## APPENDIX B – Environmental Studies for Proposed Airstrip and Connecting Road

# Memorandum

| | |
|---|---|
| **DATE:** | October 27, 2010 |
| **TO:** | Elizabeth Sherlock, Environmental/Permitting Coordinator<br>Dan Russell, Project Environmental Coordinator<br>(Sabina Gold and Silver Corporation) |
| **FROM:** | Colin Fyfe, B.Eng. (Hons), Ph.D. (Rescan Hydrogeologist) |
| **CC:** | Deborah Muggli, M.Sc., Ph.D., R.P.Bio. (Project Manager)<br>Gerry Papini, M.Sc., P.Geo. (Manager, Hydrogeology) |
| **SUBJECT:** | Thermistor Data Summary, Back River Project |

## 1. Introduction

Two thermistor strings currently exist within the Goose Lake Property of the Back River Project. This memorandum provides a summary of the available data and its adequacy in characterizing the permafrost layer.

The thermistors were installed to characterize the permafrost layer beneath the property. One string is installed to approximately 7 m below ground surface (Goose Trench) while the second is installed to a depth of 300 mbgl (08GSE009). The data for the Goose Trench are anomalous and cannot be explained without further information on the history of this instrument. Figure 1 shows the locations of the thermistors and Table 1 summarizes the thermistor installation details.

The data presented in this memorandum was provided to Rescan Environmental Services Ltd. (Rescan) by Sabina Gold and Silver Corporation (Sabina) who have been collecting data since September 2007. The thermistor data has been collected manually. Measurements of thermistor resistance have been converted to temperature using a calibration curve provided by Sabina. Curves were fitted to the calibration data; the calibration fit was good.

## 2. Results

### 2.1 Goose Trench Thermistor

The Goose Trench thermistor was installed in 1997. Five datasets were provided by Sabina covering the period from September 20, 2007 to September 17, 2010 (Table 2). Four of the data sets were collected in August or September and one collected in May 2010. Node 3 of this thermistor is noted as non-functional.

Figure 2 is a time-series graph that shows the variation in temperature with depth. The data collected in August and September 2010 show the active layer (non-frozen ground conditions) to a depth of about 4.5 mbgl. The pre-2010 data suggest an active layer greater than 7 m.

Communications with Dan Russell, Project Environmental Coordinator (Sabina), has indicated that the area around the Goose Trench thermistor was reclaimed in August 2009 and resulted in increased depth of overburden at the site. The reclamation may explain the variability between the pre-2010 and 2010 data. The data from the uppermost node on this thermistor (1.2 m below the original ground surface) is suspect as it is thought to be measuring air temperatures (up to 19.7 degrees Celsius shown in Figure 2).

## 2.2 08GSE009 Thermistor

The 08GSE009 thermistor was installed in 2008. Since installation the thermistor has been read nine times from May 9, 2008 to September 17, 2010. The data are provided in Table 3 and Figures 3 through 6 present these data.

Figure 3 shows the equilibration of selected thermistor nodes with time. The selected thermistors are all installed at depths below the point of zero amplitude (the depth at which there is no seasonal temperature variation). The figure shows "freeze back" post-installation in June 10, 2008 and that the data from August 8, 2009 are suspect as they deviate by about one degree Celsius from the steady state temperatures at the individual nodes, which are not expected to vary with time. It was also noted that some of the data from August 8, 2009 was highlighted as questionable by field personnel. This data was subsequently excluded from the later figures.

Figure 4 shows the temperature to depth profile for the full 300 m installation depth of the thermistor string whereas Figure 5 shows the temperature trend observed in the upper 40 m of the thermistor profile. The point of zero amplitude is approximately 20 m below ground surface (Figure 5). Additional information showing seasonal fluxes would be required to better define this depth both spatially and with greater confidence.

Figure 6 shows the temperature trend observed in the upper 10 m of the thermistor profile. The three most recent data sets have been presented in these figures only. The profiles recorded in this thermistor are expected in a permafrost environment with an active layer (the surficial zone which experiences a freeze thaw cycle seasonally) of approximately 1 m and a permafrost layer beneath. The active layer is best illustrated in Figure 6 from which it can be seen that the near surface temperature is highly variable; as the depth increases, the variability decreases. The May 8, 2010 data shows sub-zero temperatures at surface. The later (August and September) data shows temperatures above freezing to a depth of approximately 1.25 m below ground surface. This information indicates an active layer of 1.25 m. There are no temporal data to accurately define the duration and maximum depth of the active layer.

The profiles show that the temperature trends towards zero with increasing depth as a result of the geothermal gradient. An estimation of the geothermal gradient was carried out by fitting a linear function to the lower 150 m of the thermistor string (4 data points) for September 17, 2010 ($R^2$ value of 0.977). The predicted depth for zero degrees Celsius in the bedrock is approximately 520 m below ground surface. This represents a simplification of the thermal gradient and is not necessarily the base of frozen ground and groundwater (e.g. high salinity could depress the freezing point).

# 3. Conclusions, Limitations and Recommendations

- The data for the Goose Trench thermistor are anomalous and may have been affected by site activities or instrument damage. The inferred 2010 permafrost depth of approximately 4.5 m below the original ground surface is greater than expected based on experience of permafrost depth at similar latitude at other locations. Further interpretation of the data and permafrost conditions may only be possible with more background and history for this instrument. Currently, the data are not considered reliable.

- The available data for the 08GSE009 thermistor string follows the typical trend observed in a permafrost environment. The active layer is approximately 1.25 m thick at the end of summer, the expected maximum and will vary through the annual freeze/thaw cycle.
- The thermistor string does not extend deep enough to directly measure the level where the temperature reaches zero degrees Celsius. Extrapolation of the data indicates that this point would be approximately 500 m below ground surface.
- The data available has been manually read. It is recommended that data loggers be installed at the two thermistor strings to better define the seasonal fluxes in sub-surface temperatures. This would allow the variations in the active layer and the point zero amplitude to be better, and more confidently, defined.

## 4. Closure

The contents herein reflect Rescans best understanding of the scope and the information available. This memorandum has been written for the sole use of our client, Rescan accepts no liability associated with third party use of the contents.

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Reviewed By:

Deborah L. Muggli

Deborah Muggli, M.Sc., Ph.D., R.P.Bio. (Project Manager)

# Tables

## Table 1. Thermistor Details

| Thermistor ID | Hole ID | Coordinates | | | Installation Hole Details | | | Installation Date | Installation Contractor | Thermistor String Manufacturer | Number of Thermistor Nodes | Comments |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Easting | Northing | Elevation (m-amsl) | Hole Strike | Hole Dip (Degrees from horizontal) | Depth of Installation | | | | | |
| Goose Trench | 97GO-14 | 434055 | 7269263 | 282.6 | 44 | 45 | 7 m | 1997 | NA | RST Instruments | 6 | Thermistor string contains 6 nodes, but node 3 (3.7 m below ground surface) is not functional. |
| 08GSE009 | 08GSE009 | 433904 | 7269461 | 285 | 44 | 56 | 300 m | 2008 | Dundee | RST Instruments | 18 | |

Notes:
Coordinates are NAD 83, Zone 13
NA - Not Available/Not Applicable
m-amsl - metres above mean sea level

## Table 2. Goose Trench Data

| Thermistor Node | Node Length Along String (ft) | Node Depth Below Ground Surface (m) | September 20, 2007 | | August 8, 2009 | | May 8, 2010 | | August 30, 2010 | | September 17, 2010 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Measured Resistance (k-Ohms) | Temperature (Degrees C) | Measured Resistance (k-Ohms) | Temperature (Degrees C) | Measured Resistance (k-Ohms) | Temperature (Degrees C) | Measured Resistance (k-Ohms) | Temperature (Degrees C) | Measured Resistance (k-Ohms) | Temperature (Degrees C) |
| 1 | -4 | -1.2 | 8.18 | -2.5 | 4.205 | 10.9 | 5.85 | 4.1 | 2.775 | 19.7 | 5.95 | 3.8 |
| 2 | -8 | -2.4 | 6.81 | 1.1 | 4.616 | 8.9 | 10.76 | -7.7 | 5.442 | 5.6 | 6.45 | 2.2 |
| 3 | -12 | -3.7 | NA | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| 4 | -16 | -4.9 | 6.62 | 1.6 | 5.82 | 4.2 | 11.17 | -8.4 | 7.47 | -0.7 | 7.31 | -0.3 |
| 5 | -20 | -6.1 | 6.89 | 0.8 | 6.62 | 1.6 | 11.07 | -8.2 | 7.95 | -1.9 | 7.75 | -1.5 |
| 6 | -24 | -7.3 | 7.1 | 0.3 | 6.74 | 1.3 | 10.75 | -7.7 | 8.29 | -2.8 | 8.07 | -2.2 |

Notes:
NA - Not Available/Not Applicable
ft - Feet
m - Metres
k-Ohms - Kilo Ohms
C - Celcius

## Table 3A. 08GSE009 Data

| Thermistor Node | Node Length Along String (m) | Node Depth Below Ground Surface (m) | May 9, 2008 | | May 11, 2008 | | May 13, 2008 | | May 19, 2008 | | June 10, 2008 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Measured Resistance (k-Ohms) | Temperature (Degrees C) | Measured Resistance (k-Ohms) | Temperature (Degrees C) | Measured Resistance (k-Ohms) | Temperature (Degrees C) | Measured Resistance (k-Ohms) | Temperature (Degrees C) | Measured Resistance (k-Ohms) | Temperature (Degrees C) |
| 1 | -0.1 | -0.1 | 7.51 | -0.3 | 7.78 | -0.9 | 8.32 | -2.2 | 9.09 | -3.9 | 7.85 | -1.1 |
| 2 | -0.6 | -0.5 | 7.26 | 0.4 | 7.49 | -0.2 | 8.02 | -1.5 | 9.43 | -4.6 | 8.98 | -3.7 |
| 3 | -1.2 | -1 | 7.35 | 0.2 | 7.99 | -1.5 | 8.75 | -3.2 | 10.22 | -6.2 | 9.71 | -5.2 |
| 4 | -1.8 | -1.5 | 7.36 | 0.1 | 8.51 | -2.7 | 9.93 | -5.6 | 11.00 | -7.5 | 10.35 | -6.4 |
| 5 | -2.4 | -2 | 7.38 | 0.1 | 9.65 | -5.1 | 10.76 | -7.1 | 11.58 | -8.5 | 10.90 | -7.4 |
| 6 | -6 | -5 | 7.35 | 0.2 | 9.86 | -5.5 | 10.72 | -7.1 | 11.58 | -8.5 | 11.83 | -8.9 |
| 7 | -9 | -7.5 | 7.31 | 0.3 | 7.63 | -0.6 | 9.27 | -4.3 | 10.38 | -6.5 | 11.13 | -7.8 |
| 8 | -12.1 | -10 | 7.41 | 0.0 | 8.52 | -2.7 | 8.96 | -3.7 | 9.59 | -5.0 | 10.40 | -6.5 |
| 9 | -18.1 | -15 | 7.75 | -0.9 | 8.90 | -3.5 | 9.26 | -4.3 | 9.66 | -5.1 | 10.03 | -5.8 |
| 10 | -24.1 | -20 | 8.16 | -1.9 | 9.12 | -4.0 | 9.46 | -4.7 | 9.80 | -5.4 | 10.06 | -5.9 |
| 11 | -36.2 | -30 | 8.33 | -2.3 | 9.28 | -4.3 | 9.59 | -5.0 | 9.90 | -5.6 | 10.15 | -6.0 |
| 12 | -48.2 | -40 | 8.50 | -2.6 | 9.36 | -4.5 | 9.65 | -5.1 | 9.96 | -5.7 | 10.20 | -6.1 |
| 13 | -84.4 | -70 | 8.89 | -3.5 | 9.56 | -4.9 | 9.76 | -5.3 | 9.99 | -5.7 | 10.16 | -6.1 |
| 14 | -120.6 | -100 | 8.69 | -3.1 | 9.36 | -4.5 | 9.66 | -5.1 | 9.83 | -5.4 | 10.06 | -5.9 |
| 15 | -189.2 | -150 | 9.06 | -3.9 | 9.46 | -4.7 | 9.57 | -4.9 | 9.70 | -5.2 | 9.79 | -5.4 |
| 16 | -241.2 | -200 | 8.85 | -3.4 | 9.26 | -4.3 | 9.36 | -4.5 | 9.47 | -4.7 | 9.53 | -4.8 |
| 17 | -301.6 | -250 | 8.45 | -2.5 | 8.93 | -3.6 | 9.03 | -3.8 | 9.12 | -4.0 | 9.17 | -4.1 |
| 18 | -361.9 | -300 | 7.89 | -1.2 | 8.52 | -2.7 | 8.62 | -2.9 | 8.69 | -3.1 | 8.73 | -3.2 |

**Notes:**
NA - Not Available/Not Applicable
m - Metres
k-Ohms - Kilo Ohms
C - Celcius
Underline - Data noted as questionable by field personnel

## Table 3B. 08GSE009 Data

| Thermistor Node | Node Length Along String (m) | Node Depth Below Ground Surface (m) | August 8, 2009 | | May 8, 2010 | | August 30, 2010 | | September 17, 2010 | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Measured Resistance (k-Ohms) | Temperature (Degrees C) | Measured Resistance (k-Ohms) | Temperature (Degrees C) | Measured Resistance (k-Ohms) | Temperature (Degrees C) | Measured Resistance (k-Ohms) | Temperature (Degrees C) |
| 1 | -0.1 | -0.1 | 6.18 | 3.6 | 12.35 | -9.7 | 5.78 | 4.9 | 6.94 | 1.3 |
| 2 | -0.6 | -0.5 | 7.04 | 1.0 | 12.47 | -9.9 | 6.49 | 2.6 | 6.95 | 1.3 |
| 3 | -1.2 | -1 | 7.74 | -0.8 | 12.64 | -10.1 | 7.32 | 0.2 | 7.31 | 0.3 |
| 4 | -1.8 | -1.5 | 8.28 | -2.2 | 12.71 | -10.2 | 7.75 | -0.9 | 7.66 | -0.6 |
| 5 | -2.4 | -2 | 9.19 | -4.2 | 12.71 | -10.2 | 8.14 | -1.8 | 8.00 | -1.5 |
| 6 | -6 | -5 | <u>7.81</u> | -1.0 | 11.89 | -9.0 | 9.81 | -5.4 | 9.52 | -4.8 |
| 7 | -9 | -7.5 | 11.23 | -7.9 | 11.07 | -7.7 | 10.50 | -6.7 | 10.29 | -6.3 |
| 8 | -12.1 | -10 | 10.83 | -7.3 | 10.55 | -6.8 | 10.78 | -7.2 | 10.67 | -7.0 |
| 9 | -18.1 | -15 | 10.67 | -7.0 | 10.36 | -6.4 | 10.53 | -6.7 | 10.53 | -6.7 |
| 10 | -24.1 | -20 | <u>9.33</u> | -4.4 | 10.36 | -6.4 | 10.40 | -6.5 | 10.42 | -6.5 |
| 11 | -36.2 | -30 | 10.40 | -6.5 | 10.33 | -6.4 | 10.33 | -6.4 | 10.34 | -6.4 |
| 12 | -48.2 | -40 | 10.59 | -6.8 | 10.33 | -6.4 | 10.34 | -6.4 | 10.34 | -6.4 |
| 13 | -84.4 | -70 | 10.60 | -6.8 | 10.26 | -6.2 | 10.26 | -6.2 | 10.27 | -6.3 |
| 14 | -120.6 | -100 | 10.44 | -6.6 | 10.17 | -6.1 | 10.16 | -6.1 | 10.17 | -6.1 |
| 15 | -189.2 | -150 | 9.90 | -5.6 | 9.85 | -5.5 | 9.87 | -5.5 | 9.87 | -5.5 |
| 16 | -241.2 | -200 | 9.86 | -5.5 | 9.58 | -4.9 | 9.62 | -5.0 | 9.62 | -5.0 |
| 17 | -301.6 | -250 | 9.63 | -5.0 | 9.20 | -4.2 | 9.25 | -4.3 | 9.25 | -4.3 |
| 18 | -361.9 | -300 | 9.22 | -4.2 | 8.76 | -3.2 | 8.79 | -3.3 | 8.78 | -3.3 |

**Notes:**
NA - Not Available/Not Applicable
m - Metres
k-Ohms - Kilo Ohms
C - Celcius
<u>Underline</u> - Data noted as questionable by field personnel

# Figures

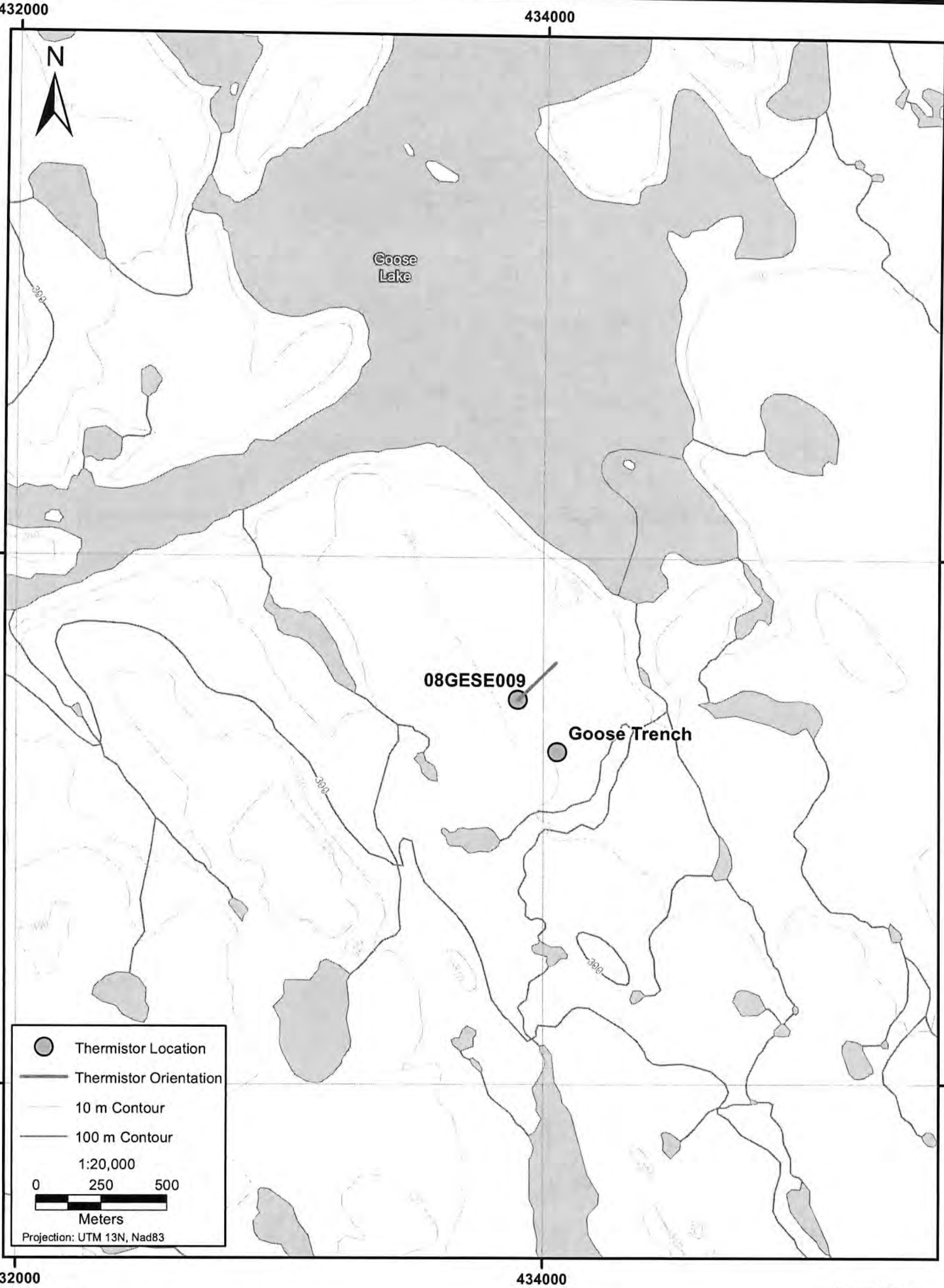


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FIGURE 1

# Thermistor Locations

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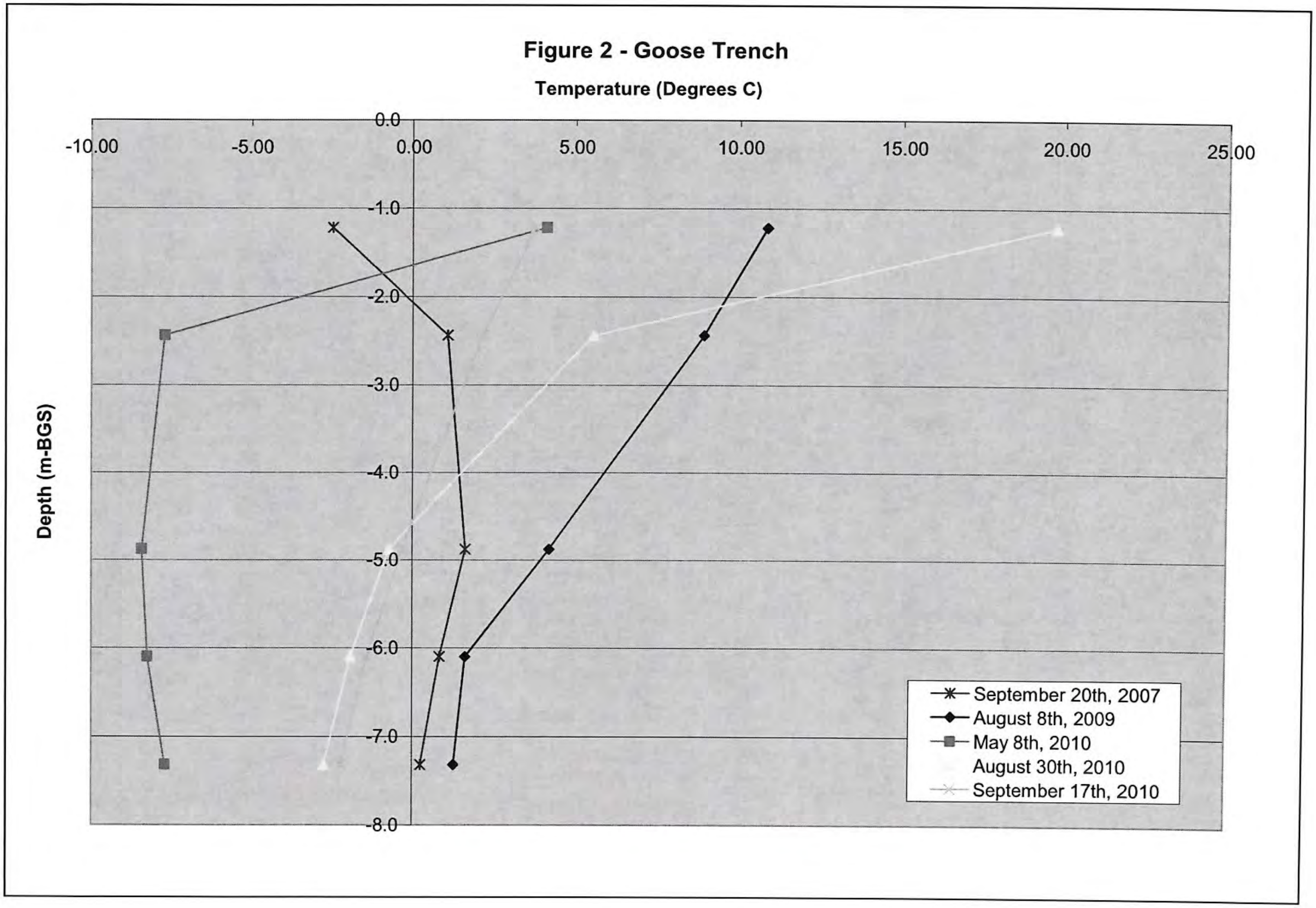


Figure 2 - Goose Trench
Temperature (Degrees C)
-10.00
-5.00
0.00
5.00
10.00
15.00
20.00
25.00
Depth (m-BGS)
0.0
-1.0
-2.0
-3.0
-4.0
-5.0
-6.0
-7.0
-8.0
September 20th, 2007
August 8th, 2009
May 8th, 2010
August 30th, 2010
September 17th, 2010

## Figure 3 - Equilibration of Thermistors

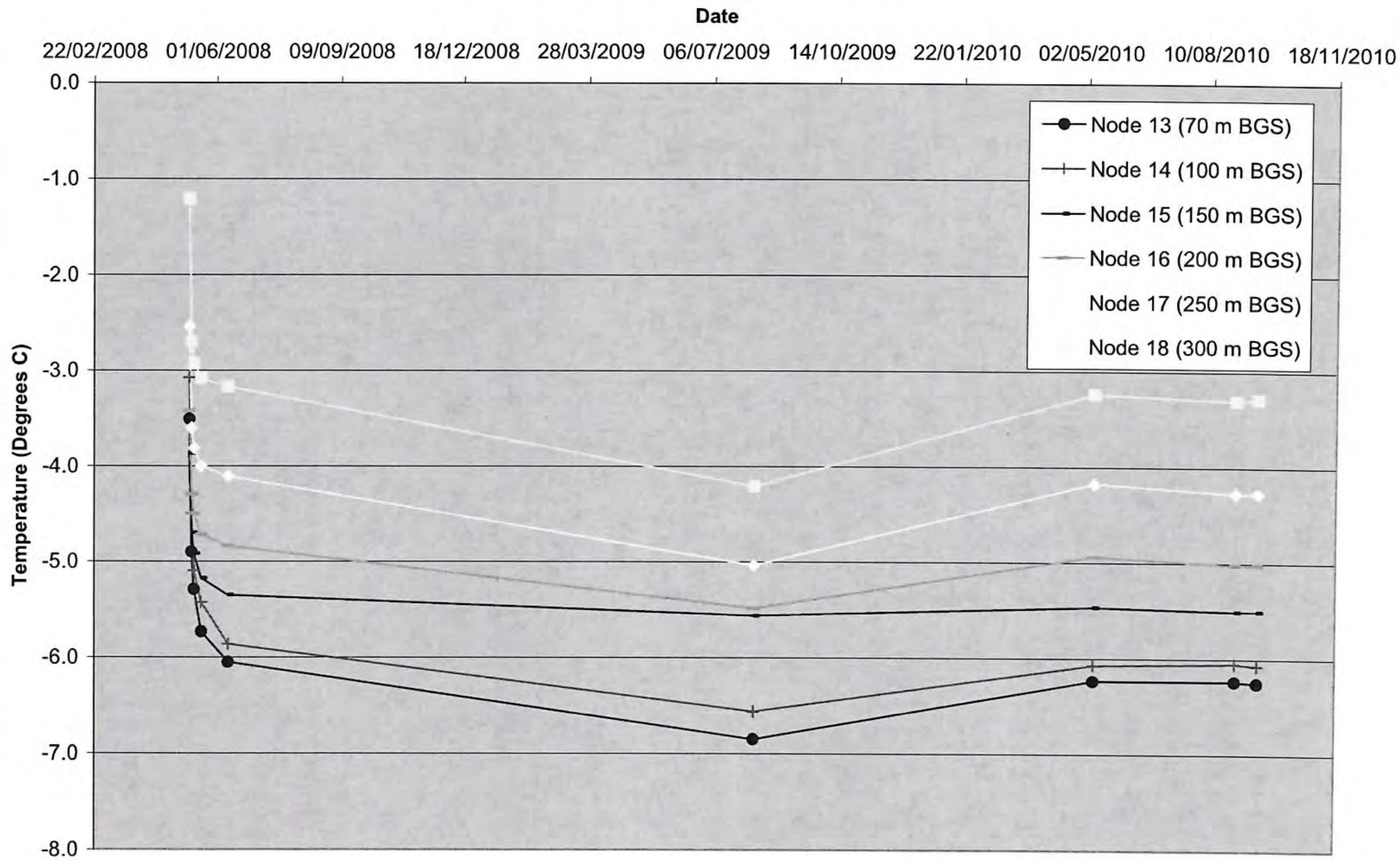
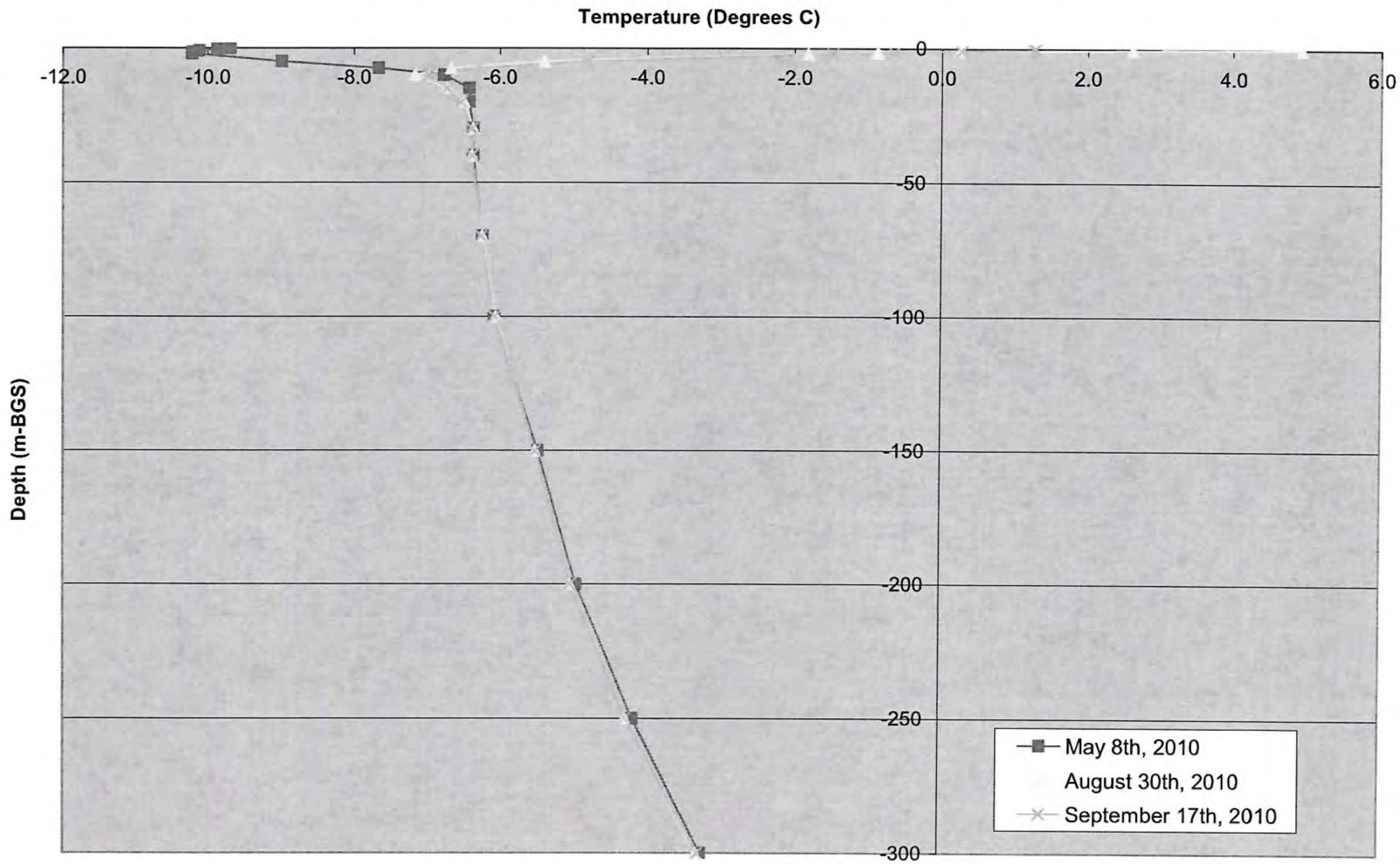


Figure 4 - Temperature vs Depth for Full Thermistor Profile



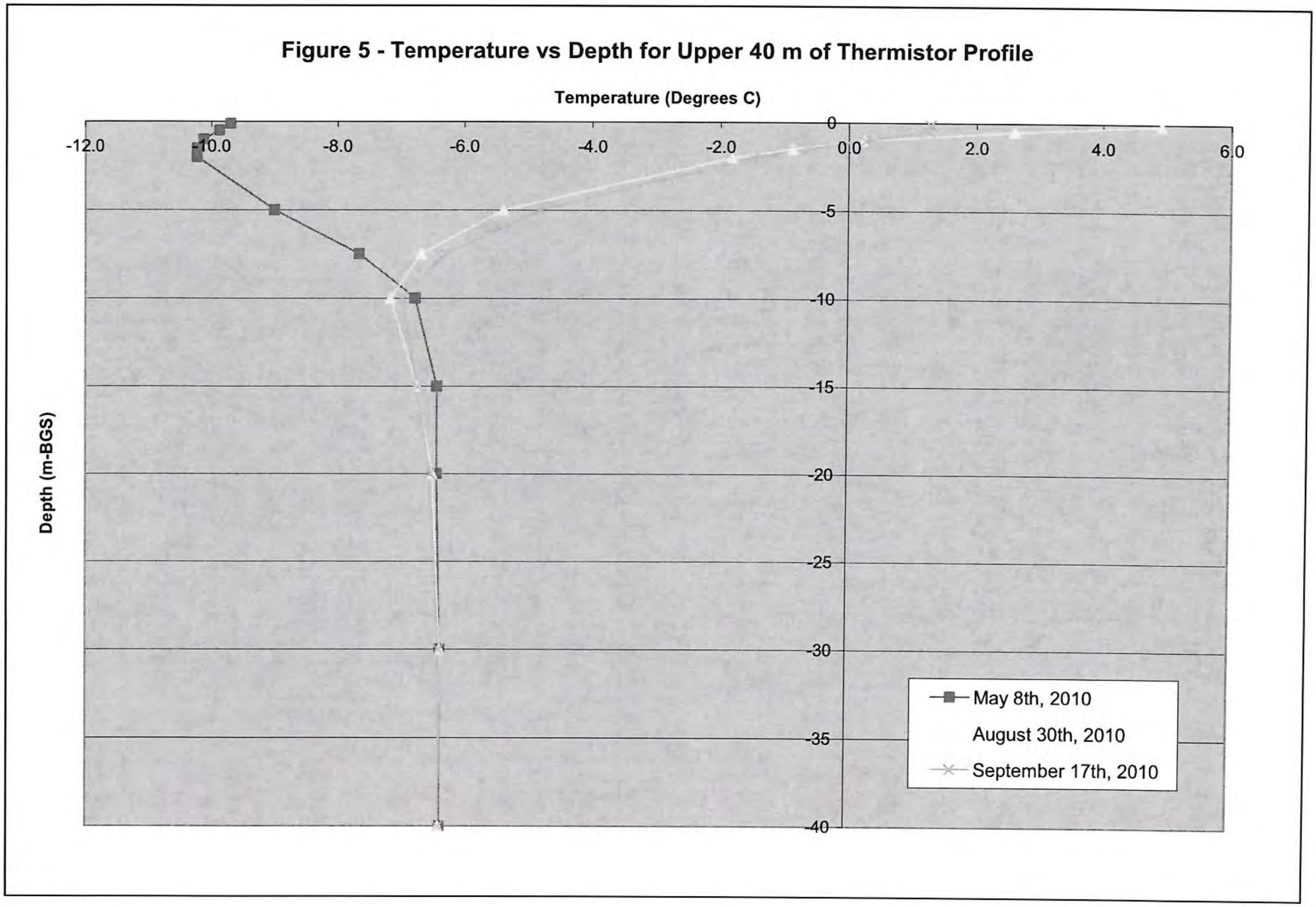
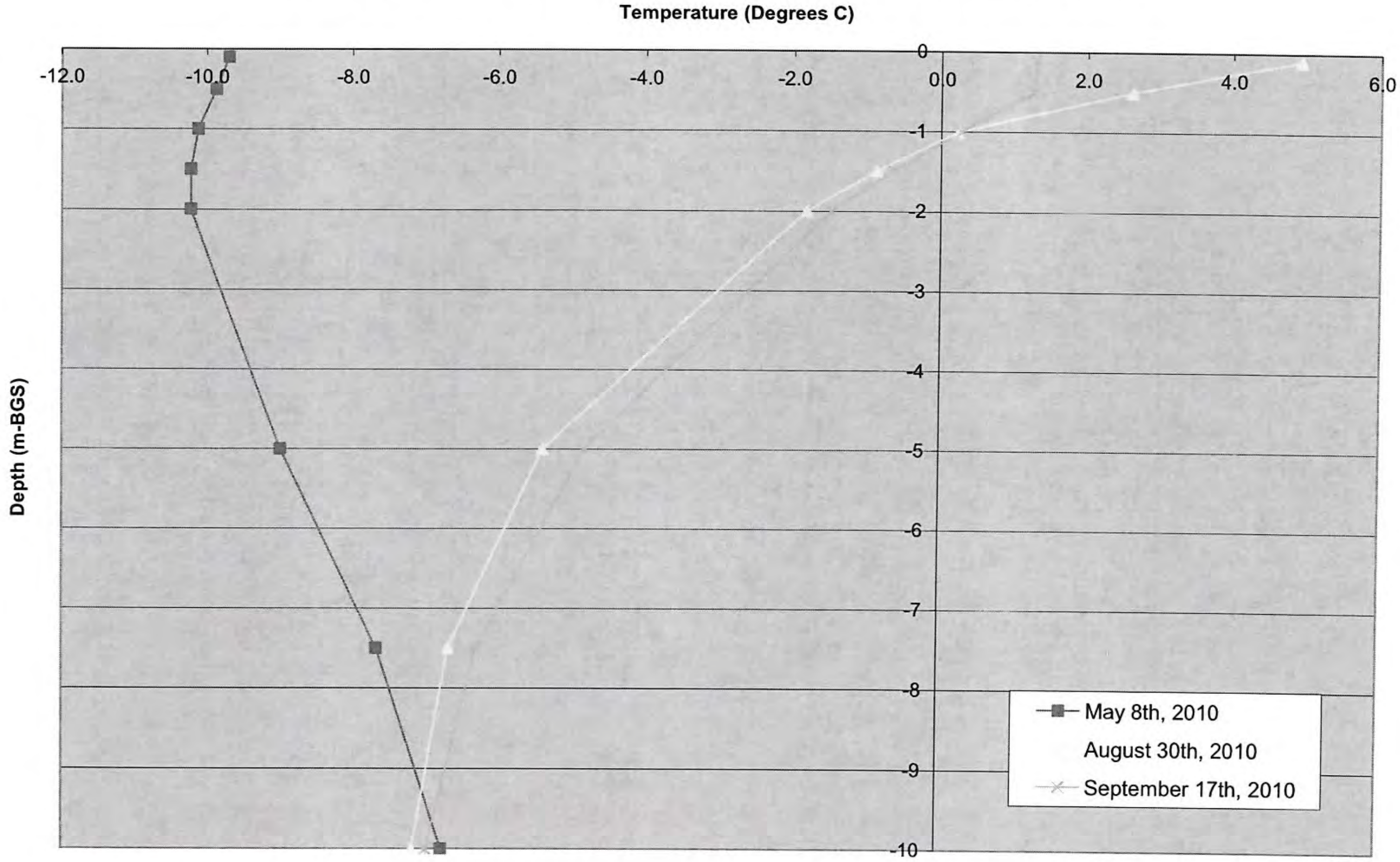


Figure 5 - Temperature vs Depth for Upper 40 m of Thermistor Profile
Temperature (Degrees C)
-12.0
-10.0
-8.0
-6.0
-4.0
-2.0
0.0
2.0
4.0
6.0
0
-5
-10
-15
-20
-25
-30
-35
-40
Depth (m-BGS)
May 8th, 2010
August 30th, 2010
September 17th, 2010

Figure 6 - Temperature vs Depth for Upper 10 m of Thermistor Profile



# Memorandum

Refer to File No.: N:\833 Sabina\833-002-06 MLARD\Working Folder\Airstrip memo\A.2-833-02-014- Back River Airstrip MLARD Memo.doc

| | |
|---|---|
| **DATE:** | November 15, 2011 |
| **TO:** | Matthew Pickard B.Sc., MBA, P.Geo, CCEP, CRSP, Director, Environment & Community Relations, Sabina Gold & Silver Corp. |
| **FROM:** | Mark Nelson |
| **CC:** | Deborah Muggli |
| **SUBJECT:** | ML/ARD Characterization of Goose Lake Airstrip Material |

## 1. Introduction

The metal leaching/acid rock drainage (ML/ARD) potential of material to be disturbed during the construction of the Goose Lake Camp airstrip is presented in this memorandum. The purpose of the characterization is to identify suitable construction material (from an ML/ARD perspective) and also to propose management measures to prevent or mitigate potential environmental impact from ML/ARD.

The airstrip is being designed by SRK and will involve stripping a portion of the overburden from the tundra and then covering the airstrip with crushed ballast material. The ballast material will be excavated from one or more quarries located to the south of the proposed airstrip.

## 2. Methodology

Samples were collected during a site visit in July 2011. Sixty nine samples of overburden, outcrop, and drill core were collected (Table 1, Figure 1, and Appendix A).

**Table 1. Summary of Samples Collected for ML/ARD Characterization**

| Sample Matrix | Location | # Samples |
|---|---|---|
| Overburden | Proposed airstrip | 28 |
| Outcrop | Proposed quarry | 4 |
| Drill core | Near proposed quarry | 37 |

All samples were selected by Rescan personnel and given a unique identifier supplied by Sabina personnel. Overburden and outcrop samples were bagged immediately while the drill core samples were split with diamond rotary blades and bagged by Sabina personnel. All samples were shipped by Sabina directly to Maxxam Analytics for analysis.

Overburden samples were subsampled from drill core that SRK drilled in 2011 while the ground was still frozen. Typically, the core was sampled whole, over half metre intervals. The intent of the sampling was to collect representative samples from each soil horizon.

PROJECT # 0833-002-06 GIS # BAC-09-001 October-21-11

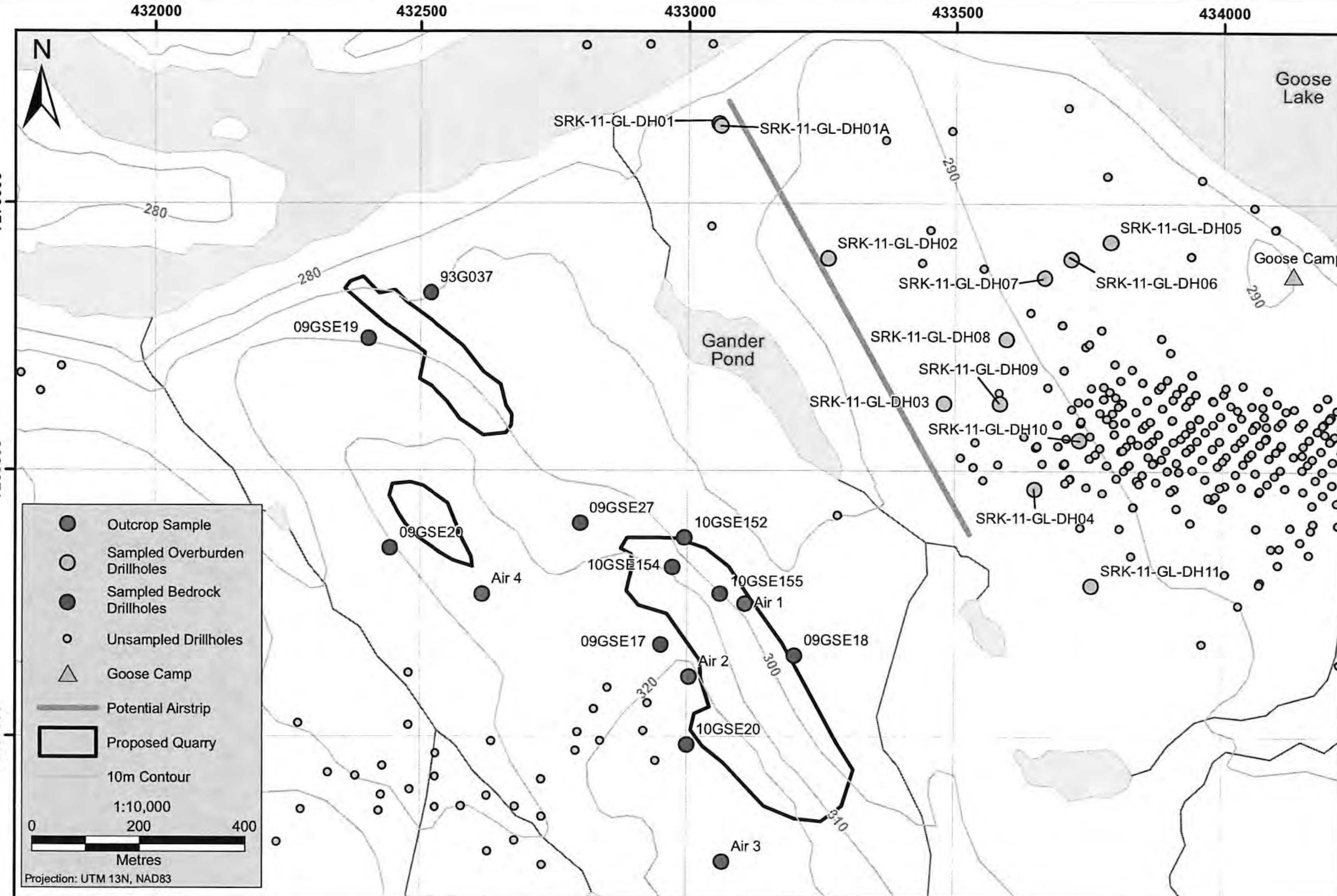



Figure 1

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# ML/ARD Sample Locations

Figure 1

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Outcrop samples were collected from an outcrop south of the airstrip where the airstrip ballast quarry will be located. Three greywacke and one basalt sample was collected. The sample locations were recorded using a Garmin 60CSx GPS unit and are shown in Figure 1.

The core samples were selected from drill holes that were located close to the proposed quarry. Basalt and greywacke were sampled more frequently as they represent most of material that will be used as ballast. Table 2 lists the number of samples collected by rock type. The core samples were each approximately two kilograms. Sabina's sample intervals were used for core that had already been sampled by Sabina (i.e. the interval used the same -to and -from interval as the assay sample). The core samples used half of whatever core was in the core box.

**Table 2. Number of Drill Core Samples Collected by Rock Type**

| Rock Type | # Samples |
|---|---|
| Greywacke | 19 |
| Basalt | 5 |
| Iron Formation | 3 |
| Volcanics | 3 |
| Veins | 3 |
| Mudstone | 3 |
| Overburden | 1 |
| Total | 37 |

## 2.1 ABA Calculations

The neutralization potential (NP) was derived from the standard Sobek method.

*Sulphide-sulphur = total-sulphur - HCl leachable sulphate-sulphur.*

*Sulphide acid potential (SAP) = sulphide-sulphur * 32.35.*

*Sulphide net potential ratio (SNPR) = NP / SAP.*

## 2.2 ABA Criteria

Based on the MEND (2009) prediction manual, commonly applied ABA screening criteria are:

*SNPR <1: Acid generating (PAG)*

*SNPR ≥ 1 and ≤ 2: Uncertain acid generating (uPAG)*

*SNPR > 2: Not acid generating (nPAG)*

The more conservative approach (Price 1997) is to consider material with a SNPR value between 2.0 and 4.0 to be not likely acid generating and material with SNPR greater than 4.0 to be not acid generating.

# 3. Results and Observations

The results of the ABA analyses are presented in Appendix A.

### 3.1 SNPR

A summary of the SNPR calculations are presented in Table 3. The mean SNPR values of all the materials collected are above 4.0. The veins, gabbro and overburden sample types had minimum SNPR values greater than 2.0 and should be considered nPAG.

**Table 3. Summary Statistics of SNPR**

| | Count | Min | Mean | Max |
|---|---|---|---|---|
| All | 69 | 0.24 | 15.45 | 158.14 |
| Overburden | 29 | 5.24 | 19.55 | 130.49 |
| Greywacke | 22 | 0.54 | 15.82 | 158.14 |
| Gabbro | 6 | 2.35 | 12.39 | 44.70 |
| Iron Formation | 3 | 0.24 | 4.26 | 11.75 |
| Mudstone | 3 | 1.48 | 7.60 | 19.69 |
| Volcanics | 3 | 1.07 | 9.31 | 24.83 |
| Veins | 3 | 2.44 | 4.40 | 7.52 |

Figures 2a and 2b display the NP and SAP values of the samples, divided into sample type. The diagonal, dashed lines represent a fixed ratio of NP/SAP or SNPR. Samples to the left of the steepest line have a SNPR ratio greater than 4.0; samples to the right of the shallowest line have a SNPR less than 1.0.

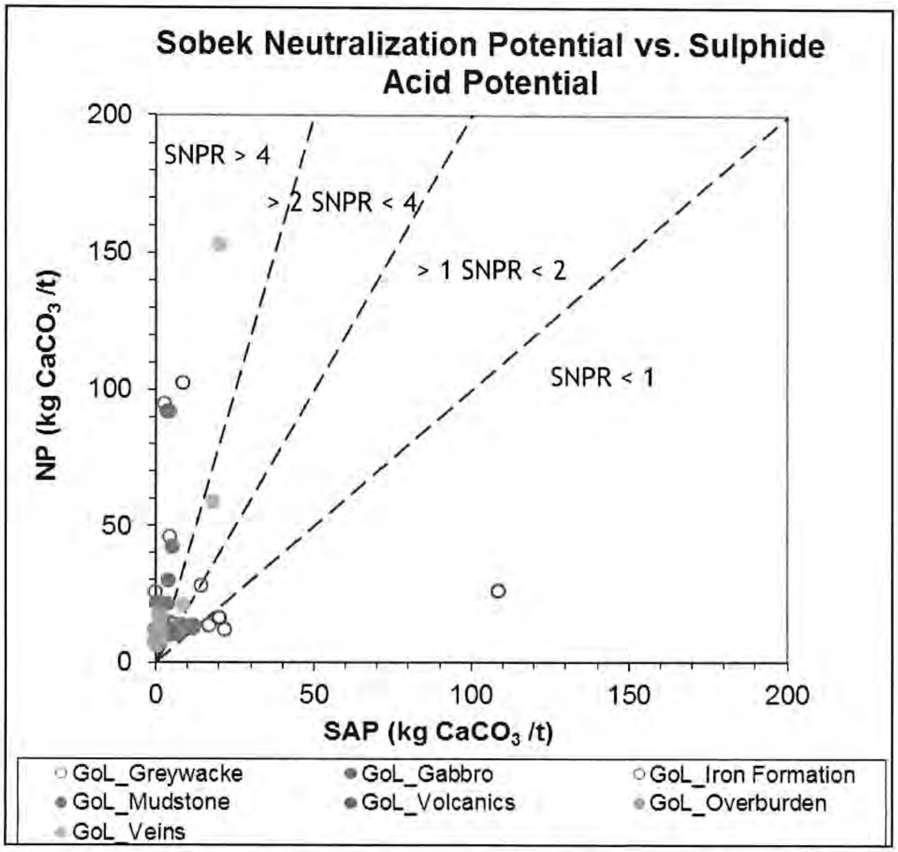


*Figure 2a. Sobek Neutralization Potential versus Sulphide Acid Potential*

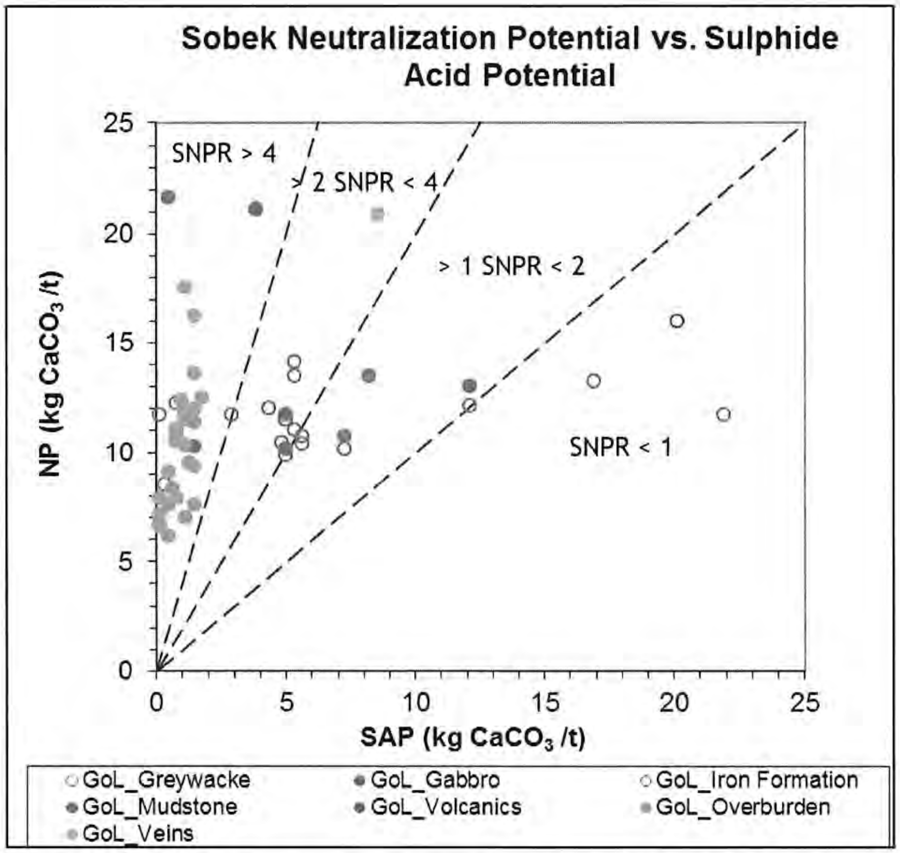


*Figure 2b. Sobek Neutralization Potential versus Sulphide Acid Potential*

### 3.2 Paste pH

A paste pH value of 6.0 or less is the criteria used to determine if a sample is presently acid generating, i.e. its NP is not available to counteract any acid being produced. Overburden is the only material with a paste pH below 6.0 (Figures 3 and 4). The four overburden samples with paste pH less than 6.0 were from the very top of the SRK drill holes from the organic-rich humic layer of the overburden which is characterized by organic acids with little neutralization potential. As a result, the NP value of 9 (kg $CaCO_3$ /t) was not used as the unavailable NP in the overburden.

## 4. Discussion

The summary of the sample types and the material classification is presented in Table 4. The results of the ML/ARD characterization program indicate that the gabbro samples are all nPAG and therefore this material is recommended as the ballast for the airstrip. The greywacke unit only has two samples that are definitely PAG material and the volcanics units have no samples with an SNPR < 1.0. The volcanics and greywacke units could be used as ballast material; however, it would be preferable to place this material in the middle of the landing strip bordered by the nPAG gabbro. This would allow any incidental ARD generated by the volcanics and greywacke to be neutralized by the gabbro.

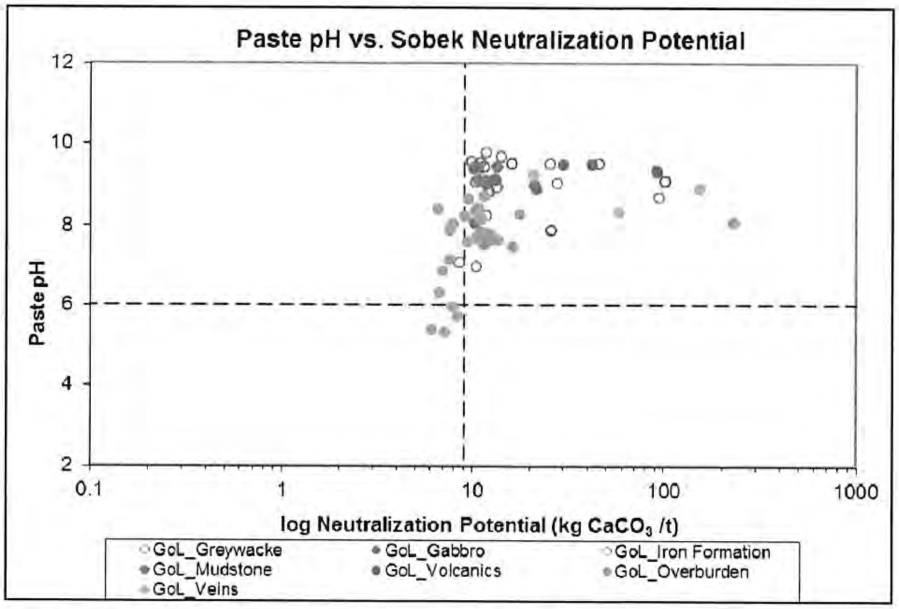


*Figure 3. Paste pH versus Neutralization Potential*

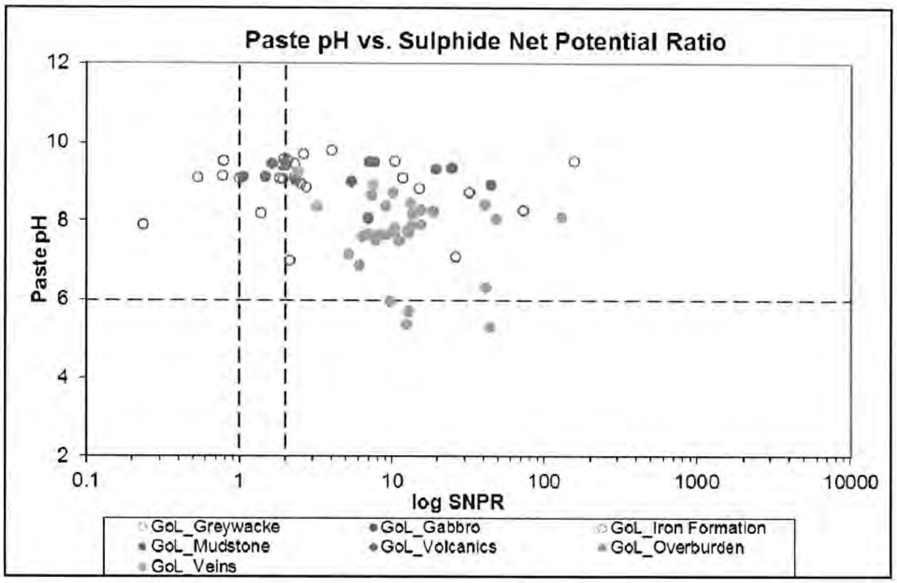


*Figure 4. Paste pH versus Sulphide Net Potential Ratio Illustrating PAG versus nPAG Samples.*

**Table 4. Summary of Sample Types and ABA Criteria with Percentage of Sample nPAG in Parenthesis**

| ABA Criteria | Sample Type (% nPAG) |
|---|---|
| PAG | Iron formation (33%) |
| uPAG | Greywacke (63%), Volcanics (66%), Mudstone (33%) |
| nPAG | Overburden (100%), Gabbro (100%), Veins (100%) |

The iron formation and mudstone should not be used as ballast as they will probably have poor mechanical properties in addition to moderate ML/ARD potential. These units should be backfilled into the quarry pits and covered with less reactive material. The SNPR values could be placed in a 3D visualization program to determine if the low SNPR values are spatially clustered and avoidable during quarrying.

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## References


Price. 1997. DRAFT Guidelines and Recommended Methods for the Prediction of Metal Leaching and Acid Rock Drainage at Minesites in British Columbia Ministry of Employment and Investment.

Price. 2009. Prediction Manual for Drainage Chemistry from Sulphidic Geologic Materials. Prepared for MEND by CANMET, Mining and Mineral Services Laboratories: Smithers, BC

# - Appendix A -

| Sample ID | Hole ID | From | To | Litho_Desc | Comment | Paste pH Unity | Total % | S2_CALC % | $SO_4$_HCl % | S_BaSO4 % | TAP $tCaCO_3$/1000t ore | SAP | NP kg $CaCO_3$/t | Total % | INORG C $CO_2$ % | NPR | SNPR | FIZZ RATING Unity |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 433402 | 09-17 | 19.05 | 21.6 | Greywacke | Airstrip | 9.53 | 0.17 | 0.165 | 0.005 | 0.0009 | 5.313 | 5.156 | 11 | 0.1 | 0.03 | 2.07 | 2.13 | 1 |
| 433403 | 09-17 | 28.9 | 31 | Greywacke | Airstrip | 9.04 | 0.46 | 0.45 | 0.01 | 0.0010 | 14.375 | 14.063 | 27.875 | 0.25 | 0.48 | 1.94 | 1.98 | 2 |
| 433405 | 09-17 | 75.5 | 77.5 | Greywacke | Airstrip | 9.52 | 0.14 | 0.135 | 0.005 | 0.0030 | 4.375 | 4.219 | 46.03581 | 0.11 | 0.41 | 10.52 | 10.91 | 3 |
| 433407 | 09-18 | 11 | 13 | Greywacke | Airstrip | 9.41 | 0.18 | 0.175 | 0.005 | 0.0007 | 5.625 | 5.469 | 10.75 | 0.18 | 0.05 | 1.91 | 1.97 | 1 |
| 433408 | 09-18 | 18.5 | 21 | Greywacke | Airstrip | 9.13 | 0.53 | 0.525 | 0.005 | 0.0011 | 16.563 | 16.406 | 13.25 | 0.54 | 0.17 | 0.80 | 0.81 | 1 |
| 433409 | 09-19 | 20.5 | 22.5 | Greywacke | Airstrip | 9.68 | 0.17 | 0.165 | 0.005 | 0.0010 | 5.313 | 5.156 | 14.125 | 0.11 | 0.27 | 2.66 | 2.74 | 1 |
| 433410 | 09-19 | 39.5 | 41.55 | Greywacke | Airstrip | 9.78 | 0.12 | 0.09 | 0.03 | 0.0044 | 3.750 | 2.813 | 11.75 | 0.09 | 0.16 | 3.13 | 4.18 | 1 |
| 433413 | 09-20 | 20 | 22 | Greywacke | Airstrip | 9.09 | 0.16 | 0.155 | 0.005 | 0.0007 | 5.000 | 4.844 | 11.5 | 0.11 | 0.06 | 2.30 | 2.37 | 1 |
| 433414 | 09-20 | 50 | 52 | Greywacke | Airstrip | 9.56 | 0.16 | 0.155 | 0.005 | 0.0009 | 5.000 | 4.844 | 9.875 | 0.05 | 0.06 | 1.98 | 2.04 | 1 |
| 433418 | 09-27 | 29 | 31 | Greywacke | Airstrip | 9.06 | 0.38 | 0.375 | 0.005 | 0.0010 | 11.875 | 11.719 | 12.125 | 0.03 | 0.07 | 1.02 | 1.03 | 1 |
| 433421 | 93-GO-37 | 9.68 | 12.5 | Greywacke | Airstrip | 8.71 | 0.11 | 0.09 | 0.02 | 0.0020 | 3.438 | 2.813 | 94.62916 | 0.21 | 0.78 | 27.53 | 33.65 | 3 |
| 433424 | 10-20 | 30 | 32 | Greywacke | Airstrip | 9.06 | 0.18 | 0.175 | 0.005 | 0.0006 | 5.625 | 5.469 | 10.375 | 0.11 | 0.11 | 1.84 | 1.90 | 1 |
| 433425 | 10-20 | 60 | 62 | Greywacke | Airstrip | 9.44 | 0.16 | 0.155 | 0.005 | 0.0011 | 5.000 | 4.844 | 11.5 | 0.06 | 0.05 | 2.30 | 2.37 | 1 |
| 433429 | 10-152 | 26.5 | 28.5 | Greywacke | Airstrip | 9.52 | 0.01 | 0.005 | 0.005 | 0.0020 | 0.313 | 0.156 | 25.5 | 0.66 | 0.43 | 81.60 | 163.20 | 2 |
| 433431 | 10-154 | 31 | 33 | Greywacke | Airstrip | 8.18 | 0.23 | 0.225 | 0.005 | 0.0006 | 7.188 | 7.031 | 10.125 | 0.11 | 0.03 | 1.41 | 1.44 | 1 |
| 433432 | 10-154 | 77.5 | 80.5 | Greywacke | Airstrip | 9.09 | 0.69 | 0.68 | 0.01 | 0.0018 | 21.563 | 21.250 | 11.75 | 0.49 | 0.15 | 0.54 | 0.55 | 1 |
| 433434 | 10-155 | 27 | 29 | Greywacke | Airstrip | 8.94 | 0.17 | 0.165 | 0.005 | 0.0006 | 5.313 | 5.156 | 13.5 | 0.13 | 0.03 | 2.54 | 2.62 | 1 |
| 433435 | 10-155 | 30.5 | 33.5 | Greywacke | Airstrip | 8.83 | 0.14 | 0.135 | 0.005 | 0.0008 | 4.375 | 4.219 | 12 | 0.09 | 0.03 | 2.74 | 2.84 | 1 |
| 433436 | 10-155 | 39 | 41 | Greywacke | Airstrip | 8.82 | 0.03 | 0.025 | 0.005 | 0.0011 | 0.938 | 0.781 | 12.25 | 0.04 | 0.16 | 13.07 | 15.68 | 1 |
| 433439 | | 0 | | Greywacke | Airstrip outcrop | 8.26 | 0.01 | 0.005 | 0.005 | 0.0020 | 0.313 | 0.156 | 11.75 | 0.08 | 0.05 | 37.60 | 75.20 | 1 |
| 433441 | | 0 | | Greywacke | Airstrip outcrop | 6.98 | 0.16 | 0.15 | 0.01 | 0.0010 | 5.000 | 4.688 | 10.42714 | 0.12 | 0.02 | 2.09 | 2.22 | 1 |
| 433442 | | 0 | | Greywacke | Airstrip outcrop | 7.07 | 0.03 | 0.01 | 0.02 | 0.0039 | 0.938 | 0.313 | 8.542714 | 0.14 | 0.03 | 9.11 | 27.34 | 1 |
| 433422 | 93-GO-37 | 33.9 | 35.33 | Iron Formation | Airstrip | 9.1 | 0.31 | 0.27 | 0.04 | 0.0052 | 9.688 | 8.438 | 102.3018 | 0.37 | 1.3 | 10.56 | 12.12 | 4 |
| 433430 | 10-152 | 39.3 | 41 | Iron Formation | Airstrip | 7.88 | 3.38 | 3.37 | 0.01 | 0.0002 | 105.625 | 105.313 | 26 | 0.8 | 0.3 | 0.25 | 0.25 | 1 |
| 433433 | 10-154 | 85.5 | 89 | Iron Formation | Airstrip | 9.51 | 0.63 | 0.625 | 0.005 | 0.0002 | 19.688 | 19.531 | 16 | 1.21 | 0.39 | 0.81 | 0.82 | 1 |
| 433416 | 09-20 | 80 | 82 | Mudstone | Airstrip | 9.32 | 0.15 | 0.145 | 0.005 | 0.0011 | 4.688 | 4.531 | 92.07161 | 0.36 | 1.11 | 19.64 | 20.32 | 4 |
| 433419 | 09-27 | 65.65 | 67.1 | Mudstone | Airstrip | 9.11 | 0.23 | 0.225 | 0.005 | 0.0007 | 7.188 | 7.031 | 10.75 | 0.12 | 0.08 | 1.50 | 1.53 | 1 |
| 433427 | 10-20 | 79 | 81 | Mudstone | Airstrip | 9.44 | 0.26 | 0.255 | 0.005 | 0.0011 | 8.125 | 7.969 | 13.5 | 0.07 | 0.16 | 1.66 | 1.69 | 1 |
| 433415 | 09-20 | 63 | 65 | Felsic Dyke | Airstrip | 9.11 | 0.38 | 0.375 | 0.005 | 0.0008 | 11.875 | 11.719 | 13 | 0.04 | 0.04 | 1.09 | 1.11 | 1 |
| 433420 | 09-27 | 157.85 | 160 | Felsic Dyke | Airstrip | 9.35 | 0.12 | 0.115 | 0.005 | 0.0010 | 3.750 | 3.594 | 92.07161 | 0.51 | 1.79 | 24.55 | 25.62 | 4 |
| 433426 | 10-20 | 62 | 64 | Felsic Dyke | Airstrip | 9.41 | 0.16 | 0.155 | 0.005 | 0.0010 | 5.000 | 4.844 | 10.125 | 0.04 | 0.03 | 2.03 | 2.09 | 1 |
| 433411 | 09-19 | 97.6 | 99.15 | Veins | Airstrip | 9.24 | 0.27 | 0.265 | 0.005 | 0.0005 | 8.438 | 8.281 | 20.875 | 0.22 | 0.8 | 2.47 | 2.52 | 1 |
| 433412 | 09-19 | 142.5 | 144.1 | Veins | Airstrip | 8.92 | 0.68 | 0.63 | 0.05 | 0.0002 | 21.250 | 19.688 | 152.8133 | 0.42 | 0.92 | 7.19 | 7.76 | 3 |
| 433428 | 10-152 | 18 | 19.9 | Veins | Airstrip | 8.34 | 0.76 | 0.56 | 0.2 | 0.0002 | 23.750 | 17.500 | 58.5 | 1.71 | 2.61 | 2.46 | 3.34 | 2 |
| 433401 | 09-17 | 8 | 10 | Gabbro | Airstrip | 8.99 | 0.13 | 0.12 | 0.01 | 0.0015 | 4.063 | 3.750 | 21.125 | 0.08 | 0.26 | 5.20 | 5.63 | 2 |
| 433404 | 09-17 | 69 | 71 | Gabbro | Airstrip | 9.48 | 0.22 | 0.13 | 0.09 | 0.0059 | 6.875 | 4.063 | 29.75 | 0.07 | 0.29 | 4.33 | 7.32 | 2 |

**Blue denotes calculated value*

| Sample ID | Hole ID | From | To | Litho_Desc | Comment | Paste pH Unity | Total % | S2_CALC % | $SO_4$_HCl % | S_BaSO4 % | TAP $tCaCO_3/1000t$ ore | SAP | NP kg $CaCO_3/t$ | Total % | INORG C $CO_2$ % | NPR | SNPR | FIZZ RATING Unity |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 433406 | 09-17 | 80 | 82 | Gabbro | Airstrip | 9.48 | 0.18 | 0.17 | 0.01 | 0.0020 | 5.625 | 5.313 | 42.19949 | 0.11 | 0.43 | 7.50 | 7.94 | 4 |
| 433417 | 09-27 | 9 | 11 | Gabbro | Airstrip | 9.01 | 0.16 | 0.155 | 0.005 | 0.0021 | 5.000 | 4.844 | 11.75 | 0.02 | 0.03 | 2.35 | 2.43 | 1 |
| 433437 | 10-155 | 49 | 51 | Gabbro | Airstrip | 8.9 | 0.02 | 0.015 | 0.005 | 0.0003 | 0.625 | 0.469 | 21.625 | 0.01 | 0.09 | 34.60 | 46.13 | 1 |
| 433440 | | 0 | | Gabbro | Airstrip outcrop | 8.05 | 0.05 | 0.045 | 0.005 | 0.0011 | 1.563 | 1.406 | 10.25 | 0.13 | 0.06 | 6.56 | 7.29 | 1 |
| 433423 | 93-GO-37 | 7.85 | 9.68 | Overburden | Airstrip | 8.64 | 0.05 | 0.04 | 0.01 | 0.0015 | 1.563 | 1.250 | 9.5 | 0.11 | 0.05 | 6.08 | 7.60 | 1 |
| B08-108644 | SRK-11-GL-DH008 | 1 | 1.5 | Overburden | SRK overburden | 5.37 | 0.02 | 0.015 | 0.005 | 0.0011 | 0.625 | 0.469 | 6.109726 | 0.81 | 0.04 | 9.78 | 13.03 | 1 |
| B08-108646 | SRK-11-GL-DH008 | 5.5 | 6 | Overburden | SRK overburden | 7.64 | 0.05 | 0.045 | 0.005 | 0.0014 | 1.563 | 1.406 | 13.59102 | 0.08 | 0.28 | 8.70 | 9.66 | 1 |
| B08-108647 | SRK-11-GL-DH008 | 9 | 9.7 | Overburden | SRK overburden | 7.69 | 0.03 | 0.025 | 0.005 | 0.0014 | 0.938 | 0.781 | 10.47382 | 0.08 | 0.23 | 11.17 | 13.41 | 1 |
| B08-108648 | SRK-11-GL-DH008 | 13 | 13.5 | Overburden | SRK overburden | 6.86 | 0.04 | 0.035 | 0.005 | 0.0011 | 1.250 | 1.094 | 6.982544 | 0.12 | 0.05 | 5.59 | 6.38 | 1 |
| B08-108649 | SRK-11-GL-DH008 | 15.5 | 16 | Overburden | SRK overburden | 7.48 | 0.05 | 0.045 | 0.005 | 0.0008 | 1.563 | 1.406 | 16.20948 | 0.09 | 0.06 | 10.37 | 11.53 | 1 |
| B08-108650 | SRK-11-GL-DH005 | 0 | 0.5 | Overburden | SRK overburden | 6.31 | 0.01 | 0.005 | 0.005 | 0.0009 | 0.313 | 0.156 | 6.733167 | 0.43 | 0.04 | 21.55 | 43.09 | 1 |
| B08-108651 | SRK-11-GL-DH005 | 3 | 3.5 | Overburden | SRK overburden | 7.76 | 0.04 | 0.03 | 0.01 | 0.0018 | 1.250 | 0.938 | 12.34414 | 0.11 | 0.26 | 9.88 | 13.17 | 1 |
| B08-108652 | SRK-11-GL-DH005 | 4.5 | 5 | Overburden | SRK overburden | 8.08 | 0.06 | 0.055 | 0.005 | 0.0011 | 1.875 | 1.719 | 231.4578 | 2.86 | 10.6 | 123.44 | 134.67 | 3 |
| B08-108653 | SRK-11-GL-DH004 | 0 | 0.5 | Overburden | SRK overburden | 5.71 | 0.03 | 0.02 | 0.01 | 0.0007 | 0.938 | 0.625 | 8.354115 | 1.71 | 0.24 | 8.91 | 13.37 | 1 |
| B08-108654 | SRK-11-GL-DH004 | 2.5 | 3 | Overburden | SRK overburden | 8.23 | 0.02 | 0.015 | 0.005 | 0.0009 | 0.625 | 0.469 | 9.102244 | 0.07 | 0.18 | 14.56 | 19.42 | 1 |
| B08-108655 | SRK-11-GL-DH004 | 4.5 | 5.3 | Overburden | SRK overburden | 8.27 | 0.04 | 0.035 | 0.005 | 0.0012 | 1.250 | 1.094 | 17.58105 | 0.15 | 0.51 | 14.06 | 16.07 | 1 |
| B08-108656 | SRK-11-GL-DH004 | 12 | 12.5 | Overburden | SRK overburden | 7.14 | 0.05 | 0.045 | 0.005 | 0.0008 | 1.563 | 1.406 | 7.605985 | 0.07 | 0.04 | 4.87 | 5.41 | 1 |
| B08-108657 | SRK-11-GL-DH006 | 4.5 | 5 | Overburden | SRK overburden | 7.65 | 0.06 | 0.055 | 0.005 | 0.0019 | 1.875 | 1.719 | 12.46883 | 0.07 | 0.17 | 6.65 | 7.25 | 1 |
| B08-108658 | SRK-11-GL-DH009 | 0 | 0.5 | Overburden | SRK overburden | 5.31 | 0.01 | 0.005 | 0.005 | 0.0011 | 0.313 | 0.156 | 7.107232 | 0.83 | 0.04 | 22.74 | 45.49 | 1 |
| B08-108659 | SRK-11-GL-DH009 | 6 | 6.5 | Overburden | SRK overburden | 8.17 | 0.03 | 0.025 | 0.005 | 0.0018 | 0.938 | 0.781 | 11.09726 | 0.09 | 0.2 | 11.84 | 14.20 | 1 |
| B08-108660 | SRK-11-GL-DH009 | 11.5 | 12 | Overburden | SRK overburden | 8.35 | 0.04 | 0.035 | 0.005 | 0.0010 | 1.250 | 1.094 | 10.34913 | 0.07 | 0.2 | 8.28 | 9.46 | 1 |
| B08-108661 | SRK-11-GL-DH009 | 13.5 | 14 | Overburden | SRK overburden | 7.62 | 0.05 | 0.045 | 0.005 | 0.0012 | 1.563 | 1.406 | 11.97007 | 0.07 | 0.06 | 7.66 | 8.51 | 1 |
| B08-108662 | SRK-11-GL-DH010 | 7.75 | 8.25 | Overburden | SRK overburden | 8.72 | 0.04 | 0.035 | 0.005 | 0.0012 | 1.250 | 1.094 | 11.47132 | 0.07 | 0.18 | 9.18 | 10.49 | 1 |
| B08-108663 | SRK-11-GL-DH010 | 17 | 17.5 | Overburden | SRK overburden | 8.04 | 0.01 | 0.005 | 0.005 | 0.0009 | 0.313 | 0.156 | 7.855362 | 0.02 | 0.05 | 25.14 | 50.27 | 1 |
| B08-108664 | SRK-11-GL-DH010 | 18 | 18.5 | Overburden | SRK overburden | 8.41 | 0.01 | 0.005 | 0.005 | 0.0008 | 0.313 | 0.156 | 6.608479 | 0.02 | 0.06 | 21.15 | 42.29 | 1 |
| B08-108665 | SRK-11-GL-DH001 | 0 | 0.6 | Overburden | SRK overburden | 5.94 | 0.03 | 0.025 | 0.005 | 0.0013 | 0.938 | 0.781 | 7.855362 | 0.93 | 0.08 | 8.38 | 10.05 | 1 |
| B08-108666 | SRK-11-GL-DH001 | 4 | 4.4 | Overburden | SRK overburden | 7.88 | 0.02 | 0.015 | 0.005 | 0.0008 | 0.625 | 0.469 | 7.605985 | 0.06 | 0.16 | 12.17 | 16.23 | 1 |
| B08-108667 | SRK-11-GL-DH001 | 10.3 | 10.7 | Overburden | SRK overburden | 7.81 | 0.04 | 0.035 | 0.005 | 0.0013 | 1.250 | 1.094 | 11.84539 | 0.07 | 0.19 | 9.48 | 10.83 | 1 |
| B08-108668 | SRK-11-GL-DH001 | 13.7 | 14.3 | Overburden | SRK overburden | 7.59 | 0.05 | 0.045 | 0.005 | 0.0013 | 1.563 | 1.406 | 9.351621 | 0.06 | 0.1 | 5.99 | 6.65 | 1 |
| B08-108669 | SRK-11-GL-DH001 | 15.7 | 16.2 | Overburden | SRK overburden | 7.51 | 0.05 | 0.045 | 0.005 | 0.0012 | 1.563 | 1.406 | 11.34663 | 0.1 | 0.22 | 7.26 | 8.07 | 1 |
| B08-108670 | SRK-11-GL-DH001A | 10 | 10.5 | Overburden | SRK overburden | 7.85 | 0.03 | 0.025 | 0.005 | 0.0008 | 0.938 | 0.781 | 10.97257 | 0.09 | 0.22 | 11.70 | 14.04 | 1 |
| B08-108671 | SRK-11-GL-DH002 | 4.6 | 5.1 | Overburden | SRK overburden | 8.43 | 0.03 | 0.025 | 0.005 | 0.0013 | 0.938 | 0.781 | 10.72319 | 0.05 | 0.17 | 11.44 | 13.73 | 1 |
| B08-108672 | SRK-11-GL-DH007 | 5.5 | 6 | Overburden | SRK overburden | 7.71 | 0.04 | 0.035 | 0.005 | 0.0012 | 1.250 | 1.094 | 11.84539 | 0.07 | 0.18 | 9.48 | 10.83 | 1 |

**Blue denotes calculated value*