure A-8, indicates that all beads in the thermistor string are either frozen or are subject to seasonal freezing. The active layer at this location extends into the original ground.

The first two beads, at 1148.2 and 1147.2 m, show questionable results. The seasonal ground temperature changes warm during the winter and summer months and cool during the spring and fall. The beads for this particular string are read in °C, thus there is a potential that the negative sign was missed for some of the winter readings. Should this be the case the classical pattern of warming during the summer and fall months and cooling during the winter and spring months would be seen.

Excluding the first two beads, the remaining eight have remained frozen throughout 2000 and 2001. The permafrost temperature was found to range between –0.1 and –0.4 °C with the colder temperatures being reported at depth.

Review of the data from this installation suggests that the 0 °C isotherm typically lies at an elevation of 1146.2 m. During the installation of this instrument, June 26, 1995, permafrost was encountered at 1145.5 m. It appears that the permafrost elevation has actually aggraded since the installation in 1995 by approximately 0.7 m.

4.2 CPT Data Review

CPT testing was completed in the summer of 2000 to help evaluate the liquifaction characteristics and stability of Dam #1. CPT test holes CPT 1 through CPT 9 were conducted between July 31 and August 5, 2000 and CPT 10 through CPT 17 were conducted on September 14 and 15, 2000. All testing was completed by Conetec Investigations Ltd.

Results from the testing help evaluate the ground temperature data, specifically the depth of permafrost within the given testing period. The depths to increased pore pressure and depth to refusal for a given CPT is presented in Table #2. Locations of the CPT test holes are presented in Figure 1. The CPT refusal depths are potentially in the vicinity of the permafrost contact. However, the test could have met refusal in a dense soil prior to reaching the permafrost or push through the actual permafrost contact and hit refusal deeper within the permafrost. To accommodate the potential of pushing through the permafrost contact, the depth at which the pore pressures dramatically increase was also examined and referenced.

Table #2:
Increased Pore Pressure and Refusal Depths

Test Number	Approximate Current Ground Elevation (m)	Approximate Original Ground Elevation (m)	Depth to Increased Pore Pressure (m)	Depth to Refusal (m)
CPT 1	1151.4	1135.5		12.0 (1139.4)
CPT 2	1143.5	1143.5		2.2 (1141.3)
CPT 3	1140.5	1131.0	10.2 (1130.3)	13.4 (1127.1)
CPT 4	1151.2	1132.5		4.5 (1146.7)
CPT 5	1151.2	1134.5		3.6 (1147.6)
CPT 6	1140.5	1131.5		7.4 (1133.1)
CPT 7	1140.5	1133.0	8.3 (1132.2)	8.4 (1132.1)
CPT 8	1140.5	1130.5		7.4 (1133.1)
CPT 9	1142.5	1140.0		8.1 (1134.4)
CPT 10	1151.4	1140.5	12.0 (1129.4)	12.6 (1128.8)
CPT 11	1151.3	1136.0	16.8 (1124.5)	17.0 (1124.3)
CPT 12	1151.2	1132.5		10.9 (1140.3)
CPT 12A	1151.4	1135.5		13.6 (1137.8)
CPT 13	1151.4	1145.5	12.4 (1139.0)	12.6 (1138.8)
CPT 14	1151.6	1149.0	5.2 (1146.4)	5.9 (1145.7)
CPT 15	1140.5	1131.5	9.4 (1131.1)	10.8 (1129.7)
CPT 16	1145.8	1145.5	5.0 (1140.8)	5.4 (1140.4)
CPT 17	1141.5	1141.5	8.3 (1133.2)	8.4 (1133.1)

Two CPT tests, CPT 10 and CPT 11, were conducted in the vicinity of Borehole #12861-01. CPT 10 is located approximately 13 m south of the borehole while CPT 11 is located approximately 13 m north of the borehole. The depth at which the pore pressure readings dramatically increased and the refusal depth of the tests support the results of the thermistor beads and consequently the estimated 0 °C isotherm.

Two CPT tests, CPT 4 and CPT 12, were conducted in the vicinity of Borehole #12861-02 and were both located approximately 5 m southeast of the borehole. Neither CPT 4 nor CPT 12 were able to achieve the depth at which the ground was reported to be frozen based on the thermistors. Therefore, no conclusion can be made regarding the CPT data and the thermistor data.

CPT 1 and CPT 12A were conducted south of Borehole #12861-03 located approximately 6 and 9 m away, respectively. CPT 1 met refusal at a depth of 12.0 m while CPT 12A met refusal at 13.55m. These depths correspond to the elevations of 1139.5 and 1137.95 m. These elevations may represent the 0 °C isotherm which would mean the fill interface was potentially frozen; however, without ground temperature data no formal conclusions can be made. These elevations could just represent a dense material which the CPT test could not penetrate as experienced in CPT 4 and CPT 12.

CPT 6, CPT 7 and CPT 15 were conducted in the vicinity of Borehole #12861-05. CPT 6 is located approximately 5 m northwest of the borehole while CPT 7 is approximately 5 m southwest. CPT 15 is approximately 6 m north of the borehole. CPT 6 met refusal in the sand fill; therefore, no conclusions can be made. The depth at which the pore pressure dramatically increased and the refusal depths of CPT 7 and CPT 15 support the results of the ground temperature data.

CPT 3 and CPT 8 were conducted in the vicinity of Borehole #12861-06. CPT 3 is located approximately 5 m southeast while CPT 8 is approximately 6 m northwest of the borehole. CPT 8 met refusal in the sand fill and does not provide any relevant information regarding correlation with the ground temperatures. However, the depth at which the pore pressure dramatically increased for CPT 3 supports the ground temperature data.

Two CPT tests, CPT 9 and CPT 16, were conducted in the vicinity of Borehole # 12861-07. CPT 9 is located approximately 14 m southeast while CPT 16 is approximately 22 m northwest of the borehole. The refusal depths of the CPT testing corresponds with the ground temperature data.

4.3 Permafrost Probe Hole Data Review

Boreholes were drilled on August 05, 2000 along the spillway alignment and several other locations to determine the depth to permafrost. A CME 75 nodwell drill was used by Midnight Sun Drilling Co. Ltd. to complete the work. A total of 20 probe holes, locations presented in Figure 2, were completed and the resulting permafrost depths are presented in Table #3.

Table #3:
Permafrost Depths

Borehole No.	Approximate Current Ground Elevation (m)	Approximate Original Ground Elevation (m)	Depth of Permafrost (m)
00-BH 01	1144.4	1142.5	11.6 (1132.8)
00-BH 02	1146.4	N/A	3.7 (1142.7)
00-BH 03	1147.7	N/A	2.6 (1145.1)
00-BH 04	1149.5	N/A	2.4 (1147.1)
00-BH 05	1143.0	N/A	3.0 (1140.0)
00-BH 06	1124.5	1126.0	2.9 (1121.6)
00-BH 07	1128.5	1135.0	3.2 (1125.3)
00-BH 08	1132.2	1138.0	3.0 (1129.2)
00-BH 09	1136.2	1141.0	3.5 (1132.7)
00-BH 10	1140.2	1144.0	2.9 (1137.3)
00-BH 11	1143.0	1146.0	2.9 (1140.1)
00-BH 12	1147.0	1148.2	2.2 (1144.8)
00-BH 13	1148.5	1149.7	2.4 (1146.1)
00-BH 14	1148.5	N/A	3.4 (1145.2)
00-BH 15	1142.5	N/A	2.6 (1139.9)
00-BH 16	1144.7	N/A	3.0 (1141.7)
00-BH 17	1124.1	N/A	0.5 (1123.6)
00-BH 18	1135.0	N/A	2.4 (1132.6)
00-BH 19	1148.7	N/A	2.4 (1146.3)
00-BH 20	1150.8	N/A	2.0 (1148.8)

5.0 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, and seepage rates.

5.1 Permafrost Table

5.1.1 Spillway and Terrace Area

Fifteen probe holes, 00-BH06 to 00-BH20, are located in the vicinity of the spillway. At the time of the investigation, permafrost depths ranged from 0.5 to 3.5 m with an average of 2.62 m.

The terrace area contains of 4 probe holes, 00-BH02, 00-BH03, 00-BH04, and 00-BH05, and one instrumentation borehole, DH 95-04. The permafrost depth for 00-BH02, 00-BH03, 00-BH04, and 00-BH05 were 3.7, 2.6, 2.4, and 3.0 m, respectively. Borehole DH 95-04 instrumentation indicates that the permafrost elevation has aggraded since the installation and construction of the dam. The active layer is to 3.0 m in this location.

5.1.2 North and South Abutments

A total of ten boreholes, 12861-01 to 12861-10, and one probe hole, 00-BH01, are located throughout the north and south abutments. The majority of boreholes have some level of permanent and/or seasonal thawing of the permafrost.

The greatest amount of thaw has occurred in the north abutment of Dam #1. Borehole 12861-03 and 12861-07 show a maximum thaw depth of 3.6 to 4.9 m and >9.6 m, respectively. Probe hole 00-BH01 had a permafrost depth of 11.6 m. The centre portion of Dam#1 and Dam #2 had varying amounts of permafrost degradation. Values ranged from 0.4 to 2.2 m with an average of 1.2 m. The south abutment slope indicated negligible thaw at the dam centre line (12861-01) but up to 4.5 m of seasonal thaw at the toe berm crest (12861-05). The maximum depth of thaw and seasonal variations in the depth to the permafrost table (where known) are shown in Table #4.

Table #4
Thaw Depth and Seasonal Variation in Permafrost Depth

Borehole	Maximum Thaw depth[1]	Seasonal Variation in Permafrost Depth[2]
12861-01	0 m	Above fill to 0 m
12861-02	1.4 m	1.2 m – 1.4 m
12861-03	3.6 m to 4.9 m[3]	Unknown
12861-05	4.5 m	Above fill to 4.5 m below
12861-06	0.4 m	Above fill to 0.4 m below
12861-07	>9.6 m	Unknown
12861-08	0.7 m	Ground surface to 0.9 m[4]
12861-10	2.2 m	Ground surface to 2.2 m[4]

Notes:

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

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

3 Depth of thaw estimated from design drawings and drilling records.

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

5.2 Piezometric Data

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 3.4 m to 3.9 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 5.4 m below the crest elevation (south side) to over 8.5 m below the crest elevation (north side).

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 1.3 m to 2.5 m below the toe crest elevation. In terms of a cross fall at the toe berm crest, data from Borehole #12861-07 and Borehole #12861-05 show these locations have phreatic levels within 0.4 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.

5.3 Seepage Data Review

To evaluate the seepage data monthly seepage rates were calculated as discussed in section 3.4 and are presented in Table #5.

Table #5:
Monthly Average Seepage Rates

Month	1999 Average Seepage Rate (l/s)	2000 Average Seepage Rate (l/s)	2001 Average Seepage Rate (l/s)
January		2.5	2.8
February		2.4	2.8
March	5.2 (3)[2]	2.3	2.7
April	4.4 (19)[2]	2.4	2.7
May	2.9 (30)	3.0	3.1
June	2.4 (19)[2]	2.8	2.8
July	3.7 (5)[2]	3.0	2.9
August	Unknown (0)[2]	3.8	2.6
September	1.6 (2)[2]	4.1	2.6
October	2.8 (13)[2]	3.8	3.2
November	2.6 (2)[2]		
November[1]	2.6 (28)[2]	2.6	
December	2.8	2.9	

Notes:
1 Seepage based on flowmeter data.
2 Parentheses indicate number of readings

As can be seen the monthly rates in Table #5 show good agreement between the flowmeter based rates (2000) and pumped back based rates (1999) except for the months of March, April, July, and September.

For March, April and July, the pumped back method results in much higher rates than the flowmeter method indicated for November and December 1999. For September the pumped back rate is much lower.

Comparison of these rates shows that the months of March and September are each based on only two days of data and are likely not reasonable as a result. For April, the pumped back rate may be reasonable but it is possibly affected by snowmelt into the seepage pond. The July rate is higher than the November flowmeter rate but not greatly so. It may have been reasonable and simply higher due to rainstorms during that month. It should also be noted that it was based on only five days of data.

The average seepage rate for January to April 2001 is consistently 0.3 to 0.4 l/s higher than that of the 2000 data over the same period. This increase could indicate increased seepage rates but is more likely explained by the fact that the reconstructed seepage dyke is retaining a greater amount of the seepage and consequently being pumped back to the impoundment. The seepage dyke was reconstructed in October 2000. The seepage rates for May, June and July 2001 are basically consistent with those measured in 2000. However, rates measured in August, September and October are significantly lower, from 0.6 to 1.5 l/s, than those in 2000. This decrease in the seepage rate is likely a result of the lower pond elevations present in 2001. Lower pond elevations result in a decreased area in which seepage can occur and a lower hydraulic head.

Considering all of the data it is reasonable to state that the seepage rate into the seepage pond is on the order of 2.6 l/s to 2.9 l/s when not significantly effected by snowmelt or precipitation. In comparison, the seepage analysis for the facility had predicted that a seepage rate in this range would require on the order of 16 m of foundation thawing to occur. It is known that this level of thawing has not occurred at this time.

6.0 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. 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.

7.0 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.

Yours truly,
EBA Engineering Consultants Ltd.

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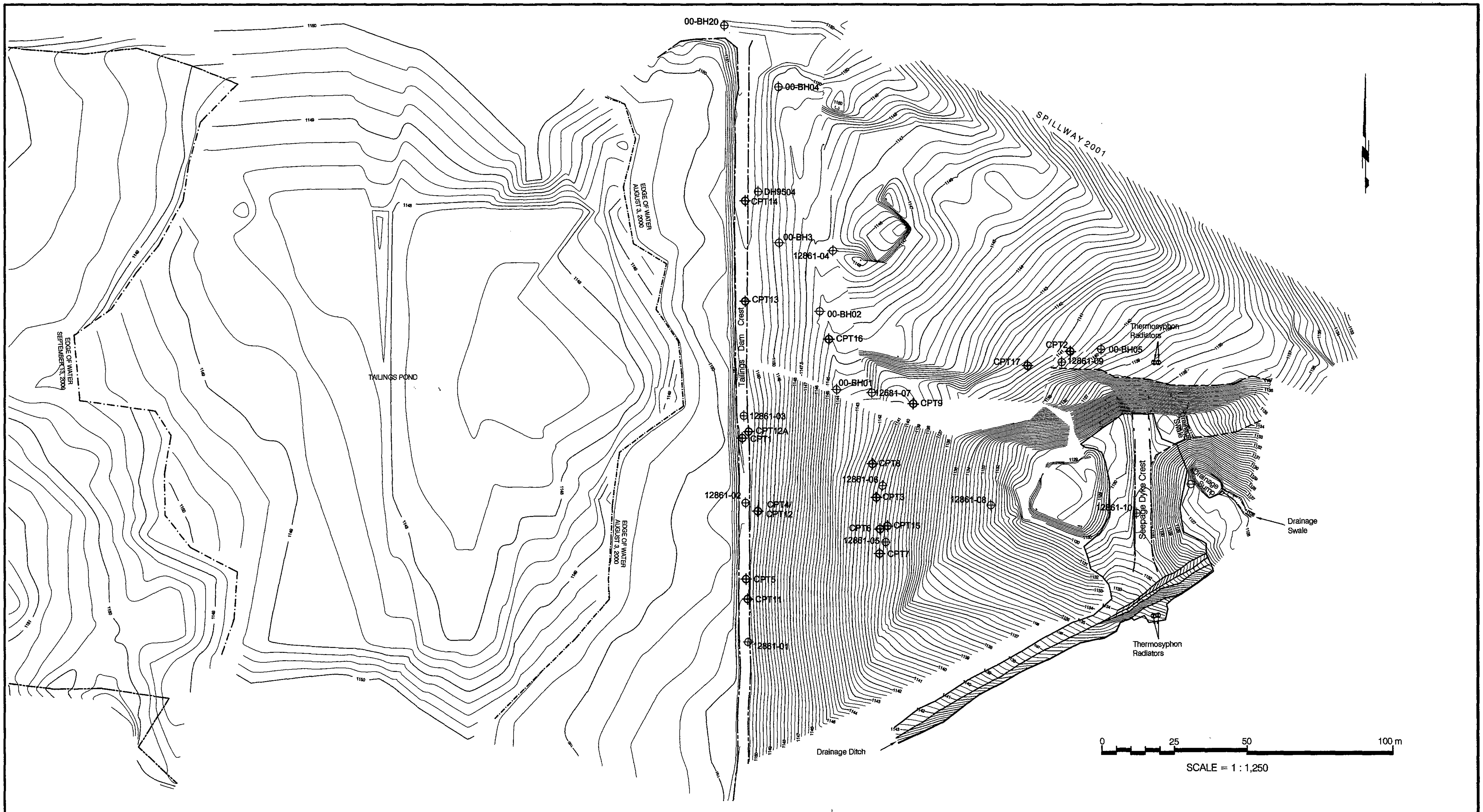
FIGURES



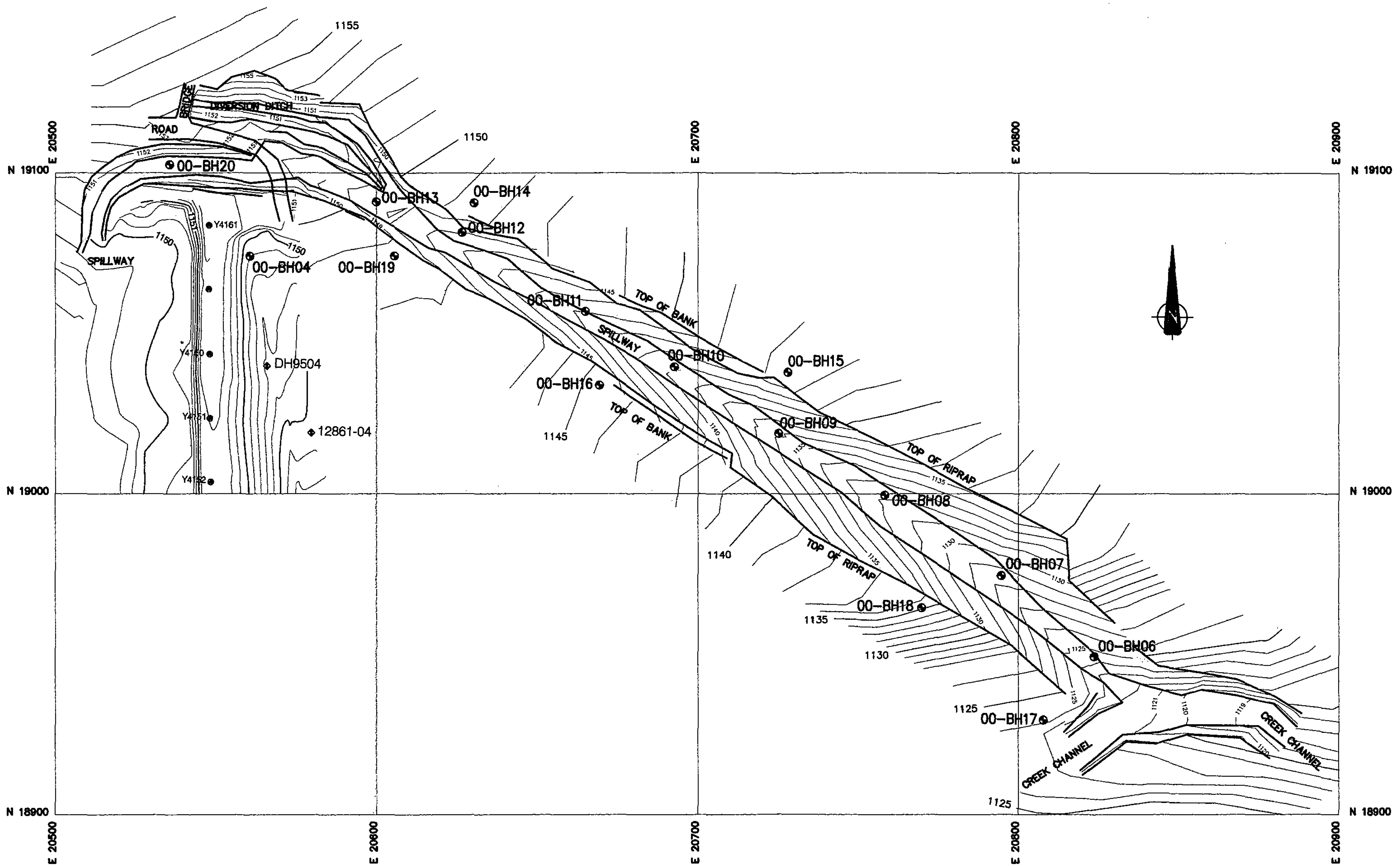
EBA Engineering Consultants Ltd.

PROJECT
MT. NANSEN
DAM SAFETY ASSESSMENT

CLIENT
DIAND

TITLE
SITE PLAN SHOWING
TESTHOLE LOCATIONS

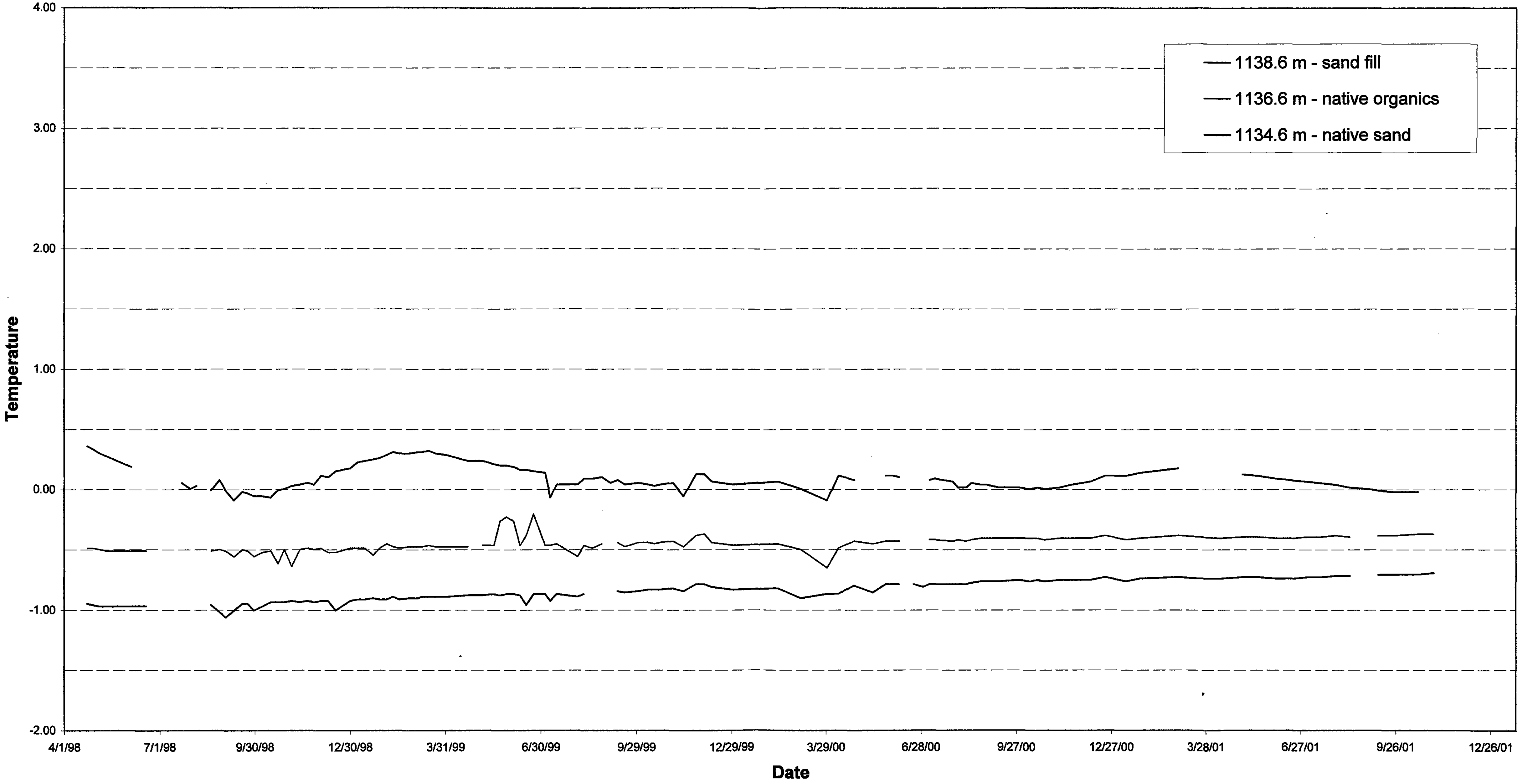
DATE SEPTEMBER 2002
DWN. JSB
CHKD. JRT
FILE NO. 0201-00-14618
DRWG. FIGURE 1



NOTES:
1. ELEVATION CONTOURS IN METRES.
2. GRID IS LOCAL MINE GRID.
3. CONTOURS BASED ON AUGUST, 2000 SURVEY, BY YUKON ENGINEERING SERVICES.

0 25 50
SCALE 1:2000

EBA Engineering Consultants Ltd.				PROJECT	MT. NANSEN TAILINGS DAM ASSESSMENT
CLIENT	DIAND			TITLE	SPILLWAY PLAN SHOWING TESTHOLE LOCATIONS
DATE	September 2002	DWN. JPB	CHKD. JRT	FILE NO. 0201-00-14618	DRWG. FIGURE 2

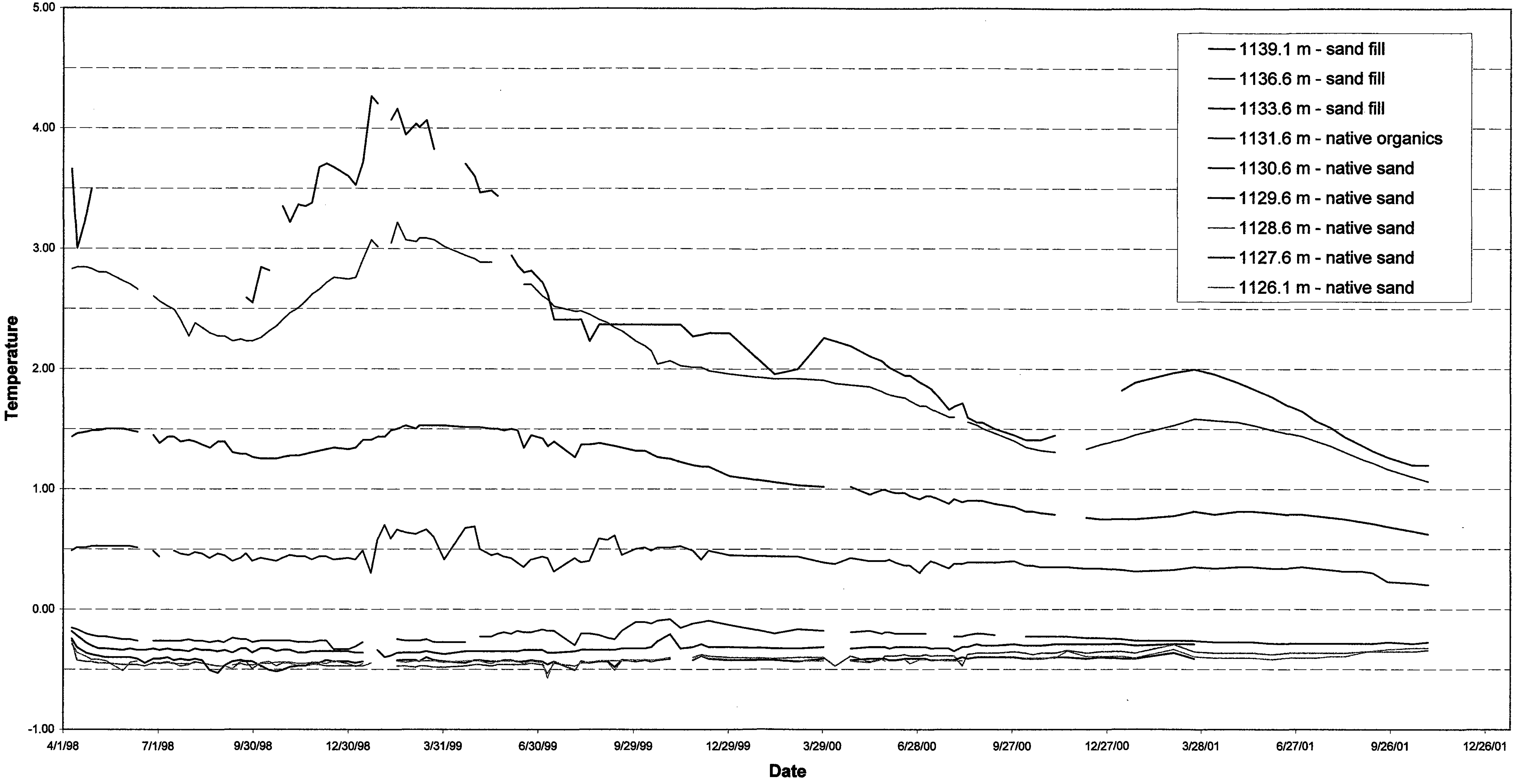


NOTE: 1) BH Location: Crest of Dam
2) Ground surface: 1151.4 m.
3) Fill and native ground interface: 1137.7 m.

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

Figure A-1

Ground Temperature Profiles
BH # 12861-01

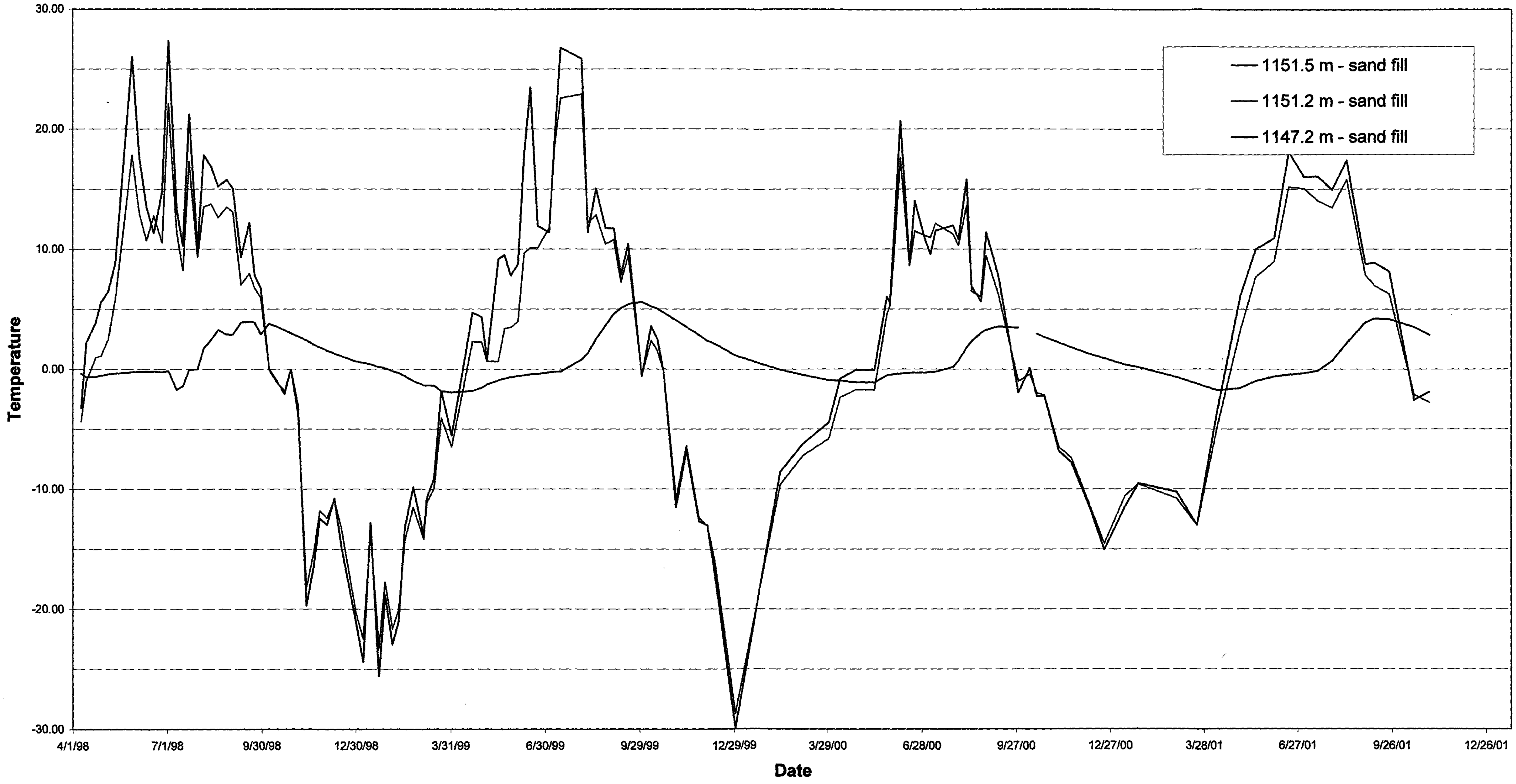


NOTE: 1) BH Location: Crest of Dam
2) Ground surface: 1151.4 m.
3) Fill and native ground interface: 1132.2 m.

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

Figure A-2

Ground Temperature Profiles
BH # 12861-02

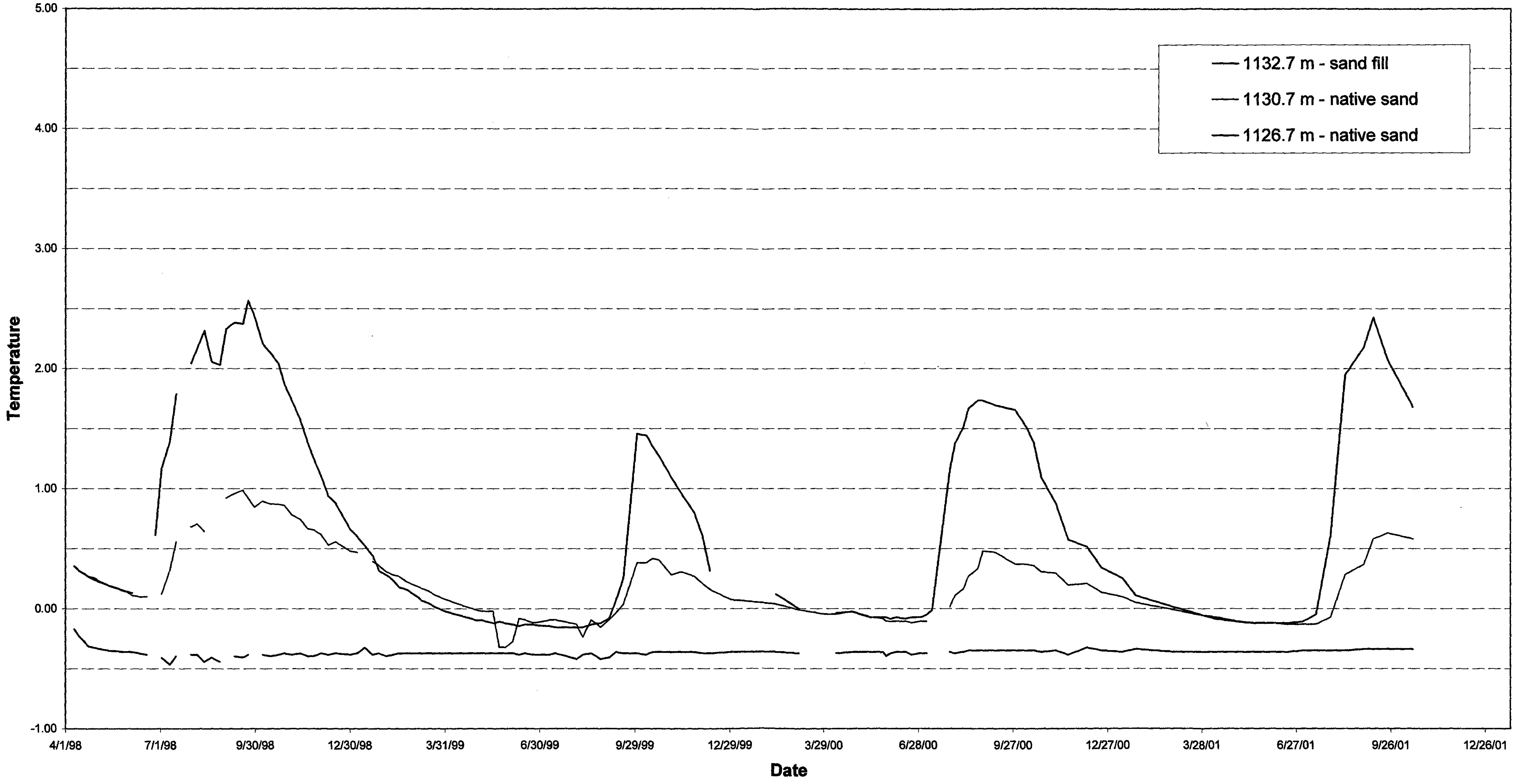


NOTE: 1) BH Location: Crest of Dam
2) Ground surface: 1151.5 m.
3) Fill and native ground interface: unknown.

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

Figure A-3

Ground Temperature Profiles
BH # 12861-03

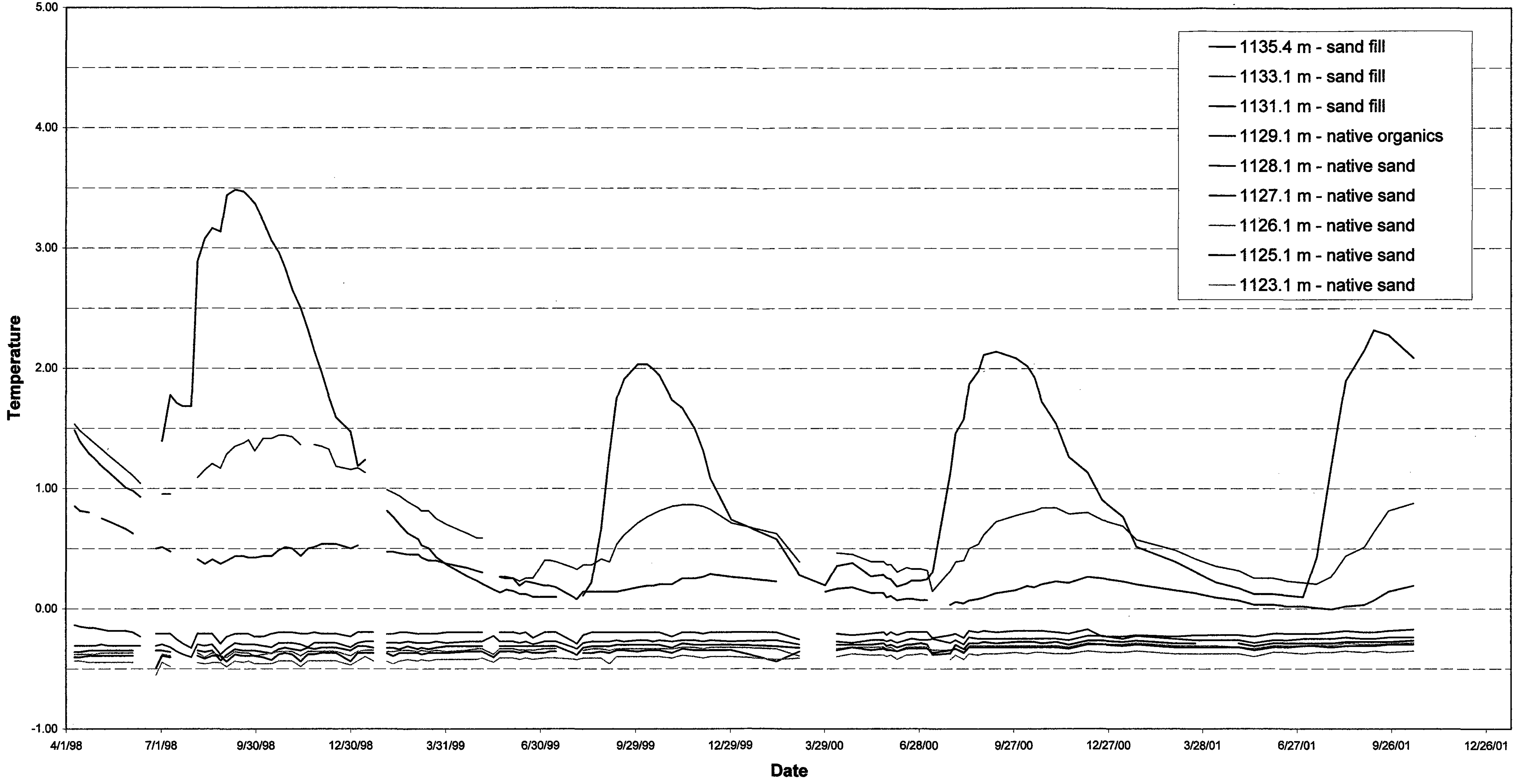


NOTE: 1) BH Location: Crest of Toe Berm
2) Ground surface: 1139.7 m.
3) Fill and native ground interface: 1132.4 m.

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

Figure A-4

Ground Temperature Profiles
BH # 12861-05

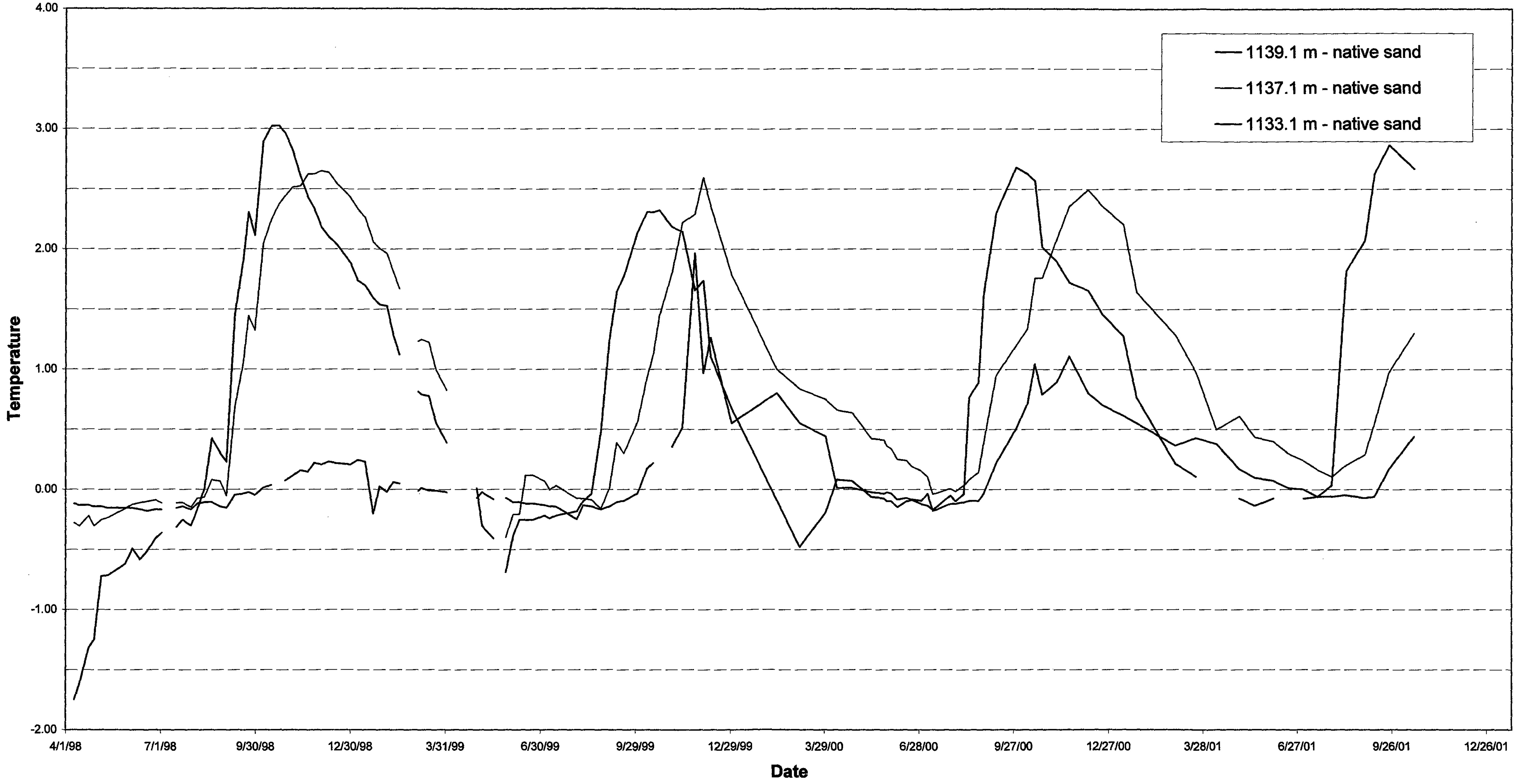


NOTE: 1) BH Location: Crest of Toe Berm
2) Ground surface: 1139.9 m.
3) Fill and native ground interface: 1129.9 m.

Figure A-5

Ground Temperature Profiles
BH # 12861-06

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

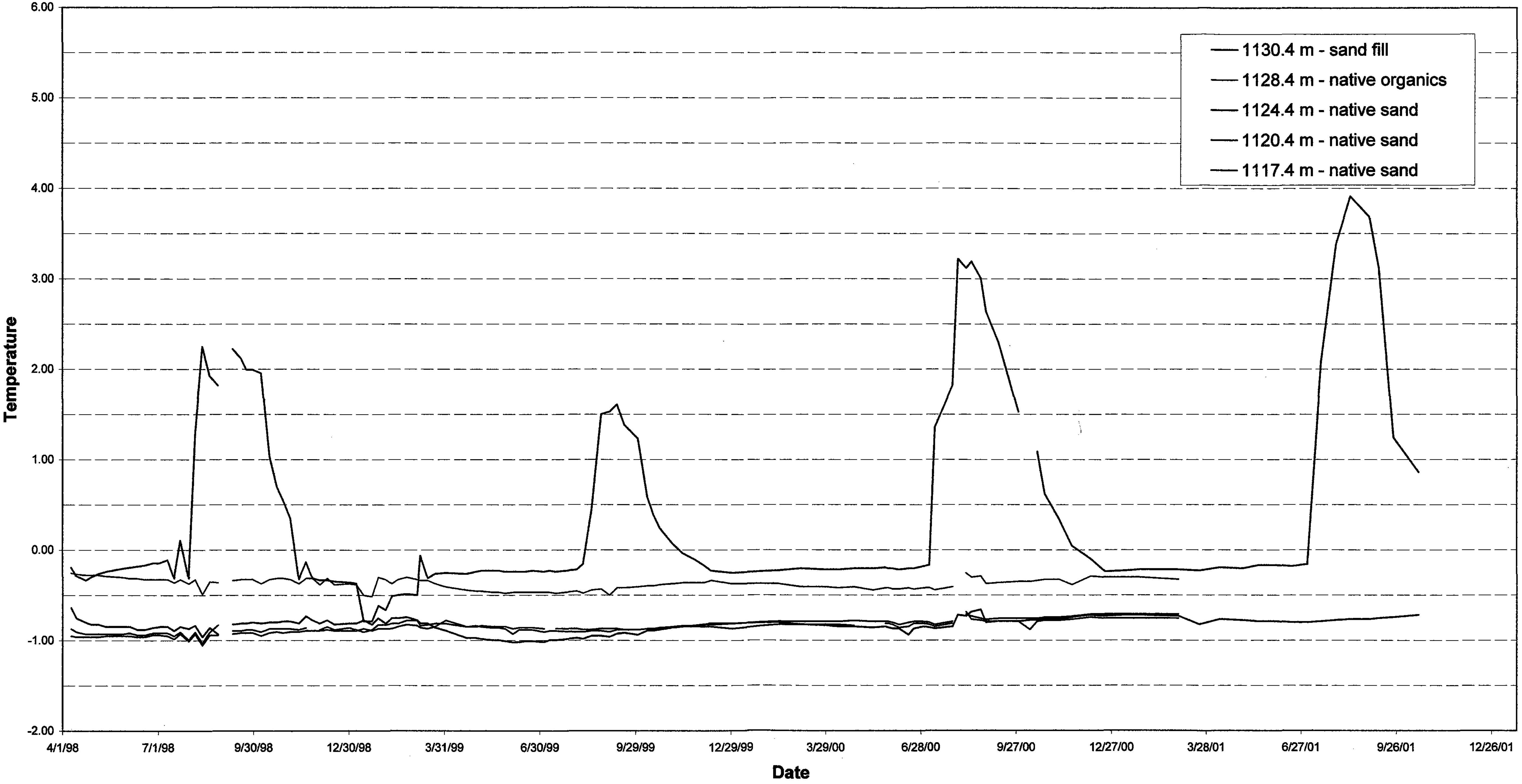


NOTE: 1) BH Location: North End of Toe Berm
2) Ground surface: 1143.3 m.
3) Fill and native ground interface: 1142.7 m.

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

Figure A-6

Ground Temperature Profiles
BH # 12861-07

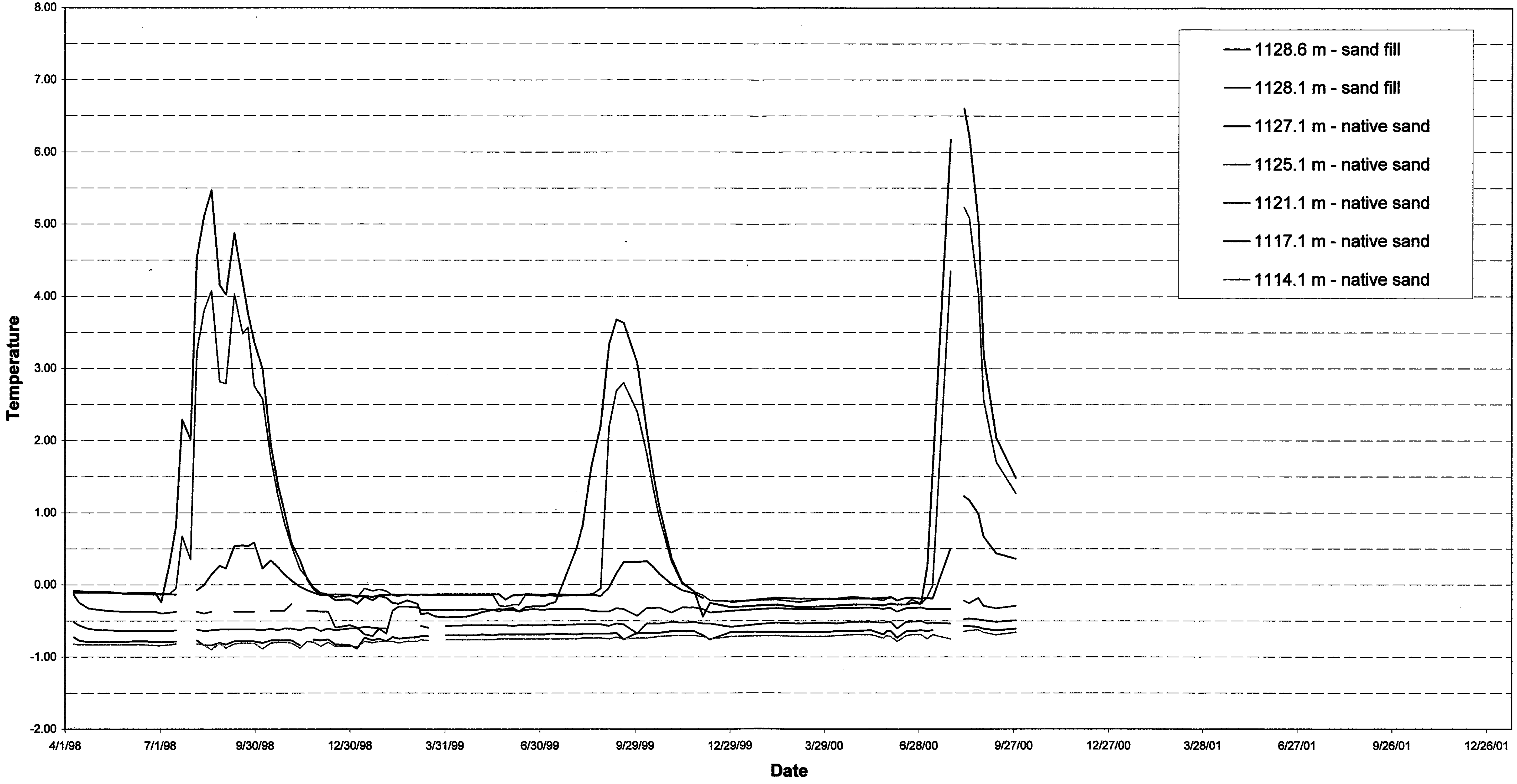


NOTE: 1) BH Location: Downstream Toe of Dam
2) Ground surface: 1132.6 m.
3) Fill and native ground interface: 1129.3 m.
4) Thermistor Beads at 1139.3 and 1131.4 not shown.

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

Figure A-7

Ground Temperature Profiles
BH # 12861-08

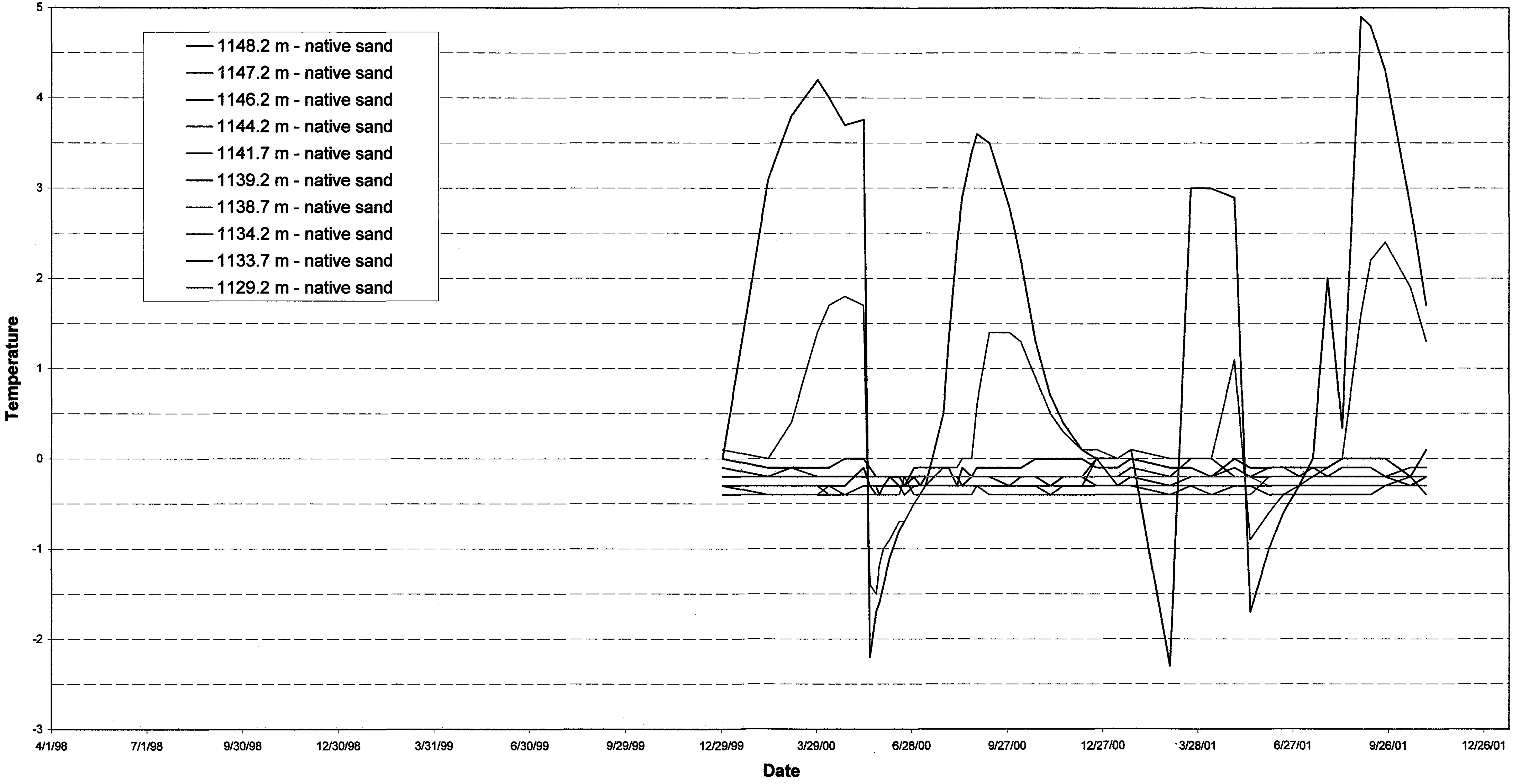


NOTE: 1) BH Location: Crest of Seepage Dam
2) Ground surface: 1130.7 m.
3) Fill and native ground interface: 1127.6 m.

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

Figure A-8

Ground Temperature Profiles
BH # 12861-10

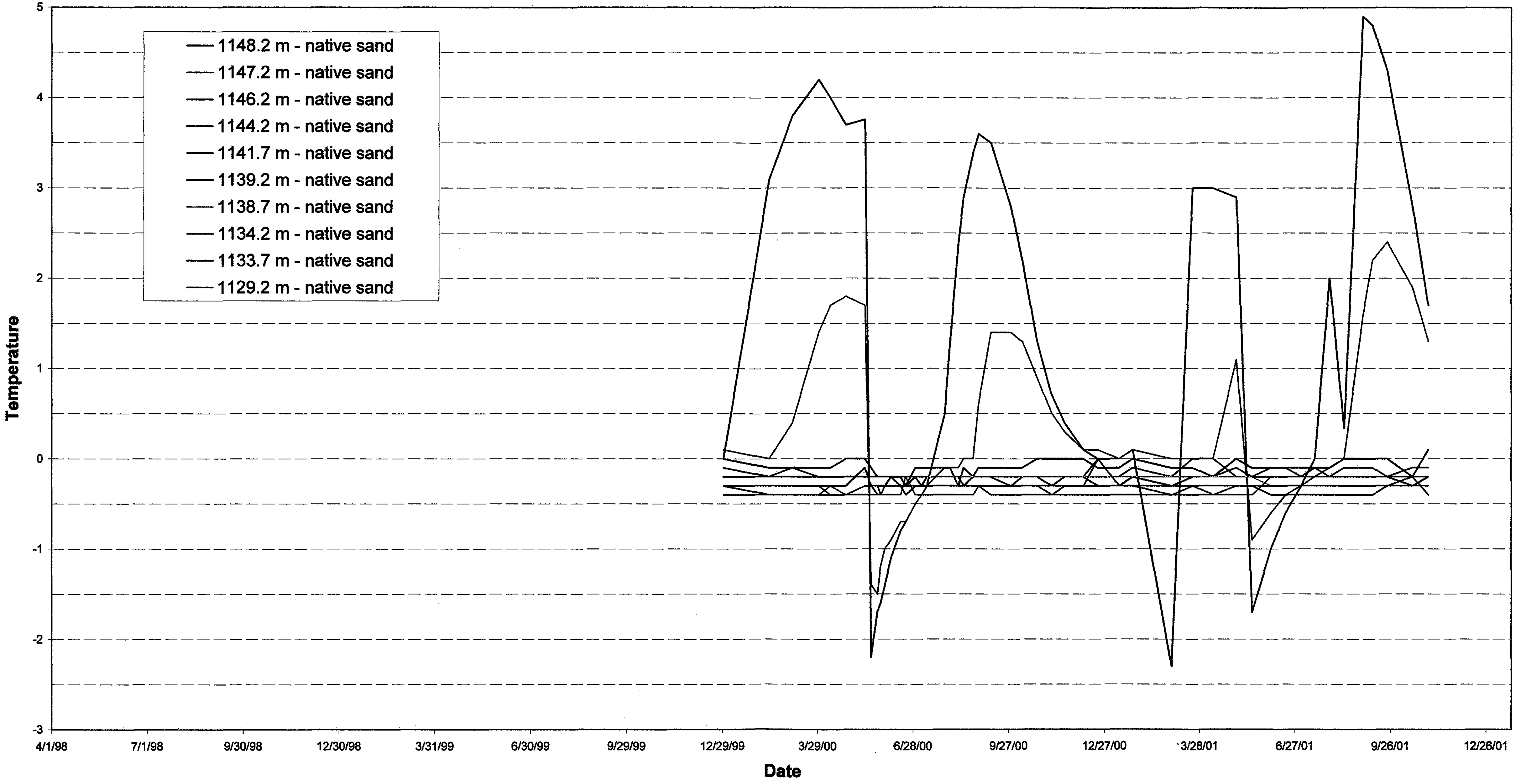


NOTE: 1) BH Location: North Abuttment of Dam #1
2) Ground surface: 1150.6 m.
3) Fill and native ground interface: 1149.2 m.

Figure A-9

Ground Temperature Profiles
DH # 95-04

Serial No.
Date Installed: 95-06-26

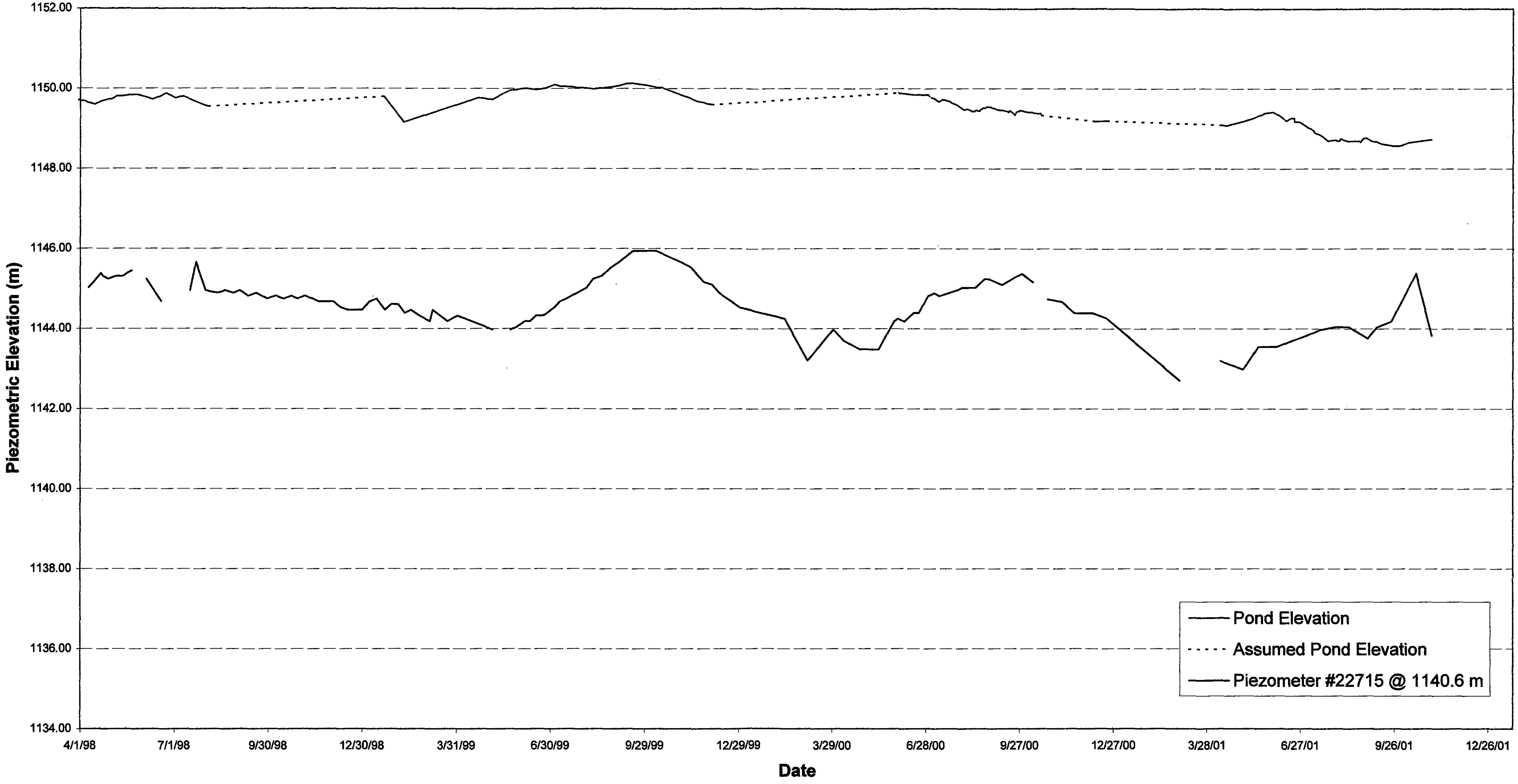


NOTE: 1) BH Location: North Abuttment of Dam #1
2) Ground surface: 1150.6 m.
3) Fill and native ground interface: 1149.2 m.

Serial No.
Date Installed: 95-06-26

Figure A-9

Ground Temperature Profiles
DH # 95-04

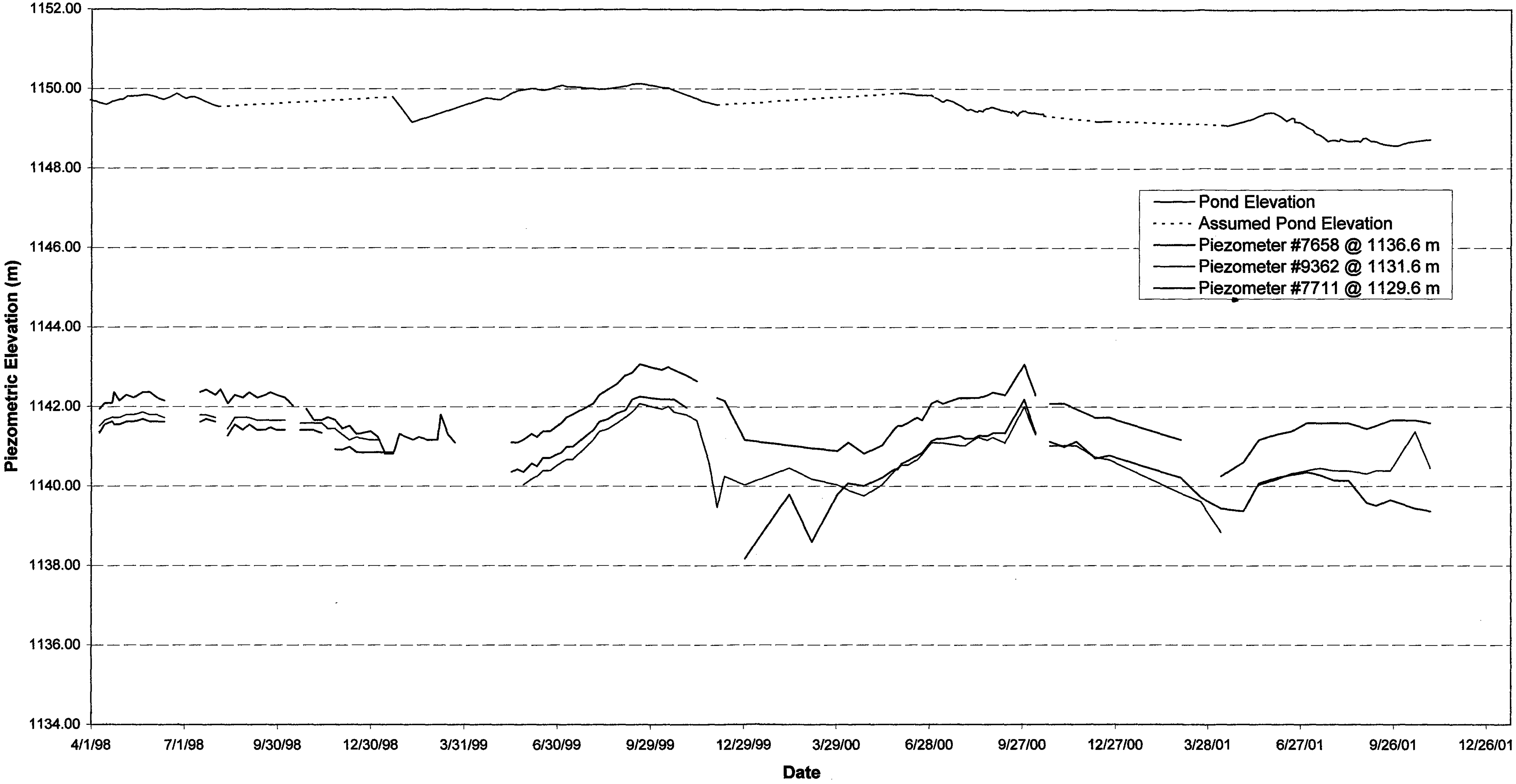


NOTE: 1) BH Location: Crest of Dam
2) Ground surface: 1151.4 m.
3) Fill and native ground interface: 1137.7 m.

Date Installed: 98-03-24

Figure B-1

Piezometric Elevation Profile
BH # 12861-01

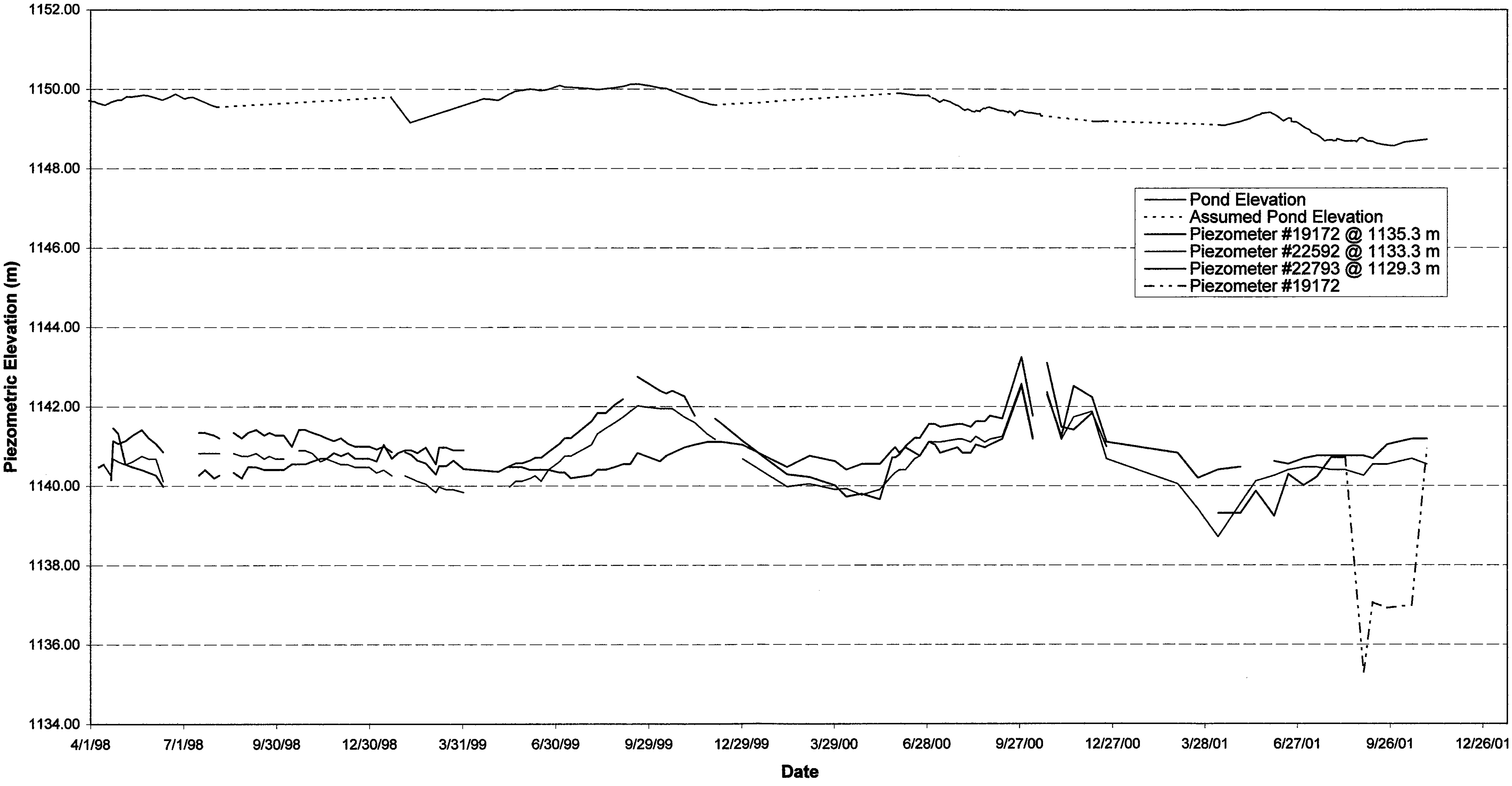


NOTE: 1) BH Location: Crest of Dam
2) Ground surface: 1151.4 m.
3) Fill and native ground interface: 1132.2 m.

Date Installed: 98-03-25

Figure B-2

Piezometric Elevation Profiles
BH # 12861-02

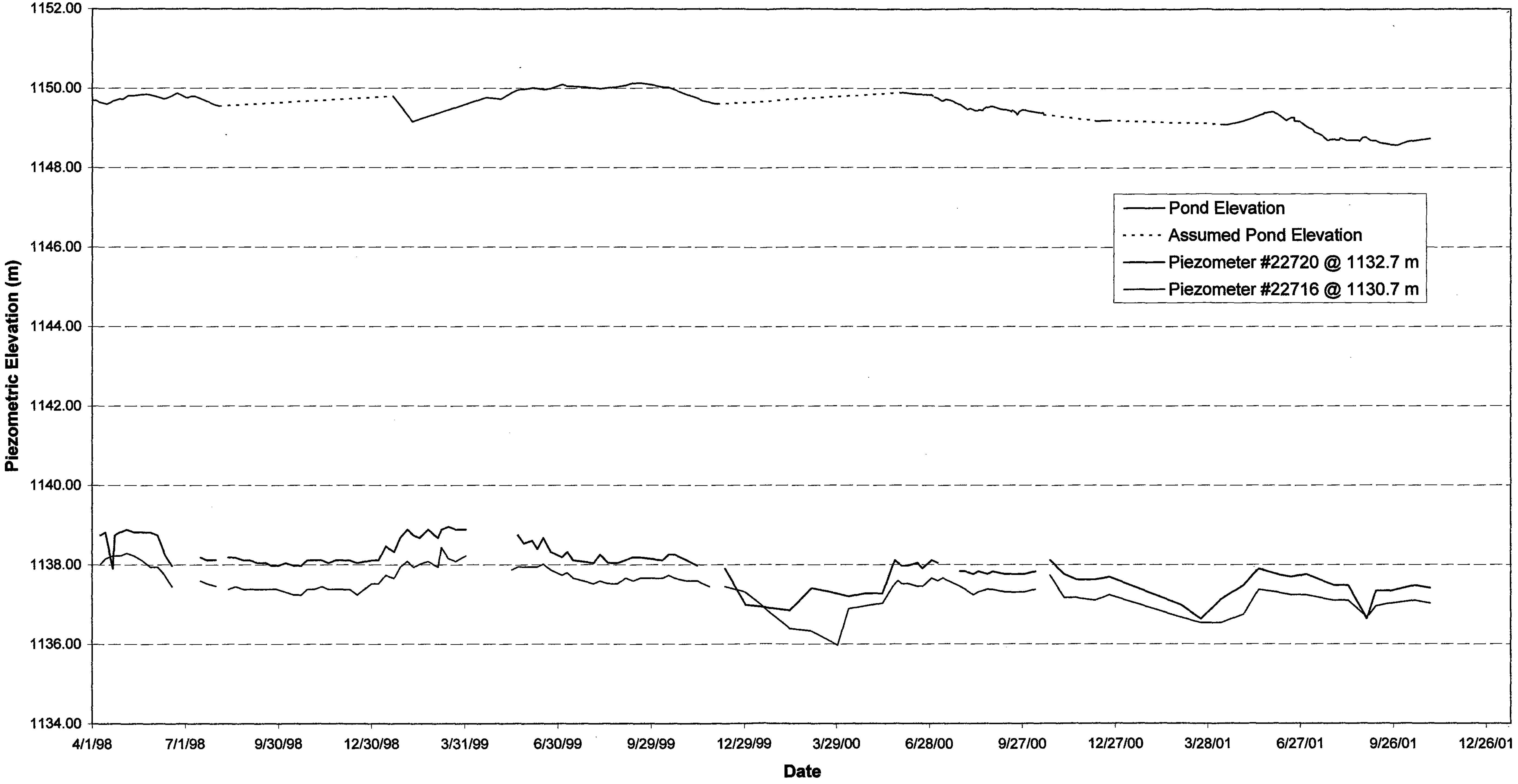


NOTE: 1) BH Location: Crest of Dam
2) Ground surface: 1151.4 m.
3) Fill and native ground interface: unknown.
4) Temperatures of Piezometers are unknown.
5) Dashed line segments represent potentially erroneous readings.

Date Installed: 98-03-31

Figure B-3

Piezometric Elevation Profiles
BH # 12861-03

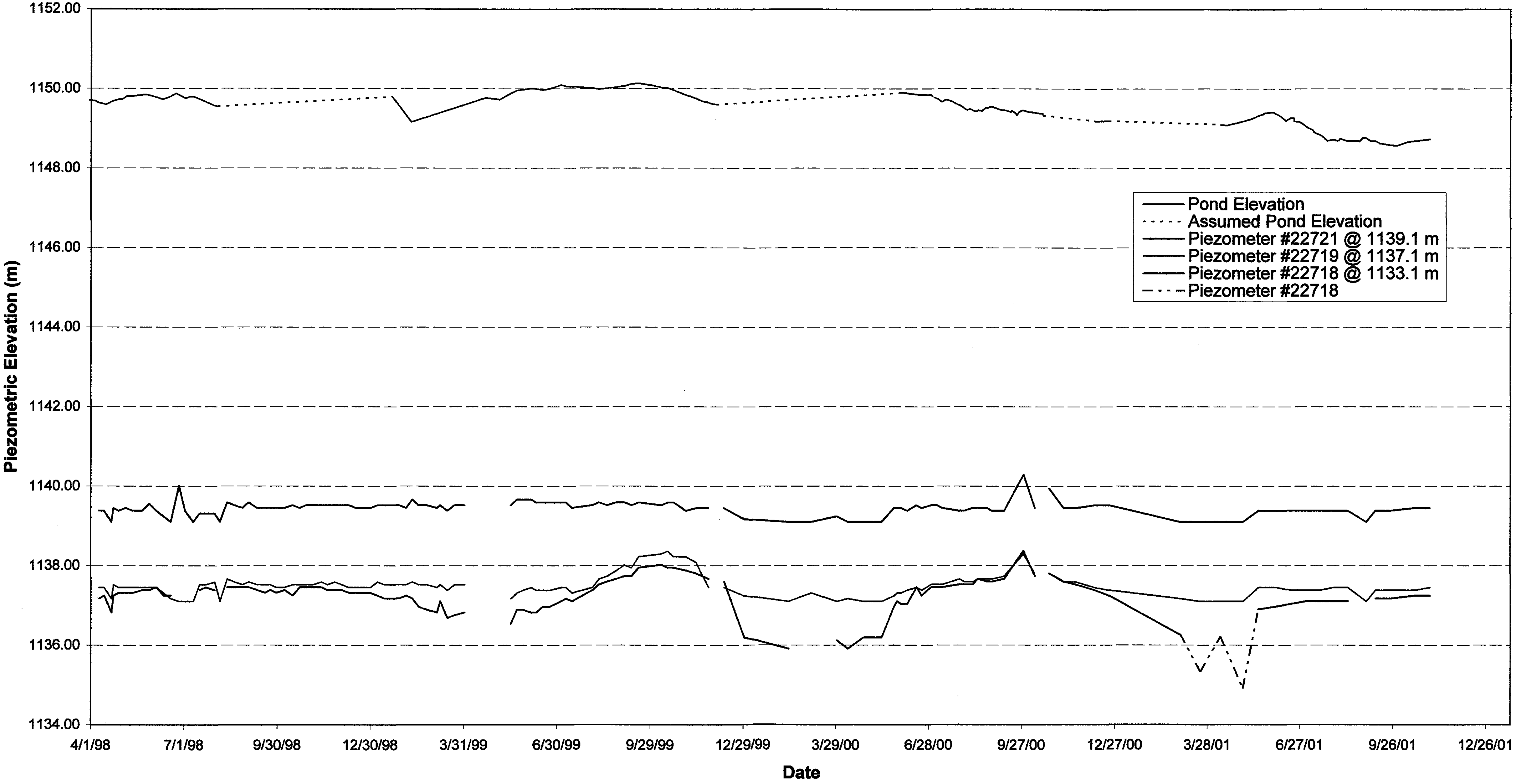


NOTE: 1) BH Location: Crest of Toe Berm
2) Ground surface: 1139.7 m.
3) Fill and native ground interface: 1132.4 m.

Date Installed: 98-03-28

Figure B-4

Piezometric Elevation Profiles
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) Dashed line segments represent potentially erroneous readings.

Date Installed: 98-03-31

Figure B-5

Piezometric Elevation Profiles
BH # 12861-07

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.

Unit 6, 151 Industrial Road, Whitehorse, YT Y1A 2V3
• Phone (867) 668-3068 • FAX (867) 668-4349 •

2.0 FIELD WORK

EBA Engineering and Midnight Sun Drilling personnel and equipment mobilized to Mt. Nansen on March 20, 1998. The drilling program commenced on March 21, 1998 and was completed on March 31, 1998. Demobilization back to Whitehorse took place on April 1, 1998.

Generally, the instrumentation installation program consisted of drilling 10 boreholes to a depth of approximately 4 m into permafrost soils; installing thermistor cables to monitor ground temperatures in all of the boreholes; and installing piezometers in five of the boreholes (at the same depth as specific thermistor beads) to measure pore water pressure for determining ground water table elevations throughout Dam # 1. Drawing 12861-A-01, attached, presents the location of the boreholes drilled for this project as well as the locations of the previously installed instrumentation.

Drilling was completed utilizing Midnight Sun Drilling's Schramm 455 Air Rotary drill rig. Sampling was primarily accomplished by collecting cuttings from the cyclone or from the split spoon sampler during the completion of Standard Penetration Testing (SPT). All samples collected were returned to EBA's Whitehorse laboratory for natural moisture content determination. The field work was supervised by Mr. Myles Plaunt, C.E.T., of EBA's Whitehorse office.

In all boreholes, except BH's 12861-04 & -09, solid 40 mm diameter PVC pipe was placed to the desired depth with the piezometers attached to the outside. The placement of the piezometers was governed by the depth to permafrost and the bead configuration of the thermistor cables. Once installed, the drill casing was pulled while backfill with frac sand, bentonite and concrete was completed. Finally, the thermistor cable was placed inside the 40 mm diameter PVC and the pipe was filled with antifreeze. In BH's 12861-04 & -09, a single bead thermistor was attached to the bottom of a 50 mm diameter PVC standpipe with a geotextile wrapped screened section (typical standpipe installation for monitoring ground water levels) and backfilled with cuttings with a bentonite cap at surface.

A summary of the instrumentation installation details, including cable numbers and elevations for each of the instruments in each of the boreholes, is presented on Table 1, following. Installation and backfill details are also presented on the detailed borehole logs, attached.

3.0 GEOTECHNICAL CONDITIONS

Soil conditions at each of the borehole locations are detailed on the borehole logs attached to this letter, following the site plan showing borehole locations. General geotechnical conditions are summarized in Table 2, below.

Table 2
GEOTECHNICAL CONDITIONS
(based on observations during drilling)

Borehole & Depth	General Soil Conditions	Depth To Foundation Soils	Depth to Permafrost
BH 1 / 18.3 m	Sand fill over organics underlain by silty sand with some gravel and cobbles	13.7 m	13.6 m*
BH 2 / 26.5 m	Sand fill over organics underlain by sand with some silt, gravel & lenses of organics	19.2 m	19.8 m
BH 3 / 22.3 m	Sand fill over sand (stripping of organics was complete in this area)	uncertain	18.2 m
BH 4 / 10.7 m	Sand with some silt and gravel	0.0 m	3.7 m
BH 5 / 13.0 m	Gravelly sand and sand fill over organics, underlain by sand with gravel & cobbles	7.3 m	7.2 m*
BH 6 / 16.8 m	Gravelly sand and sand fill over organics, underlain with sand with some silt & gravel	10.0 m	10.3 m
BH 7 / 10.2 m	Gravel pad constructed over natural sand with some silt, gravel and cobbles	0.6 m	7.6 m
BH 8 / 15.2 m	Rip Rap at surface over sand fill over organics underlain by sand with some silt	3.3 m	3.0 m*
BH 9 / 18.9 m	Sand with some silt and gravel	0.0 m	7.6 m
BH 10 / 16.6 m	Gravel and sand fill over organics underlain by sand with some silt and gravel	3.1 m	3.1 m

* Indicates boreholes where some freezeback into the fill soils was noted.

4.0 INSTRUMENTATION READINGS AND INTERPRETATION

Four sets of readings have been collected from the thermistor cables and piezometers installed. Plots of the ground temperatures for Boreholes 12867-01, 02, 03, 05, 06, 07, 08 and 10 are presented following the borehole logs. Piezometer data is still being reduced and will be forwarded upon completion.

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.

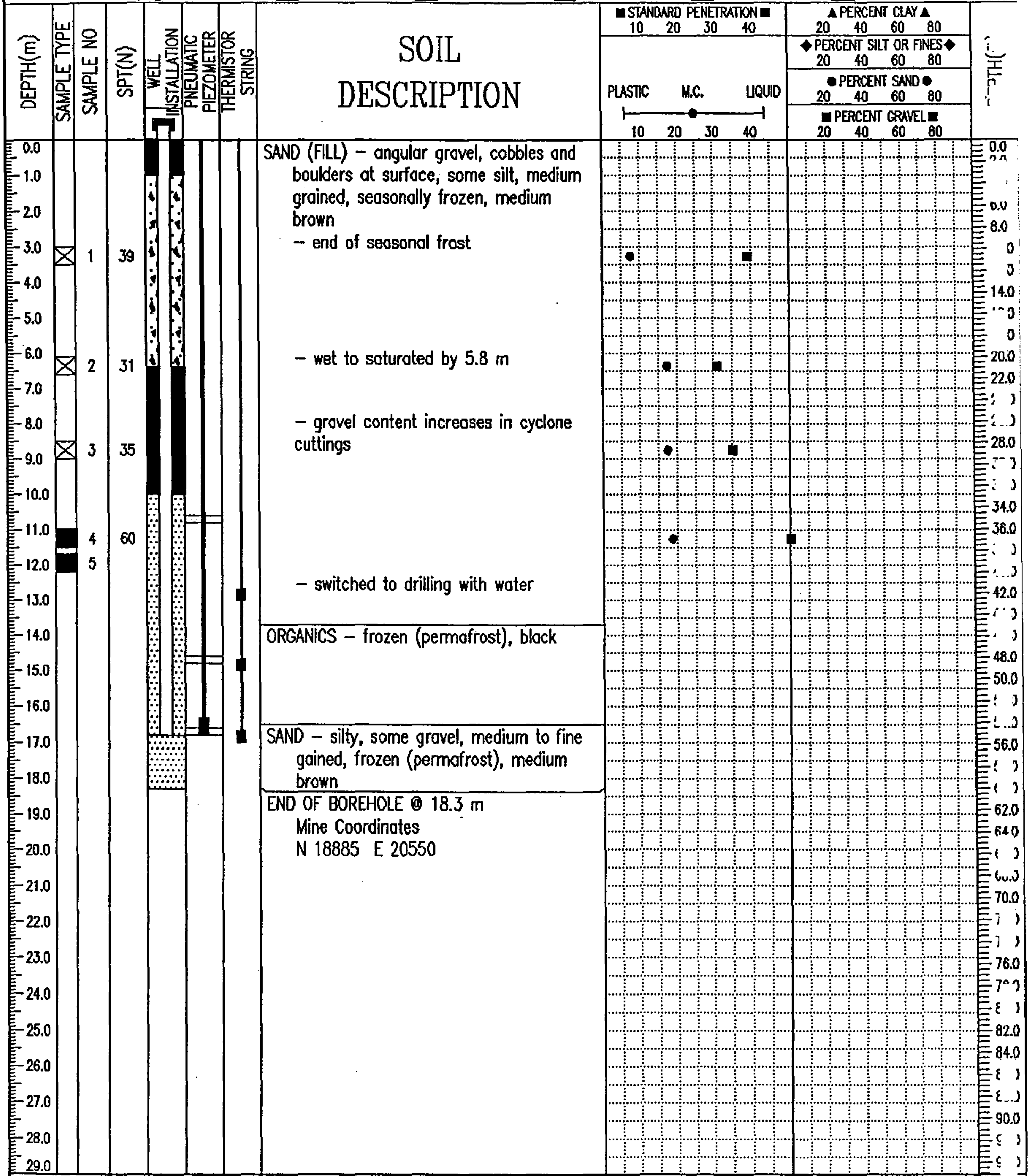
Myles Plaunt, C.E.T.
Engineering Technologist

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

INSTRUMENTATION INSTALLATION	BYG NATURAL RESOURCES	BOREHOLE NO: 12861-01
MT. NANSEN MINE	DRILL: SCHRAMM AIR ROTARY	PROJECT NO: 0201-97-12861
NW OF CARMACKS, YT	UTM ZONE: - N - E -	ELEVATION: 1151.4 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

– end of seasonal frost

– wet to saturated by 5.8 m

– gravel content increases in cyclone cuttings

– switched to drilling with water

ORGANICS – frozen (permafrost), black

SAND – silty, some gravel, medium to fine gained, frozen (permafrost), medium brown

END OF BOREHOLE @ 18.3 m

Mine Coordinates

N 18885 E 20550

SAMPLE TYPE	SAMPLE NO	SPT(N)
☒	1	39
☒	2	31
☒	3	35
■	4	60
■	5	

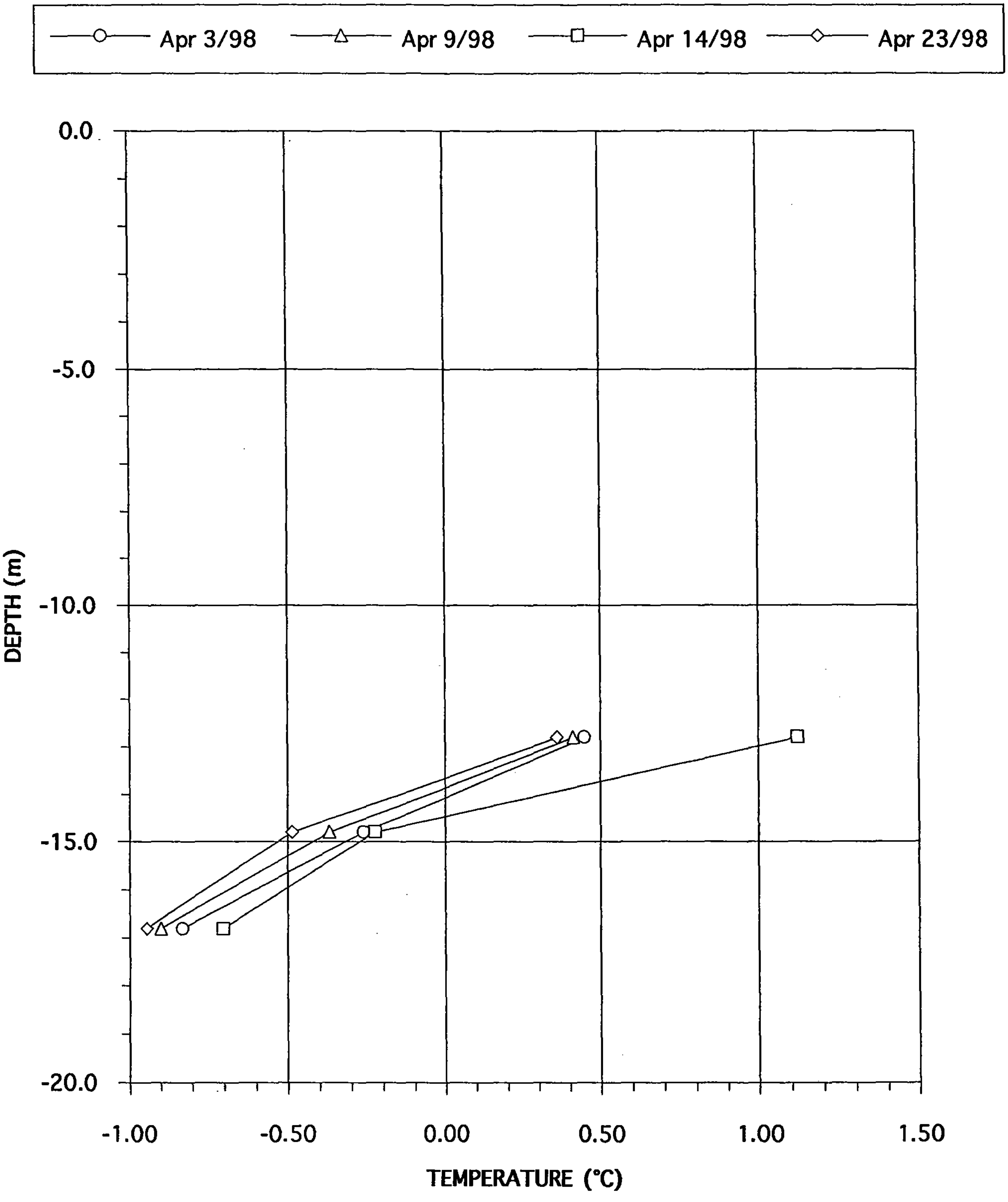
EBA Engineering Consultants Ltd.

Whitehorse, Yukon

LOGGED BY: MCP	COMPLETION DEPTH: 18.3 m
REVIEWED BY: JRT	COMPLETE: 98/03/24
Fig. No:	Page 1 of

98/04/17 07:58AM (WELL28)

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

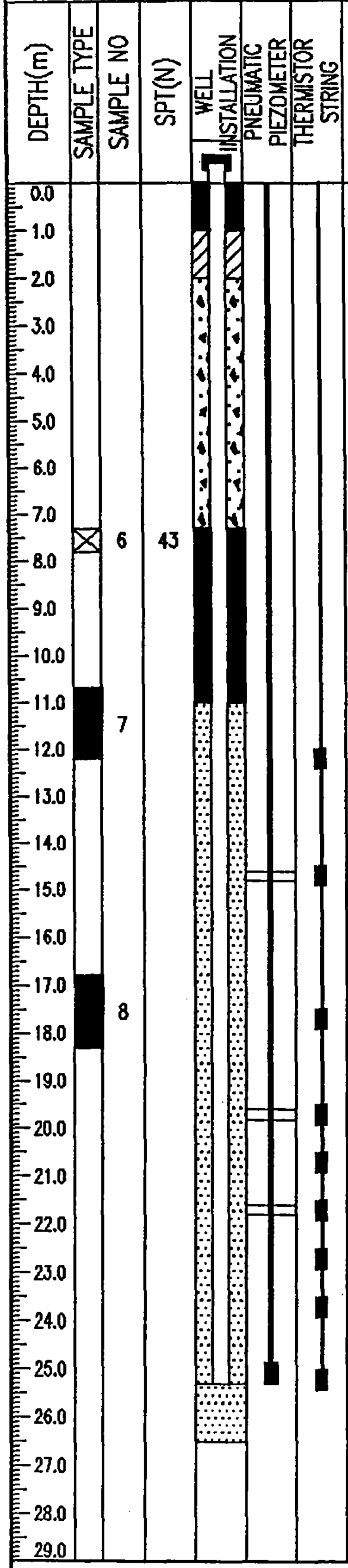


GROUND TEMPERATURE PROFILE
MT. NANSEN - TAILINGS DAM
BOREHOLE 12861-01 (el. 1151.4)

INSTRUMENTATION INSTALLATION	BYG NATURAL RESOURCES	BOREHOLE NO: 12861-02
MT. NANSEN MINE	DRILL: SCHRAMM AIR ROTARY	PROJECT NO: 0201-97-12861
NW OF CARMACKS, YT	UTM ZONE: - N - E -	ELEVATION: 1151.4 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

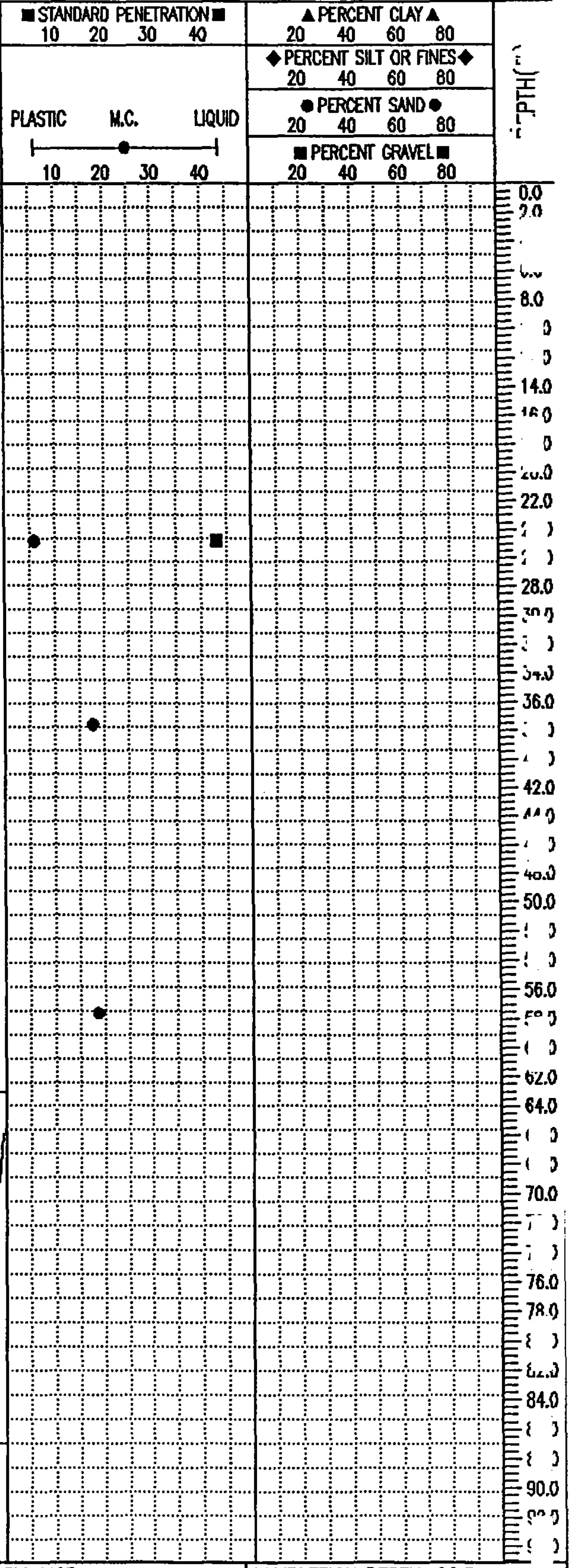
SAND (FILL) – angular gravel, cobbles and boulders at surface, some silt, medium grained, seasonally frozen, medium brown

– wet to saturated by 9 m +/– 1 m

ORGANICS – fibrous with wood chips throughout, saturated, black
– frozen (permafrost)

SAND – some silt, some gravel, lenses of organics throughout, sand is medium to fine grained, frozen (permafrost), medium brown
– gravel content increases below 22.9

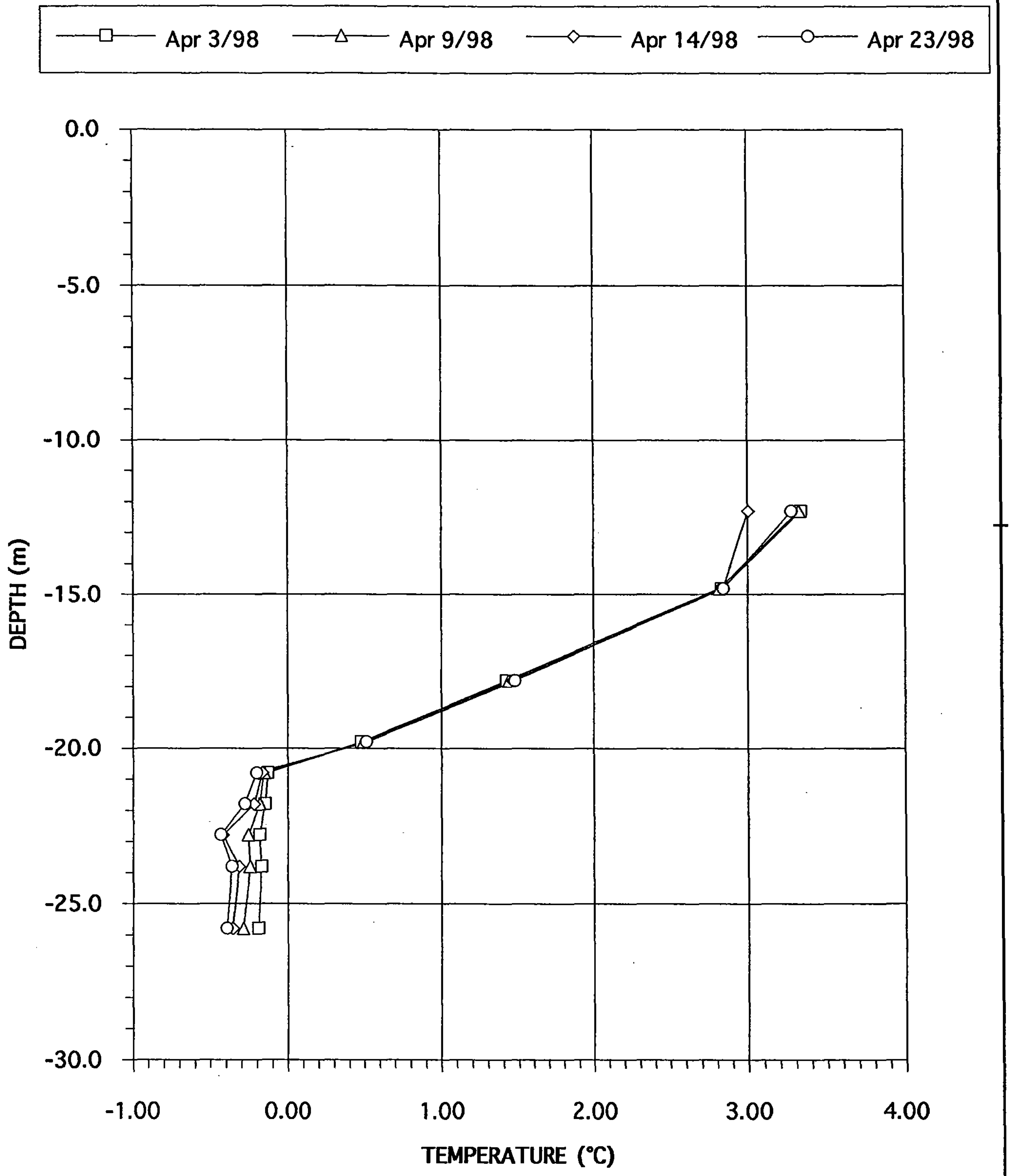
END OF BOREHOLE @ 26.5 m
MINE COORDINATES
N 18935 E 20550



EBA Engineering Consultants Ltd. Whitehorse, Yukon	LOGGED BY: MCP	COMPLETION DEPTH: 26.5 m
	REVIEWED BY: JRT	COMPLETE: 98/03/25
	Fig. No:	Page 1 of

98/04/17 07:59AM (WELL2B)

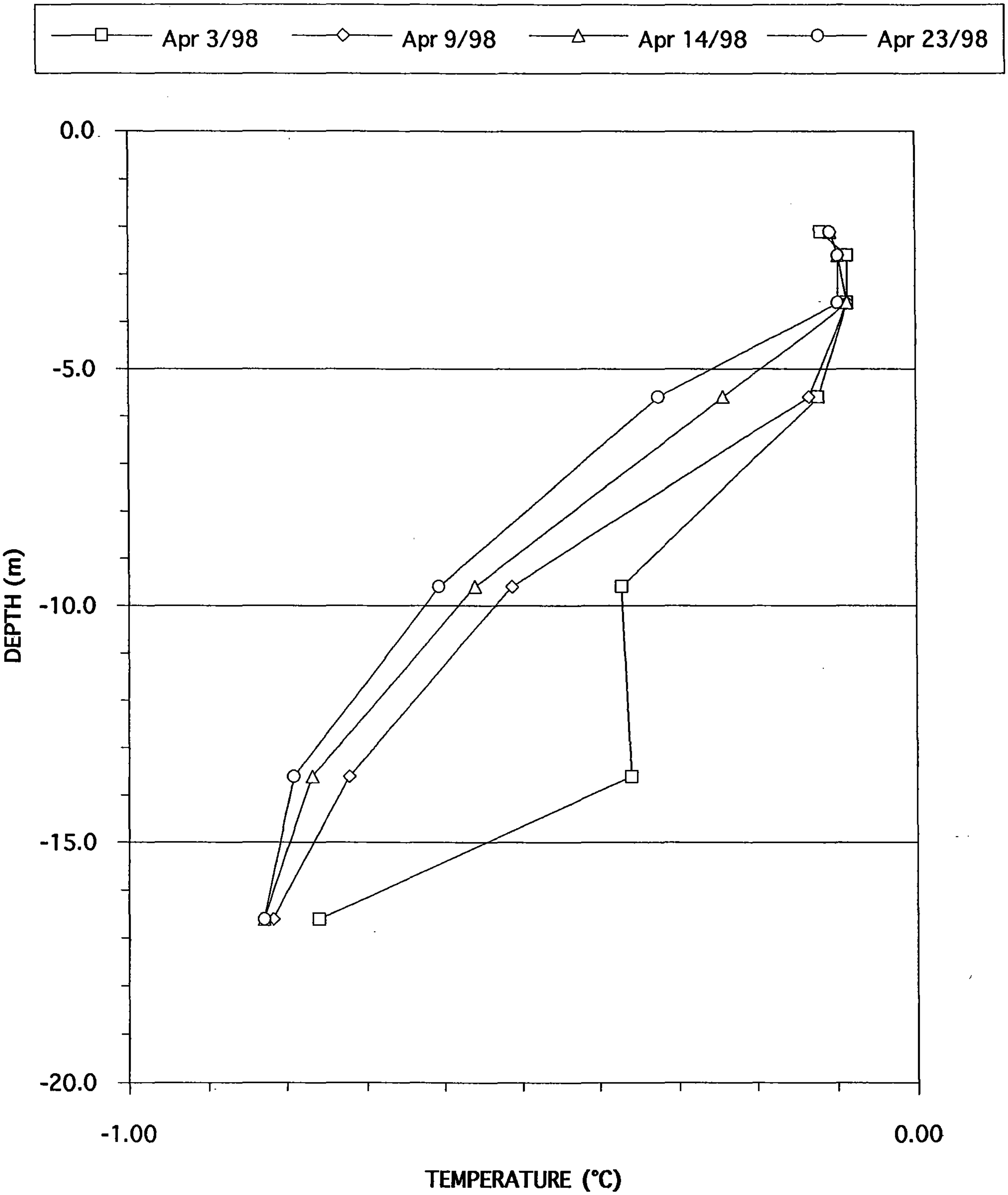
Thermistor No.: 1179
Date Installed: 98-03-25



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

eba

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



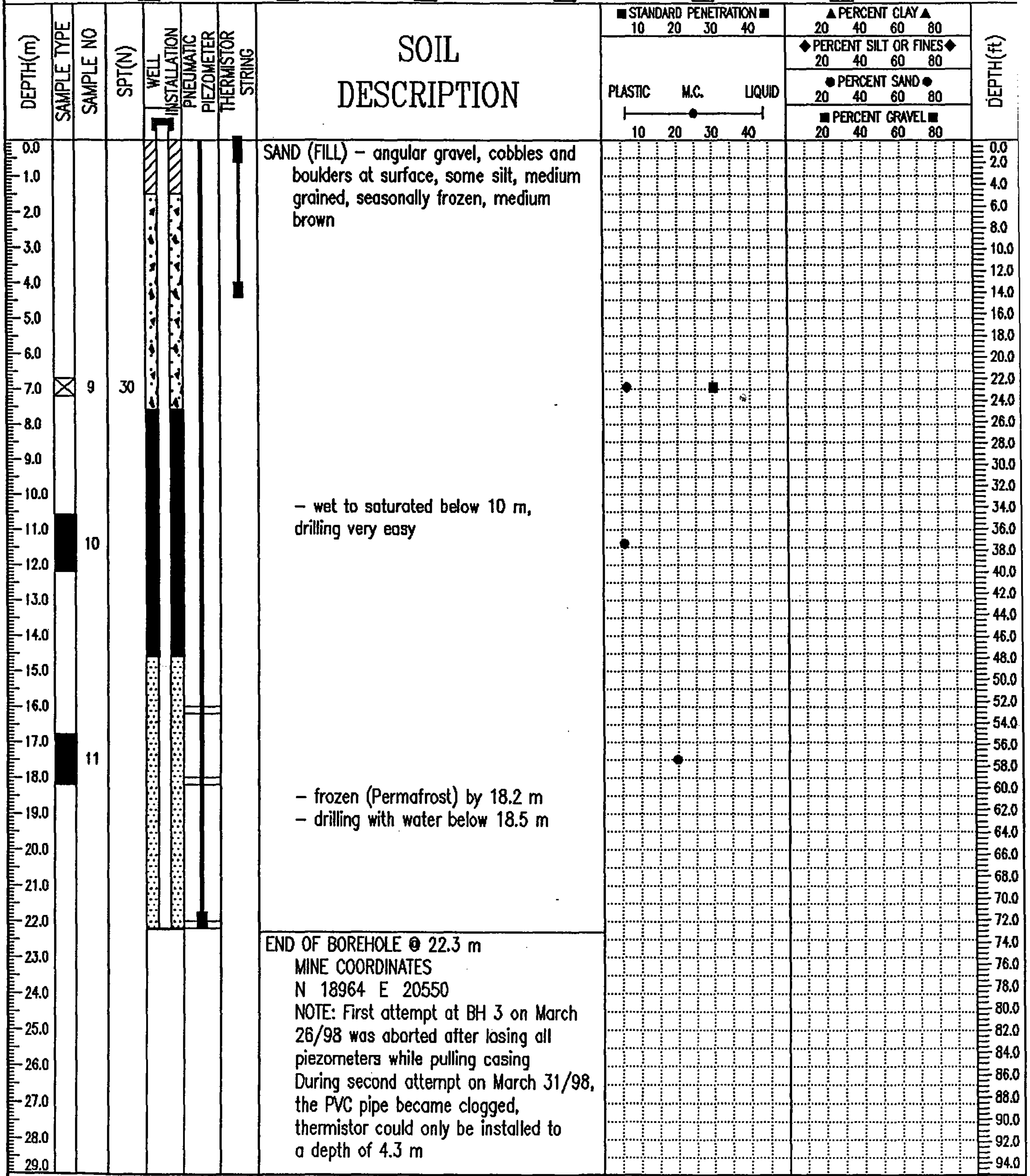
GROUND TEMPERATURE PROFILE
MT. NANSEN - TOP OF TAILINGS DAM #2
BOREHOLE 12861-10 (el. 1130.7)

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

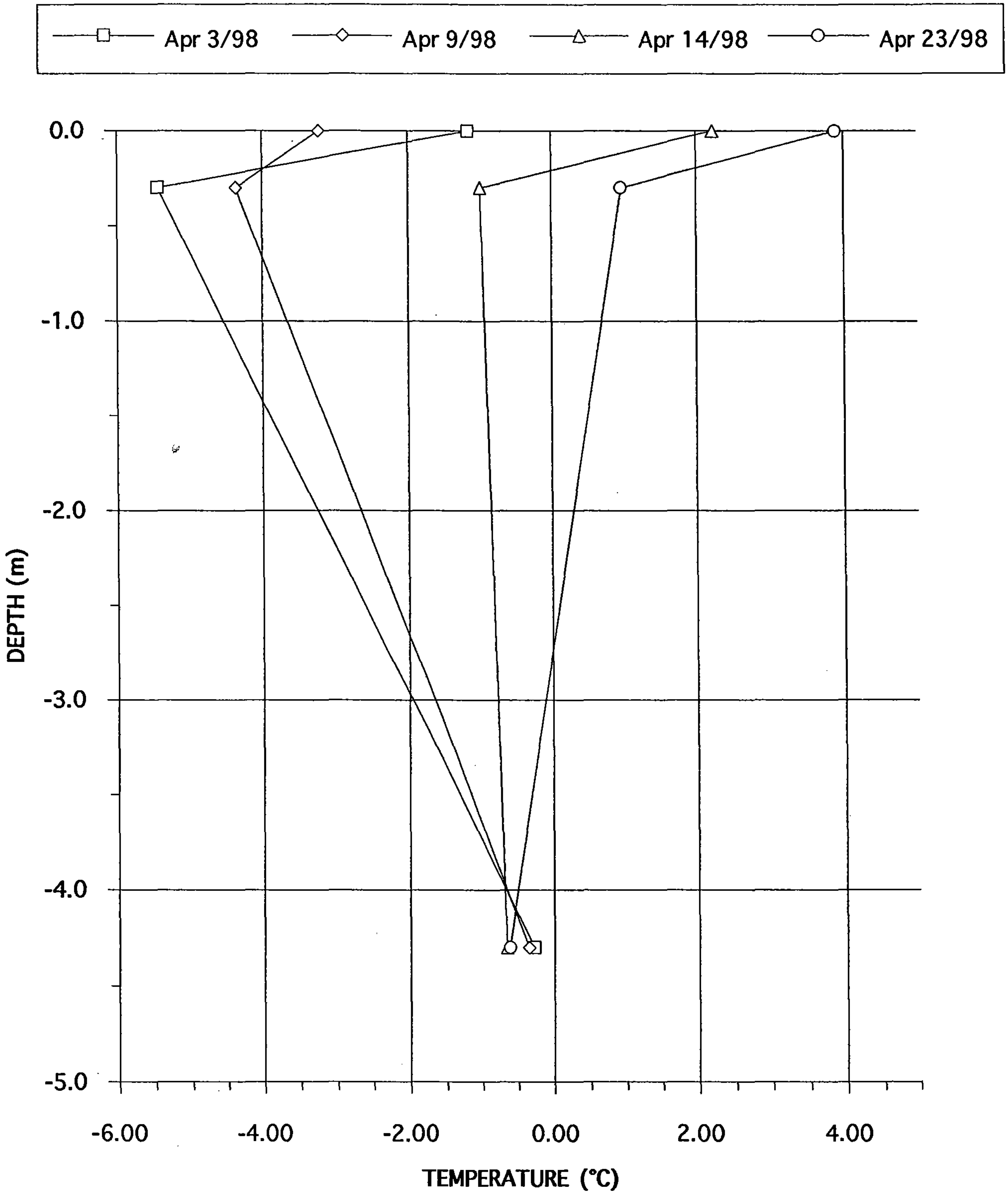
– frozen (Permafrost) by 18.2 m
– drilling with water below 18.5 m

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

98/04/17 07:41AM (WELL2B)

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

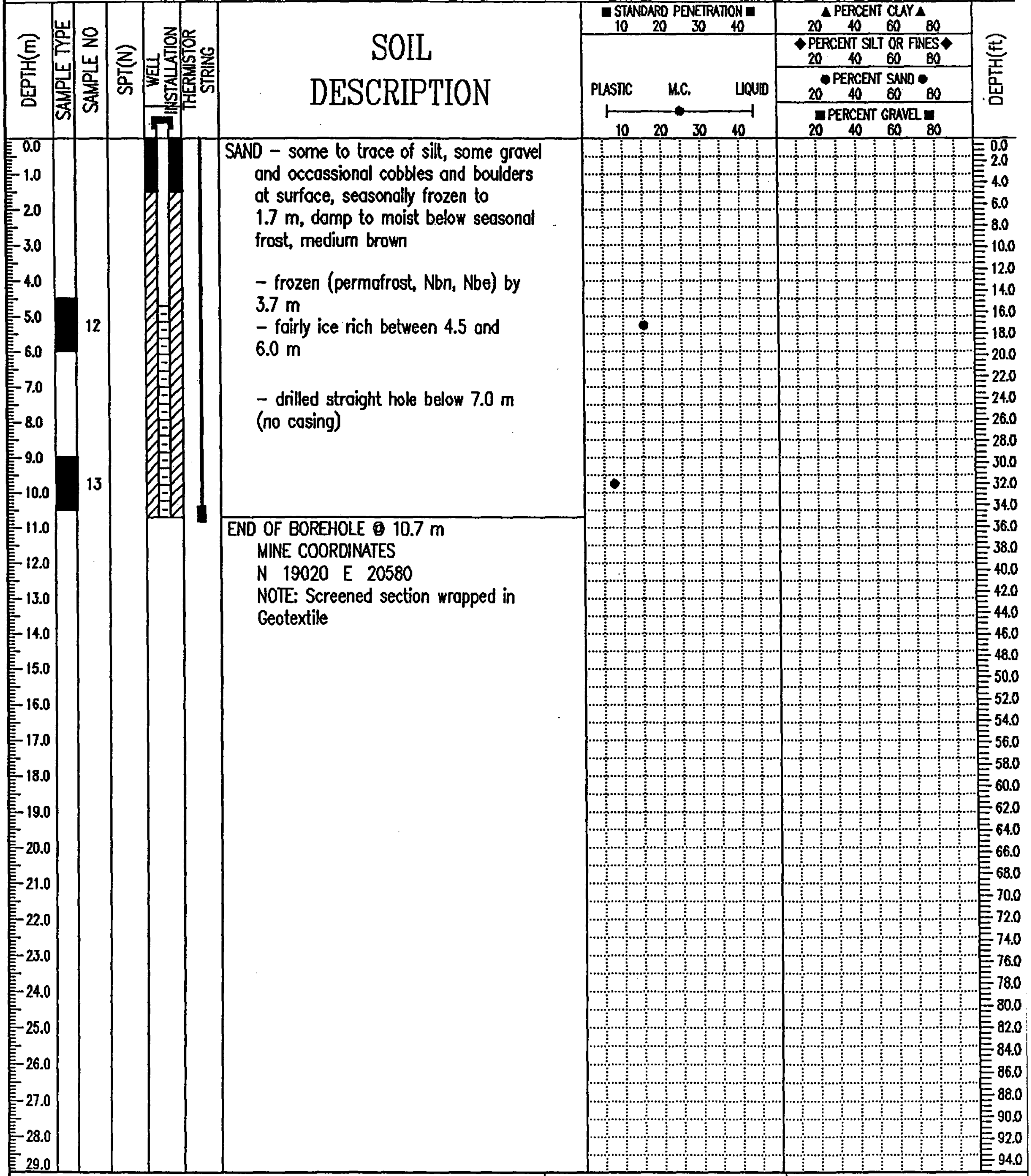


GROUND TEMPERATURE PROFILE
MT. NANSEN - TAILINGS DAM
BOREHOLE 12861-03 (el. 1151.5)

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



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

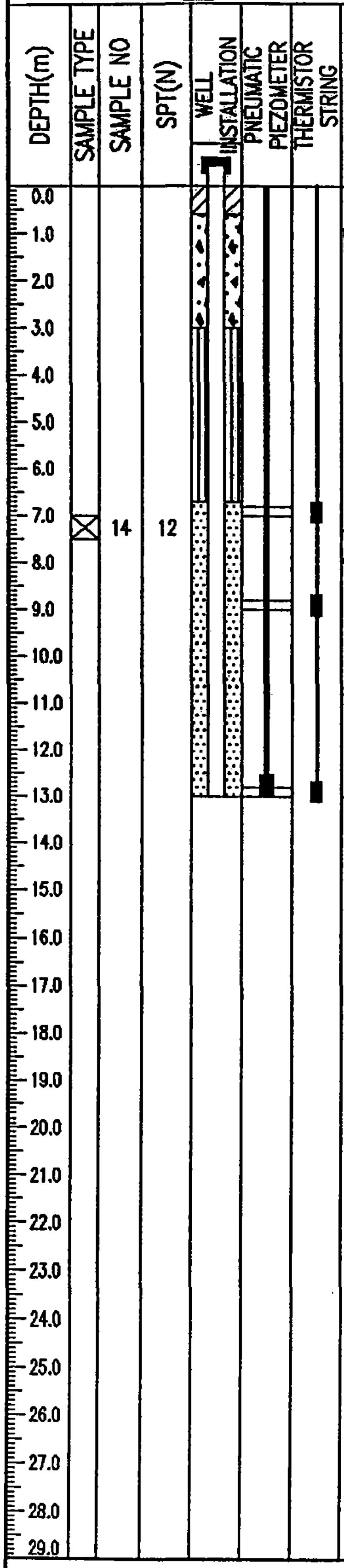
EBA Engineering Consultants Ltd.	LOGGED BY: MCP	COMPLETION DEPTH: 10.7 m
	REVIEWED BY: JRT	COMPLETE: 98/03/27
Whitehorse, Yukon	Fig. No:	Page 1 of 1

98/04/17 07:42AM (WELL2B)

INSTRUMENTATION INSTALLATION	BYG NATURAL RESOURCES	BOREHOLE NO: 12861-05
MT. NANSEN MINE	DRILL: SCHRAMM AIR ROTARY	PROJECT NO: .901-97-12861
NW OF CARMACKS, YT	UTM ZONE: – N – E –	ELEVATION: 1139.7 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



SOIL DESCRIPTION

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

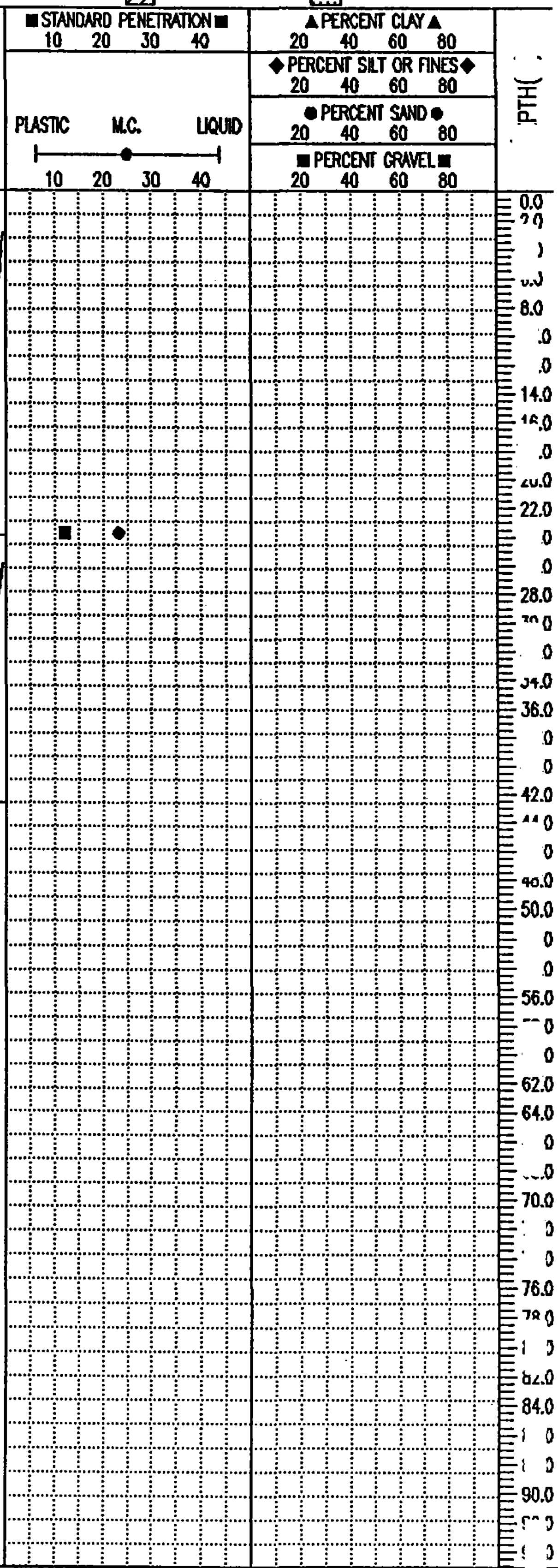
SAND (FILL) – some silt, medium to fine grained, seasonally frozen to 1.9 m, moist to wet below frost, dark olive brown

– saturated with water table at approximately 6.0 m

ORGANICS – frozen (permafrost), black
– slow drilling below 7.3 m

SAND – some silt, some gravel, occassional cobbles and boulders, coarser with depth (more rock chips in cuttings), frozen (permafrost), medium brown

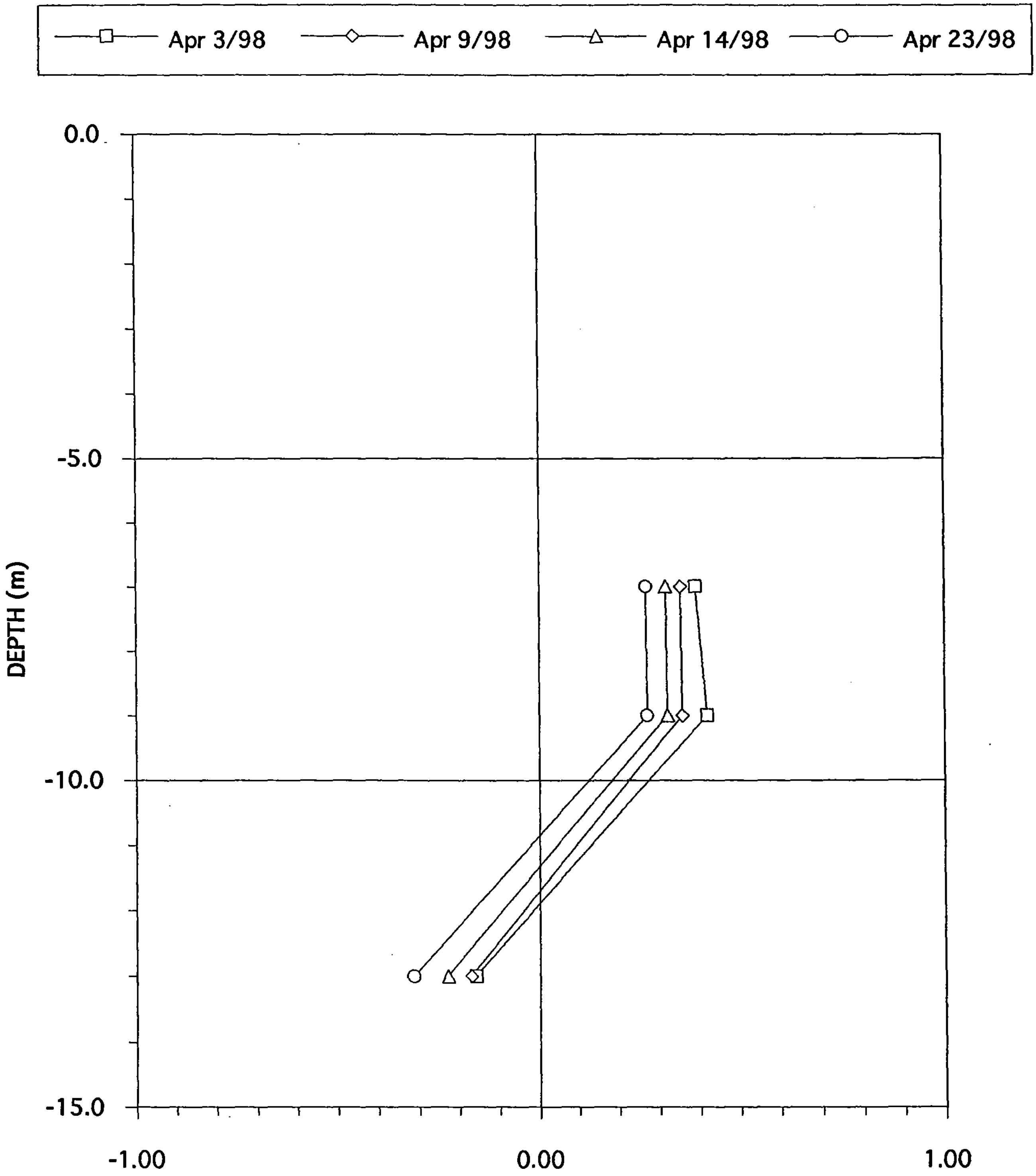
END OF BOREHOLE @ 13 m
MINE COORDINATES
N 18920 E 20598
NOTE: The 100 mm above the fill line at 7.3 m is frozen indicating possible freezeback into fill
NOTE: Last 150 mm section of split spoon was into permafrost therefore use first two blow counts for strength determinations



EBA Engineering Consultants Ltd. Whitehorse, Yukon	LOGGED BY: MCP	COMPLETION DEPTH: 13 m
	REVIEWED BY: JRT	COMPLETE: 98/03/28
	Fig. No:	Page 1 of

98/04/17 02:03PM (WELL28)

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



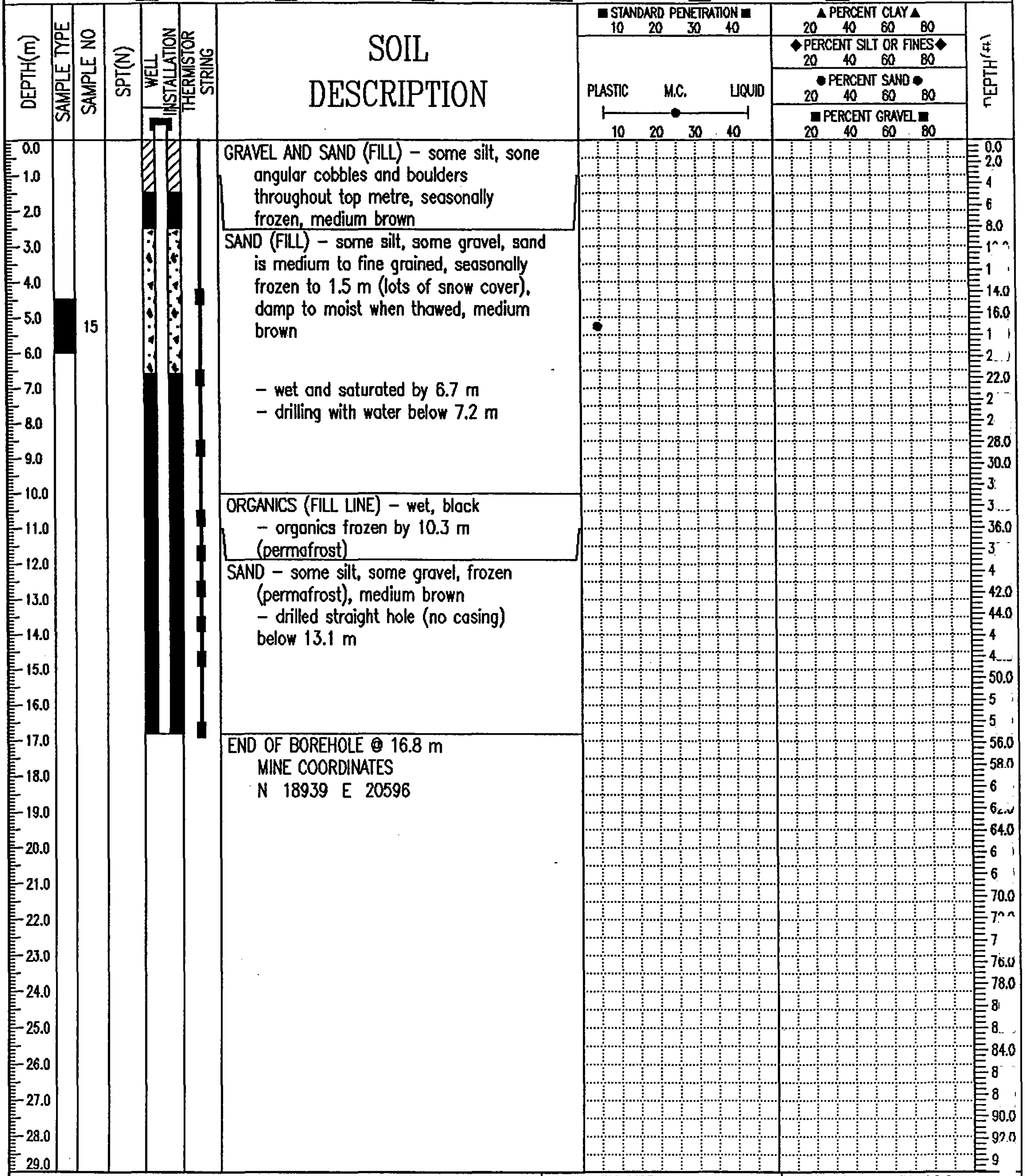
GROUND TEMPERATURE PROFILE
MT. NANSEN - TAILINGS DAM TOE BERM
BOREHOLE 12861-05 (el. 1139.7)

eba

INSTRUMENTATION INSTALLATION	BYG NATURAL RESOURCES	BOREHOLE NO: 12861-06
MT. NANSEN MINE	DRILL: SCHRAMM AIR ROTARY	PROJECT NO: 0201-97-12861
NW OF CARMACKS, YT	UTM ZONE: - N - E -	ELEVATION: 1139.9 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

GRAVEL AND SAND (FILL) - some silt, sone angular cobbles and boulders throughout top metre, seasonally frozen, medium brown

SAND (FILL) - some silt, some gravel, sand is medium to fine grained, seasonally frozen to 1.5 m (lots of snow cover), damp to moist when thawed, medium brown

- wet and saturated by 6.7 m
- drilling with water below 7.2 m

ORGANICS (FILL LINE) - wet, black
- organics frozen by 10.3 m (permafrost)

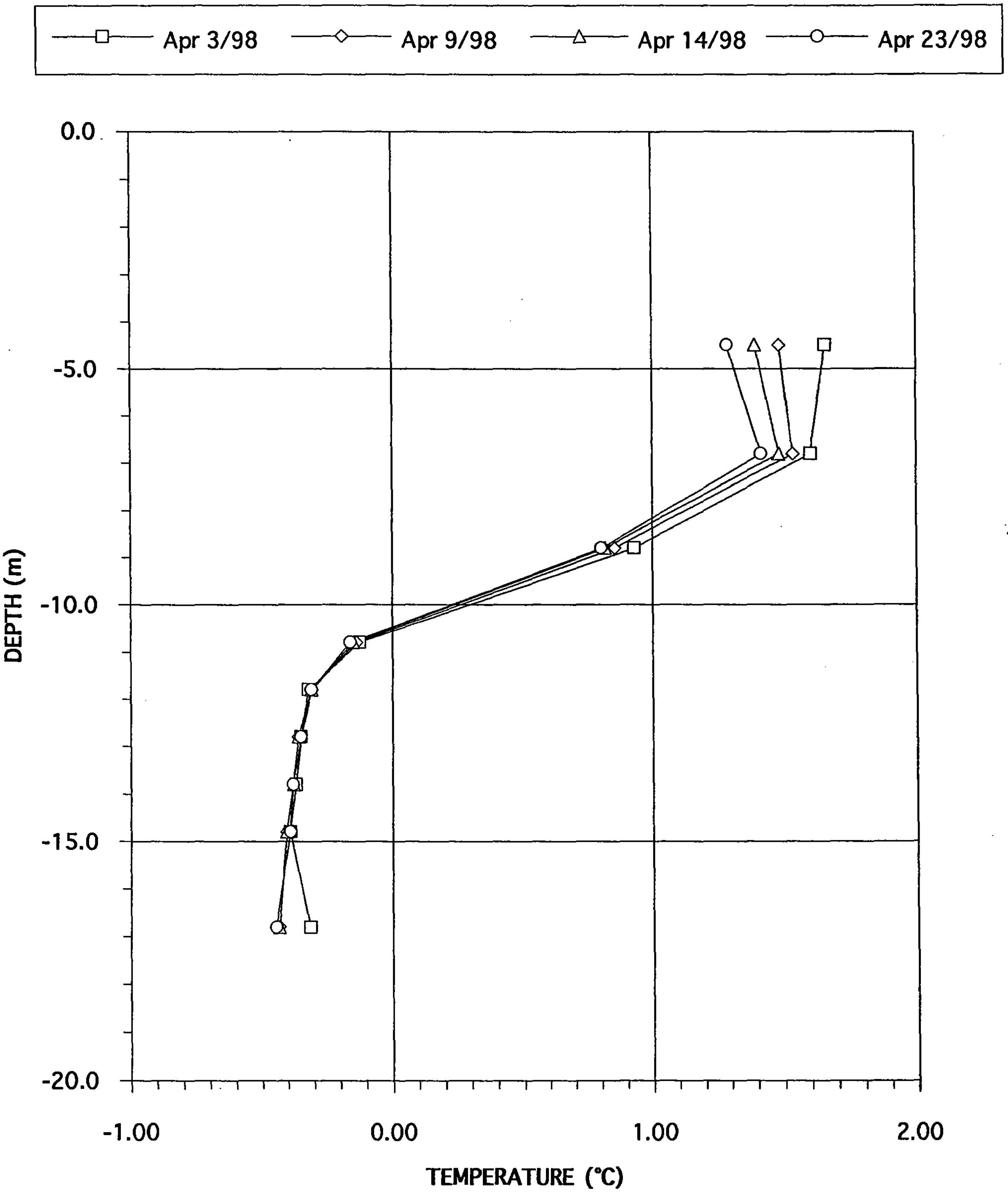
SAND - some silt, some gravel, frozen (permafrost), medium brown
- drilled straight hole (no casing) below 13.1 m

END OF BOREHOLE @ 16.8 m
MINE COORDINATES
N 18939 E 20596

EBA Engineering Consultants Ltd.	LOGGED BY: MCP	COMPLETION DEPTH: 16.8 m
Whitehorse, Yukon	REVIEWED BY: JRT	COMPLETE: 98/03/30
	Fig. No:	Page 1 of

98/04/17 07:45AM (WELL28)

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



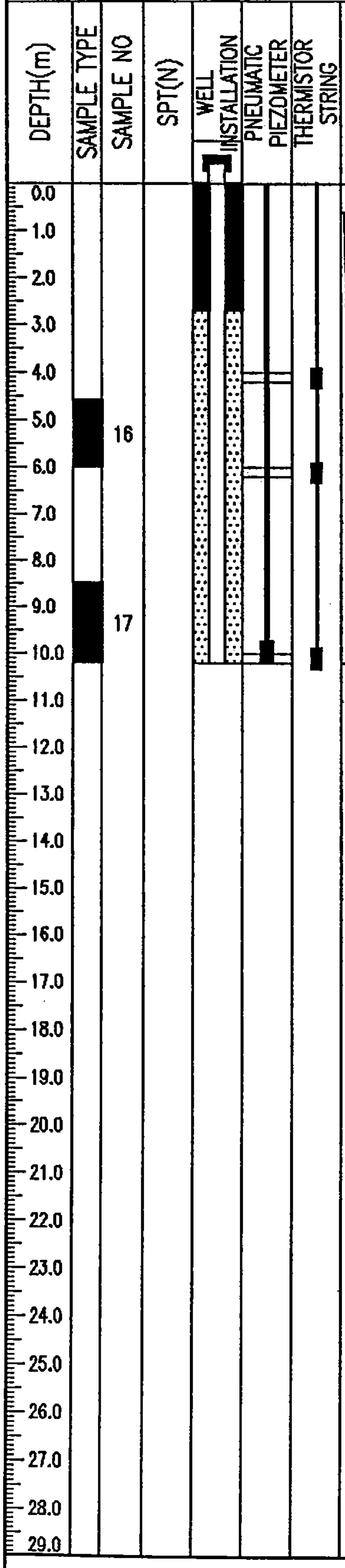
GROUND TEMPERATURE PROFILE
MT. NANSEN - TAILINGS DAM TOE BERM
BOREHOLE 12861-06 (el. 1139.9)

eba

INSTRUMENTATION INSTALLATION	BYG NATURAL RESOURCES	BOREHOLE NO: 12861-07
MT. NANSEN MINE	DRILL: SCHRAMM AIR ROTARY	PROJECT NO: .901-97-12861
NW OF CARMACKS, YT	UTM ZONE: - N - E -	ELEVATION: 1143.3 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

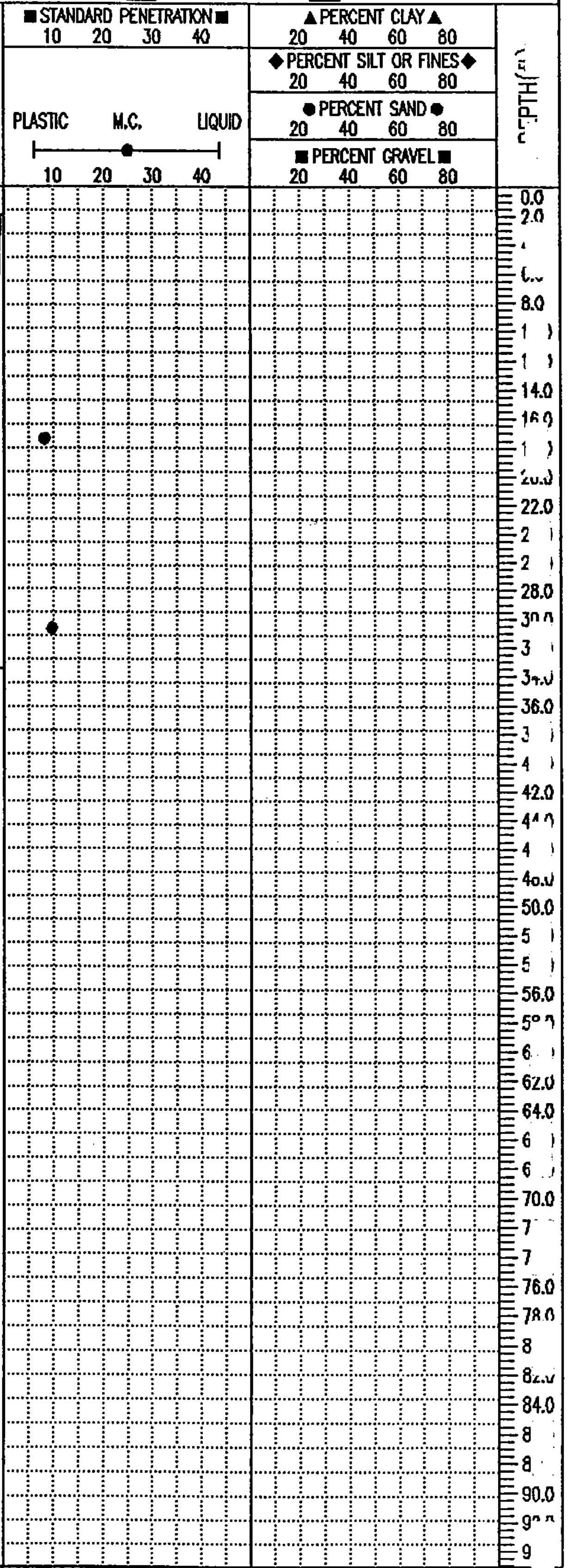
GRAVEL (PAD CONSTRUCTED TO LEVEL OFF DRILLING AREA) – sandy, trace of silt, angular cobbles and boulders, (from ripped bedrock source), damp, dark rusty brown

SAND – some silt, some gravel, seasonally frozen to 1.5 m, damp below frost, medium brown

– frozen (permafrost)

– consistent to bottom of hole

END OF BOREHOLE @ 10.2 m
MINE COORDINATES
N 18972 E 20593

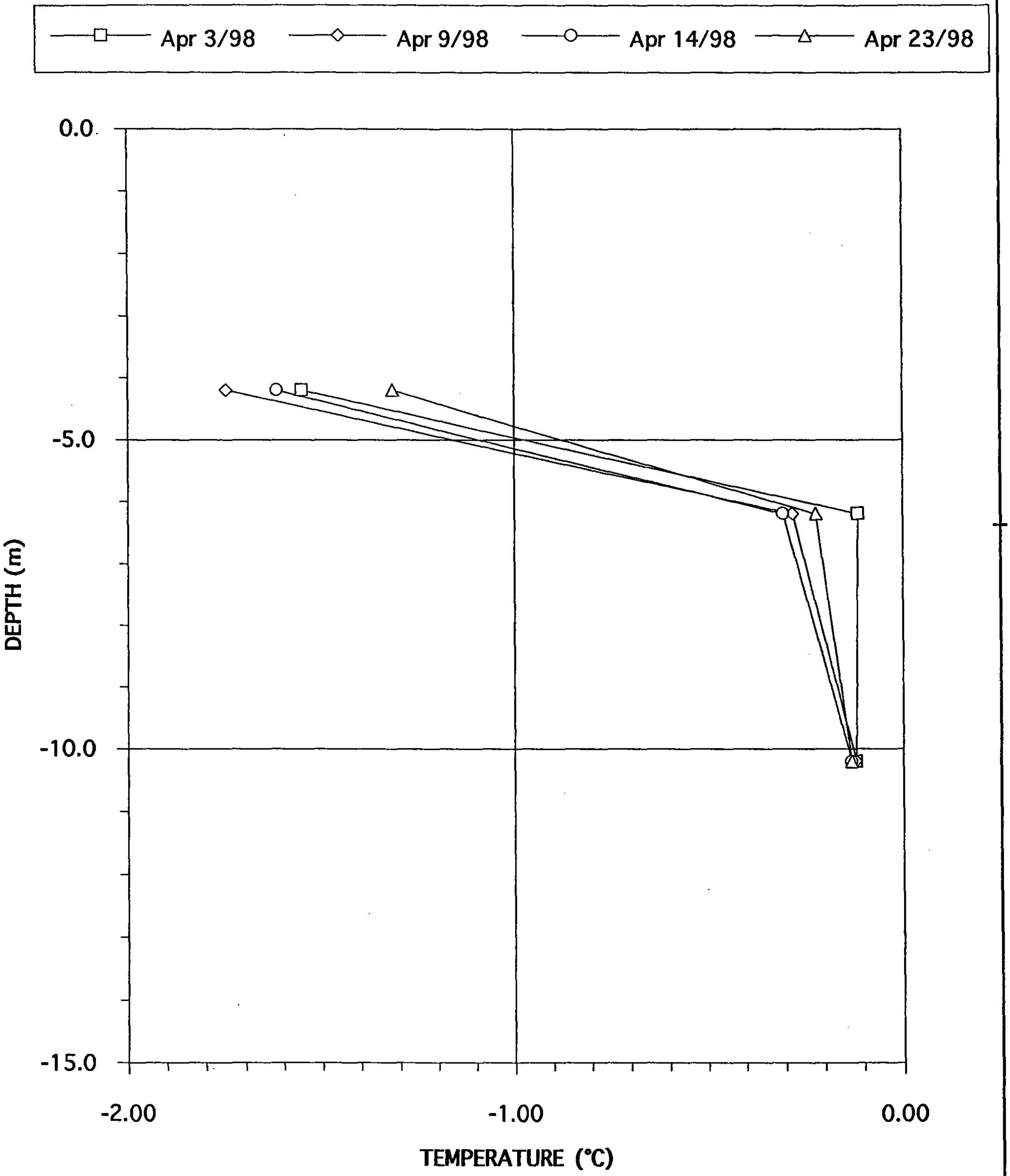


EBA Engineering Consultants Ltd.
Whitehorse, Yukon

LOGGED BY: MCP	COMPLETION DEPTH: 10.2 m
REVIEWED BY: JRT	COMPLETE: 98/03/31
Fig. No:	Page 1 of

98/04/17 07:46AM (WELL2B)

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: 12861-08
MT. NANSEN MINE	DRILL: SCHRAMM AIR ROTARY	PROJECT NO: .901-97-12861
NW OF CARMACKS, YT	UTM ZONE: - N - E -	ELEVATION: 1132.6 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

■ STANDARD PENETRATION ■ 10 20 30 40

PLASTIC M.C. LIQUID 10 20 30 40

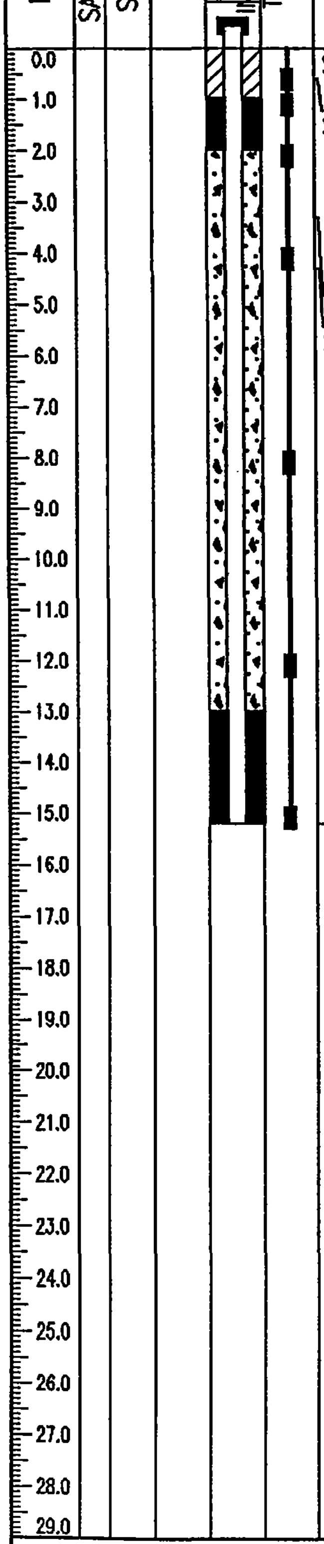
▲ PERCENT CLAY ▲ 20 40 60 80

◆ PERCENT SILT OR FINES ◆ 20 40 60 80

● PERCENT SAND ● 20 40 60 80

■ PERCENT GRAVEL ■ 20 40 60 80

DEPTH(ft)



SURFACE BOULDER (DITCH ARMOUR) – up to 1 m in size, angular

SAND (FILL) – some silt, some gravel, occassional cobbles and boulders throughout, seasonally frozen, medium brown
– frozen (permafrost), indicates some freeze back into fill

ORGANICS – frozen (permafrost) black

SAND – some silt, some gravel, frozen (permafrost) drilling, wet so can't determine permafrost description, medium brown
– drilled straight hole (no casing) below 7.0 m

END OF BOREHOLE @ 15.2 m
MINE COORDINATES
N 18932 E 20634
NOTE: No samples; drilled with water from surface

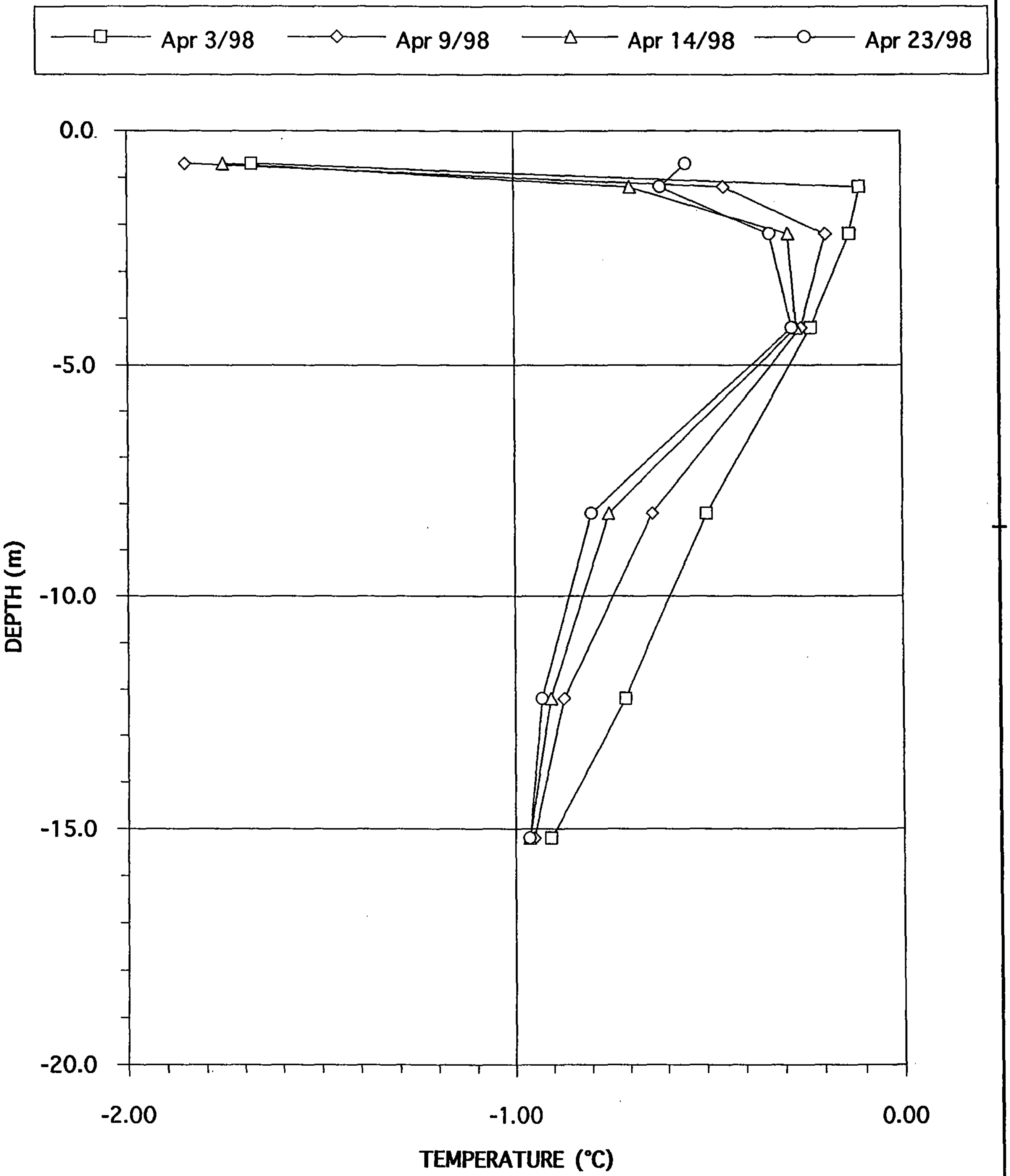
0.0 2.0 4 6 8.0 10.0 1 14.0 16.0 1 2 22.0 2 2 28.0 30.0 3 3 36.0 3 4 42.0 44.0 4 4 50.0 5 5 56.0 58.0 6 6 64.0 6 6 70.0 72.0 7 76.0 78.0 8 8 84.0 8 8 90.0 92.0 9

EBA Engineering Consultants Ltd.
Whitehorse, Yukon

LOGGED BY: MCP	COMPLETION DEPTH: 15.2 m
REVIEWED BY: JRT	COMPLETE: 98/03/30
Fig. No:	Page 1 of

98/04/17 07:47AM (WELL28)

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



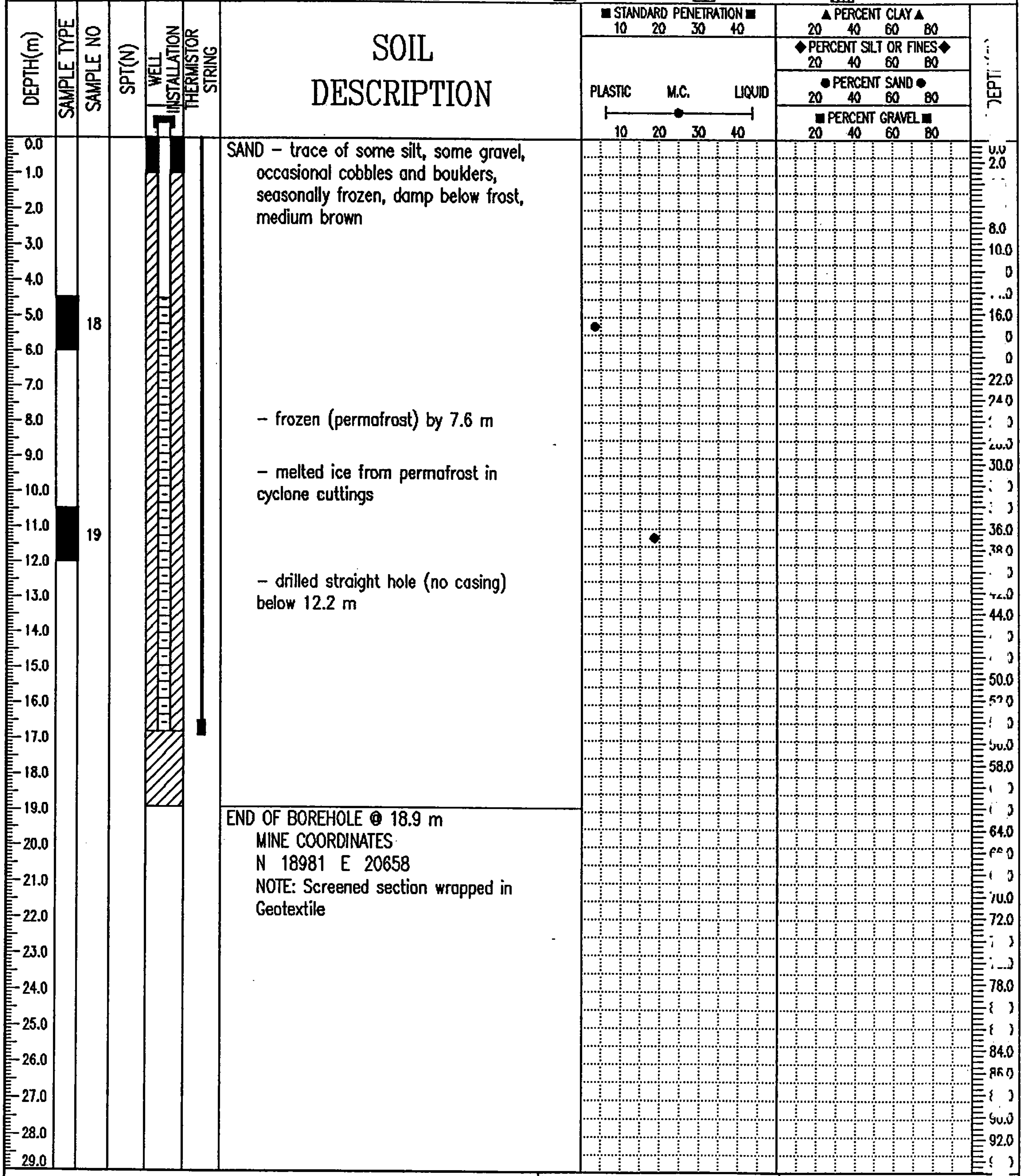
GROUND TEMPERATURE PROFILE
MT. NANSEN - DOWNSTREAM EDGE OF TOE BERM
BOREHOLE 12861-08 (el. 1132.6)

eba

INSTRUMENTATION INSTALLATION	BYG NATURAL RESOURCES	BOREHOLE NO: 12861-09
MT. NANSEN MINE -	DRILL: SCHRAMM AIR ROTARY	PROJECT NO: .901-97-12861
NW OF CARMACKS, YT	UTM ZONE: - N - E -	ELEVATION: 1142.3 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



SAND – trace of some silt, some gravel, occasional cobbles and boulders, seasonally frozen, damp below frost, medium brown

– frozen (permafrost) by 7.6 m

– melted ice from permafrost in cyclone cuttings

– drilled straight hole (no casing) below 12.2 m

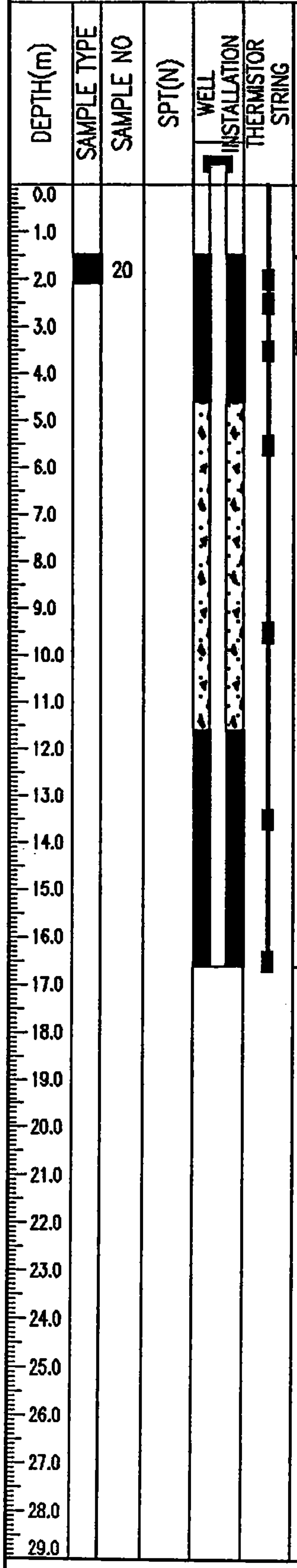
END OF BOREHOLE @ 18.9 m
MINE COORDINATES
N 18981 E 20658
NOTE: Screened section wrapped in Geotextile

EBA Engineering Consultants Ltd. Whitehorse, Yukon	LOGGED BY: MCP	COMPLETION DEPTH: 18.9 m
	REVIEWED BY: JRT	COMPLETE: 98/03/27
	Fig. No:	Page 1 of '

98/04/17 08:00AM (WELL2B)

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



SOIL DESCRIPTION

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

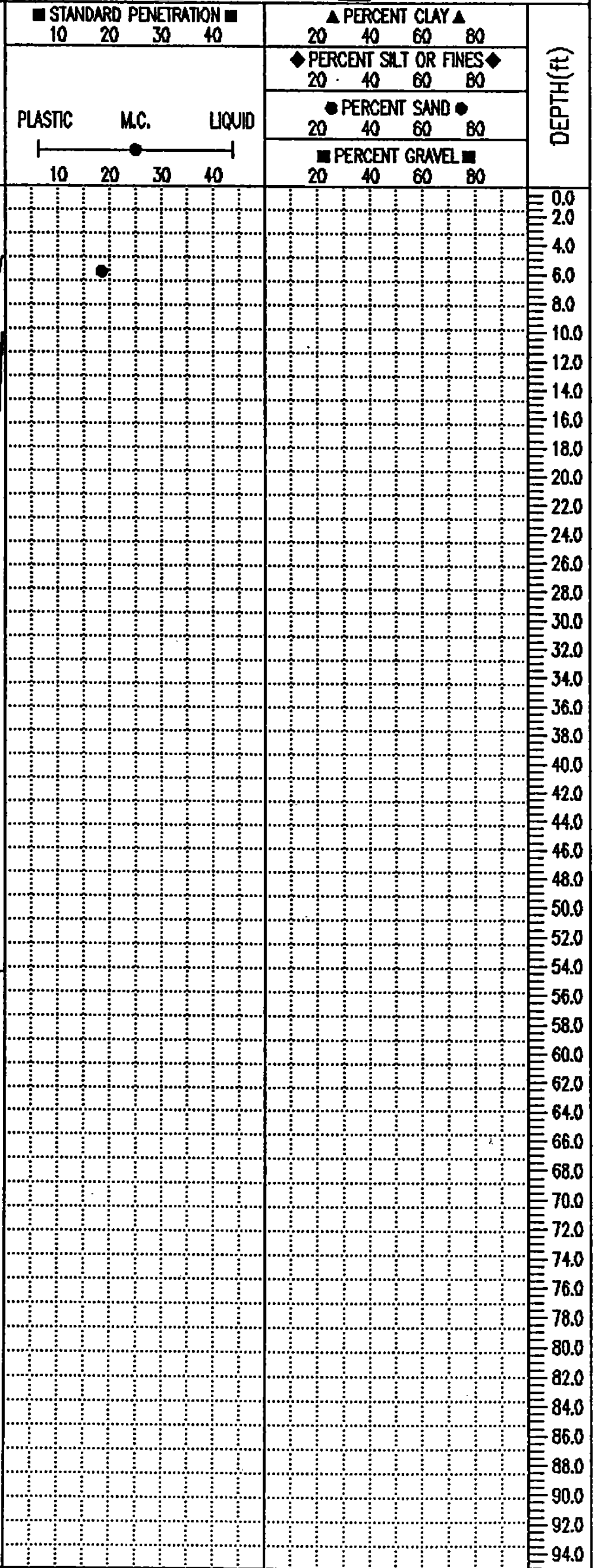
SAND (FILL) - some silt, some gravel, medium grained, moist to wet, dark olive brown
- saturated by 3.0 m

ORGANICS - frozen (permafrost), black

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

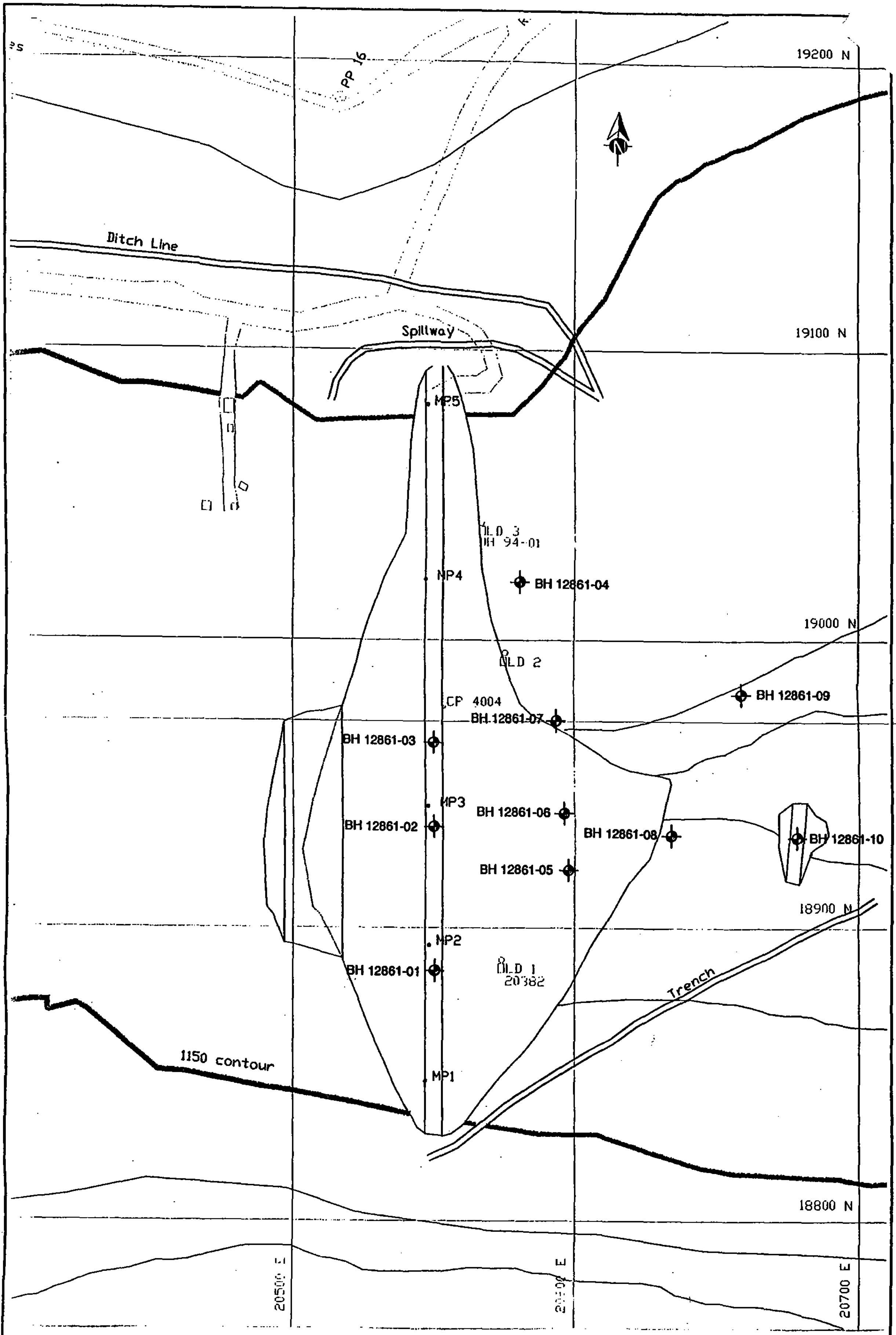
- may be drilling through the occassional boulder below 9.0 m
- lots of water in borehole during drilling

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 (WELL2B)



SCALE 1:1250

EBA Engineering Consultants Ltd.	PROJECT **INSTRUMENTATION INSTALLATION MT. NANSEN GOLD MINE**
CLIENT **BYG NATURAL RESOURCES**	TITLE **SITE PLAN SHOWING BOREHOLE LOCATIONS**
DATE MARCH '98 | DWN. MCP | CHKD.	FILE NO. 0201-97-12861 | 12861-A-01

TEST HOLE LOG

VERTICAL SCALE: 1cm = 0.25m

DATE DRILLED: 26 JUN 95 - 26 JUN 95

DRILL TYPE: Track-mounted CME-75

ELEV. GROUND (m): 1149.23

CO-ORDINATES (m): N 19,040 E 20,555

SAMPLE DATA

HAMMER WEIGHT kg

DROP HEIGHT m

Depth (m)	Method	Rec %	Run No.
	CRREL	31	CT1
1.0			
	CRREL	39	CT2
2.0			
	CRREL	37	CT3
3.0			
	CRREL	36	CT4
	CRREL	46	CT5
4.0			
	CRREL	67	CT6

SYMBOL

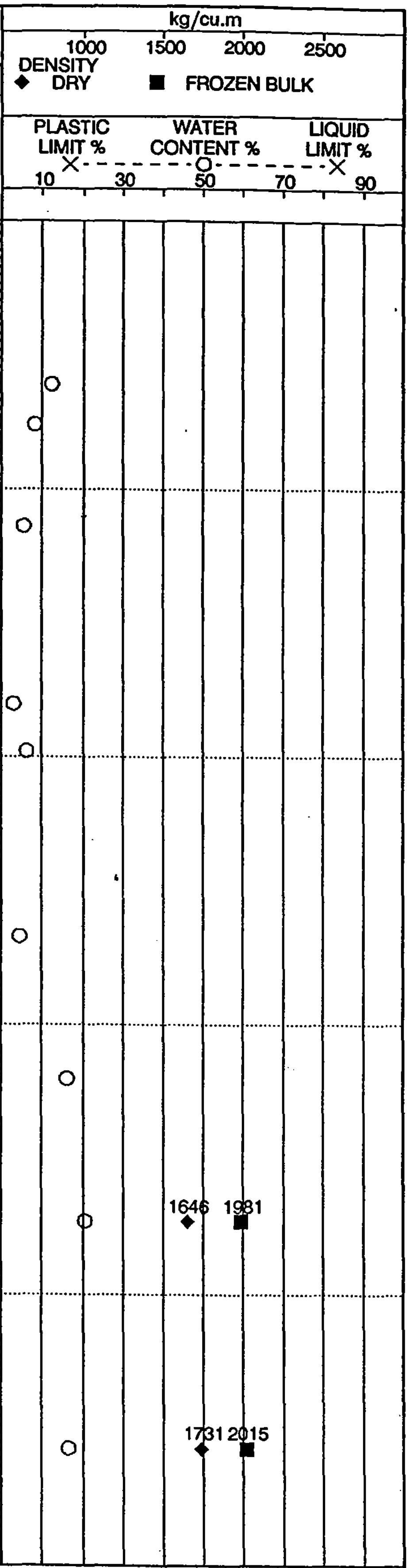
THERMISTOR DETAILS

DESCRIPTION OF MATERIALS

SAND (SP-SM)
- fine to medium
- some silt to silty
- trace to some rounded gravel
- trace organics
- trace mica
- occasional grey sandy SILT lenses <10mm thick
- dry to moist
- light brown to reddish brown
- frozen below 3.73 m
- SAMPLE SP1 taken @ 0.61m
- SAMPLE SP2 taken @ 1.14m
- SAMPLE SP3 taken @ 1.98m
- SAMPLE SP4 taken @ 2.67m
- SAMPLE SP5 taken @ 3.73m

3.73

- becoming frozen, Nbn to Nbe, excess ice content <5%
- becoming fine to coarse sand with trace to some silt
- SAMPLE SP6 taken @ 4.57m



Continued

KLOHN-CRIPPEN

11/07/95

JOB NO: PM 5314 0502

PROJECT: Mt. Nansen Gold Project

LOCATION: Carmacks, Yukon Territory

LOGGED BY: JM

CHECKED BY:

PLATE: 1 of 5

HOLE NO: DH95-04

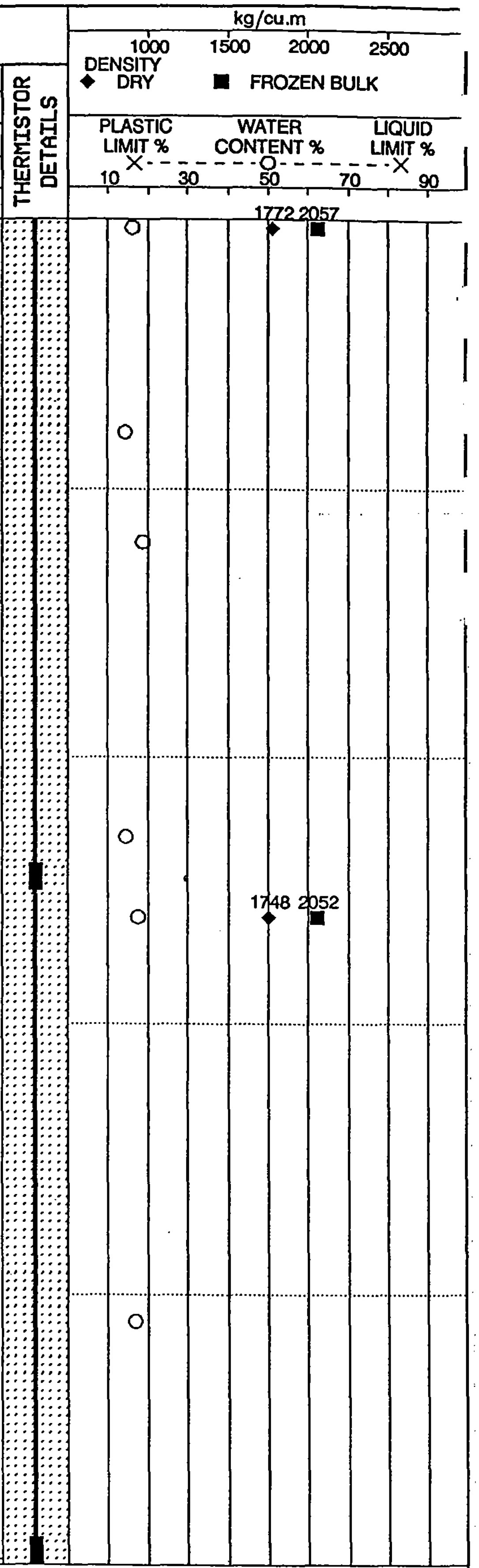
TEST HOLE LOG

VERTICAL SCALE: **1cm = 0.25m**
DATE DRILLED: **26 JUN 95 - 26 JUN 95**
DRILL TYPE: **Track-mounted CME-75**
ELEV. GROUND (m): **1149.23**
CO-ORDINATES (m): **N 19,040 E 20,555**

SAMPLE DATA

HAMMER WEIGHT kg
DROP HEIGHT m

Depth (m)	Method	Rec %	Run No.	SYMBOL	DESCRIPTION OF MATERIALS
	CRREL	39	CT7		SAND (SP-SM) - as above - SAMPLE SP7 taken @ 5.03m
6.0	CRREL	61	CT8		- SAMPLE SP8 taken @ 5.79m - 30mm thick grey sandy SILT layer
7.0	CRREL	8	CT9		- SAMPLE SP9 taken @ 7.3m
	CRREL	100	CT10		- SAMPLE SP10 taken @ 7.6m
8.0	CRREL	0	CT11		
9.0	CRREL	75	CT12		- 75mm sandy GRAVEL layer - SAMPLE SP11 taken @ 9.1m
	CRREL		CT13		
					9.98



Continued

KLOHN-CRIPPEN

11/07/95

JOB NO: **PM 5314 0502**
PROJECT: **Mt. Nansen Gold Project**
LOCATION: **Carmacks, Yukon Territory**
LOGGED BY: **JM** CHECKED BY:
PLATE: **2 of 5** HOLE NO: **DH95-04**

TEST HOLE LOG

VERTICAL SCALE: 1cm = 0.25m

DATE DRILLED: 26 JUN 95 - 26 JUN 95

DRILL TYPE: Track-mounted CME-75

ELEV. GROUND (m): 1149.23

CO-ORDINATES (m): N 19,040 E 20,555

SAMPLE DATA

HAMMER WEIGHT kg

DROP HEIGHT m

kg/cu.m: 1000 1500 2000 2500

DENSITY ◆ DRY ■ FROZEN BULK

PLASTIC LIMIT % ✕ - - - WATER CONTENT % ○ - - - LIQUID LIMIT % ✕

10 30 50 70 90

SYMBOL

THERMISTOR DETAILS

Depth (m)	Method	Rec %	Run No.
	AUGER		
11.0	CRREL	0	CT14
12.0			
13.0			
14.0			

DESCRIPTION OF MATERIALS

GRAVEL and COBBLES (GP)
- no recovery

10.29

SAND (SP-SM)
- as above

11.10

GRAVEL (GP)
- no recovery
- auger refused in gravel
- moved over and redrilled as DH95-04A

11.41

SAND (SP-SM)
- fine to medium
- silty
- trace of rounded gravel
- trace organic odour
- grey

- gravelly layer @ 14.9m, 200mm thick

Continued

KLOHN-CRIPPEN

11/07/95

JOB NO: PM 5314 0502

PROJECT: Mt. Nansen Gold Project

LOCATION: Carmacks, Yukon Territory

LOGGED BY: JM CHECKED BY:

PLATE: 3 of 5 HOLE NO: DH95-04

TEST HOLE LOG

VERTICAL SCALE: **1cm = 0.25m**

DATE DRILLED: **26 JUN 95 - 26 JUN 95**

DRILL TYPE: **Track-mounted CME-75**

ELEV. GROUND (m): **1149.23**

CO-ORDINATES (m): **N 19,040 E 20,555**

SAMPLE DATA

HAMMER WEIGHT kg

DROP HEIGHT m

kg/cu.m
1000 1500 2000 2500
DENSITY
◆ DRY ■ FROZEN BULK

PLASTIC LIMIT % ✕ - - - WATER CONTENT % ○ - - - LIQUID LIMIT % ✕
10 30 50 70 90

Depth (m)	Method	Rec %	Run No.	SYMBOL	DESCRIPTION OF MATERIALS	THERMISTOR DETAILS
					SAND (SP-SM) - as above	
16.0						
17.0					- gravelly layer @ 17.2m, 50mm thick	
					- gravelly layer @ 17.8m, 200mm thick	
18.0						
					- gravelly layer @ 18.4m, 75mm thick	
19.0						

Continued

KLOHN-CRIPPEN

11/07/95

JOB NO: **PM 5314 0502**

PROJECT: **Mt. Nansen Gold Project**

LOCATION: **Carmacks, Yukon Territory**

LOGGED BY: **JM** CHECKED BY:

PLATE: **4 of 5** HOLE NO: **DH95-04**

TEST HOLE LOG

VERTICAL SCALE: **1cm = 0.25m**

DATE DRILLED: **26 JUN 95 - 26 JUN 95**

DRILL TYPE: **Track-mounted CME-75**

ELEV. GROUND (m): **1149.23**

CO-ORDINATES (m): **N 19,040 E 20,555**

SAMPLE DATA

HAMMER WEIGHT kg

DROP HEIGHT m

Depth (m)	Method	Rec %	Run No.	SYMBOL	DESCRIPTION OF MATERIALS	THERMISTOR DETAILS
					SAND (SP-SM) - as above	
21.0					21.18	
					GRAVEL and COBBLES (GP) - hard drilling	
22.0					22.55	
					End of Hole @ 22.55m - auger refusal in gravel and cobbles	

kg/cu.m

DENSITY 1000 1500 2000 2500

◆ DRY ■ FROZEN BULK

PLASTIC LIMIT % × - - - WATER CONTENT % ○ - - - LIQUID LIMIT % ×

10 30 50 70 90

NOTES:

1. A 30m long prepared thermistor string was installed folded into the borehole. The 10 individual thermistors are located at the following depths from the surface:

#1 @ 1.0m
#2 @ 2.0m
#3 @ 3.0m
#4 @ 5.0m
#5 @ 7.5m
#6 @ 10.0m
#10 @ 10.5m
#7 @ 15.0m
#9 @ 15.5m
#8 @ 20.0m

KLOHN-CRIPPEN

11/07/95

JOB NO: **PM 5314 0502**

PROJECT: **Mt. Nansen Gold Project**

LOCATION: **Carmacks, Yukon Territory**

LOGGED BY: **JM** CHECKED BY:

PLATE: **5 of 5** HOLE NO: **DH95-04**

APPENDIX E

Movement Surveys

MEMORANDUM

TO: Dr. Robert Lo, P.Eng.
Klohn Crippen Consultants

DATE: May 27, 2001

FROM: Cord Hamilton

FILE: 0201-99-14097

SUBJECT: **Review of Settlement Pin Data**
Mount Nansen Tailings Dam

EBA has reviewed the available crest settlement pin data obtained from BYG's computer files at the Mount Nansen site. The data that was discovered is shown on the attached spreadsheet. As can be seen there were 12 settlement pins installed along the crest of Dam #1 after construction of the dam in the fall of 1996. The as-built drawing prepared by Klohn Crippen shows the original locations and elevations of these pins. However, the elevations as shown on the as-built drawing are clearly in error as they are at least one metre below the actual crest elevation as shown on the drawing.

It should also be noted that the actual settlement pins were not installed according to the proposed protocol recommended by Klohn in the Final Design Report. The pins used were lighter in gauge and EBA believes that they were also shorter in length. Moreover, the pins were not driven in flush with the dam crest; instead they had a stick-up of around 0.3 m.

Because the as-built elevations are clearly incorrect, the initial set of readings that can be used as the original elevations were recorded on March 13, 1997. Including that reading set, a total of 10 reading sets were made using these original pins up to July 1997.

After July 1997, the BYG data file indicates that the pins were re-set to new elevations in October 1997; however, EBA is only aware that the initial reading set from the re-set pins was obtained. Note that EBA can not confirm whether the October 1997 monitoring pin elevations are related directly to the crest surface or to the head of the pins that may have been elevated from the ground surface. Comparison of the October 1997 readings to the reading sets from the summer of 1997 suggests that the October 1997 elevations are ground surface valves.

The next data series available to EBA indicates that five new pins were established flush with the ground surface on the dam crest on March 17, 1998. Again, EBA is not aware of any subsequent reading sets that were completed using these five new pins.

After March 1998, the next reading set from the dam was obtained in October 1999 when another set of monitoring pins were established across the dam crest. Yukon Engineering Services Ltd. (YES) installed this set of pins as part of a dam survey commissioned by Water Resources. Only the initial reading set is available from these new pins.

Review of the data from the original pins obtained during the spring and summer of 1997 indicates that each of the pins both heaved and settled over the course of the ten measurements. No pattern that would indicate a trend of settlement or heaving can be determined from the data. It is EBA's opinion that the surveys used to obtain the data were flawed and/or the pins were disturbed. Therefore, no quantitative conclusion on the magnitude of settlement (if any) can be made based on the settlement pin data from the readings sets obtained in the spring and summer of 1997.

While no quantitative conclusions can be reached, review of the elevations of the three sets of monitoring pins from October 1997, March 1998, and October 1999 indicates a similar range in elevation across the crest of the dam. The readings from these three sets of monitoring pins are shown in Table #1. Because each of these readings is from a different series of settlement pins a direct comparison is not possible. Nevertheless, the fact that the range in elevations (minimum to maximum) is very similar provides some level of confidence that settlements that may have occurred are not large. Comparison of the as-built drawing to the recent (October 1999) survey also suggests that settlements that may have occurred are not of great magnitude.

Table #1: Monitoring Pin Elevations

Settlement Pin[1]	October 1997 (m)	March 1998 (m)	October 1999 (m)
1	1151.849	1151.85	1151.897
2	1151.619	1151.36	1151.613
3	1151.601	1151.47	1151.593
4	1151.375	1151.39	1151.529
5	1151.396	1151.41	1151.442
6	1151.302		1151.386
7	1151.561		1151.515
8	1151.429		1151.240
9	1151.262		1151.231
10	1151.332		1151.413
11	1151.427		1151.491
12	1151.438		

[1] Settlement pins shown in order from North side to South side, each data set is from a different series of actual pins installed at different locations.

Yukon Engineering Services Inc.

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May 3, 2001

EBA Engineering Consultants Ltd. Our File E99-075
#6 Calcite Business Centre
151 Industrial Rd.
Whitehorse, YK
Y1A-2V3

Attention: Mr. C. Hamilton, P.Eng.

Dear Sir:

Regarding: Report on Mt. Nansen Tailings Dam Monitoring Surveys
Coordinate and Elevation Comparison 1999-2000

In October 1999 Yukon Engineering Services inc. (YES) was retained to undertake a Movement Study for the above noted project, at which time Jerry Quaile traveled to the site to perform the initial survey.

In August, 2000 Tony Gaw returned to the site to undertake the comparison survey.

Executive Summary:

The attached comparison table (19992000compare.xls) indicates that:

- ☐ The control was reestablished very close to its original position and ***there was no significant movement between October 1999 and August 2000*** or,
- ☐ ***There was no significant movement between October 1999 and August 2000.***

Significant movement for the purposes of this study should be considered to be greater than 30 mm horizontally, and 20 mm vertically.

Please refer to the following methodology.

Methodololgy:

Budget and Schedule constraints prevented a formal Deformation Study of the Dam structure. The 1999 Survey control and monitoring pins were established during -30° C temperatures. It was known at the time that these points may be susceptible to some movement through normal thaw.

The following methodology was employed.

1. Existing Survey data was recovered from files and digital records at the BYG site office and located in the field during this period.
    1.1. All elevations were derived from a coordinated benchmark CP4001 located in a 400mm spruce stump, near the north abutment of the tailings dam, as shown on the Asbuilt 1999 YES Drawing (Nov. 11/99). The published elevation is 1160.890m.
    1.2. All coordinates were derived from control point CP4004, located on the dam, and shown on the Asbuilt 1999 YES Drawing.
    1.3. Azimuth was derived between supplied coordinates for CP4004 and CP1006 located at highest point east of existing camp and mill site.
2. A base line was established longitudinally along the dam crest using what is believed to be the Design Dam centreline. Two 20mm (tagged with YES Tags Y4162, and Y4164) rebar were found at the south abutment of dam with one having a stake reading "DAM CENTERLINE". Two additional control pins were placed on north abutment of dam (tagged with YES Tags Y4170, and Y4171) as additional reference to this baseline.
3. From this line 11, 1524mm x 20mm reinforcing bar pins were driven flush to the dam crest, ~~and as close to dam centre line as practical. These pins are at an average~~ interval of approximately 20 metres. Positioning of the pins was derived thus:
    3.1. Measurements were made by observing the distance along the dam centreline (stationing value).
    3.2. Distance left or right of the baseline (offset) was then measured using plumb bob and pocket tape. This method provides measurable distance perpendicular to the baseline, an anticipated direction of possible movement through cracking or sloughing.
    3.3. Coordinate values were then calculated using the distance and offset values observed in 3.1 and 3.2.
    3.4. Double loop / closed circuit precise levels were then completed to derive acceptable elevations for all points, using standard deviation techniques.

4. 16, 1524mm x 20mm rebar pins were pounded flush to the downstream dam slope along lines delineated by C. Hamilton of EBA, and shown on the Nov. 18/99 YES Asbuilt Drawing. As well, nine borehole collars were incorporated into the survey (at the highest point on the "hinge") Positioning of the pins and collars was determined using the following methodology:
    4.1. Occupying CP Y4162, and backsighting CP 4004, one set of trigonometric observations were made to all points, then:
    4.2. Occupying CP 4004, and backsighting CP Y4162, another set of trigonometric observations were made once again to all points.
    4.3. Values were then compared. Standard deviation was used to eliminate coordinates that disagreed by more than 25mm in any one direction. The remaining values were then averaged to obtain acceptable coordinate values.
    4.4. Double loop / closed circuit precise levels were then completed to derive acceptable elevations for all points, using similar standard deviation techniques.

On August 2, 2000 a subsequent trip was made by Tony Gaw to continue the study. On this visit it was discovered that some of the control points that were employed by Mr. Quaile had either heaved significantly (presumably from frost movement), or had become unstable over the summer months.

At this time it was necessary to recreate the control network used by Mr. Quaile in the original survey. Although we were able to reestablish the control, it would be impossible to replace the monuments to their exact original positions. With this in mind we conclude that there will be minor error inherent in comparing the results of the two surveys.

During the second site visit it was noted that mine equipment had been working in the area and that some of this equipment had traveled over top of the monitoring pins, both on the dam crest and the downstream slope. During the second visit a drill was on site doing some investigative drilling and it was noted that this machine also came in contact with some of the monitoring pins. It is imperative that great care be taken to protect these points from any construction or continued remediation on site.

If you have any questions regarding this survey, please contact either of the undersigned.

Yours truly,
Yukon Engineering Services Inc.

Tony Gaw
Sr. Technician
Enclosure: *19992000compare.xls*
Dampins2000.xls

Yukon Engineering Services Inc.

Michael T. Kearney, CLS, P.Eng.
Survey Manager

Mount Nansen Tailings Dam Crest Monitoring Pins

Settlement/Vertical Movement Surveys

Pin	Elevation (m)		Annual Change (mm)[A]
	1999	2000	1999 - 2000
Y4163	1151.491	1151.489	-2
Y4159	1151.413	1151.399	-14
BH1	1152.409	1152.395	-14
Y4157	1151.231	1151.216	-15
Y4156	1151.240	1151.224	-16
BH2	1151.839	1151.826	-13
Y4155	1151.515	1151.506	-9
BH3	1152.400	1152.386	-14
Y4153	1151.386	1151.381	-5
Y4152	1151.442	1151.443	1
Y4151	1151.529	1151.532	3
Y4150	1151.593	1151.596	3
Y4154	1151.613	1151.611	-2
Y4161	1151.897	1151.894	-3

[A] Negative values represent settlements.

Horizontal Position Surveys 1999 to 2001[B]

Pin	Northing (m)		Easting (m)	
	1999	2000	1999	2000
Y4163	18864.499	18864.53	20549.370	20549.359
Y4159	18884.585	18884.609	20549.335	20549.320
BH1	18885.216	18885.239	20550.158	20550.156
Y4157	18904.314	18904.346	20549.264	20549.264
Y4156	18924.381	18924.410	20549.162	20549.158
BH2	18934.725	18934.751	20549.875	20549.876
Y4155	18944.376	18944.393	20549.064	20549.042
BH3	18963.494	18963.502	20549.905	20549.899
Y4153	18984.063	18984.089	20548.858	20548.842
Y4152	19004.517	19004.541	20548.788	20548.822
Y4151	19024.381	19024.395	20548.648	20548.634
Y4150	19044.382	19044.406	20548.572	20548.572
Y4154	19064.274	19064.297	20548.594	20548.586
Y4161	19084.465	19084.481	20548.350	20548.343

[B] Horizontal Control was disturbed prior to 2000 readings; hence, horizontal movements are suspect.

Change in Position[C]

Pin	From 1999 to 2000			
	ΔNorthing (mm)	ΔEasting (mm)	Movement (mm)	Direction (degrees)[D]
Y4163	31	-11	33	340
Y4159	24	-15	28	328
BH1	24	-2	24	355
Y4157	32	0	32	360
Y4156	29	-4	29	352
BH2	26	1	26	3
Y4155	17	-22	28	308
BH3	8	-5	10	325
Y4153	26	-16	31	328
Y4152	24	34	42	55
Y4151	14	-14	20	315
Y4150	24	0	24	360
Y4154	23	-8	24	341
Y4161	16	-7	17	336

[C] Movements Mine North or Mine East are positive.

[D] Direction is measured clockwise from Mine Grid North

Mount Nansen Tailings Dam South Abutment Monitoring Pins

Settlement/Vertical Movement Surveys

Pin	Elevation (m)		Annual Change (mm)[A]
	1999[B]	2000	1999 - 2000
Y7602		1144.383	
Y4174	1144.809	1144.799	-14
Y7414		1143.520	
Y4175	1142.129	1142.121	-8
Y7601		1140.908	
Y4173	1139.979	1139.969	-10
Y7603		1139.840	
BH5	1140.543	1140.533	-10
Y7604		1138.783	
Y4172	1138.553	1138.541	-12
Y4176	1138.438	1138.421	-17
Y7606		1136.996	
Y6014		1135.718	
Y4177	1135.828	1135.809	-19
BH8	1133.434	1133.420	-14

[A] Negative values represent settlements.

[B] Pins without readings from 1999 were added to the monitoring system in 2000.

Horizontal Position Surveys 1999 to 2001[C]

Pin	Northing (m)		Easting (m)	
	1999	2000	1999	2000
Y7602		18861.405		20580.446
Y4174	18888.989	18889.011	20574.421	20574.418
Y7414		18864.802		20583.655
Y4175	18903.894	18903.916	20585.391	20585.391
Y7601		18878.948		20593.093
Y4173	18887.889	18887.899	20596.964	20596.973
Y7603		18888.939		20595.741
BH5	18919.562	18919.564	20597.839	20597.843
Y7604		18897.126		20601.172
Y4172	18908.778	18908.786	20605.035	20605.026
Y4176	18922.205	18922.211	20605.204	20605.197
Y7606		18899.760		20606.792
Y6014		18912.258		20614.189
Y4177	18925.871	18925.884	20615.996	20615.983
BH8	18931.707	18931.730	20633.969	20633.946

[C] Horizontal Control was disturbed prior to 2000 readings; hence, horizontal movements are suspect.

Change in Position[D]

Pin	From 1999 to 2000			
	ΔNorthing (mm)	ΔEasting (mm)	Movement (mm)	Direction (degrees)[E]
Y7602				
Y4174	22	-3	23	328
Y7414				
Y4175	23	0	23	360
Y7601				
Y4173	10	9	14	3
Y7603				
BH5	2	4	5	308
Y7604				
Y4172	8	-9	12	328
Y4176	7	-6	9	55
Y7606				
Y6014				
Y4177	13	-13	19	341
BH8	23	-23	33	336

[D] Movements Mine North or Mine East are positive.

[E] Direction is measured clockwise from Mine Grid North

Mount Nansen Tailings Dam North Abutment Monitoring Pins

Settlement/Vertical Movement Surveys

Pin	Elevation (m)		Annual Change (mm)[A]
	1999	2000	1999 - 2000
Y4178	1148.097	1148.089	-8
Y4187	1148.413	1148.409	-4
DH9504	1149.158	1149.165	7
Y4179	1144.003	1143.989	-14
Y4186	1143.743	1143.732	-11
BH4	1148.235	1148.233	-2
BH6	1140.842	1140.828	-14
BH7	1144.226	1144.214	-12
Y4180	1139.631	1139.611	-20
Y4185	1141.559	1141.548	-11
Y4184	1135.927	1135.910	-17
Y4181	1134.118	1134.097	-21
Y4182	1132.091	1132.072	-19
Y4183	1131.650	1131.633	-17

[A] Negative values represent settlements.

Horizontal Position Surveys 1999 to 2001[B]

Pin	Northing (m)		Easting (m)	
	1999	2000	1999	2000
Y4178	18943.892	18943.898	20564.789	20564.782
Y4187	18976.760	18976.770	20565.195	20565.194
DH9504	19040.726	19040.732	20566.428	20566.424
Y4179	18943.508	18943.517	20578.667	20578.661
Y4186	18969.072	18969.080	20582.388	20582.377
BH4	19019.896	19019.901	20580.413	20580.416
BH6	18939.247	18939.266	20596.003	20595.999
BH7	18971.715	18971.724	20593.285	20593.276
Y4180	18942.757	18942.769	20601.869	20601.864
Y4185	18961.472	18961.488	20599.391	20599.389
Y4184	18956.743	18956.751	20620.018	20620.012
Y4181	18942.065	18942.078	20625.015	20625.012
Y4182	18941.763	18941.758	20635.133	20635.146
Y4183	18954.002	18954.006	20639.013	20639.004

[B] Horizontal Control was disturbed prior to 2000 readings; hence, horizontal movements are suspect.

Change in Position[C]

Pin	From 1999 to 2000			
	ΔNorthing (mm)	ΔEasting (mm)	Movement (mm)	Direction (degrees)[D]
Y4178	6	-7	9	314
Y4187	11	-1	11	355
DH9504	6	-5	7	321
Y4179	9	-6	11	326
Y4186	8	-10	13	309
BH4	5	4	6	35
BH6	19	-4	20	349
BH7	9	-9	13	313
Y4180	12	-5	13	338
Y4185	16	-1	16	356
Y4184	8	-5	10	329
Y4181	13	-3	14	347
Y4182	-4	13	14	108
Y4183	4	-9	9	293

[C] Movements Mine North or Mine East are positive.

[D] Direction is measured clockwise from Mine Grid North

Yukon Engineering Services Inc.

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November 14, 2001

EBA Engineering Consultants Ltd. Our File E99-075
#6 Calcite Business Centre
151 Industrial Rd.
Whitehorse, YK
Y1A-2V3

Attention: Mr. C. Hamilton, P.Eng.

Dear Sir:

Regarding: Report on Mt. Nansen Tailings Dam Monitoring Surveys
Coordinate and Elevation Comparison 2000-2001

In October 1999 Yukon Engineering Services inc. (YES) was retained by EBA to undertake a Movement Study for the above noted project, at which time Jerry Quaile traveled to the site to perform the initial survey. In August 2000 Tony Gaw returned to the site to perform a Survey as a comparison between the 1999 and 2000 data. At this time it was observed that there had been some movement in the main Survey Control Points. These were replaced as close to their original positions as possible and the movement survey was undertaken. It was determined from the comparisons (1999-2000) that there had not been any significant movement.

Glen McKenna continued the Comparison Survey by returning to the site in September 2001.

Executive Summary:

The attached comparison table, *20002001compare.xls, Dampins2001.xls,* indicates that:

- ***There appears to be some settlement on the Main Dam between the Surveys of 2000 and 2001*** from the survey data as shown on attached spreadsheet, *dampins.xls*. The settlement is most significant on the south side of the dam from Control Points Y4163 to Y4155 (refer to plan *sept2001_mas.dwg*, attached). Elevation differences vary in this area from 24 – 47mm. There does not appear to be any East /West settlement from the data comparison.

- ☐ ***There also appears to be to be movement on the east (down stream) side of the Main Dam.*** This is evident from the data as shown from the spreadsheet, *20002001compare.xls*. Evidence of movement is most obvious in the southeast section of the dam (refer to plan *sept2001_mas.dwg*). From the contours and field observations it appears that there is a funnel or troughing affect in this area that would attract more moisture. Horizontal movement varies from 10mm to 64mm in this area. Vertical movement ranges from 8mm to 46mm.

- ☐ **From the Survey Data Comparison of 2000 and 2001 it appears that there has been some disturbance of Borehole #7.** The data shows movement of 227mm horizontally and 104mm vertically. We feel that this movement is from disturbance and not settlement. This can be confirmed from Surveys in 2002.

  Please note that the level of accuracy from this survey is plus or minus 15mm horizontally and 10mm vertically.

Please refer to the following methodology.

Methodololgy:

Budget and Schedule constraints prevented a formal Deformation Study of the Dam structure. The 1999 Survey control and monitoring pins were established during -30° C temperatures. It was known at the time that these points might have been susceptible to some movement through normal thaw.

The following methodology was employed.

1. Existing Survey data was recovered from files and digital records at the BYG site office and located in the field during this period.
   1.1. All elevations were derived from a coordinated benchmark CP4001 located in a 400mm spruce stump, near the north abutment of the tailings dam, as shown on the Asbuilt 1999 YES Drawing (Nov. 11/99). The published elevation is 1160.890m.
   1.2. All coordinates were derived from control point CP4004, located on the dam, and shown on the Asbuilt 1999 YES Drawing.
   1.3. Azimuth was derived between supplied coordinates for CP4004 and CP1006 located at highest point east of existing camp and mill site.

2. A base line was established longitudinally along the dam crest using what is believed to be the Design Dam centreline. Two 20mm dia. rebar (tagged with YES Tags Y4162, and Y4164) were found, from earlier surveys, at the south abutment of dam with one having a stake reading “DAM CENTERLINE”. Two additional control pins were placed on north abutment of dam (tagged with YES Tags Y4170, and Y4171) as additional reference to this baseline.
3. From this line 11, 1524mm x 20mm reinforcing bar pins were driven flush to the dam crest, and as close to dam centre line as practical. These pins are at an average interval of approximately 20 metres. Positioning of the pins was derived thus:
    - 3.1. Measurements were made by observing the distance along the dam centreline (stationing value).
    - 3.2. Distance left or right of the baseline (offset) was then measured using plumb bob and pocket tape. This method provides measurable distance perpendicular to the baseline, an anticipated direction of possible movement through cracking or sloughing.
    - 3.3. Coordinate values were then calculated using the distance and offset values observed in 3.1 and 3.2.
    - 3.4. Double loop / closed circuit precise levels were then completed to derive acceptable elevations for all points, using standard deviation techniques.

4. 16, 1524mm x 20mm rebar pins were pounded flush to the downstream dam slope along lines delineated by Cord Hamilton of EBA, and shown on the Nov. 18/99 YES Asbuilt Drawing. As well, nine borehole collars were incorporated into the survey (at the highest point on the “hinge”) Positioning of the pins and collars was determined using the following methodology:
    - 4.1. Occupying CP Y4162, and backsighting CP 4004, one set of trigonometric observations were made to all points, then:
    - 4.2. Occupying CP 4004, and backsighting CP Y4162, another set of trigonometric observations were made once again to all points.
    - 4.3. Values were then compared. Standard deviation was used to eliminate coordinates that disagreed by more than 25mm in any one direction. The remaining values were then averaged to obtain acceptable coordinate values.
    - 4.4. Double loop / closed circuit precise levels were then completed to derive acceptable elevations for all points, using similar standard deviation techniques.

If you have any questions regarding this survey, please contact either of the undersigned.

Yours truly,
Yukon Engineering Services Inc.

Tony Gaw
Sr. Technician

Yukon Engineering Services Inc.

Michael T. Kearney, CLS, P.Eng.
Survey Manager

Enclosure: *20002001compare.xls*
Dampins2001.xls
Sept2001_mas.dwg

Mount Nansen Tailings Dam North Abutment Monitoring Pins

Settlement/Vertical Movement Surveys

Pin	Elevation (m)			Annual Change (mm)[A]		Cumulative Change (mm)
	1999	2000	2001	1999 - 2000	2000 - 2001	1999 - 2001
Y4178	1148.097	1148.089	1148.076	-8	-13	-21
Y4187	1148.413	1148.409	1148.400	-4	-9	-13
DH9504	1149.158	1149.165	1149.138	7	-27	-20
Y4179	1144.003	1143.989	1143.974	-14	-15	-29
Y4186	1143.743	1143.732	1143.729	-11	-3	-14
BH4	1148.235	1148.233	1148.234	-2	1	-1
BH6	1140.842	1140.828	1140.811	-14	-17	-31
BH7	1144.226	1144.214	1144.318	-12	104	92
Y4180	1139.631	1139.611	1139.597	-20	-14	-34
Y4185	1141.559	1141.548	1141.546	-11	-2	-13
Y4184	1135.927	1135.910	1135.902	-17	-8	-25
Y4181	1134.118	1134.097	1134.076	-21	-21	-42
Y4182	1132.091	1132.072	1132.047	-19	-25	-44
Y4183	1131.650	1131.633	1131.623	-17	-10	-27

[A] Negative values represent settlements.

Horizontal Position Surveys 1999 to 2001[B]

Pin	Northing (m)			Easting (m)		
	1999	2000	2001	1999	2000	2001
Y4178	18943.892	18943.898	18943.886	20564.789	20564.782	20564.787
Y4187	18976.760	18976.770	18976.774	20565.195	20565.194	20565.214
DH9504	19040.726	19040.732	19040.730	20566.428	20566.424	20566.434
Y4179	18943.508	18943.517	18943.505	20578.667	20578.661	20578.669
Y4186	18969.072	18969.080	18969.077	20582.388	20582.377	20582.382
BH4	19019.896	19019.901	19019.910	20580.413	20580.416	20580.403
BH6	18939.247	18939.266	18939.247	20596.003	20595.999	20596.002
BH7	18971.715	18971.724	18971.504	20593.285	20593.276	20593.334
Y4180	18942.757	18942.769	18942.768	20601.869	20601.864	20601.881
Y4185	18961.472	18961.488	18961.479	20599.391	20599.389	20599.395
Y4184	18956.743	18956.751	18956.743	20620.018	20620.012	20620.011
Y4181	18942.065	18942.078	18942.093	20625.015	20625.012	20625.027
Y4182	18941.763	18941.758	18941.759	20635.133	20635.146	20635.158
Y4183	18954.002	18954.006	18954.011	20639.013	20639.004	20639.018

[B] Horizontal Control was disturbed prior to 2000 readings; hence, 1999-2000 horizontal movements are suspect.

Change in Position[C]

Pin	From 1999 to 2000		From 2000 to 2001		From 1999 to 2001	
	ΔNorthing (mm)	ΔEasting (mm)	ΔNorthing (mm)	ΔEasting (mm)	ΔNorthing (mm)	ΔEasting (mm)
Y4178	6	-7	-12	5	-6	-1
Y4187	11	-1	3	20	14	19
DH9504	6	-5	-2	10	4	5
Y4179	9	-6	-12	9	-3	2
Y4186	8	-10	-4	4	5	-6
BH4	5	4	10	-14	14	-10
BH6	19	-4	-19	4	1	0
BH7	9	-9	-220	59	-211	49
Y4180	12	-5	-1	16	11	12
Y4185	16	-1	-9	6	8	5
Y4184	8	-5	-8	-1	0	-6
Y4181	13	-3	15	15	28	12
Y4182	-4	13	1	12	-3	25
Y4183	4	-9	5	14	9	5

[C] Movements Mine North or Mine East are postive.

Horizontal Movement of Monitoring Pins

Pin	Annual Change				Cumulative Movement	
	1999 - 2000		2000 - 2001		1999 - 2001	
	Movement (mm)	Direction (degrees)[D]	Movement (mm)	Direction (degrees)	Movement (mm)	Direction (degrees)
Y4178	9	314	13	157	6	191
Y4187	11	355	21	81	24	54
DH9504	7	321	10	101	7	58
Y4179	11	326	15	145	4	142
Y4186	13	309	6	130	7	309
BH4	6	35	17	305	18	325
BH6	20	349	19	169	1	342
BH7	13	313	227	165	217	167
Y4180	13	338	16	94	16	48
Y4185	16	356	11	145	9	33
Y4184	10	329	8	187	6	272
Y4181	14	347	21	45	30	22
Y4182	14	108	12	84	26	97
Y4183	9	293	15	70	10	32

[D] Direction is measured clockwise from Mine Grid North

Mount Nansen Tailings Dam South Abutment Monitoring Pins

Settlement/Vertical Movement Surveys

Pin	Elevation (m)			Annual Change (mm)[A]		Cumulative Change (mm)
	1999[B]	2000	2001	1999 - 2000	2000 - 2001	1999 - 2001
Y7602		1144.383	1144.358		-25	
Y4174	1144.809	1144.799	1144.783	-14	-47	-61
Y7414		1143.520	1143.491		-29	
Y4175	1142.129	1142.121	1142.102	-8	-19	-27
Y7601		1140.908	1140.891		-17	
Y4173	1139.979	1139.969	1139.943	-10	-26	-36
Y7603		1139.840	1139.831		-9	
BH5	1140.543	1140.533	1140.515	-10	-18	-28
Y7604		1138.783	1138.772		-11	
Y4172	1138.553	1138.541	1138.527	-12	-14	-26
Y4176	1138.438	1138.421	1138.407	-17	-14	-31
Y7606		1136.996	1136.970		-26	
Y6014		1135.718	1135.710		-8	
Y4177	1135.828	1135.809	1135.784	-19	-25	-44
BH8	1133.434	1133.420	1133.399	-14	-21	-35

[A] Negative values represent settlements.

[B] Pins without readings from 1999 were added to the monitoring system in 2000.

Horizontal Position Surveys 1999 to 2001[C]

Pin	Northing (m)			Easting (m)		
	1999	2000	2001	1999	2000	2001
Y7602		18861.405	18861.414		20580.446	20580.476
Y4174	18888.989	18889.011	18889.017	20574.421	20574.418	20574.434
Y7414		18864.802	18864.808		20583.655	20583.679
Y4175	18903.894	18903.916	18903.923	20585.391	20585.391	20585.406
Y7601		18878.948	18878.957		20593.093	20593.114
Y4173	18887.889	18887.899	18887.893	20596.964	20596.973	20597.001
Y7603		18888.939	18888.941		20595.741	20595.772
BH5	18919.562	18919.564	18919.567	20597.839	20597.843	20597.857
Y7604		18897.126	18897.130		20601.172	20601.196
Y4172	18908.778	18908.786	18908.783	20605.035	20605.026	20605.047
Y4176	18922.205	18922.211	18922.209	20605.204	20605.197	20605.209
Y7606		18899.760	18899.770		20606.792	20606.855
Y6014		18912.258	18912.256		20614.189	20614.210
Y4177	18925.871	18925.884	18925.885	20615.996	20615.983	20616.005
BH8	18931.707	18931.730	18931.727	20633.969	20633.946	20633.967

[C] Horizontal Control was disturbed prior to 2000 readings; hence, 1999-2000 horizontal movements are suspect.

Change in Position[D]

Pin	From 1999 to 2000		From 2000 to 2001		From 1999 to 2001	
	ΔNorthing (mm)	ΔEasting (mm)	ΔNorthing (mm)	ΔEasting (mm)	ΔNorthing (mm)	ΔEasting (mm)
Y7602			9	30		
Y4174	22	-3	5	16	28	13
Y7414			6	24		
Y4175	23	0	6	15	29	15
Y7601			9	21		
Y4173	10	9	-6	28	4	37
Y7603			3	31		
BH5	2	4	3	14	5	18
Y7604			4	24		
Y4172	8	-9	-4	21	5	12
Y4176	7	-6	-2	11	5	5
Y7606			10	63		
Y6014			-2	21		
Y4177	13	-13	1	22	14	10
BH8	23	-23	-3	21	20	-2

[D] Movements Mine North or Mine East are postive.

Horizontal Movement of Monitoring Pins

Pin	Annual Change				Cumulative Movement	
	1999 - 2000		2000 - 2001		1999 - 2001	
	Movement (mm)	Direction (degrees)[E]	Movement (mm)	Direction (degrees)	Movement (mm)	Direction (degrees)
Y7602			31	74		
Y4174	23	328	17	72	30	25
Y7414			24	75		
Y4175	23	360	17	68	33	28
Y7601			23	68		
Y4173	14	3	29	103	38	84
Y7603			31	85		
BH5	5	308	14	79	19	74
Y7604			25	81		
Y4172	12	328	21	100	13	68
Y4176	9	55	12	102	7	49
Y7606			64	81		
Y6014			21	96		
Y4177	19	341	22	87	17	34
BH8	33	336	21	97	20	353

[E] Direction is measured clockwise from Mine Grid North

Mount Nansen Tailings Dam Crest Monitoring Pins

Settlement/Vertical Movement Surveys

Pin	Elevation (m)			Annual Change (mm)[A]		Cumulative Change (mm)
	1999	2000	2001	1999 - 2000	2000 - 2001	1999 - 2001
Y4163	1151.491	1151.489	1151.462	-2	-27	-29
Y4159	1151.413	1151.399	1151.352	-14	-47	-61
BH1	1152.409	1152.395	1152.349	-14	-46	-60
Y4157	1151.231	1151.216	1151.177	-15	-39	-54
Y4156	1151.240	1151.224	1151.188	-16	-36	-52
BH2	1151.839	1151.826	1151.792	-13	-34	-47
Y4155	1151.515	1151.506	1151.482	-9	-24	-33
BH3	1152.400	1152.386	1152.372	-14	-14	-28
Y4153	1151.386	1151.381	1151.375	-5	-6	-11
Y4152	1151.442	1151.443	1151.434	1	-9	-8
Y4151	1151.529	1151.532	1151.521	3	-11	-8
Y4150	1151.593	1151.596	1151.588	3	-8	-5
Y4154	1151.613	1151.611	1151.588	-2	-23	-25
Y4161	1151.897	1151.894	1151.886	-3	-8	-11

[A] Negative values represent settlements.

Horizontal Position Surveys 1999 to 2001[B]

Pin	Northing (m)			Easting (m)		
	1999	2000	2001	1999	2000	2001
Y4163	18864.499	18864.53	18864.531	20549.370	20549.359	20549.363
Y4159	18884.585	18884.609	18884.611	20549.335	20549.320	20549.323
BH1	18885.216	18885.239	18885.247	20550.158	20550.156	20550.162
Y4157	18904.314	18904.346	18904.349	20549.264	20549.264	20549.267
Y4156	18924.381	18924.410	18924.413	20549.162	20549.158	20549.163
BH2	18934.725	18934.751	18934.739	20549.875	20549.876	20549.878
Y4155	18944.376	18944.393	18944.392	20549.064	20549.042	20549.043
BH3	18963.494	18963.502	18963.493	20549.905	20549.899	20549.904
Y4153	18984.063	18984.089	18984.084	20548.858	20548.842	20548.843
Y4152	19004.517	19004.541	19004.541	20548.788	20548.822	20548.823
Y4151	19024.381	19024.395	19024.398	20548.648	20548.634	20548.634
Y4150	19044.382	19044.406	19044.408	20548.572	20548.572	20548.574
Y4154	19064.274	19064.297	19064.298	20548.594	20548.586	20548.574
Y4161	19084.465	19084.481	19084.481	20548.350	20548.343	20548.343

[B] Horizontal Control was disturbed prior to 2000 readings; hence, 1999-2000 horizontal movements are suspect.

Change In Position[C]

Pin	From 1999 to 2000		From 2000 to 2001		From 1999 to 2001	
	ΔNorthing (mm)	ΔEasting (mm)	ΔNorthing (mm)	ΔEasting (mm)	ΔNorthing (mm)	ΔEasting (mm)
Y4163	31	-11	1	4	32	-7
Y4159	24	-15	2	3	26	-12
BH1	24	-2	8	6	31	4
Y4157	32	0	3	3	35	3
Y4156	29	-4	3	5	32	1
BH2	26	1	-12	2	14	3
Y4155	17	-22	-1	1	16	-21
BH3	8	-5	-9	5	-1	-1
Y4153	26	-16	-5	1	21	-15
Y4152	24	34	0	1	24	35
Y4151	14	-14	3	0	17	-14
Y4150	24	0	2	2	26	2
Y4154	23	-8	1	-12	24	-20
Y4161	16	-7	0	0	16	-7

[C] Movements Mine North or Mine East are postive.

Horizontal Movement of Monitoring Pins

Pin	Annual Change				Cumulative Movement	
	1999 - 2000		2000 - 2001		1999 - 2001	
	Movement (mm)	Direction (degrees)[D]	Movement (mm)	Direction (degrees)	Movement (mm)	Direction (degrees)
Y4163	33	340	4	76	33	348
Y4159	28	328	4	56	29	335
BH1	24	355	10	38	31	7
Y4157	32	360	4	45	35	5
Y4156	29	352	6	59	32	2
BH2	26	3	12	172	14	12
Y4155	28	308	1	135	26	307
BH3	10	325	10	153	2	212
Y4153	31	328	5	169	26	324
Y4152	42	55	1	90	42	56
Y4151	20	315	3	360	22	321
Y4150	24	360	3	45	26	4
Y4154	24	341	12	275	31	320
Y4161	17	336	0	360	17	336

[D] Direction is measured clockwise from Mine Grid North

APPENDIX F

Tailings Volume Estimate

Yukon Engineering Services Inc.

#1 Calcite Business Centre
151 Industrial Road
Whitehorse, Yukon, Canada
Y1A 2V3
e-mail: yes@polarcom.com
Tel. (867) 668-2000 Fax. (867) 667-2220

EBA Engineering Consultants Limited
#6 Calcite Business Centre
151 Industrial Road
Whitehorse, Yukon
Y1A 2V3

Attention: Cord Hamilton, P. Eng.

Dear Sir:

Regarding: Report on Mount Nansen Tailings Pond Volumes

Tailings Volumes were calculated using Yukon Engineering Services (YES) surveys from 2000 and 2001, bathymetry surveyed by Laberge Environmental Services in 1999 and from the original ground survey surveyed by Klohn Crippen in 1996.

The top of tailings was achieved by merging the two separate YES surveys and the bathymetry provided by EBA. The bathymetry was in the form of a contour plan (paper print) and had to be digitized in order to extract points, which completed the surface of the tailings. The original ground survey was obtained from the BYG office in 1999 by Jerry Quaile (YES) and Cord Hamilton (EBA). This plan was in digital form. Points were extracted from this plan, which created the original ground surface. Volumes were then calculated by *Planar Tin* method.

Tailing Volumes are an estimate only and would be considered to be within five to ten percent.

Mount Nansen Tailings Volume Report:
Reported in Cu. Meters

Using 1.0000 cubic units/Cu. Meters
Volume of 1999OG-TAIL2001 based on a planar tin.

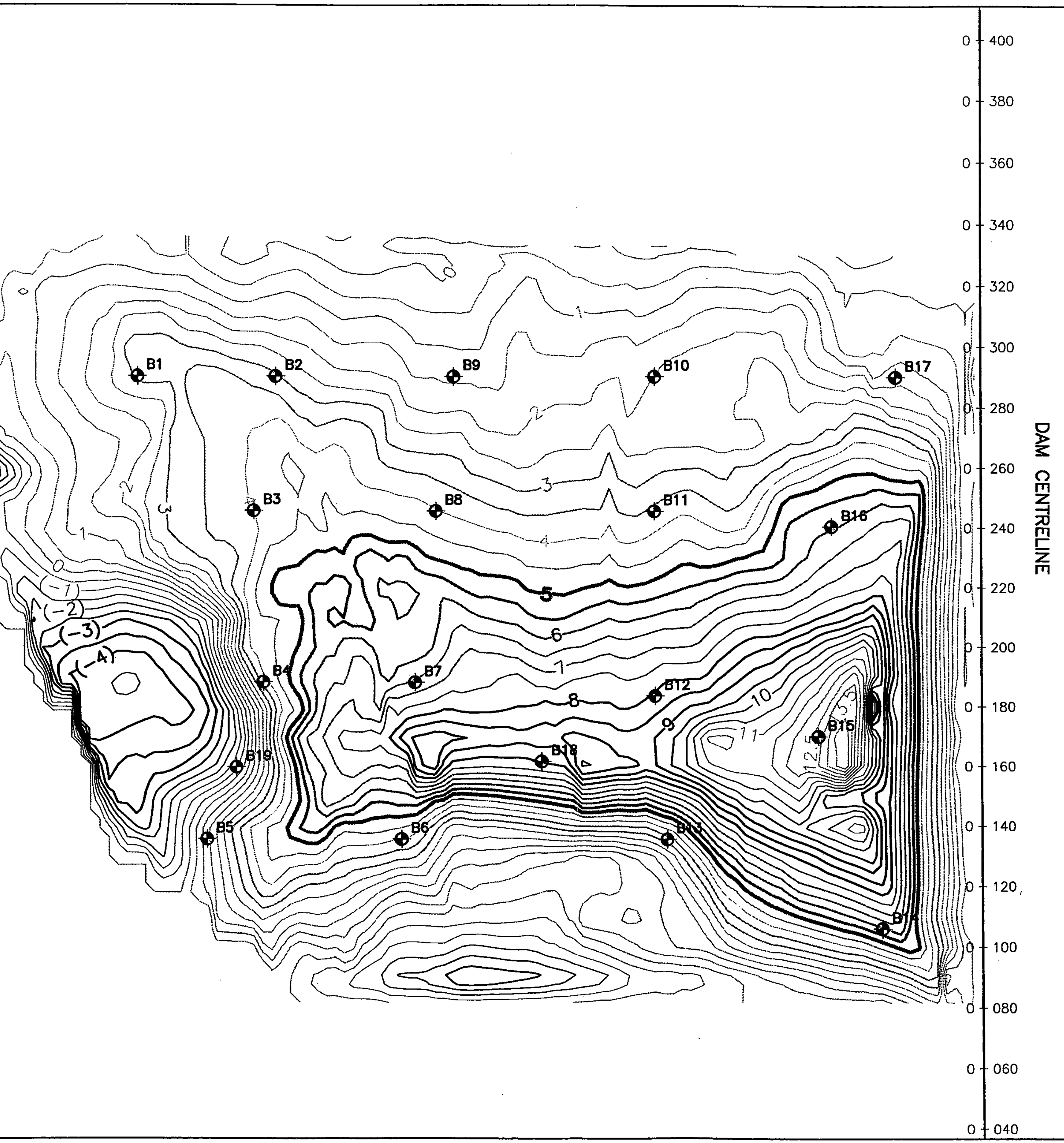
Positive Volume	Negative Volume	Net Volume
21,495m^3	304,949m^3	283,454m^3

If you have any questions, please do not hesitate to call the undersigned.

Yours truly,

Yukon Engineering Services Inc.

Tony Gaw
Sr. Technician, Project Manager



Borehole no.	Actual Tailings Thickness (m)	Predicted Tailings Thickness (m)
B1	2.6	3.2
B2	2.9	3.1
B3	>2.8	4.1
B4	4.4	4.0
B5	2.1	1.5
B6	5.0	4.0
B7	5.6	6.5
B8	>2.6	4.1
B9	1.8	1.4
B10	1.0	2.1
B11	3.1	3.6
B12	7.5	8.1
B13	>5.9	3.3
B14	6.0	6.1
B15	>8.9	12.8
B16	6.5	6.0
B17	2.6	1.3
B18	7.9	8.0
B19	4.3	−1.0

NOTES
1. Contours are 0.5 metre.
2. Grid is Local Mine Grid

LEGEND

EBA Engineering Consultants Ltd.

P. ENG. SEAL

DESIGN	CHECKED
DRAWN J. QUAILE	DATE JAN. 2002

SCALE
HOR: 1:1500 VER: N/A

Yukon Engineering Services

MT NANSEN TAILINGS DAM ASSESSMENT

IMPOUNDMENT TAILINGS THICKNESS CONTOUR PLAN

DWG. NO.
\JOBS\99075\DIFF2002.DWG

SHEET 1 OF 1 REV. 0