Hope Bay
Mining Ltd.

Water and Ore/Waste Rock Management Plan for the Boston Site Hope Bay Project, Nunavut

Prepared for:

Hope Bay Mining Ltd.

Prepared by:

SRK Consulting
Engineers and Scientists

Project Reference Number
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Water and Ore/Waste Rock Management Plan for the Boston Site, Hope Bay Project, Nunavut

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Executive Summary

Ore and waste rock were generated as part of a 1996/1997 BHP Billiton underground exploration program at the Boston deposit. The waste rock was used to construct a camp pad, roads, and an airstrip at the Boston site. Ore was placed in stockpiles on the camp pad. As a condition of Water Licence 2BB BOS0112 (Part E, Item 8), Hope Bay Mining Ltd. (HBML) is required to develop a water and ore/waste rock management plan that addresses the ARD and metal leaching potential of the materials at the site (NWB 2007). This requirement is outstanding from the previous owners, Miramar Mining. After HBML assumed ownership of the property in 2008, SRK was hired to conduct the necessary geochemistry re-evaluation at Boston and develop this plan to fulfill the requirement.

The primary objectives of the water and ore/waste rock management plan are to document the current status and conditions at the site, and to present ongoing water and materials management, closure plans and verification and monitoring plans for these materials. The plan is intended primarily for use by HBML and its contractors to ensure that appropriate management procedures are followed and that the information needed to support final closure of the site is collected.

Current Site Conditions

The main components at the site are the mine portal, camp pad, ore stockpiles, airstrip and roads. The camp pad, airstrip and roads are comprised primarily of waste rock. Approximately half of the ore extracted during the exploration programs remains in place. The remainder was used by Miramar to construct a new tank farm and as surfacing material for the camp pad, roads and airstrip.

The main geochemical issue associated with the ore and waste rock is the potential for leaching of metals under neutral pH conditions. Monitoring has demonstrated that seepage immediately down-gradient of the camp pad and ore stockpiles has elevated concentrations of sulphate, chloride, arsenic, nickel and selenium. However, prior to reaching the shoreline of the lake, concentrations of these metals are substantially lower, indicating that there is considerable attenuation as these flows pass over the tundra.

A water and load balance was developed to predict concentrations in the ephemeral streams down-gradient of the site, in the small inlet east of the site (East Bay) below the Stickleback Lake outlet, and in the main part of Aimaokatalok (Spyder) Lake. The results indicate that under base case assumptions, concentrations in the ephemeral streams may exceed CCME water quality guidelines, but that by the time these flows are allowed to mix with other inflows into East Bay, they will be below the guidelines, and by the time they mix with the main part of Aimaokatalok Lake, they will be very close to background levels. Under worst case assumptions, there is some potential for concentrations above the CCME guidelines. Therefore, the closure plans for the site should consider some efforts to reduce the amount of seepage from the ore stockpiles.

Management Plans

There are currently no plans to excavate additional waste rock or ore from Boston. Therefore the scope of materials management is limited to the existing waste rock and ore stored on site. Ongoing management of these materials will limit further use of ore as a construction material and will limit the expansion of the camp pad. If rock is required for maintenance or construction activities, it will be obtained from the waste rock pad. Further mine development is under evaluation. If further underground exploration or mine development are considered, this plan will be updated at that time to reflect the change.

Seepage and runoff are not currently having an impact on the downstream environment. Therefore, they will continue to be allowed to discharge directly to the tundra. Areas that collect runoff will be periodically pumped onto the tundra. Monitoring will continue to provide a tool to detect changes in runoff quality.

Closure Plans

If a processing facility is developed within the Hope Bay Project site, HBML intends to consolidate the ore, and haul it to that facility for processing. Alternatively, the ore will be consolidated, resloped and then covered with either a 0.3 metre thick cover of waste rock to promote runoff and reduce seepage, a 1.5 metre thick cover of waste rock to promote freezing within the stockpile, or an HDPE liner to substantially reduce seepage through the ore and minimize oxidation of the sulphides. Seepage monitoring will be continued throughout operations and the results of this work will be used to make the final decision on which type of cover to use.

Monitoring and Verification Plans

Monitoring will include rinse pH and conductivity surveys every 10 years to assess whether there are any locally acidic conditions developing in the piles, seepage monitoring, discharge monitoring, and ephemeral stream monitoring.

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Supporting Documents

Supporting Document A:	Geochemical Characterization of Historic Waste Rock and Ore Stockpiles at the Boston Deposit, Hope Bay Project, Nunavut (DRAFT)
Supporting Document B:	Water and Load Balance
Supporting Document C:	Closure Options

1 Introduction

Ore and waste rock were generated as part of a 1996/1997 BHP Billiton underground exploration program at the Boston deposit. The waste rock was used to construct a camp pad, roads, and an airstrip at the Boston site. Ore was placed in stockpiles on the camp pad. As a condition of Water Licence 2BB-BOS0112 (Part E, Item 8), Hope Bay Mining Ltd. (HBML) is required to develop a water and ore/waste rock management plan that addresses the ARD and metal leaching potential of the materials at the site (NWB 2007). This requirement is outstanding from the previous owners, Miramar Mining. After HBML assumed ownership of the property in 2008, SRK was hired to conduct the necessary geochemistry re-evaluation at Boston and develop this plan to fulfill the requirement.

Although there was extensive geochemical characterization of this material during the 1996/1997 exploration program, several years had passed since that work had been completed, and it was felt that some additional information on the current condition, particularly with respect to seepage quality, would be needed to develop a meaningful plan. In June 2008, HBML retained SRK to complete a geochemical assessment in support of developing a water and ore/waste management plan. Data from previous investigations were reviewed, and in August 2008, two geochemists from SRK visited the site to inspect the ore and waste rock and to collect seepage and rock samples for laboratory testing. The samples were submitted for water quality analyses, ABA tests, elemental analyses, and shake flask extraction tests. A report presenting the findings of this study was recently prepared and issued to HBML (Supporting Document A). SRK have now been asked to develop the water and ore/waste rock management plan.

HBML does not currently have any plans for underground exploration or development activities at Boston. Therefore, the primary objectives of this plan are to document the current status and conditions at the site, and to present ongoing water and materials management, closure plans and verification and monitoring plans for these materials. The plan meets two needs, one is to fulfill requirement Part E, Item 8 in the water licence, and second and perhaps most important is for use by HBML and its contractors to ensure that appropriate management procedures are followed and that the information needed to support final closure of the site is collected.

The Boston ore body is currently part of the feasibility analysis being conducted by HBML on potential development of the Hope Bay Greenstone Belt. Any plans to either re-open the Boston underground for further exploration or to place Boston into a proposed mine plan will require an appropriate revision of this plan at the time.

2 Background Information

2.1 Site History

A brief summary of the site history is listed in Table 2.1.

Table 2.1: Summary of Pertinent Site Ownership History

Period	Comment
1964	Sporadic exploration in the Hope Bay area begins, resulting in several gold and silver showings including Ida Point, Ida Bay and Roberts Lake.
1970	Roberts Bay Mining explores the area for about a decade up to 1980.
1977	Noranda begins exploring for volcanogenic massive sulphide deposits. They leave the belt in 1990. Prior to 1980, Roberts Bay Mining also explored the area.
1987	Albermin Corporation stake claims in the vicinity of Aimaokatalok (Spyder) and Doris Lakes. After completing some exploration they allow their claims to expire.
1988	BHP Minerals Canada Inc. (BHP) explores the southern portion of Hope Bay Volcanic Belt.
1991	BHP acquires a contiguous block of claims covering about 1,106 square kilometres.
1992	BHP commences exploration drilling at the Boston property.
1993	The first camp is constructed on the southwest shores of Aimaokatalok Lake by BHP.
1994	Construction of 35 person camp at Stickleback Lake. The camp is dismantled and moved to the current site.
1996 and 1997	BHP complete 2,300 m of underground development, underground exploration (drilling and sampling) and bulk sampling of the Boston deposit.
1999	BHP sells all its interests in the Hope Bay Belt to Hope Bay Joint Venture (HBJV), a 50:50 joint venture between Hope Bay Gold Corporation Inc. (formerly Cambiex Exploration Inc.), and Miramar Hope Bay Limited (MHBL), a wholly owned subsidiary of Miramar Mining Corporation (MMC).
2002	Hope Bay Gold Corporation Inc. formerly merges with MMC, and the Hope Bay site is operated under MHBL.
2008	Hope Bay Mining Limited (HBML), a wholly owned subsidiary of Newmont Mining Corporation (NMC) buys out all interests in the Hope Bay Belt from MMC.

2.2 Development History

The underground development and bulk sample program was conducted over a two year period between April 1996 and November 1997 (BHP 1998). Five separate cross-cuts were established off an access decline to give access to the B2 and B3 ore horizons. Drifts were also established to follow veins horizontally and raises were developed to follow veins vertically. Each blast round of the ore from cross-cuts, drifts and raises was processed through an on-site crusher, and was then stockpiled separately on the surface pad. Stockpiles were then surveyed and tagged according to blast round ID, and sampled for detailed analysis of grade, recovery and metallurgical characteristics.

During this program, a total of 105,400 tonnes of waste rock and 26,760 tonnes of ore were mined and brought to surface. Waste rock generated from the operation was used to construct roadways, the airstrip, the camp pad, as well as the pad on which the ore is stored. Ore remained stockpiled.

2.3 Historical Waste Management Practices

Sometime after the underground development was complete and BHP Billiton had sold it's interest in the property (likely between 2001 and 2007), some of the material from the ore stockpiles was used as top dressing for the roads, airstrip and camp base as well as for construction of the tank farm base and berms. SRK understands that the use of ore material for construction purposes was first formally documented in 2007 during a geotechnical site inspection of the airstrip (SRK 2008). At this time it was confirmed by site staff that ore stockpile material had been used for repairs in previous years as well. Observations during the 2008 geochemical investigation program also found that ore had been used as surface dressing over the majority of the site.

Aerial photos taken in August 2008 (Figure 2.1) and in the summer of 2000 (Figure 2.2) as well as maps showing the original configuration of the ore stockpiles (Figure 2.3), illustrate the change in stockpiles configuration compared to previous years. A detailed inventory of the ore stockpile area in 2008 indicated the absent stockpiles were mostly ore material from the 1997 campaign (Supporting Document A). Volumetric calculations indicate that almost half of ore may have been redistributed to other locations on the site. A substantial portion of this material was used in the construction of the tank berm and the remainder has been used as surfacing material.

Under HBML's ownership, use of material from the ore stockpiles has been stopped.

2.4 Current Site Configuration

The current site configuration is shown in Figure 2.4. The relative areas of each of the site components are shown in Table 2.2.

The site is situated on a ridge which comprises a peninsula extending northwards into Aimaokatalok (Spyder) Lake, as illustrated on Figure 2.4. The main camp pad spans about 325 m from north to south, and 150 m east to west and was constructed using waste rock from the underground development. The camp pad ranges in thickness from 0.6 m to 3 m and slopes generally north at a gradient of about 1%. The majority of the facilities, including the camp and office facilities, industrial site and laydown areas, and ore stockpiles are located on the camp pad. Roads provide access from the camp to an airstrip located south of camp, and from the camp to a boat ramp located northwest of the site. The roads and airstrip were also constructed using waste rock.

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Boston Ore and Waste Rock Management Plan

Aerial Photo of Boston Camp Ore Piles, August 2008

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Filename:	Figure 2.1_20090722.ppt				

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Aerial Photograph of
Boston Camp, Summer 2000 (HBJV 2001)

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Filename: Figure 2.2_20090722.ppt

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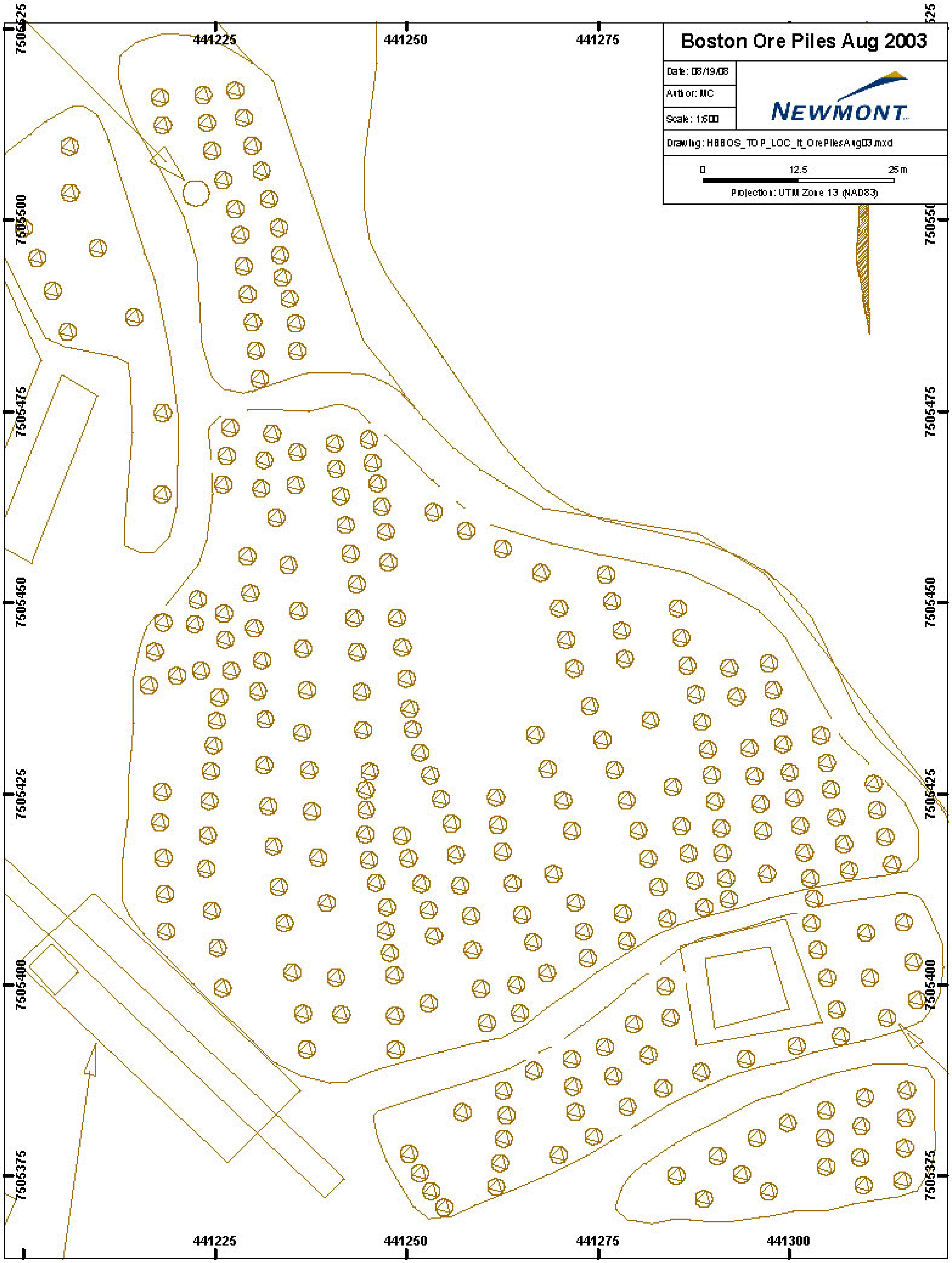
Date: July 2009
Approved:
Figure: 2.2



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Map of Previous Ore Stockpile Configuration

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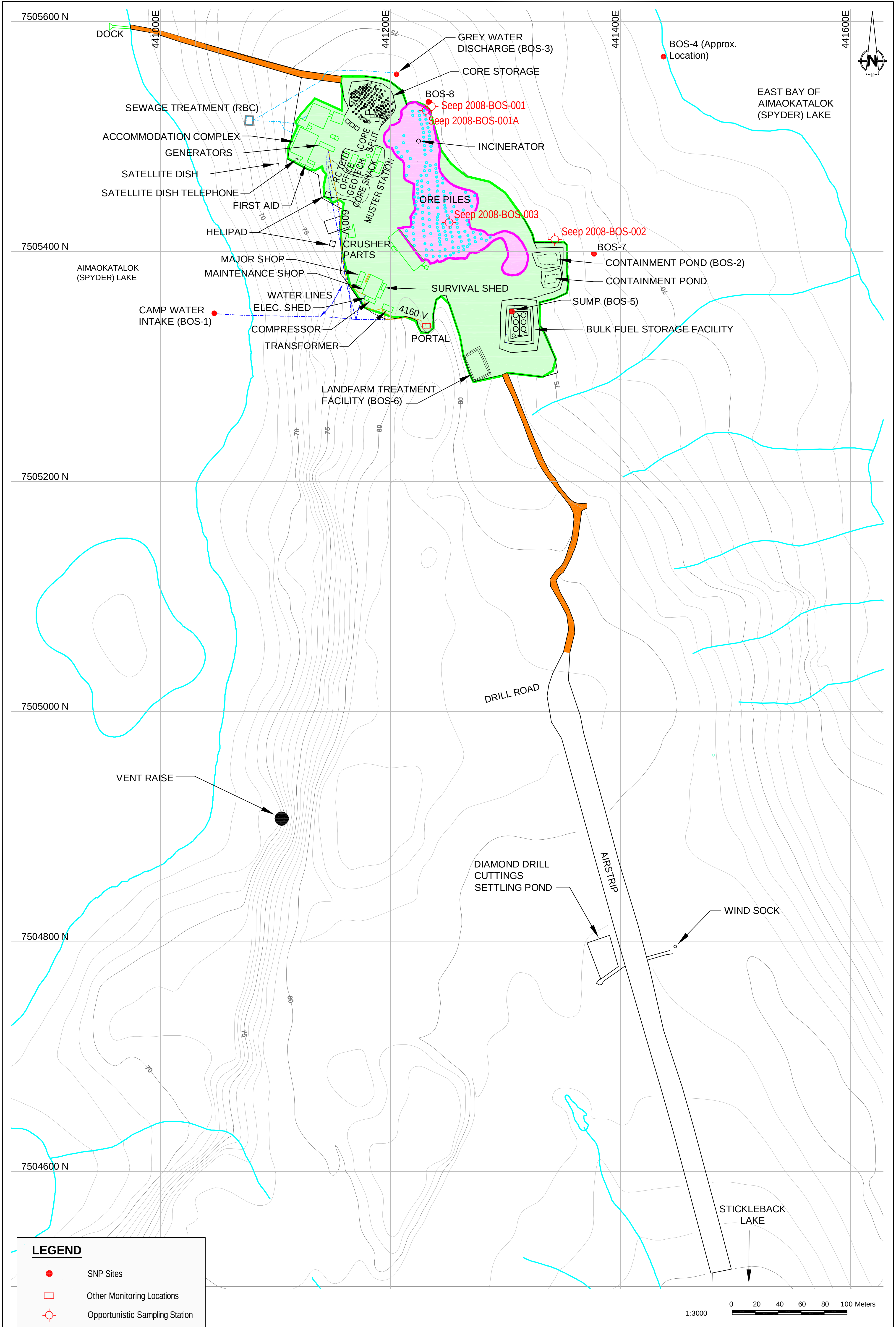

LEGEND

●	SNP Sites
▭	Other Monitoring Locations
⌖	Opportunistic Sampling Station
▬	Roads
▭	Airstrip
🟩	Pad, Camp and Industrial sites
🟪	Ore Stockpile

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Boston Ore and Waste Rock Management Plan

Current Site Layout and Water Quality Monitoring Site

DATE:	APPROVED:	FIGURE:
July 2009	–	2.4

Table 2.2: Surface Areas of Boston Site Components

Site Component	Area (m2)
Camp and Industrial Areas	26,700
Ore Stockpiles	6,800
Airstrip	15,600
Roads	4,700
Total	53,800

2.5 Geochemical Characteristics of Ore and Waste Rock

There have been a number of historical field and laboratory testing programs to characterize the geochemistry of the ore and waste rock at Boston, as documented in Rescan 1999, Rescan 2001a, and Rescan 2001b. A more recent field and laboratory investigation to assess the current status of this material was completed by SRK in 2008. A detailed summary of the historical results and results from the 2008 investigation are presented in Supporting Document A. In brief, the results of these studies indicate that all of the waste rock and the majority of the ore is non-acid generating and that a small proportion of the ore has an uncertain potential for acid rock drainage (ARD). However, even if localized ARD were to develop in the ore stockpiles, the presence of non-acid generating waste rock in the underlying pad is expected to maintain neutral pH conditions. Although pH conditions are expected to remain neutral, seepage monitoring indicates that concentrations of arsenic, and to a lesser extent, nickel and selenium may be somewhat elevated in comparison to CCME guidelines for aquatic life.

2.6 Historical Reclamation Plans

Throughout the development of this site, plans have been in place for closure and reclamation of the ore and waste rock. These were developed at a conceptual level on the basis of the information and opportunities available at the time they were proposed, and some of them may no longer be applicable given the current understanding of the site. The earlier plans are summarized in Table 2.3. Section 4 of this report presents an assessment of the current closure options that are currently under consideration for this site.

2.7 Current Monitoring Activities

Current monitoring activities are outlined in Water Licence 2BB-BOS0112. These include water quality monitoring and annual geotechnical inspections. Table 2.4 and Figure 2.4 document the routine water quality stations that contribute information on the interaction between waste rock/ore and surface water.

Table 2.3: Summary of Previous Closure and Reclamation Plans

Date	Document	Assumptions	Closure Plans
March 1995	Bulk sampling application (Rescan 1995)	Rock assumed to be non-PAG on the basis of limited test data. A precautionary approach was followed.	Stockpiled materials and 70% of the camp pad and road material were to be backfilled into the workings. The balance of the material was to be re-sloped to resemble an esker.
July 1997	Abandonment and Restoration Plan (Rescan 1997)	Rock classified as non-PAG on the basis of a more robust dataset.	Stockpiles were to be re-contoured so as to not inhibit wildlife. They were expected to provide relief to the terrain and wildlife habitat.
September 1998	Abandonment and Restoration Plan (Rescan 1998)	As above.	As above, with the clarification that the ore stockpiles would be re-contoured.
October 2000	Estimate for Bonding Agreement (Golder 2000)	Unclear assumptions with respect to ARD potential. Other documents from this time period indicate there was greater awareness of the potential for metal leaching.	Ore stockpiles were to be re-contoured and covered with waste rock to facilitate permafrost development.
May 2001	Revised Abandonment and Restoration Plan (HBJV 2001).	Rock classified as having low acid generation potential.	If not processed, the ore was to be re-contoured or placed underground. Further monitoring was recommended to provide a basis for this decision.
December 2006	Boston Exploration Camp Closure and Reclamation Plan (MHBL 2006)	Considered chemically stable on the basis of ongoing runoff monitoring since the mid-1990's.	Stockpiles were to be regarded and levelled to promote runoff. Some material was to be used to seal the underground workings.
September 2007	Closure and Reclamation Plan for the Boston Advanced Exploration Project (MHBL 2007)	Ore stockpiles considered to be a valuable resource. Waste rock considered non acid generating.	Ore was to be transported to Doris for processing. Waste rock was to be used to backfill the underground decline.

Table 2.4: Routine Monitoring Stations for Discharges and Seepages from Boston Camp

Monitoring Station	Discharge Source	Description	Relevance for Ore and Waste Rock Management
BOS-2 (N67º39.489'/ W106 º 2.970')	Containment pond discharge	Ponds were originally designed to accommodate excess water from the underground. One pond is lined and is used to hold surface water only. The other pond is unlined and is presently used to temporarily hold non-hazardous solid waste materials pending packaging for offsite disposal. Water discharge, as required, is onto tundra east of the ponds and only after fulfilling specific discharge criteria. Monitoring is performed prior to discharge only. Under the current site activities, this pond is not used on a regular basis and is therefore not monitored on a regular basis.	Sources of water reporting to this location are not well documented but it is assumed that these may include runoff from the camp pad or water accumulating in the fuel containment area and may therefore reflect water quality associated with runoff from the ore and waste rock.
BOS-5 (N67 º39.458'/ W106 23.020')	Bulk fuel storage facility	Discharge, as required, is pumped to the lined containment pond (BOS-2), sampled and released only after fulfilling specific discharge criteria. Monitoring is performed prior to discharge only. Water is pumped in the spring and after any major rainfall.	This water interacts with the crushed ore used to protect the liner and therefore provides an indication of water quality associated with the ore.
BOS-7 (N67 º39.476', W106 º 2.955')	Landfill leachate	The landfill originally proposed for this site was never constructed due to concerns raised by the Kitikmeot Inuit Association (KIA). However, the unlined containment pond is temporary storage of non-hazardous wastes. BOS-7 is now used to monitor seepage from the temporary storage area.	Seepage emerging from this area may also interact with ore and waste rock, it also provides an indication of water quality from those materials.
BOS-8 (N67 º 39.554', W106 º 3.128')	Ore stockpiles	Monitoring of seepage from the ore stockpiles and camp pad. Monitored on the tundra to the east of the ore stockpiles.	This station has always been intended primarily to provide an indication of water quality from the ore and waste stockpiles.
N/A	Portal decline	Surface water is pumped, as required, onto tundra west of portal and only after fulfilling specific discharge criteria. Monitoring performed prior to discharge only. Pumping typically occurs once in the spring, and maybe more if the camp is active.	Water accumulating at the portal consists of runoff from the camp pad. Therefore this station provides an indication of water quality from waste rock in the camp pad.

2.8 Assessment of Potential Impacts to Receiving Environment

The majority of the seepage and runoff from the camp pad flow along poorly defined drainages or ephemeral streams into the small inlet at the mouth of the Stickleback/Fickleduck drainage east of the camp (referred to as East Bay) and eventually into the main part of Aimaokatalok Lake. A small component of the seepage flows directly into Aimaokatalok Lake. Flows from the airstrip report to East Bay or to Stickleback Lake and then East Bay. A water and load balance was developed to assess the potential impacts of seepage from the camp pad at key locations downstream of the site. Details of the model and results are provided in Supporting Document B.

The modelling results are summarized as follows:

- Predicted concentrations of nitrate, nitrite, arsenic, copper, iron, nickel and selenium exceeded the CCME water quality guidelines for the protection of aquatic life in the ephemeral streams. However, due to limited flows and lack of channel characteristics in these small catchments, these ephemeral streams are not considered to be aquatic habitats and the CCME guidelines are not directly applicable.
- Predicted concentrations of all modelled parameters were below CCME guidelines in East Bay. Concentrations of most parameters were estimated to be an order of magnitude below their respective CCME guideline, with the exceptions of arsenic and nickel. These parameters were predicted to be close to the CCME guidelines and are sensitive to the assumptions of source concentrations and contributing areas. Sensitivity analyses to evaluate the potential effects of higher source concentrations indicate that concentrations of arsenic could exceed the CCME guidelines for aquatic life in East Bay if more conservative source concentrations are used in the assessment. Similarly, sensitivity analyses show that concentrations of arsenic and nickel could exceed CCME guidelines in East Bay if loadings from the airstrip are considered in the assessment.
- Predicted concentrations for all parameters were close to background levels in the main part of Aimaokatalok Lake due to the very large inflows to this lake from the Aimaokatalok River.

Recent sampling of ephemeral streams down-gradient of the site (Attachment 1 of Supporting Document C) indicate that metal concentrations are all very low, suggesting that there is considerable attenuation of these parameters occurring along the flow paths in the tundra. Concentrations of sulphate and chloride were within the range predicted by the dilution model indicating that the model is valid for parameters that are less strongly affected by attenuation processes. Over time, the effectiveness of the attenuation processes may diminish, resulting in increased concentrations in the ephemeral streams. The timing of breakthrough will be difficult to establish through predictive modelling. Therefore ongoing monitoring of both source and downstream concentrations is recommended.

The sensitivity analyses suggest that some additional efforts to reduce the amount of seepage from the ore stockpiles would help to ensure that water quality in East Bay is not affected over the longer term.

3 Proposed Management Plans for Ongoing Exploration Phase

3.1 Materials Management

There are currently no plans to excavate additional waste rock or ore from Boston. As a result, the scope of materials management is limited to the existing camp pad, roads, airstrip and ore stockpiles. The objective of the materials management is to maintain the surface facilities and to minimize the footprint of the site and the ore stockpiles. Accordingly, ore is not to be used as construction material, as already mandated by HBML, and the camp pad is not to be extended beyond its current configuration unless clean rock is available for the construction. If additional materials are required for repairs or minor construction projects, excavation of existing waste rock from the camp pad may be used.

If further expansion of the pad or additional materials are required to support future activities at this site, the waste rock management plan will be modified accordingly.

3.2 Water Management

3.2.1 Current Procedures

Water sources to the Boston camp include natural precipitation (rain and snow) and raw water sourced from Aimaokatalok Lake during periods of camp activity. Aimaokatalok Lake water is used for camp operations (e.g. drinking water, kitchen, etc.) and is discharged via the sewage treatment plant at SNP station BOS-3. Natural precipitation interacts with waste rock and ore and flows to the tundra either as runoff from the surface of the pile or as seepage that has infiltrated through ore and waste rock in the stockpiles and underlying pad. Flowing seeps have been located at a few locations on the east side of the camp (Figure 2.4).

A small portion of the runoff is allowed to accumulate in containment ponds or other low areas on site. These are infrequently pumped and discharged onto the tundra. These active discharges have been documented from the following sites:

- Containment ponds (BOS-2);
- Bulk fuel storage sump (BOS-5)[1];
- Landfarm (BOS-6);
- Portal to the underground;

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[1] Water is pumped to the lined containment pond (BOS-2) prior to discharge.

- Area adjacent to the helicopter pad, just south of the camp complex[2]; and
- Area between geology offices and core shack.

Water accumulating in these areas is typically monitored prior to discharge.

3.2.2 Proposed Modifications

Seepage, runoff and direct discharges from the camp pad are not having an impact on the downstream environment (Supporting Document C). Therefore, there is no need to change any of the current management procedures. However, HBML intends to more clearly document the criteria and procedures used to initiate active pumping and discharges. In addition, HBML will start to record the frequency, duration and volume of water that is actively discharged at each of these locations.

If seepage concentrations increase, the need to implement further measures to control the amount of seepage or seepage concentrations will be considered. The decision to implement further controls will depend on the results of the ephemeral stream monitoring that has recently been implemented to assess water quality downgradient of the site (Section 5). If metal concentrations downgradient of the site continue to be very low, indicating that metals are continuing to be strongly attenuated, it may be possible to delay the implementation of further controls until HBML is ready to process this material or to implement final closure measures for the site. If breakthrough of the more mobile metals starts to occur, then interim seepage controls will be implemented.

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[2] It is anticipated that the helicopter pad area will be filled in to prevent the pooling of water and active pumping will no longer be required.

4 Closure Plans

As discussed in Section 2.8, the site is currently not having an impact on water quality in the East Bay or the main part of Aimaokatalok Lake. However, if arsenic concentrations increase, or if the ore used as surfacing material on the airstrip results in seepage concentrations that are similar in character to those currently discharging from the ore stockpiles, there is some potential for impacts to East Bay. Therefore, closure measures planned for this site should incorporate features that would reduce the amount of arsenic loadings from the site.

An assessment of potential closure options for the ore and waste rock at this site is presented in Supporting Document C. The assessment considered a wide range of potential closure options and the relative advantages and disadvantages of each. On the basis of this assessment several options were eliminated from further consideration either because they would not provide an adequate reduction in loading, or because of technical limitations. Options that were identified as worthy of further consideration are described as follows:

- Consolidation and processing of the ore to recover the gold and disposal of the tailings into an approved facility.
- Consolidation of ore, re-sloping of the ore stockpiles, and covering the stockpiles with 0.3 metres of waste rock to reduce the footprint, promote runoff, and to isolate the ore from surface receptors.
- Consolidation of ore, re-sloping of the ore stockpiles and covering the stockpiles with a 1.5 metre thermal cover to promote freezing.
- Consolidation of ore, re-sloping of the ore stockpiles, and placement of an HDPE or bitumen cover with 0.3 metres of waste rock to protect the liner.

Consolidation of the ore is common to all of these options. Ore that has been used for surfacing would be scraped from the pad and relocated to the ore stockpile area. The stockpiles would be consolidated to 2/3 of the original area and re-sloped to promote runoff. The removal of ore from the rest of the camp pad is expected to substantially reduce the potential for metal leaching. If an opportunity to process this material arises, consolidation would also ensure that the ore is accessible during a winter road hauling campaign. Reduction of the footprint would also make it more feasible to install covers which would further reduce the loading.

Processing of the ore was proposed in the most recent closure plan (MHBL 2007). At the time, plans were in place to develop an underground mine at the Doris deposit. The Boston ore would have been hauled to the Doris site for processing and tailings disposal. HBML is currently advancing alternative development plans for the site. The 26,760 tonne ore stockpiles contain approximately 13,000 to 17,000 ounces of gold, and based on $800/oz are worth approximately 10 to 13 million dollars versus potential haul costs of 2.2 million dollars, processing costs of approximately 0.7 million and some loss due to processing inefficiencies. Therefore, if a processing facility is developed within the Hope Bay Project site, it is likely that the ore would be removed from the site and processed.

If an opportunity to process the ore does not arise, the material would be closed in-situ with a cover to reduce metal loadings. There are a number of different types of covers that could be implemented at this site. The performance of these covers would be expected to differ substantially. The simple waste rock cover is unlikely to reduce loading substantially but would eliminate any risks associated with exposure of this material to terrestrial receptors. Both the thermal cover and the geo-synthetic cover would provide substantial reduction in loading, but are more costly and difficult to implement. Further monitoring of the seepage should provide improved confidence in the estimates of metal loading that could be occurring from this site and therefore the types of covers that would be required to reduce the metal loading to acceptable levels.

In summary, the closure plan for the ore and waste rock components of the Boston site should include consolidation of ore that was used a surfacing material at the site into the main ore stockpile area. If an opportunity arises, the ore would be removed from site and processed. Otherwise, the ore stockpiles would be re-sloped and covered in place. The type of cover has not been determined, but could range from a simple waste rock cover to a thermal cover or geo-synthetic.

Remaining areas on the camp pad and airstrip would be graded to promote runoff and to ensure wildlife access.

5 Verification and Monitoring Plans

5.1 Monitoring of Solids

Geochemical characterization of waste rock and ore materials has indicated that all waste rock and most of the ore is non-acid generating (Supporting Document A). Some of the ore was classified as having an uncertain potential for ARD. To monitor the oxidation of the ore, a survey of rinse pH and conductivity will be completed every ten years. The inspection and monitoring will be conducted by a professional geochemist and would include ore in the stockpiles, and any other area that was originally constructed of waste rock but now contains ore (e.g. camp pad surface, berms, roads and airstrip). Materials will be identified as ore based on high visual sulphide levels and presence of quartz.

The last rinse pH and conductivity survey was conducted in 2008 (Supporting Document A), although the berm for the fuel tank storage was not inspected or sampled at this time. The berm and other facilities not sampled in 2008 will be inspected in 2009 or 2010 for the presence of sulphides, and if present then a sample obtained. The next comprehensive rinse pH survey will be conducted in 2018. Ore stockpiles characterized in the 2008 would be selected for the survey (Figure 5.1) to allow direct comparison of the results.

5.2 Water Quality Monitoring

The following verification and monitoring activities will be completed in addition to all water quality sampling outlined in Water Licence 2BB-BOS0112 (e.g. BOS-1 through BOS-8).

5.2.1 Seepage

Seepage monitoring provides data for the source concentrations from the waste rock and ore. According to Water Licence 2BB-BOS0112, sampling of water quality station BOS-8, and any opportunistic seeps, is required initially during spring thaw and at a minimum frequency of monthly whenever flow is observed (NWB 2007). BOS-7 will also be sampled at the same frequency because this station also monitors seepage from the ore stockpiles and camp pad (Section 2.6). The seep survey will include the north and east sides of the camp pad, and the southern end of the airstrip. Locations of the current SNP seepage monitoring stations and other seeps that have been detected in previous surveys are shown in Figure 2.4.

5.2.2 Discharges

The permit outlines protocol and discharge criteria for water that is pumped from various camp facilities onto the tundra (e.g. BOS-2 or containment pond). HBML will also monitor other areas that collect appreciable amounts of water but that are not specifically included in the permit, such as the entrance of the underground workings, and the water that collects adjacent to the helicopter pad.

5.2.3 Streams

Ephemeral streams in the catchment of the Boston camp (ES-A through ES-E) will be monitored to establish the degree of the natural attenuation of the tundra (Figure 5.2). The monitoring will be completed during freshet and in the late summer.

Depending on the results of the seepage survey at the southern end of the airstrip, HBML may also monitor the area down-gradient of the airstrip. Monitoring could be within the stream draining the southern end of the airstrip to Stickleback Lake or within Stickleback Lake itself.

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Boston Ore and Waste Rock Management Plan

Ore Stockpiles Recommended for Solids Monitoring Program

SRK JOB NO.:	1CH008.022
FILE NAME:	Boston_Seepage Sampling.dwg

Hope Bay Project

DATE:	APPROVED:	FIGURE:
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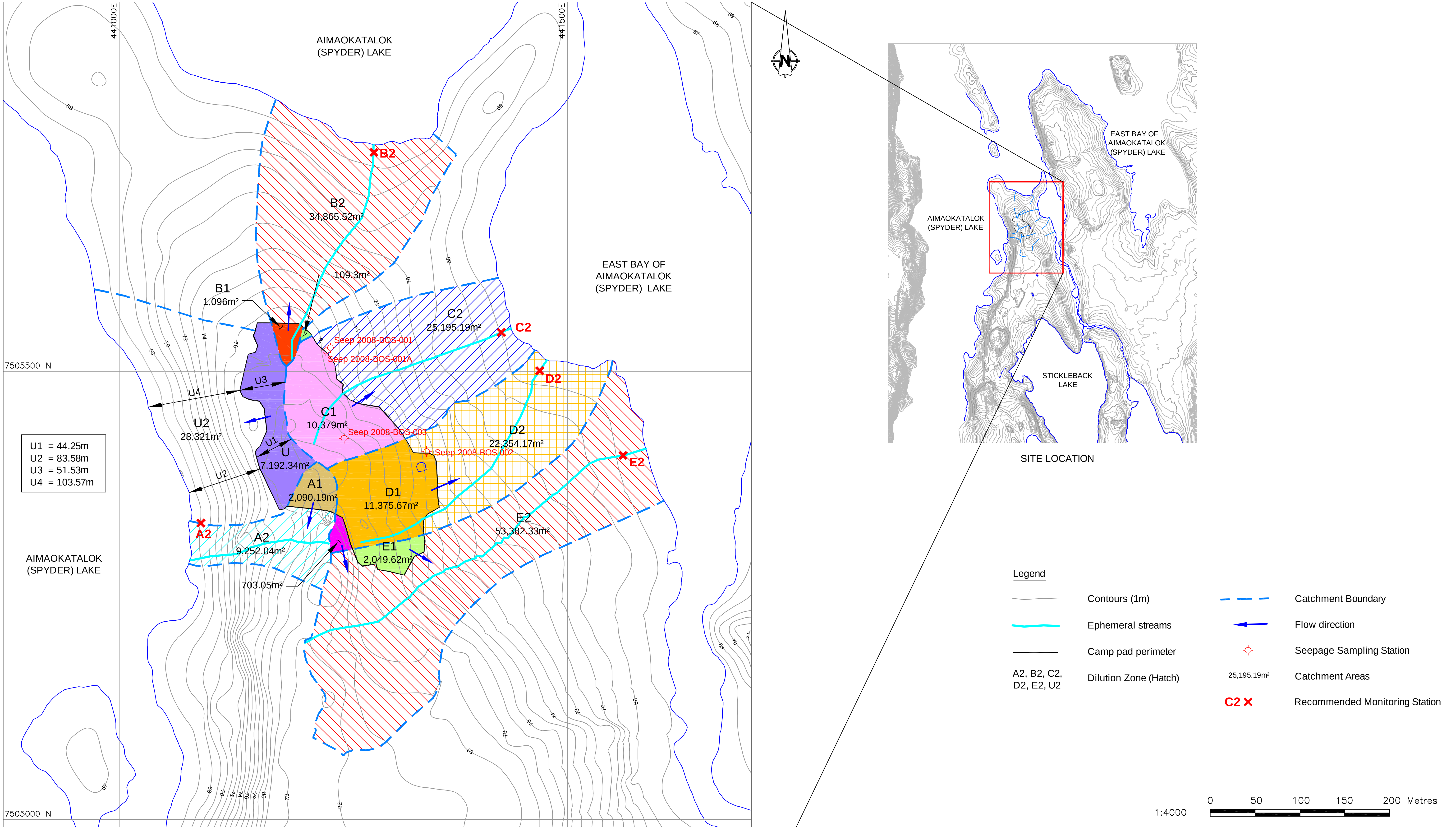

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Hope Bay Project

Boston Waste Rock Management Plan

Recommended Sites for Ephemeral Stream Monitoring

SRK JOB NO.: 1CH008.022

FILE NAME: Boston Catchments.dwg

DATE: July 2009

APPROVED:

FIGURE: 5.2

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“This report and the opinions and conclusions contained herein (“Report”) contains the expression of the professional opinion of SRK Consulting (Canada) Inc. (“SRK”) as to the matters set out herein, subject to the terms and conditions of the agreement dated September 30, 2008 (the “Agreement”) between Consultant and Hope Bay Mining Ltd. (“Hope Bay Mining”), the methodology, procedures and sampling techniques used, SRK’s assumptions, and the circumstances and constraints under which Services under the Agreement were performed by SRK. This Report is written solely for the purpose stated in the Agreement, and for the sole and exclusive benefit of Hope Bay Mining, whose remedies are limited to those set out in the Agreement. This Report is meant to be read as a whole, and sections or parts thereof should thus not be read or relied upon out of context. In addition, this report is based in part on information not within the control of SRK. Accordingly, use of such report shall be at the user's sole risk. Such use by users other than Hope Bay Mining and its corporate affiliates shall constitute a release and agreement to defend and indemnify SRK from and against any liability (including but not limited to liability for special, indirect or consequential damages) in connection with such use. Such release from and indemnification against liability shall apply in contract, tort (including negligence of SRK whether active, passive, joint or concurrent), strict liability, or other theory of legal liability; provided, however, such release, limitation and indemnity provisions shall be effective to, and only to, the maximum extent, scope or amount allowable by law.”

This final report, “**1CH008.022– Boston Ore and Waste Rock Management Plan, Hope Bay, Nunavut,**” was prepared by SRK Consulting (Canada) Inc.

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Supporting Documents

Supporting Document A

Geochemical Characterization of Historic Waste Rock and Ore Stockpiles at the Boston Deposit, Hope Bay Project, Nunavut (DRAFT)

Geochemical Characterization of Historic Waste Rock and Ore Stockpiles at the Boston Deposit, Hope Bay Project, Nunavut

Prepared for:

Hope Bay Mining Ltd.

Prepared by:

SRK Consulting
Engineers and Scientists

Project Reference Number
SRK 1CH008.005.1700

April 2009

Geochemical Characterization of Historic Waste Rock and Ore Stockpiles at the Boston Deposit, Hope Bay Project, Nunavut

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SRK Project Number 1CH008.005.1700

April 2009

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1 Introduction

Ore and waste rock were generated as part of a 1996/1997 underground exploration program at the Boston deposit. The waste rock was used to construct a camp pad, roads, and an airstrip at the Boston site. Ore was placed in stockpiles on the camp pad. As a condition of Water Licence 2BB-BOS0112, Hope Bay Mining Ltd. (HBML) is required to develop a waste rock management plan for these materials (NWB 2007). Although there was extensive geochemical characterization of this material during the 1996/1997 exploration program, it has been 12 years since that work was completed and it was felt that some additional information on the current condition of these materials, particularly with respect to seepage quality, would be needed to develop a meaningful management plan.

In June 2008, HBML retained SRK to complete a geochemical assessment to support development of the waste management plan. Data from previous investigations was reviewed, and in August 2008, two geochemists from SRK visited the site to inspect the ore and waste rock and to collect seepage and rock samples for laboratory testing. The samples were submitted for water quality analyses, ABA tests, elemental analyses, and shake flask extraction tests. This report documents the findings of the data review and field investigation. The results will be used to develop a waste rock and ore management plan for the site.

2 Review of Existing Information

2.1 Development History

The underground development and bulk sample program was conducted over a two year period between April 1996 and November 1997 (BHP 1998). Five separate cross-cuts were established off an access decline to give access to the B2 and B3 ore horizons. Drifts were also established to follow veins horizontally and raises were developed to follow veins vertically. Each blast round of the ore from cross-cuts, drifts and raises was processed through an on-site crusher, and was then stockpiled separately on the surface pad. Stockpiles were then surveyed and tagged according to blast round ID, and sampled for detailed analysis of grade, recovery and metallurgical characteristics. During this program, a total of 105,400 tonnes of development (waste) rock and 26,760 tonnes of ore material were mined and brought to surface. Waste rock generated from the operation was used on roadways, the airstrip and camp pad. Ore remained stockpiled.

A 2003 map of stockpiles illustrates the location of specific ore stockpiles, labelled with the blast round ID (Figure 2.1). Material on the western side of the stockpile area is dominantly from the B2 zone from 1996. Material on the eastern side is also dominantly from the B2 Zone, but from 1997.

2.2 Historical Geochemical Data

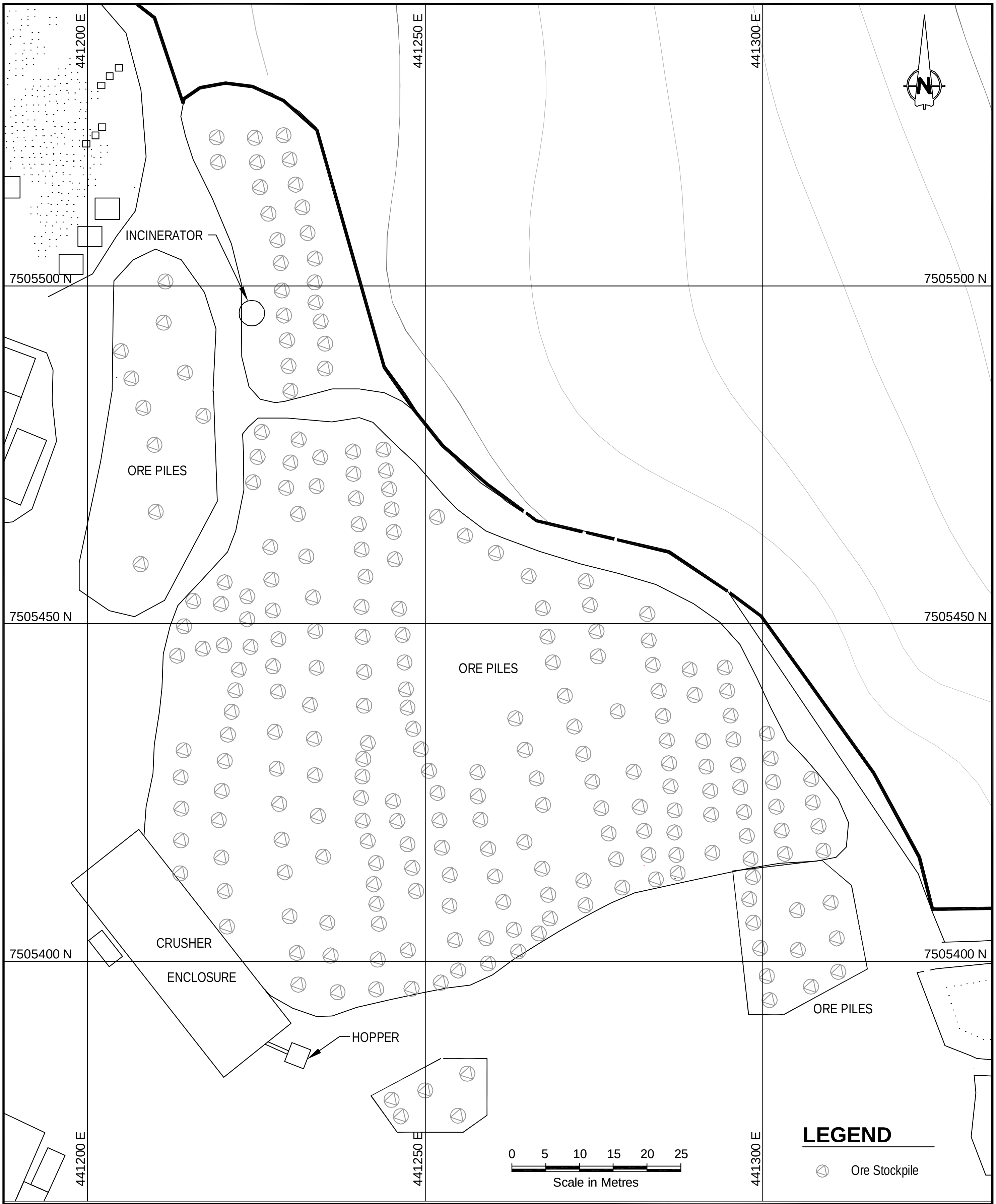
Previous geochemical programs have been carried out to characterize material from the Boston area (Rescan 1999; Rescan 2001a; Rescan 2001b).

2.2.1 Rescan (1999)

Rescan (1999) reported ABA testwork that was conducted on 283 samples collected from the underground development in 1996 and 1997 (random grab samples from material produced after every second blast) and an additional 43 drill core samples collected in 1997. Total sulphur was analysed by a Leco sulphur analyzer, total inorganic carbon (TIC) was calculated directly from CO_2 measurement, and neutralization potential was measured following the standard Sobek method (Sobek *et al.*, 1978). Humidity cell tests were completed on three of the samples collected in 1997.

Based on ABA data, the majority of tested materials were reported to have low acid-generation potential, although some of the 1996 ore samples were determined to have uncertain acid-generation potential.

The humidity cells were conducted on samples representing altered basalt, B2 mineralized zone and B3 alteration halo rock types. On the basis of depletion calculations, Rescan reported that the altered basalt and B3 alteration halo material was unlikely to generate net acidity in the long-term, but that the B2 mineralized zone material could be net acid-generating. With respect to metal-leaching, arsenic, copper and/or nickel were elevated in all three samples.



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Boston Camp Ore Piles 2003

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Hope Bay Gold Project

DATE: April 2009
APPROVED: CJ
FIGURE: 2.1

Five water quality samples were collected from ponded surface water located in and around ore stockpiles in July, 1998. Many parameters were not detected, but this may have been due to high analytical detection limits. Concentrations of arsenic, copper and nickel were in most cases above the detection limit and showed exceedances greater than ten times the CCME guidelines for aquatic life. Rescan (1999) concluded that seepage from the ore stockpiles could exceed water quality guidelines for these parameters.

2.2.2 Rescan (2001a)

Rescan (2001a) reported ABA results for four drill core samples. One of these was submitted for humidity cell testwork (Rescan 2001b).

The same ABA methods were used in 2000 as were used in the 1999 program. The results of ABA testwork indicated that three these samples had a low acid-generating potential, and one sample had an uncertain acid generating potential. All four Boston samples contained a combination of high amounts of neutralizing minerals and relatively low amounts of sulphur.

2.2.3 Rescan (2001b)

One of the samples from the Boston area, comprised of altered basalt, was subjected to humidity cell testwork. During the 39 weeks of kinetic testing, the Boston sample did not generate net acidity. However, low level analysis of leachate samples from the final 2 cycles of the test program indicated that leaching of arsenic from the Boston sample occurred at levels greater than that specified by the Canadian Water Quality Guidelines for the Protection of Aquatic Life. Rescan’s analysis of depletion times for both sulphur species and neutralization potentials indicated that acidic conditions would be unlikely to develop in this material.

2.3 Site Inspections and Routine Monitoring

2.3.1 2007 Site Inspection

SRK conducted an annual geotechnical site inspection of Boston camp on October 2 and 3, 2007, in accordance with water licence requirements (SRK 2008). During the site visit, a visual inspection of the ore stockpiles indicated no signs of oxidation.

Surface water draining from the foundation pad near the ore stockpiles was observed to flow directly onto the tundra. Site staff indicated that seepage water sampling to determine water quality emanating from the foundation fill pad, especially the ore stockpile area, is carried out at a few locations on the tundra to the east of the pad. However, these stations were not sampled in 2007 because they were not flowing during the regularly scheduled sampling events.

At the time of the 2007 inspection, material from the crushed ore stockpiles had been used as infill material for the airstrip repair, and site staff confirmed that this material was used for repairs in previous years as well.

2.3.2 2008 Site Inspection

A geotechnical inspection was also completed in 2008 (SRK 2009). No changes to the physical configuration of the site or condition of the ore stockpiles were noted.

An aerial photo taken in August, 2008 illustrates the change in stockpiles configuration compared to 2003 (Figure 2.2). This change in configuration is primarily a result of ore stockpiles being used for construction material.

2.3.3 Routine Seepage Monitoring

Monitoring Program Station BOS-8 is located to capture runoff from the existing waste rock/ore storage locations. According to Water Licence 2BB-BOS0112, sampling of Monitoring Program Station BOS-8, and any opportunistic seeps, is required initially during spring thaw and at a minimum frequency of monthly whenever flow is observed (NWB 2007). Monitoring results for this station, as well as seven other Monitoring Program Stations, are reported in the HBML annual report.

In the past, Monitoring Program Station BOS-8 has often been dry at the time of sampling. In 2008, sampling occurred at the BOS-8 three times, once in each June, July and August. Two opportunistic seeps were sampled by HBML during the August 2008 sampling round. The locations of the two opportunistic seeps sampled in 2008 are unknown.

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Geochemical Characterization of Historic Waste Rock and Ore Stockpiles, Boston Camp

Aerial Photo of Boston Camp Ore Piles, August 2008

Job No:	1CH008.005.1700	Hope Bay Gold Project	Date: April 2009	Approved: C. James	Figure: 2.2
Filename:	Figure 2.1-4.2.ppt				

3 2008 Field Investigation and Laboratory Testing Program

3.1 Methods

3.1.1 Site Inspection and Sampling

The Boston camp pad, ore stockpiles and airstrip were inspected and sampled by SRK geochemists Kelly Sexsmith and Lisa Barazzuol of SRK on August 25th and 26th, 2008 (Figure 3.1). The inspection comprised of inventorying the ore stockpiles by round number and inspecting the material at selected stockpiles, the airstrip and the periphery of the camp pad.

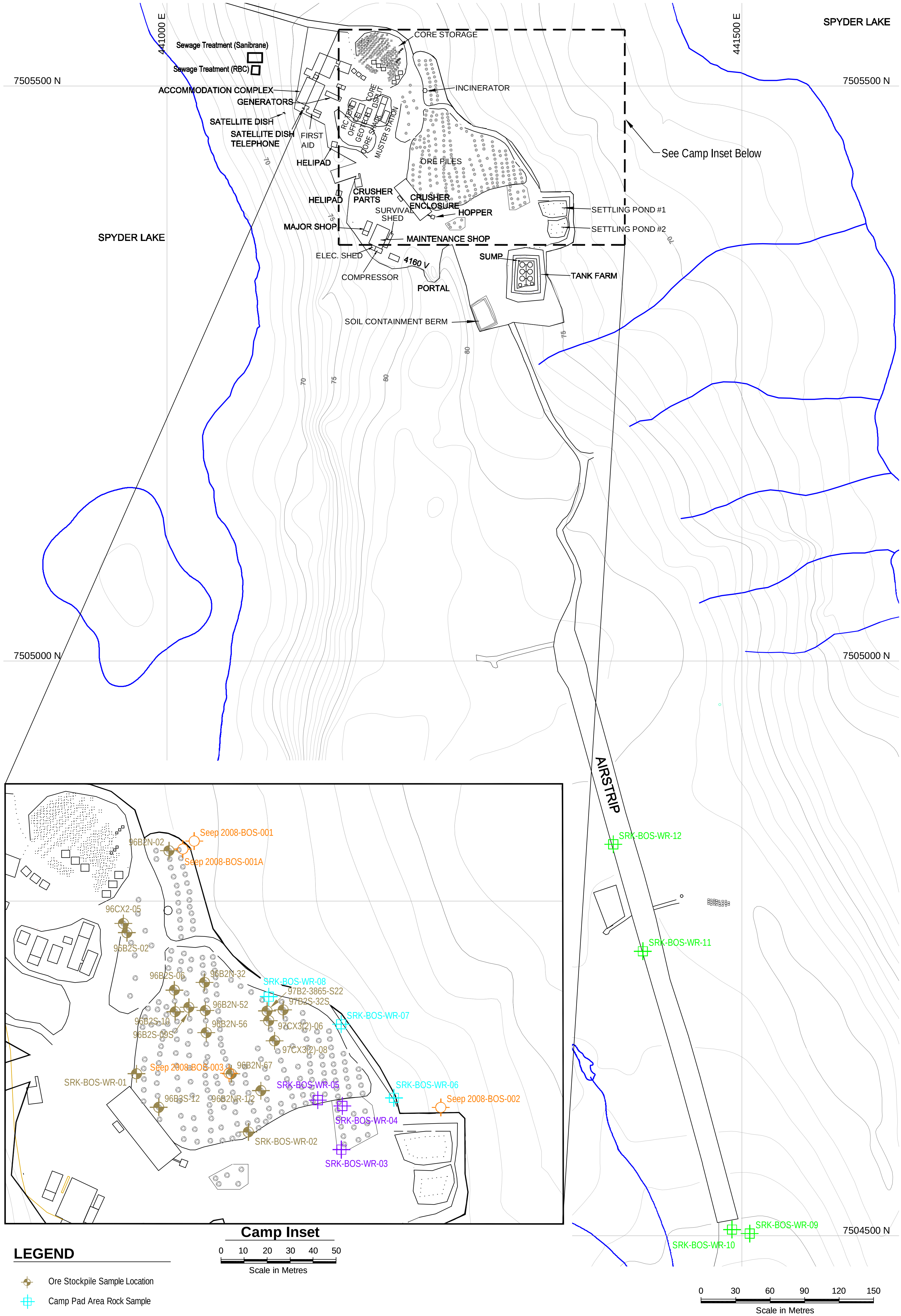
A total of 28 ore and waste rock samples were obtained from the ore stockpiles, edges of the camp pad and airstrip. Criteria for selection of ore stockpile samples included availability, year of production, provenance (B2 or B3 zone), rock type, spatial distribution on the camp pad and availability of existing geochemical data (Rescan 1999 and 2001a). Selected stockpiles that were previously characterized were sampled to compare changes in geochemistry. Conversely, stockpiles that were not previously characterized were sampled to expand the geochemical sample set. For the airstrip and camp pad, sample site selection was based on spatial distribution and areas that were definitively and exclusively waste rock or ore material, as based on visual observation.

Rock samples were collected from test pits of approximately 25 cm depth. The < 1 cm fraction was obtained for geochemical analysis. Additionally, the < 2 mm fraction from the test pit was obtained for rinse pH and conductivity. Where a colour variation was observed with depth, the < 2 mm fraction was also obtained from the surface material for rinse pH and conductivity.

The approximate grain size distribution, colour, rock type and mineralogy of samples were described (Appendix A).

Seepage samples were collected from 3 sites (Figure 3.1):

1. 2008-BOS-001: seepage from northeast side of camp pad, downstream of the core storage area, seep flows onto tundra where a small pond had formed;
2. 2008-BOS-002: northwest of Settling Pond #1, slightly upstream of the stake for routine Monitoring Program Station BOS-08; and
3. 2008-BOS-003: small pond situated in the middle of ore stockpiles and perched on tarp which prevents it from seeping through the camp pad.



LEGEND

- Ore Stockpile Sample Location
- Camp Pad Area Rock Sample
- Berm Area Rock Sample
- 2008 Seep Sampling Station
- Airstrip Area Rock Sample
- Ore Stockpile

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Rock Seepage Sampling Locations at Boston Camp Pad, Ore Stockpiles, and Airstrip, August 2008

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3.1.2 Testing Program

Rock Samples

Rock samples were submitted to CANTEST laboratories in Burnaby, B.C. for geochemical analyses. A summary of the testing program is shown in Table 3.1.

Table 3.1: SRK 2008 Boston Pad Ore and Waste Rock Testing Program

Sample	Rock Type	ABA + Metals on < 1cm fraction	ABA + Metals on < 2 mm fraction	Shake Flask Extraction on < 1 cm fraction
96-B2N-02	Ore	y	y	-
96-B2N-32	Ore	y	y	y
96-B2N-52	Ore	y	-	y
96-B2N-56	Ore	y	-	-
96-B2N-67	Ore	y	-	-
96-B2-NR-1/2	Ore	y	-	-
96-B2S-02	Ore	y	-	y
96-B2S-06	Ore	y	y	y
96-B2S-09S	Ore	y	-	-
96-B2S-10	Ore	y	y	y
96-B3S-12	Ore	y	-	-
96-CX2-05	Ore	y	y	-
97-B2-3865-S22	Ore	y	y	-
97-B2S-32S	Ore	y	-	-
97-CX3(2)-06	Ore	y	y	-
97-CX3(2)-08	Ore	y	y	-
SRK-BOS-WR-01	Ore	y	-	y
SRK-BOS-WR-02	Ore	y	y	-
SRK-BOS-WR-03	Ore	y	y	-
SRK-BOS-WR-04	Ore	y	-	-
SRK-BOS-WR-05	Ore	y	y	y
SRK-BOS-WR-06	Waste Rock	y	-	-
SRK-BOS-WR-07	Waste Rock	y	y	-
SRK-BOS-WR-08	Waste Rock	y	-	y
SRK-BOS-WR-09	Waste Rock	y	-	-
SRK-BOS-WR-10	Ore	y	-	-
SRK-BOS-WR-11	Waste Rock	y	y	y
SRK-BOS-WR-12	Ore	y	y	y

Acid-base accounting (ABA) and elemental analysis were completed on all samples collected during the site inspection. The ABA tests were completed using the Modified Sobek method with sulphur speciation and TIC analyses. Metals anlyses were completed following and aqua regia digestion with an ICP finish.

Particle size analysis (± 2 mm) was completed on a subset of samples, and ABA and elemental analysis were completed on the fine (< 2 mm) fraction. Selection of the subset was based on having representation a full range of NP/AP values, as well as representation of sample types including the B2 and B3 zones, the camp pad, airstrip waste rock and airstrip ore.

Shake flask extraction (SFE) test work was also done on a subset of samples. Samples were selected for SFE test work such that the full range of paste conductivities were represented as well as representation of sample types. Because B2 samples covered a larger range of conductivity, a greater number of B2 samples were selected for SFE test work than other sample types.

Seepage

Water samples were submitted to ALS Environmental in Vancouver, B.C. for analyses for pH, hardness, conductivity, total suspended solids, total dissolved solids, alkalinity and species, anions, nutrients and dissolved metals.

3.2 Results

3.2.1 Inspection & Sampling

The inspection included the ore stockpiles, camp pad and airstrip.

The blast round ID tags on the ore stockpiles were inventoried to cross-reference the stockpiles to Figure 2.1 and to determine which stockpiles had existing geochemical data (Rescan 1999). ID tags were present for approximately half of the stockpiles allowing for a general inventory. A number of discrete stockpiles, particularly ore material from the 1997 campaign and stockpiles on the eastern side, were notably absent, as shown on the 2003 plan (Figure 2.2). A large berm, which appeared to consist of stockpile material, was present to the south of the stockpile area (e.g. samples SRK-WR-03 to SRK-WR-05). Furthermore, a number of northern piles (see Figure 2.1, e.g. 96B2N-18 and 96B2N-28) were absent and/or graded together. The most northeast piles (e.g. 96-B2N-02, 96-B2N-03) appear to be placed on the edge of the camp pad and possibly on the tundra.

A total of 16 samples of stockpile material were collected and described in further detail. Lithologically, the stockpiles were composed of varying proportions of foliated sediments (with sericite ± ferroan carbonate ± chlorite with lesser fuchsite alteration), argillite, quartz/carbonate and lesser basalt. Gabbro was observed at one B3 stockpiles. Detailed descriptions are provided in Appendix A.

The weathering of the rock in the ore stockpiles was variable with a number of piles exhibiting iron staining due to the oxidation of iron carbonates. The iron oxidation was typically associated with the carbonate veinlets hosted in the quartz and foliated sediments. Pyrite with minor chalcopyrite was the dominant sulphide minerals and was typically hosted as disseminated or clusters crystals within sediment foliations. Visual sulphide levels were variably, ranging locally from <1% to upwards of 10%. The exposed sulphide mineral faces were overall fresh and untarnished suggesting limited sulphide oxidation and weathering.

The periphery of the camp pad consisted of waste rock with localized areas of ore stockpile material that had been placed as surfacing material. The waste rock, as observed along the periphery of the camp pad was a blend of lithologies. The three rock samples obtained from the eastern edge of the camp each targeted waste rock material and consisted of gabbro, basalt, quartz veining ± altered foliated sediments (sericite and/or chlorite). The samples contained negligible levels of disseminated, fine grained sulphide that appeared untarnished. If present, sulphides were associated with either the gabbro or the contact between basalt and quartz veins. No iron staining was observed in the waste rock samples.

The airstrip base consisted of waste rock with trace sulphide content. The surface layer consisted of a thin layer of crushed rock from the ore stockpile area that appeared consistent with the graded berm directly south of the ore stockpiles (e.g. samples SRK-BOS-WR-04). Two samples each were obtained of the base and surface layers of the airstrip. Lithologies were consistent with the waste rock and ore stockpile material previously described.

3.2.2 Particle Size Analysis

Table 3.2 summarizes the particle size analysis results. Most samples had the highest proportion of material in the 2 mm to 1 cm size fraction. The samples had been sieved to < 1 cm in the field.

Table 3.2: Results of Particle Size Analysis

Sample ID	< 2 mm fraction	2 mm < x > 1 cm fraction
96-B2N-02	47%	53%
96-B2N-32	29%	71%
96-B2S-06	34%	66%
96-B2S-10	21%	79%
96-CX2-05	27%	73%
97-B2-386S-S22	26%	74%
97-CX3(2)-06	52%	48%
97-CX3(2)-08	36%	64%
SRK-BOS-WR-02	37%	63%
SRK-BOS-WR-03	30%	70%
SRK-BOS-WR-05	31%	70%
SRK-BOS-WR-07	39%	61%
SRK-BOS-WR-11	35%	65%
SRK-BOS-WR-12	26%	74%

3.2.3 ABA Analysis

The results of the ABA tests on the bulk samples are summarized in Figures 3.2 and 3.3, with complete results provided in Appendix B.

Bulk Samples

Acid potential (AP) was calculated from the sulphide content of the samples. The sulphide content was calculated as the difference between total sulphur and sulphate sulphur. Sulphate content of all samples was low, between <0.01% and 0.02%, indicating that almost all sulphur in the samples was present as sulphides (Figure 3.2). The sulphide content of the ore ranged from 0.13 to 4.0 kg $CaCO_3$ eq./t (median 2.0 kg $CaCO_3$ eq./t), corresponding to APs of 4.1 to 126 kg $CaCO_3$ eq./t (median 63 kg $CaCO_3$ eq./t). The sulphide content of the waste rock was typically lower (0.15 to 0.61 kg $CaCO_3$ eq./t, median 0.46 kg $CaCO_3$ eq./t), corresponding to APs of 4.7 to 19 kg $CaCO_3$ eq./t (median 14 kg $CaCO_3$ eq./t).

A comparison of neutralization potential (NP) measured by the Modified Sobek method and calculated by total inorganic carbon (TIC) analysis showed that values for Modified Sobek NP were consistently lower than those calculated from TIC (Carbonate NP) (Figure 3.2). This indicates the presence of iron carbonate minerals, which do not provide any buffering. The modified Sobek NP content of samples collected in 2008 was generally high, ranging from 135.1 to 312.5 kg $CaCO_3$ eq./t, with relatively little difference between ore and waste rock. Modified Sobek NP was used in ARD classification because it provides a more conservative estimate of neutralization potential than Carbonate NP.

ARD classifications were made according to DIAND (1992):

- samples with a ratio of NP/AP < 1 are classified as potentially acid generating (PAG);
- NP/AP > 3 are classified as non-PAG; and,
- 3 > NP/AP > 1 are classified as uncertain.

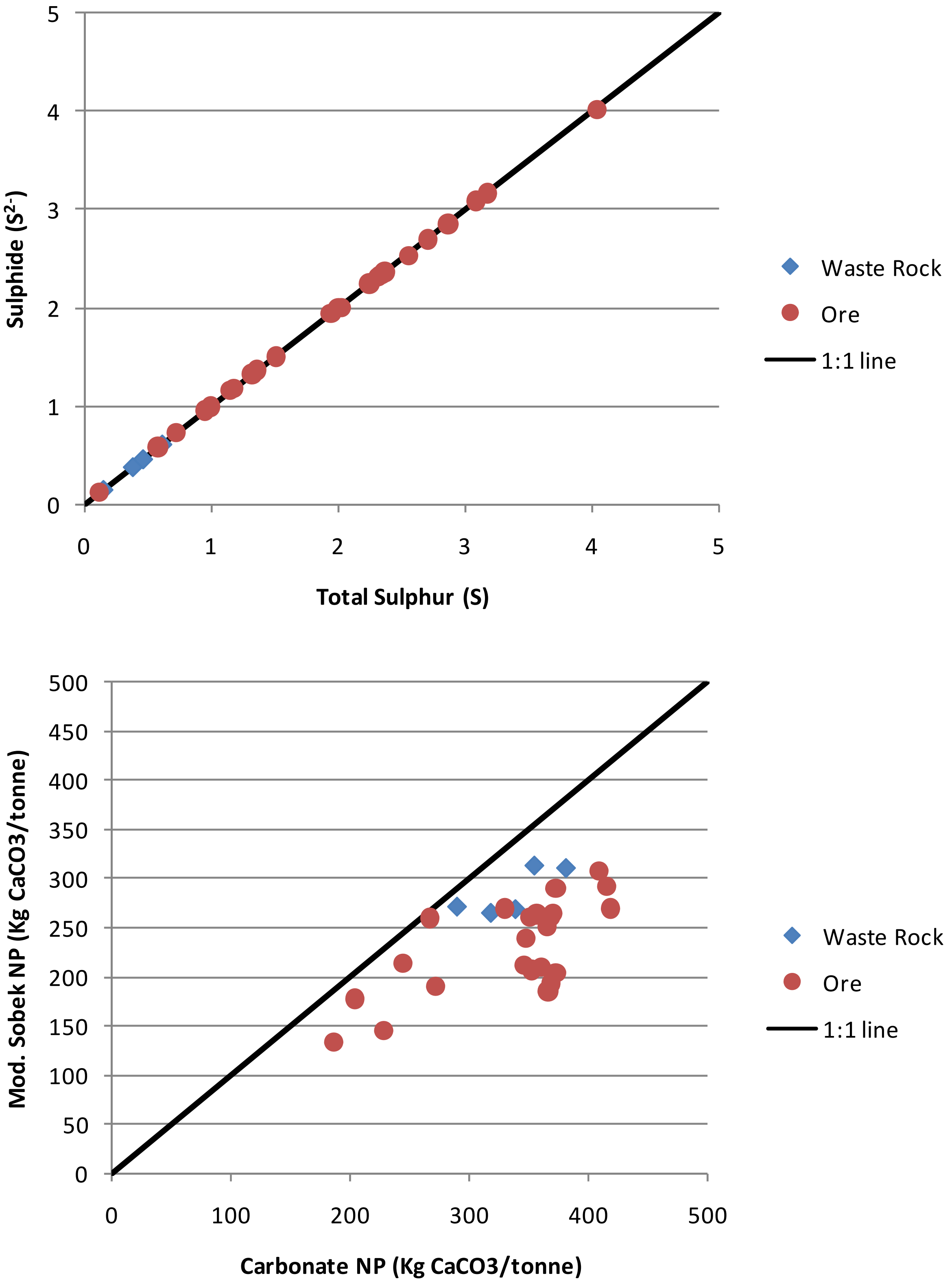
On the basis of Modified Sobek NP, all of the ore samples collected in 2008 had NP/AP ratios greater than 1, and were therefore classified as either non-PAG or uncertain (Figure 3.3). All of the waste rock samples had NP/AP ratios much greater than 3, indicating that they are non-PAG.

Comparison of Fine and Coarse Fractions

ABA results for the coarse and fine size fractions are presented in Figures 3.4 and 3.5, with complete results in Appendix C.

The AP and NP for the coarse fraction (2 mm to 1 cm) were calculated based on a mass balance approach. AP and Modified Sobek NP values for both size fractions are presented graphically in Figure 3.4. In most samples, the fine fraction had lower NP. For most samples, the AP content was similar for both size fractions, however the coarse fraction had higher levels of AP for a few samples. Sulphides are often concentrated in the fine fraction due to increased fragmentation of material in veins or on fracture surfaces.

Both size fractions have NP/AP ratios greater than 1, and fall within either the non-PAG or uncertain categories. In general, the fine fraction samples have lower NP/AP ratios than coarse fraction samples.



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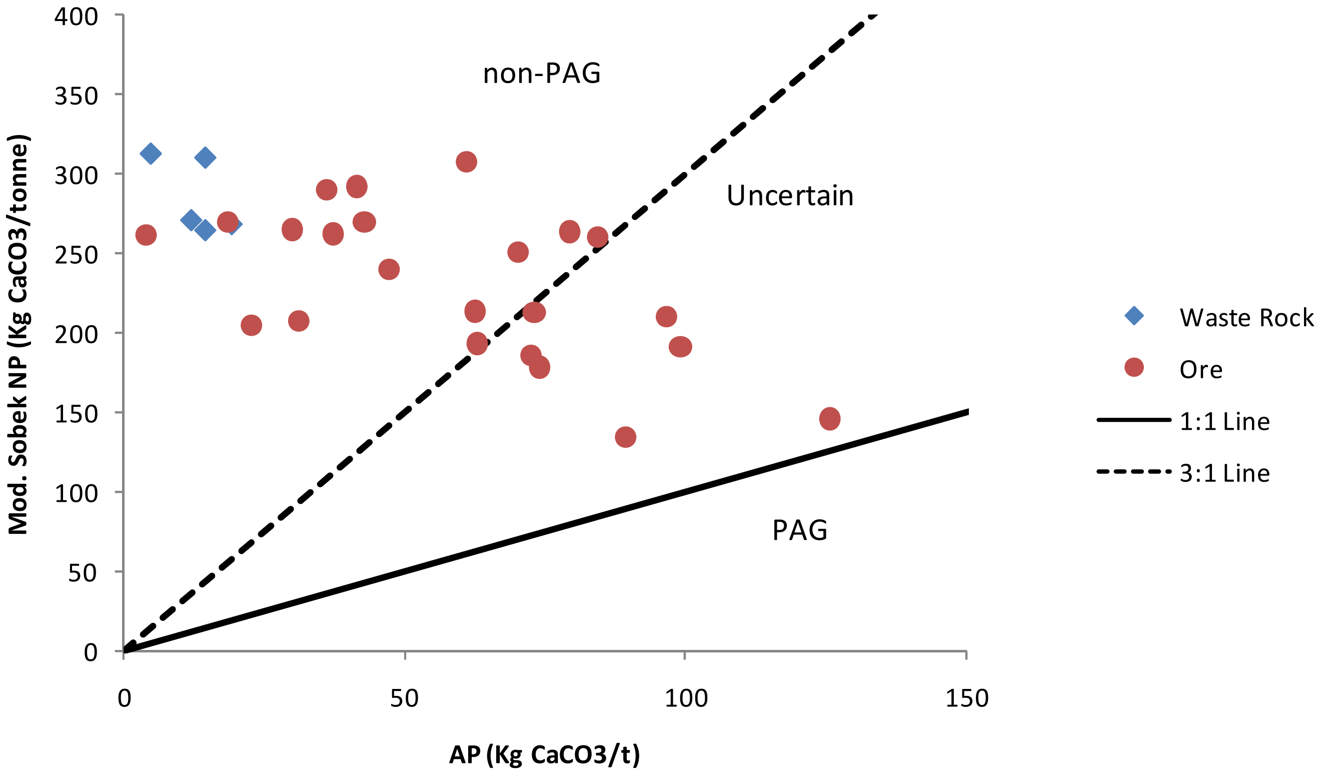
Geochemical Characterization of Historic Waste Rock and Ore Stockpiles, Boston Camp

Comparison of Total Sulphur vs. Sulphide Sulphur, Comparison of Modified Sobek NP vs. Carbonate NP for Bulk Samples

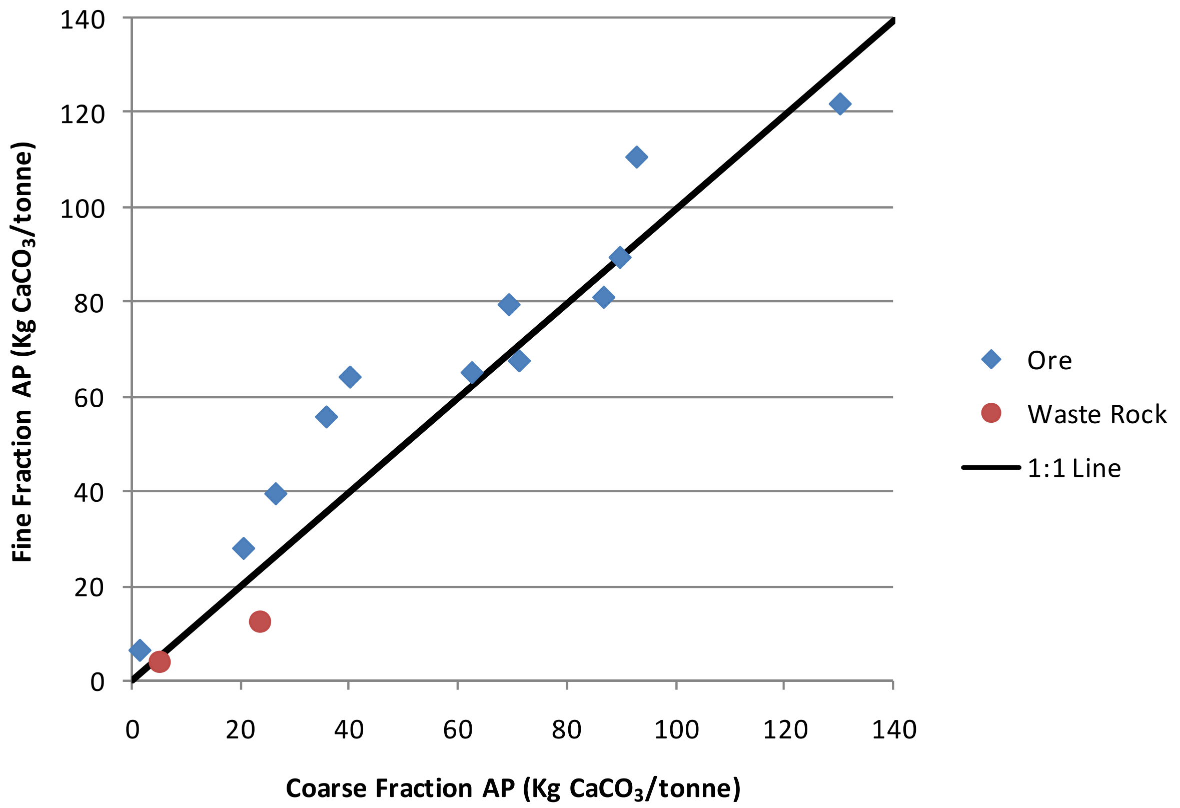
Job No: 1CH008.005.1700
Filename: Figure 4.1 NP-AP.ppt

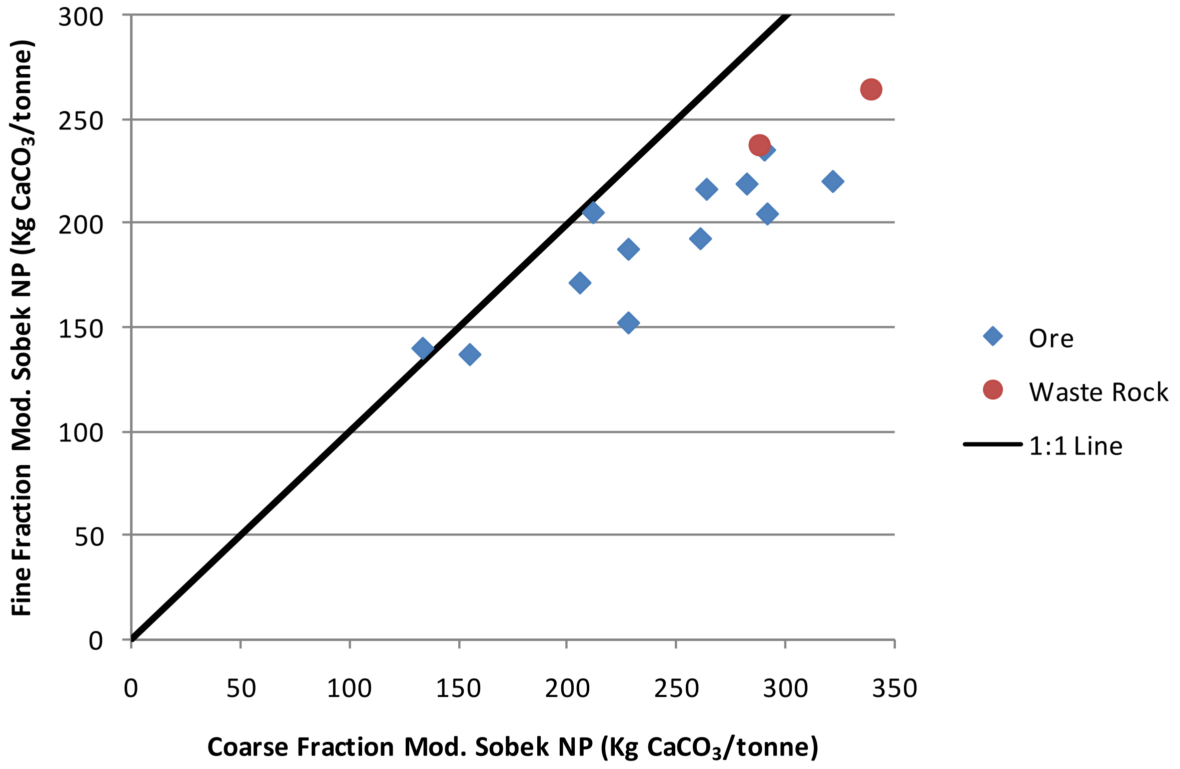
Hope Bay Gold Project

Date: April 2009
Approved: C. James
Figure: **3.2**

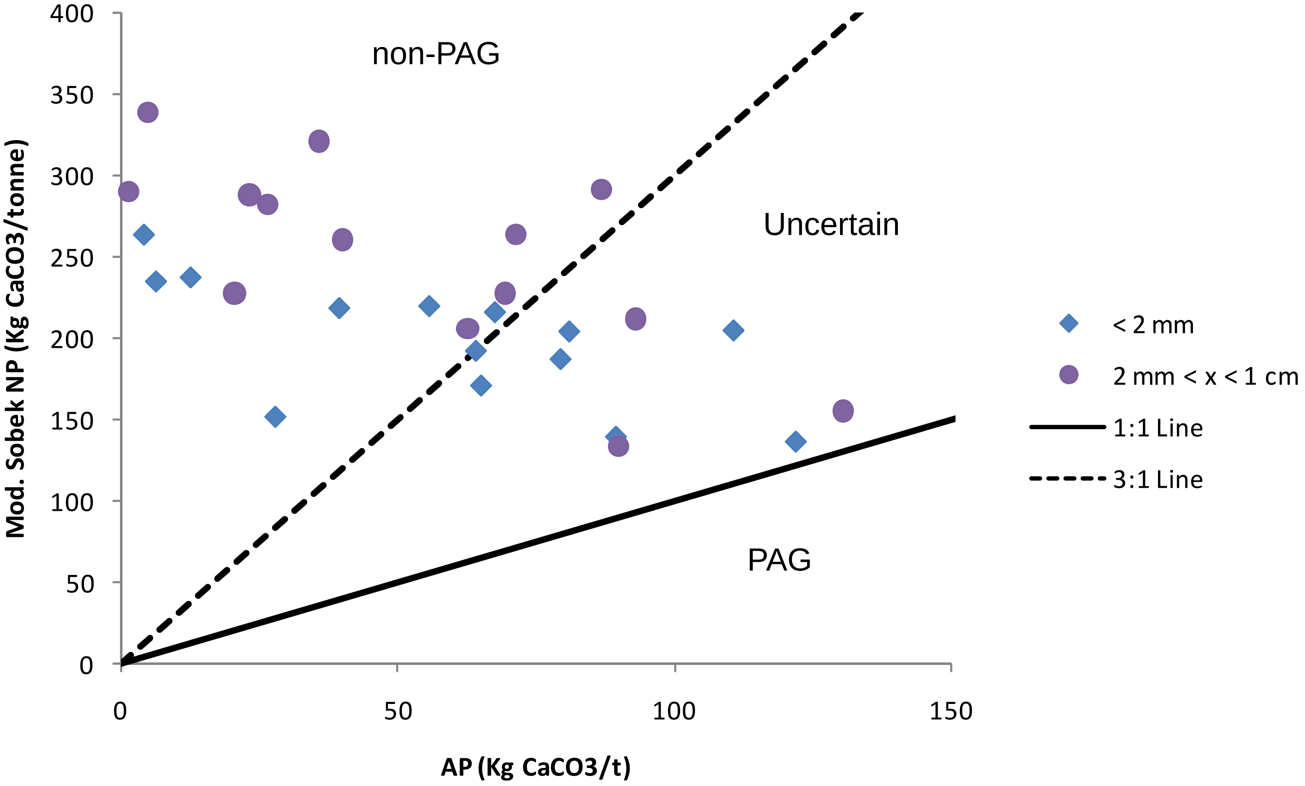


SRK Consulting *Engineers and Scientists* VANCOUVER	HOPE BAY MINING LTD.	Geochemical Characterization of Historic Waste Rock and Ore Stockpiles, Boston Camp **Comparison of Modifies Sobek NP vs. AP for Bulk Samples**
Job No: 1CH008.005.1700 Filename: Figure 4.1 NP-AP.ppt	Hope Bay Gold Project	Date: April 2009 | Approved: C. James | Figure: **3.3**





SRK Consulting Engineers and Scientists VANCOUVER	HOPE BAY MINING LTD.	Geochemical Characterization of Historic Waste Rock and Ore Stockpiles, Boston Camp		
		Comparison of AP and Modifies Sobek NP in Fine vs. Coarse Size Fractions		
Job No: 1CH008.005.1700 Filename: Figure 4.1 NP-AP.ppt	Hope Bay Gold Project	Date: April 2009	Approved: C. James	Figure: **3.4**



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Geochemical Characterization of Historic Waste Rock and Ore Stockpiles, Boston Camp

NP/AP for Coarse vs. Fine Size Fractions

Job No: 1CH008.005.1700
Filename: Figure 4.1 NP-AP.ppt

Hope Bay Gold Project

Date: April 2009
Approved: C. James
Figure: **3.5**

Comparison with Historical Data

Because several ore stockpiles were re-sampled by SRK in 2008, a comparison is possible between results obtained from ABA analysis conducted in 2008 and results obtained by Rescan (1999). Ore stockpiles were fairly homogeneous due to processing through the on-site crusher and sampling tower. However, due to potentially differing sampling procedures and the inherently heterogenic nature of the materials, samples collected from the two studies may not be representative of the same material.

Total sulphur content for samples collected by Rescan (1999) and SRK are compared in Table 3.3. The sulphur data showed a reasonable correlation with slightly higher values in the Rescan samples.

The NP also showed a reasonable correlation, with the 2008 Modified Sobek NPs typically lower than NPs measured by Rescan (1999) using the Standard Sobek method. Differences in measured NP values are likely a result of using different methods. The Standard Sobek method provides less control of the amount of acid that is added to the sample, and includes a boiling step that may lead to more aggressive reaction conditions. In addition it is allowed to react for a much shorter time, which may result in incomplete oxidation of the ferrous iron released during reaction with the iron carbonates. All of these issues may result in overestimation of Standard NP in comparison to the Modified method. Despite these differences, the quantity of NP in the Boston samples is so high, the difference in method used to measure NP does not greatly affect the NP/AP ratios.

Table 3.3: Comparison of ABA data between SRK 2008 and Previous Studies

	Rescan 1999			SRK 2008		
	Total Sulphur	Sulphate	Standard Sobek NP	Total Sulphur	Sulphate	Modified Sobek NP
Sample ID	(Wt.%)	(Wt.%)	(kg $CaCO_3$/t)	(Wt.%)	(Wt.%)	(kg $CaCO_3$/t)
96-B2N-02	4.41	-	170	4.04	0.02	146
96-B2N-32	1.70	-	323	1.33	<0.01	292
96-B2N-52	1.31	-	323	1.37	<0.01	270
96-B2N-56	0.89	-	331	1.19	<0.01	262
96-B2S-02	4.05	-	181	2.32	<0.01	186
96-B2S-06	3.13	-	291	2.03	0.02	194
96-B2S-10	3.61	-	292	3.09	<0.01	210
96-B3S-12	0.60	-	351	0.59	<0.01	270

"-" indicates that no data was available.

NP/AP ratios and ARD classifications for samples for which historical data are available are summarized in Table 3.4. NP/AP ratios are comparable between the two time periods.

The criteria used to classify relative acid-generating potential differ between studies. SRK 2008 data has been classified as described above. Rescan 1999 classified rocks with NP/AP ratios < 3 and total sulphur > 0.3% as PAG, NP/AP ratios > 3 and total sulphur < 0.3% as non-PAG, and all other cases as uncertain. Because of the difference in classification criteria, even though NP/AP ratios were similar, some samples that had been defined as PAG by Rescan were classified as uncertain or non-PAG by SRK.

Table 3.4: Comparison of NP/AP Ratios and ARD Classifications between SRK 2008 and Previous Studies

Sample ID	Rescan 1999		SRK 2008	
	NP/AP	Classification	NP/AP	Classification
96-B2N-02	1.2	PAG	1.2	uncertain
96-B2N-32	6.1	non-PAG	7.0	non-PAG
96-B2N-52	7.9	non-PAG	6.3	non-PAG
96-B2N-56	11.8	non-PAG	7.1	non-PAG
96-B2S-02	1.4	PAG	2.6	uncertain
96-B2S-06	3.0	PAG	3.1	non-PAG
96-B2S-10	2.6	PAG	2.2	uncertain
96-B3S-12	18.5	non-PAG	14.6	non-PAG

< 1 cm fraction used in SRK 2008 NP/AP calculation.

Criteria used to classify relative acid-generating potential differ between studies. See text for explanation.

3.2.4 Elemental Analysis

Results of the elemental analysis are summarized in Table 3.5. Complete results are presented in Appendix D. Elemental analysis results were compared to ten times the average crustal abundance for basaltic rocks (Price 1997) to screen for parameters that were elevated in solid phase.

Almost all samples had high concentrations of gold (95% of samples) and arsenic (100% of samples). Gold concentrations were on average 5468 ppb in rock samples; three orders of magnitude greater than the average crustal abundance in basalt (4 ppb). Arsenic concentrations were on average 681 ppm; two orders of magnitude greater than the average crustal abundance in basalt (2 ppm). Arsenic in the form of arsenopyrite is often associated with gold.

Several other parameters were measured in concentrations that were greater than ten times the crustal abundance for basalt, including silver (36% of samples), antimony (21% of samples), tungsten (29% of samples) and selenium (67% of samples). These parameters exceeded the average crustal abundance for basalt by one order of magnitude or less.

Several metals were observed in higher concentrations in the fine fraction (< 2 mm) compared to the whole sample (< 1 cm). Of note, barium, cobalt, copper, lead, manganese and mercury were higher in the fine fraction than the whole sample.

Table 3.5: Summary of Elemental Analysis

Parameter	**Units**	**Waste Rock**			**Ore**			***Average Crustal Abundance for Basaltic Rocks***
		Minimum	**Median**	**Maximum**	**Minimum**	**Median**	**Maximum**	
Ag	ppm	<0.1	<0.1	0.2	0.1	1.0	3.3	0.1
As	ppm	116	234	462	199	694	2943	2
Au	ppb	24	128	192	23	2425	40622	4
Ba	ppm	8	24	92	2	6	22	330
Ca	%	5.5	6.0	6.6	3.5	5.6	7.7	7.60
Cd	ppm	<0.1	0.1	0.3	0.1	0.2	2.0	0.2
Co	ppm	40.7	55.7	90.6	22.7	50.3	84.4	48.0
Cr	ppm	220	356	501	13	93	433	170
Cu	ppm	73	98	186	66	137	229	87
Fe	%	5.27	6.16	6.92	4.23	6.45	10.27	8.65
Hg	ppm	<0.01	<0.01	0.03	0.01	0.03	0.06	0.00009
Mg	%	2.99	3.08	3.51	1.10	2.20	3.86	4.60
Mn	ppm	1248	1374	1484	921	1540	2189	1500
Mo	ppm	0.6	0.9	1.0	0.7	2.0	7.8	1.5
Ni	ppm	167.5	240.3	371.0	30.2	123.2	316.8	130.0
P	%	0.01	0.01	0.02	0.01	0.02	0.07	0.11
Pb	ppm	2.2	3.3	12.8	2.3	8.8	31.1	6.0
Sb	ppm	0.4	0.7	1.0	0.6	1.3	4.3	0.2
Se	ppm	<0.5	<0.5	0.6	0.5	1.6	5.0	0.05
Sr	ppm	40	53	65	19	36	59	465
U	ppm	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	1.0
V	ppm	48	60	96	10	26	81	250
W	ppm	0.1	0.6	2.3	0.2	1.3	63.3	0.70
Zn	ppm	44	56	98	39	82	291	105

3.2.5 Shake Flask Extraction Tests

Results of the shake flask extractions (SFE) are summarized in Table 3.6. Complete results are presented in Appendix E. Shake flask extraction results were compared to ten times the CCME guidelines for the protection of aquatic life (CCME 1999) to screen for parameters that were elevated high in the test leachate.

Shake flask extractions used a 3:1 liquid to solid ratio. Under field conditions, rocks typically contact less water than in shake flask extractions, and therefore test results may be more dilute than rinse water (or seepage) found under field conditions. Overall, there were few instances of exceedance of the screening criteria in the shake flask extraction results.

Low concentrations of sulphate exist in the solid phase of these samples (see Section 3.2.3). The shake flask extraction tests provide a better means of detecting small quantities of soluble sulphate. Sulphate concentrations in the SFE aqueous phase ranged from 10 to 238 mg/L, indicating that sulphide oxidation was occurring at modest levels. Sulphate concentrations were well correlated with calcium concentrations indicating that calcium carbonates were buffering acidity produced during sulphide oxidation. The aqueous phase of all SFE tests had slightly alkaline pH, ranging between 8.1 and 8.3.

Table 3.6: Summary of SFE Data with Comparison to 10x CCME Guidelines

Parameter	Units	Ore								Development Rock		*CCME Guidelines x10*
		96-B2S-02	96-B2S-06	SRK-BOS-WR-01	96-B2N-32	96-B2S-10	96-B2N-52	SRK-BOS-WR-05	SRK-BOS-WR-12	SRK-BOS-WR-08	SRK-BOS-WR-11	
pH	pH Units	8.19	8.15	8.12	8.23	8.3	8.13	8.13	8.34	8.08	8.2	-
Conductivity	µs/cm	490	1617	640	711	373	548	1078	392	576	220	
Alkalinity	mg $CaCO_3$/L	111.5	99	81.5	100	129	80	91	132	72.5	101.5	
Sulphate	mg/L	108	238	231	54	53	110	176	58	69	10	
Dissolved Chloride Cl	mg/L	9.78	158	12	56	2.33	30.3	157	9.3	74.4	1.21	
Dissolved Nitrate N	mg/L	4.74	67.4	2.93	28.6	0.1	9.52	10.5	0.12	7.57	0.07	*29.3*
Nitrite N	mg/L	0.02	0.003	0.006	0.003	0.006	0.004	< 0.002	< 0.002	0.003	0.015	*0.06*
Total Ammonia	mgN/L	0.17	6.74	0.14	4.52	0.08	2.56	1.46	0.05	0.13	0.02	
Dissolved Metals												
Aluminum Al	mg/L	0.154	0.121	0.256	0.237	0.152	0.217	0.111	0.19	0.204	0.292	*1*
Antimony Sb	mg/L	0.004	0.003	0.021	0.012	0.003	0.013	0.004	0.007	0.008	0.01	
Arsenic As	mg/L	0.014	0.037	0.41	0.211	0.007	0.254	0.029	0.056	0.111	0.1	*0.05*
Barium Ba	mg/L	0.002	0.007	0.003	0.005	0.001	0.003	0.006	0.003	0.03	0.002	
Boron B	mg/L	0.19	0.19	0.26	0.25	0.14	0.2	0.39	0.21	0.15	0.1	
Cadmium Cd	mg/L	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	*0.00017*
Calcium Ca	mg/L	56	111	61.2	46.8	40.4	46.4	124	37.8	44.4	17.4	
Chromium Cr	mg/L	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	*0.089*
Cobalt Co	mg/L	0.001	0.005	0.003	0.002	0.001	0.001	0.0072	0.001	0.002	< 0.001	
Copper Cu	mg/L	0.009	0.007	0.004	0.002	0.003	0.002	0.004	0.001	0.002	0.002	*0.04*
Iron Fe	mg/L	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	*3*
Lithium Li	mg/L	0.002	0.006	0.003	0.003	0.001	0.003	0.035	0.003	0.01	0.002	
Magnesium Mg	mg/L	21	62.2	22.9	23.1	17.3	16.6	27.3	17.3	23.5	10.3	
Manganese Mn	mg/L	0.033	0.074	0.01	0.018	0.028	0.015	0.085	0.024	0.013	0.004	
Molybdenum Mo	mg/L	0.0017	0.0042	0.0014	0.008	0.001	0.0052	0.0043	0.0015	0.0016	< 0.0005	*0.73*
Nickel Ni	mg/L	0.002	0.008	0.021	0.016	0.001	0.009	0.018	0.011	0.009	< 0.001	*0.15*
Potassium K	mg/L	8.8	20.8	6.12	14.6	5.3	13.4	17.6	4.3	3.5	1.4	
Selenium Se	mg/L	0.014	0.012	< 0.001	0.004	0.003	0.003	0.004	< 0.001	0.004	< 0.001	*0.01*
Silicon Si	mg/L	1	1	1.44	1.1	0.8	1.2	0.93	0.9	1.1	1	
Silver Ag	mg/L	0.0005	0.0005	0.0004	0.0003	0.0004	< 0.00025	0.0003	0.0003	< 0.00025	0.0003	
Sodium Na	mg/L	22.6	105	35.2	42.5	9.28	26.4	28.1	9.11	22.5	9.9	
Strontium Sr	mg/L	0.064	0.375	0.153	0.158	0.039	0.119	0.881	0.09	0.304	0.048	
Zinc Zn	mg/L	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	*0.3*

SFE results are compared to CCME Guidelines for illustration purposes only. CCME Guidelines apply only to receiving environments and to do not apply to mine water.

Bolded and highlighted values exceed 10 times the CCME Guidelines for the Protection of Aquatic Life.

Arsenic concentrations were anomalously high in six of ten samples, ranging up to 80 times higher than the screening criteria for arsenic (up to 0.41 mg/L).

Nitrate concentration was anomalously high in sample 96-B2S-06 (67.4 mg/L).

Selenium concentrations were anomalously high in two samples 96-B2S-02 (0.014 mg/L) and 96-B2S-06 (0.012 mg/L).

Iron concentrations were below the analytical detection limit of 0.05 mg/L in all samples.

3.2.6 Seepage

2008 Results

Seepage data collected by SRK in 2008 is presented along with routine Monitoring Program Station BOS-8 data in Table 3.7. Seepage data were compared to ten times the CCME guidelines for the protection of aquatic life (CCME 1999) as an indication of the potential for environmental impacts. However, CCME guidelines are not directly applicable since the seepage flows in poorly defined pathways through the tundra before reaching Spyder Lake. Given the very small amount of flow and considerable dilution that will occur, it is unlikely that concentrations below ten times CCME would have any potential for impacts. Further assessment would be required to evaluate parameters greater than ten times their respective CCME guideline.

All seeps had neutral pH and elevated alkalinity, reflecting the high carbonate content of the rock.

Nitrogen species including nitrate and nitrite were elevated, likely resulting from blasting residue. Chloride was very high in some samples (up to 1890 mg/L), likely the result of calcium chlorides used in underground development.

Sulphate concentrations in seepage samples (average 340 mg/L) were higher than sulphate measured by the SFE testwork (average 111 mg/L).

Arsenic concentrations are high in Boston seeps (ranging between 0.0014 and 0.414 mg/L) compared to ten times the CCME guidelines for arsenic (10x CCME = 0.05 mg/L). This result is consistent with the SFE results, which also flagged arsenic as elevated in water that came in contact with rock samples.

Nickel concentrations are also high in Boston seeps (ranging between 0.0127 and 1.75 mg/L) compared to ten times the CCME guidelines for nickel (10x CCME = 1.5 mg/L). Nickel concentrations in the shake flask extractions were lower than seepage water.

Iron and selenium had occasional exceedances of ten times their respective CCME guidelines.

Comparison with Historical Data

A comparison between historical ponded water samples (Rescan 1999) and both routine and program specific seepage samples collected in 2008 is mostly not possible due to differences in the parameters suite analysed and high detection limits used in 1999. However, results for sulphate, arsenic, copper and nickel can be compared between the two sampling periods.

- Sulphate concentrations were available for two of the five samples collected in 1999. Concentrations of 382 and 451 mg/L were measured, which fall within the range of sulphate concentrations measured in samples collected in 2008.
- Arsenic concentrations in historical ponded water samples were on the order of 1 mg/L. This is high compared to arsenic concentrations measured in 2008. The maximum arsenic concentration measured in 2008 was 0.4 mg/L, which is a fifth of the maximum measured previously (2.1 mg/L).
- Copper concentrations, both historical and from 2008, were slightly elevated but still below the ten times CCME guideline for copper.
- Nickel concentrations were measured at comparably elevated levels in the two sampling periods, ranging from approximately 0.01 to 2 mg/L.

Table 3.7: Summary of Boston Seepage Data with Comparison to 10x CCME Guidelines

Samples		**2008-BOS-003 Ponded water in stockpile area**	**2008-BOS-001 and 2008-BOS-001a**		**Monitoring Program Station BOS-8 and Opportunistic Seeps Collected by HBML**		**CCME Guidelines x10**
General Parameters							
Conductivity	uS/cm	1890	1000 - 1470		1190 - 6720		
pH	pH	7.71	7.89 - 7.9		6.9 - 8.1		-
Total Dissolved Solids	mg/L	1490	681 - 1110		704 - 8200		
Acidity	mg $CaCO_3$/L	6.4	4.6 - 12.2		19.1 - 19.1		
Total Alkalinity	mg $CaCO_3$/L	76.7	128 - 162		42.8 - 172		
Ammonia as N	mg/L	6.04	0.0667 - 0.155		<0.05 - 14.2		
Chloride (Cl)	mg/L	73	96.9 - 152		124 - 1890		
Nitrate (as N)	mg/L	**47.6**	<0.005 - 4.1		**<0.1 - 49.7**		*29.3*
Nitrite (as N)	mg/L	**0.542**	0.0019 - 0.0217		**<0.05 - 0.261**		*0.06*
Sulfate (SO4)	mg/L	650	227 - 380		217 - 603		
Metals		**Dissolved**	**Total**	**Dissolved**	**Total**	**Dissolved**	
Aluminum (Al)	mg/L	<0.005	0.38	0.0146 - 0.0171	<0.2 - 0.94	0.023	*1*
Antimony (Sb)	mg/L	0.0142	0.00	0.00437 - 0.0123	0.003 - 0.029	0.0206	
Arsenic (As)	mg/L	0.0353	**0.134**	**0.0521 - 0.286**	**0.0155 - 0.341**	**0.134**	*0.05*
Barium (Ba)	mg/L	0.011	0.03	0.0131 - 0.0314	0.0281 - 0.088	0.126	
Cadmium (Cd)	mg/L	<0.00025	0.00	<0.00005 - <0.0001	<0.002	<0.0005	*0.00017*
Calcium (Ca)	mg/L	202	136.00	105 - 137	81.9 - 661	888	
Chromium (Cr)	mg/L	<0.0025	0.01	0.00061 - 0.0011	<0.005 - 0.0192	<0.005	*0.089*
Cobalt (Co)	mg/L	0.253	0.01	0.0113 - 0.102	0.0025 - 0.813	1.02	
Copper (Cu)	mg/L	0.00183	0.01	0.00756 - 0.0108	<0.01 - 0.011	0.0031	*0.04*
Iron (Fe)	mg/L	<0.03	1.32	0.063 - 0.253	0.044 - 3.23	0.115	*3*
Lead (Pb)	mg/L	<0.00025	0.00	<0.0001 - 0.000085	<0.005 - 0.002	<0.0005	*0.07*
Magnesium (Mg)	mg/L	96.6	62.00	36.1 - 62.1	40.5 - 87	128	
Manganese (Mn)	mg/L	0.374	0.15	0.0956 - 0.135	0.002 - 0.912	1.44	
Mercury (Hg)	mg/L	<0.00005	0.00	<0.00005 - <0.00005	0 - 0	<0.00005	
Molybdenum (Mo)	mg/L	0.00656	0.00	0.00204 - 0.00278	<0.005 - 0.079	0.00385	*0.73*
Nickel (Ni)	mg/L	0.613	0.10	0.0928 - 0.3	0.0127 - 1.35	**1.75**	*1.5*
Potassium (K)	mg/L	17.9	15.30	10.6 - 14.8	12 - 42.8	51	
Selenium (Se)	mg/L	**0.014**	0.00	0.0024 - 0.0026	0.002 - 0.017	<0.04	*0.01*
Silver (Ag)	mg/L	<0.00005	0.00	<0.00002 - 0.000014	<0.0004 - <0.005	<0.0001	*0.001*
Sodium (Na)	mg/L	50.5	86.50	46.6 - 85.9	59 - 174	182	
Strontium (Sr)	mg/L	0.553	0.78	0.419 - 0.767	0.53 - 5.83	7.26	
Uranium (U)	mg/L	0.000419	0.00	0.000186 - 0.000287	<0.001 - 0.0003	0.00019	
Zinc (Zn)	mg/L	0.0068	0.00	<0.002 - 0.002	<0.04 - 0.103	0.022	*0.3*

Seepage results are compared to CCME Guidelines for illustration purposes only. CCME Guidelines apply only to receiving environments and to do not apply to mine water.

Bolded and highlighted values exceed 10 times the CCME Guidelines for the Protection of Aquatic Life.

4 Assessment of Geochemical Performance

4.1 Potential for Acid Rock Drainage

The potential for acid rock drainage is a key issue at this site due to the potential for increases in metal concentrations that could occur under more acidic conditions.

Waste rock makes up the majority of rock (105,400 tonnes) that was mined and brought to surface. Based on Modified Sobek NP, waste rock samples collected by SRK in 2008 had high NP/AP ratios indicating that they are unlikely to generate net acidity over the long-term. This finding is consistent with results presented in previous geochemical characterization studies (Rescan 1999; Rescan 2001a). In previous studies, all or nearly all waste rock samples fell in the non-PAG category, as defined by DIAND (1992).

Table 4.1: ARD Classifications from Geochemical Characterization Studies

Classification	Criteria	Waste Rock Samples			Ore Samples	
		Rescan 1999 [1]	**Rescan 2001a** [2]	**SRK 2008** [3]	**Rescan 1999** [1]	**SRK 2008** [3]
		n = 236	n = 4	n = 5	n = 89	n = 23
Non-PAG	NP/AP > 3	98.7 %	100 %	100 %	62.9 %	69.6 %
Uncertain	3 < NP/AP < 1	1.3 %	0 %	0 %	37.1 %	30.4 %
PAG	NP/AP < 1	0 %	0 %	0 %	0 %	0 %

1: Standard Sobek NP used in NP/AP calculation.
2: Standard Sobek NP used in NP/AP calculation.
3: Modified Sobek NP used in NP/AP calculation.

The volume of ore excavated between 1996 and 1997 was much smaller (26,760 tonnes) than waste rock. Most ore samples (69.6%) collected by SRK in 2008 had Modified Sobek NP/AP ratios greater than 3 indicating that these samples are non-PAG and have low potential to generate acid. Several samples (30.4%) had NP/AP ratios between 1 and 3 and were classified as having uncertain acid generating potential. This finding is also consistent with results found previously (Table 4.1).

The humidity cell tests completed by Rescan (1999 and 2001b) provide some indication of how these materials might perform over the longer term. Previous interpretations of the humidity cell data (Rescan 1999 and 2001b) included estimates of depletion times for carbonate NP and sulphide sulphur. The results are summarized in Table 4.2.

The depletion times for sulphide sulphur in the two altered basalt samples and in the sample from the B3 alteration halo were an order of magnitude lower than the depletion times of neutralization potential for these samples, indicating that they are unlikely to become net acid-generating. These three samples all had NP/AP ratios well above 3, indicating they were not potentially acid generating.

Table 4.2: Years to Depletion for Sulphur and Neutralizing Potential from Historical Humidity Cells

Rock Type`	AP (kg $CaCO_3$/t)	Sobek NP (kg $CaCO_3$/t)	NP/AP	Time to Depletion (Years)		
				Sulphide Sulphur	Carbonate NP	Net Acid Production?
Altered Basalt [1]	2.19	313	143	38.5	446	No
B2 Mineralized Zone [1]	96.6	301	3.1	828	305	Yes
B3 Altered Halo [1]	6.56	340	51.8	43.8	523	No
Altered Basalt [2]	10.0	452	45.2	67.9	397	No

1: From Rescan, 1999.
2: From Rescan, 2001b.

The B2 mineralized zone sample had a Standard Sobek NP/AP ratio of 3.1, which is close to the boundary used to classify materials as PAG versus uncertain. Lab results indicate that the NP would be depleted almost three times sooner than the AP, suggesting that net acid generation could occur. However, the predictions also showed that even under laboratory reaction rates, this would not occur for several hundreds of years. Depletion calculations are generally considered to be conservative with respect to the relative depletion times for sulphur versus NP, particularly in samples with slow rates of sulphide oxidation (which is the case for all four of these tests). Differences in temperature and grain size result in higher sulphide oxidation rates in the lab compared to sulphide oxidation rates found under field conditions. However, high flush rates in the lab also tend to result in artificially high rates of NP depletion in comparison to the field due to limitations on the rate of flushing resulting from solubility controls on carbonate concentrations in the field. The rates of sulphide oxidation are thought to be on the order of 5x slower in the field (given average field temperatures of 5 °C), while the rates of NP depletion could be orders of magnitude lower in situations where the NP depletion is primarily as a result of flushing effects. Until the relative rates of depletion under field conditions can be evaluated, it is considered premature to conclude that acidic conditions would necessarily develop in this type of material. What is clear is that the depletion times for both sulphide and NP are very long, on the order of several hundreds of years. As such, there should be ample time to address this issue.

With the exception of ore stockpiles in the northeast corner of the camp, all ore stockpiles were placed on a thick pad of waste rock, which is classified as non-PAG. In the unlikely event that acidic conditions do develop in some of the ore stockpiles, excess NP in the waste rock is expected to buffer the pH.

4.2 Potential for Metal Leaching

The use of ore for surfacing and repairs to the airstrip and camp pad has resulted in an increase to the footprint area that could contribute metal loadings to the environment. The original stockpile area occupied an area of approximately 8,000 m^2, while the area that is now potentially influenced by the ore used as surface dressing also includes the airstrip (11,700 m^2), roadways and portions of the camp pad (35,000 m^2), and is up to 46,700 m^2.

Under neutral pH conditions, metal leaching rates are expected to be relatively consistent over time. The current seepage water quality is the best indication of metal leaching rates. A review of earlier field and laboratory testing data is presented to show that these rates have not changed appreciably over time.

Although majority of the waste rock and ore stockpiles are unlikely to generate acidity, metal leaching could be a concern, particularly for the ore, which contains higher amounts of sulphide. In previous humidity cell tests, arsenic, copper and nickel were flagged as parameters that could potentially affect seepage water quality with respect to CCME water quality guidelines. A comparison of humidity cell results, shake flask extraction test results and the 2008 seepage results for these parameters are summarized in Table 4.3.

Table 4.3: Metal Leaching Results from Historical Humidity Cell Tests, Shake Flask Tests and Seepage

Parameters	Rock Type	Humidity Cell Leachate Concentration (mg/L)	Shake Flask Extraction Tests (mg/L)	2008 Seepage	10 x CCME Guideline (mg/L)
Sulphate	Altered Basalt [1]	1.70	10 - 238	217 – 650	-
	Altered Basalt [2]	5.8			
	B2 Mineralized Zone [1]	4.0			
	B3 Altered Halo [1]	5.42			
Arsenic	Altered Basalt [1]	**0.273**	0.007 – **0.41**	0.016 – **0.34**	0.05
	Altered Basalt [2]	**0.8**			
	B2 Mineralized Zone [1]	0.0059			
	B3 Altered Halo [1]	**3.296**			
Copper	Altered Basalt [1]	0.006	0.001 – 0.009	0.0018 – 0.011	0.04
	Altered Basalt [2]	< 0.01			
	B2 Mineralized Zone [1]	0.011			
	B3 Altered Halo [1]	0.009			
Nickel	Altered Basalt [1]	0.0058	<0.001 – 0.02	0.013 - **1.75**	0.65
	Altered Basalt [2]	< 0.05			
	B2 Mineralized Zone [1]	0.0012			
	B3 Altered Halo [1]	0.237			

1: From Rescan 1999.
2: From Rescan 2001b.
Bold values are greater than ten times the CCME guidelines for the protection of aquatic life (CCME 1999).

The comparison indicates that:

- concentrations of arsenic were similar in all three sets of data and arsenic exceeded the screening criteria of 10x CCME aquatic life guidelines in some samples,
- concentrations of nickel tended to be highest in the seepage and exceeded the screening criteria of 10x CCME aquatic life guidelines in some seepage samples,
- concentrations of copper were similar in all three sets of data and were below the screening criteria.

Other parameters that were flagged through SRK's 2008 testwork include iron and selenium. These parameters were below or within five time the analytical detection limit (*i.e.*, within analytical variability) in previous geochemical studies and had not previously been flagged.

Given that acid production is not likely to occur, and that little change was observed in water quality between the two sampling periods separated by 9 years, the expected long term performance of the ore stockpile material is to continue leaching at current levels. Although some parameters in the seepage currently exceed the CCME guidelines for aquatic life, there is considerable distance between the stockpiles and receiving water, and it is likely that a risk assessment will show that these levels are within acceptable limits for a source material.

5 Conclusions

A detailed inventory of the ore stockpile area indicated that a number of the ore stockpiles, particularly ore material from the 1997 campaign and stockpiles on the eastern side, have been removed from the stockpile area. Inspections of the airstrip and camp pad indicated that this material had been used for airstrip resurfacing, for other repairs to the road, camp pad, and other construction projects.

The weathering of the rock in the ore stockpiles was variable with a number of piles exhibiting iron staining due to the oxidation of iron carbonates. The iron oxidation was typically associated with the carbonate veinlets hosted in the quartz and foliated sediments. Pyrite with minor chalcopyrite was the dominant sulphide minerals and was typically hosted as disseminated or clusters crystals within sediment foliations. Visual sulphide levels were variable, ranging locally from <1% to upwards of 10%. The exposed sulphide mineral faces were overall fresh and untarnished suggesting limited sulphide oxidation and weathering. Elevated concentrations of sulphate were present in the shake flask extraction test leachates and in seepage samples. However, the concentrations were still quite low given the relatively advanced age of these stockpiles.

According to the ARD classifications described by DIAND (1992), waste rock could be classified consistently as non-PAG. Approximately two thirds of the ore was classified as non-PAG and the remainder as uncertain. There was relatively little difference in the ABA results for fine (< 2mm) versus coarser (2mm to 1 cm) size fractions. Historical humidity cell tests completed by Rescan (1999, 2001a) indicated that, under laboratory leaching rates, both the sulphides and the NP would last for hundreds of years. Three of four samples were confirmed to be non-PAG on the basis that the NP would outlast the AP. One test indicated the NP may not outlast the sulphide in a sample with an NP/AP ratio of 3. However, given the long times to depletion and differences in the relative rates of depletion in the field versus the lab, it is not appropriate to conclude that acidic conditions would necessarily develop in this material under field conditions, and it would be preferable to retain the “uncertain” classification. Even if localized ARD develops in this material, the presence of the non-PAG development rock pad beneath the ore stockpiles would be expected to mitigate the seepage quality, particularly in areas where the ore only forms a thin veneer.

Leach extraction tests and seepage results confirmed that metal concentrations in the ore stockpile material were comparable to those measured in historical sampling programs. Soluble parameters flagged as potential concerns are arsenic and, to a lesser extent, nickel and selenium. Given that acid production is not likely to occur, and that little change was observed in water quality between the two sampling periods separated by 9 years, the expected long-term performance of the ore stockpile material is to continue leaching at current levels. Although some parameters in the seepage currently exceed the CCME guidelines for aquatic life, there is considerable distance between the stockpiles and receiving water, and it is likely that a risk assessment will show that these levels are within acceptable limits for a source material.

6 Recommendations

As a condition of Water Licence 2BB-BOS0112, HBML is required to develop a waste rock management plan for the waste rock and ore stockpile materials. Based on the results of the 2008 geochemical characterization program, it is recommended that the waste rock management plan should address both the short and long-term management issues from this site, including ongoing management and use of the waste rock and ore, monitoring, and closure.

During the ongoing exploration phase, it would be preferable not to use ore for any further repairs or resurfacing of the camp pad, road and airstrip. If these materials are required, the historical acid base accounting results should be used to identify and use piles that are clearly non-PAG and with lower sulphide content. Waste rock from other areas of the camp pad has been established as non-PAG with lower amounts of sulphide and therefore low potential for metal leaching, and would therefore be more suitable from a geochemical perspective.

Miramar Hope Bay Ltd. (MHBL), the previous owners of the Hope Bay project, proposed in their closure plan that the Boston ore stockpile material be transferred over the winter road to the Doris North Project site for milling and gold recovery at their proposed mill. Any PAG waste rock would be used to backfill the underground workings at Doris North mine. A statement in the Boston closure plan suggests that non-PAG material will be use to backfill the Boston underground decline. It is not clear is this plan refers to closure of the adit portal. Given the changes in the overall development plans for the project under HBML's ownership, this plan is no longer relevant. Other closure options for the site should be developed.

The potential for impacts to the aquatic environment will be one of the more important factors in evaluating these other closure measures. To assess the potential impacts of seepage on the receiving environment, a simple water and load balance is recommended with the specific objective of identifying if there is potential for impacts to the local aquatic environment under current and future conditions. The water and load balance could be included in the waste rock management plan.

"This report and the opinions and conclusions contained herein ("Report") contains the expression of the professional opinion of SRK Consulting (Canada) Inc. ("SRK") as to the matters set out herein, subject to the terms and conditions of the agreement dated September 30, 2008 (the "Agreement") between Consultant and Hope Bay Mining Ltd. ("Hope Bay Mining"), the methodology, procedures and sampling techniques used, SRK's assumptions, and the circumstances and constraints under which Services under the Agreement were performed by SRK. This Report is written solely for the purpose stated in the Agreement, and for the sole and exclusive benefit of Hope Bay Mining, whose remedies are limited to those set out in the Agreement. This Report is meant to be read as a whole, and sections or parts thereof should thus not be read or relied upon out of context. In addition, this report is based in part on information not within the control of SRK. Accordingly, use of such report shall be at the user's sole risk. Such use by users other than Hope Bay Mining and its corporate affiliates shall constitute a release and agreement to defend and indemnify SRK from and against any liability (including but not limited to liability for special, indirect or consequential damages) in connection with such use. Such release from and indemnification against liability shall apply in contract, tort (including negligence of SRK whether active, passive, joint or concurrent), strict liability, or other theory of legal liability; provided, however, such release, limitation and indemnity provisions shall be effective to, and only to, the maximum extent, scope or amount allowable by law."

This final report, "**1CH008.005 – Geochemical Characterization of Historic Waste Rock and Ore Stockpiles at the Boston Deposit, Hope Bay Project, Nunavut - DRAFT,**" was prepared by SRK Consulting (Canada) Inc.

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Appendix A

Visual Descriptions of Rock Samples, August 2008

Appendix A
Visual Descriptions of Rock Samples, August 2008

Sample ID	Material type	Location	Description
96-B2N-02	Ore	Stockpile	Lithologies (in order of abundance): i) quartz-carbonate and ii) chlorite altered foliated sediments, graphitic with minor fuchsite. 2 to 5% pyrite variable sizes but primarily within quartz-carbonate fragments as coarse grain to massive cubic crystals and but minor fine grain dissemiations also within foliations. Primarily fresh but few pyrite faces tarnished green. Red-brown iron staining on quartz-carbonate fragments and to lesser degree on foliated sediments.
96-B2N-32	Ore	Stockpile	Lithologies (in order of abundance): i) green-brown foliated sediments with sericite-chlorite alteration and minor fuchsite, ii) quartz-carbonate vein and iii) dark grey argillite. Abundant coarse grained sulphides in argillite and quartz-carbonate. Dominantly cubic pyrite up to 1cm in size with minor chalcopyrite. Sulphide occurence variable, dominantly disseminated but also occurs as veinlets cross-cutting quartz or as clusters. Brown-red iron oxidation associated with i) sulphides, ii) argillites and iii) quartz. Iron oxidation appearance consistent and not necessarily associated with sulphides suggesting iron carbonate weathering. Surface of test pit is subtle yellow colour.
96-B2N-52	Ore	Stockpile	Lithologies and iron oxidation same as 96-B2N-32 but foliated sediments have more sericitic alteration and less chloritic. Sulphides less abundant (1 to 2%) and 1-3 mm in size. Top 10 cm of test pit is yellowy-brown.
96-B2N-56	Ore	Stockpile	Same as sample 96-B2N-52 but foliated sediments have more chlorite alteration and less sericite. Top 2cm of test pit yellowy-brown.
96-B2N-67	Ore	Stockpile	Lithologies (in order of abundance): i) quartz-carbonate, ii) sericite-chlorite altered foliated sediments with minor fuchsite, and iii) argillite. Pyrite in all three lithologies with rare coarse grain pyrite liberated in pile. In quartz-carbonate: 1% pyrite as fine grain disseminations, untarnished; foliated sediments: rare fine grain disseminated pyrite in foliations; argillite: clusters of coarse grain (up to 1cm) pyrite, locally up to 10%, untarnished. Orange-red to brown-red iron oxidation present in carbonate veinlets in quartz-carbonate (crackle texture) and surfaces of argillite. Blue copper precipitate observed on one fragment.
96-B2-NR-1/2	Ore	Stockpile	Stockpile primarily fine crush material. Lithologies (in order of abundance): i) argillite with rare fuchsite, ii) quartz-carbonate and iii) sericite altered foliated sediments. Pyrite dominantly in argillite as localized fine grain disseminated cubes with rarer clusters, untarnished, 5%. Minor amounts also in foliated sediments, as untarnished, fine grain disseminations along foliation. Orange-red iron oxidation along foliation and as patches/veinlets in quartz-carbonate.
96-B2S-02	Ore	Stockpile	Lithologies (in order of abundance): i) foliated sediments (sericite-chlorite altered), ii) quartz-carbonate, and iii) argillite. Minor pyrite in i) foliated sediments (fine grain,euhedral, disseminated, fresh), ii) quartz-carbonate with trace chalcopyrite (medium grain, euhedral, clustered, generally fresh but minor amounts tarnished brassy or green) and iii) trace very fine disseminations in argillite. Brown-red iron oxidation on foliated sediments and quartz-carabonate.
96-B2S-06	Ore	Stockpile	Lithologies same as 96-B2N-32. Sulphides (pyrite) occur in all three lithologies but primarily in foliated sediments and quart-carbonate, overall 1-2%. Euhedral pyrite up to 1 cm in size, generally fresh but some mineral faces tarnished green-blue. Iron oxidation associated with foliated sediments and quartz-carbonate. Surface iron oxidation mm's thick.
96-B2S-09S	Ore	Stockpile	Overall pile is more coarse grained than other piles. Lithologies same as 96-B2N-56. Sulphides are ubiquitous, occuring dominantly in argillite and but also quartz-carbonate and and up to 5% in quantity. Dominantly pyrite with minor chalcopyrite, 1-5 mm in size and untarnished. Pyrite is cubic or smeared, typically clustered but also as veinlets. Iron oxidation surrounding sulphides.
96-B2S-10	Ore	Stockpile	Lithologies same as 96-B2N-32. Sulphides (pyrite) in argillite. 2-3% untarnished pyrite primarily as clusters, habit is both cubic and smeared. Brown-red iron oxidation associated with all 3 lithologies present, suggesting iron carbonate weathering.
96-B3S-12	Ore	Stockpile	Lithologies (in order of abundance): i) gabbro + basalt, ii) argillite, iii) sericite-chlorite altered foliated sediments and iv) quartz. Minor amounts (<1%) of fine grain pyrite as disseminations and localized clusters associated with basalt and along sediment foliations. Iron oxidation visible in quartz-carbonate and foliated sediments.
96-CX2-05	Ore	Stockpile	Lithologies (in order of abundance): i) foliated sediments (chlorite-sericite altered, trace fuchsite), ii) argillite and iii) quartz-carbonate. Pyrite occurs as in foliated sediments (~1%) and quartz-carbonate (trace) as fine to coarse grain disseminations, overall fresh but trace blue-green staining on striated faces. Brown-red iron oxidation on quartz-carbonate and foliated sediment lithologies.
97-B2-3865-S22	Ore	Stockpile	Lithologies (in order of abundance): i) quartz-carbonate with sedimentary flecks, ii) argillite with minor foliations, chlorite, graphitic and iii) foliated sediments with sericite alteration or graphitic. Pyrite as i) minor fine grain disseminations associated with sediments in quartz, ii) 1-2% fine to coarse grain, untarnished, cubic disseminations and clusters concentrated along foliation. Brown-red iron oxidation on veinlets/patches of carbonate in quartz and on surfaces of argillite.

Appendix A
Visual Descriptions of Rock Samples, August 2008

Sample ID	Material type	Location	Description
97-B2S-32S	Ore	Stockpile	Lithologies (in order of abundance): i) Two types foliated sediments: a) graphitic or b) sericite + chlorite + dolomite + rare fuchsite, ii) quartz-carbonate, iii) argillite and iv) intermediate dyke. Sulphides: i) <1% fine grain disseminations along foliations, ii) 2% medium to coarse grain (up to 1cm) pyrite with minor chalcopyrite disseminations and "smears" in argillite and iii) ubiquitous very fine grain disseminated phrite in intermediate dyke (as seen in core). Brown-red iron oxidation in foliations and along veinlets and surface of quartz-carbonate. Pervasive orange iron oxidation on surface of intermediate dyke.
97-CX3(02)-06	Ore	Stockpile	Lithologies (in order of abundance): i) foliated sediments, either sericitized with trace fuchsite or dolomitized with strong red-brown iron staining, ii) minor quartz and iii) rare argillite. Rare sulphides.
97-CX-3(02)-08	Ore	Stockpile	Lithologies (in order of abundance): i) argillic sediments, slightly graphitic and minor foliations; ii) sericite altered foliated sediments and iii) quartz with carbonate stringers and well developed crystals and flecks of sediments. Sulphides as 1-2% fine grain, untarnished disseminated pyrite within foliations of argillite and also assocaited with sedimentary phase in quartz. Iron oxidation along foliations (brown red).
SRK-BOS-WR-01	Ore	Stockpile	Sample taken in location of surface salts and fine grained sediments, with no discernible features. Fragments from within test pit (in no particular order): i) argillite, ii) basalt cross-cut by quartz-carbonate veins and iii) chlorite-sericite altered foliated sediments, extremely weathered. Pyrite associated with i) basalt (trace to minor amounts, euhedral, very fine grain to medium grain, untarnished) and ii) foliated sediments (pervaisve, disseminated,fine grain, euhedral, untarnished). No iron oxides observed on fragments but present in pile fragments not sampled.
SRK-BOS-WR-02 / 96-B3N-06	Ore	Stockpile	Lithologies (in order of abundance): i) foliated sediments (strong sericite, less chlorite with minor fuchsite), ii) quartz-carbonate with carbonate intergrowths and iii) rare argillite. Pyrite occurs in foliated sediments only as 2-3% fine grain disseminated cubic pyrite, untarnished, occassionally occurs as clusters. Orange-red iron oxidation localized to veinlets and patches of quartz-carbonate and along selected folations of foliated sediments. No gabbro observed.
SRK-BOS-WR-03	Ore	Berm	Argillite with minor foliations, with and without chlorite alteration and slightly silicified. <1% very fine grain and untarnished disseminated pyrite. Rare quartz fragments. Overall pile varied lithologically, with minor iron stain.
SRK-BOS-WR-04	Ore	Berm	i) Argillite, slightly foliated with bands of sericite, minor chlorite, slightly graphitic, ii) quartz with thin argillic bands and iii) sericite altered foliated sediments. Sulphides in argillite only, dominantly cubic pyrite with minor chalcopyrite. Sulphides fine grain, untarnished and clustered. Concentration variable, raning from 2-5% and up to 10% locally. Rare orange-red iron oxiation in thin microveinlets in quartz (crackle texture).
SRK-BOS-WR-05	Ore	Berm	Argillite with minor foliations, graphitic, minor sericite, containing localized clusters of fresh pyrite, 1%. Quartz fragments with rare fine grain pyrite and lesser chalcopyrite, untarnished. Rare iron oxidation overall, concentrated as orange-red microveinlets in quartz.
SRK-BOS-WR-06	Development Rock	Camp pad	Lithologies: i) gabbro with trace (<1%) fine grain, untarnished disseminated pyrite; ii) light brown foliated sediments (sericite and chlorite altered) with quartz veining along foliation and iii) basalt. No iron staining.
SRK-BOS-WR-07	Development Rock	Camp pad	Dominated by gabbro without sulphides with minor amounts of fine grain basalt (chlorite altered) intersected by quartz veins. Trace fine grain disseminated pyrite along contact of basalt and quartz veins. No iron staining.
SRK-BOS-WR-08	Development Rock	Camp pad	Dark grey fine grain basalt with quartz veining; fine grain basalt with chlorite alteration; Fine grain argillite with strong sericite and chlorite alteration; massive quartz. No visible sulphides. No iron staining.
SRK-BOS-WR-09	Development Rock	Airstrip	Dominated by foliated sediments with lesser argillite without sulphides. Foliated sediments as a) pistachio coloured sericite altered with quartz-carbonate veining between foliations, no sulphides; b) purply hue with no sulphides; c) chlorite + sericited altered, no sulphides and d) chlorite with minor fuchiste, with ~5% fine grain, untarnished disseminations of pyrite and iron oxidation along foliation.
SRK-BOS-WR-10	Ore	Airstrip	i) Argillite with quartz veining with variable levels of sulphides occuring at contact (1 to 30%). Pyrite is up to 0.5 cm, fresh in appearance and occurs as disseminations and clusters. ii) Sericite altered sediments foliated sediments with no pyrite. iii) Quartz-carbonate with sedimentary flecks containing minor fine grain pyrite. Relatively unoxidized but iron staining occurs along veinlets creating a crackle texture.
SRK-BOS-WR-11	Development Rock	Airstrip	Foliated sediments with sericte + chlorite + dolomite and argilltie. No sulphides. No iron staining.
SRK-BOS-WR-12	Ore	Airstrip	Same as sample SRK-BOS-WR-10

Appendix B

ABA Results

Appendix B.1

ABA Results for Bulk Samples

S. No.	Sample ID	Paste pH	Rinse pH*	Rinse EC* (µS/cm)	CO2 (Wt.%)	CaCO3 NP (Kg CaCO3/Tonne)	Total Sulphur (Wt.%)	Sulphate Sulphur (Wt.%)	Sulphide Sulphur** (Wt.%)	Maximum Potential Acidity*** (Kg CaCO3/Tonne)	Modified Sobek Neutralization Potential (Kg CaCO3/Tonne)	Net Neutralization Potential (Kg CaCO3/Tonne)	NP/AP	Fizz Rating
1	96-B2S-02	8.7	7.8	674	16.10	365.9	2.32	<0.01	2.32	72.5	186.2	113.7	2.6	Strong
2	96-B2N-02	8.4	7.7	928	10.01	227.5	4.04	0.02	4.02	125.6	146.5	20.8	1.2	Strong
3	96-CX2-05	8.8	8.0	161	16.28	370.0	0.96	<0.01	0.96	30.0	265.2	235.2	8.8	Strong
4	96-B2S-06	8.2	7.3	15170	16.21	368.4	2.03	0.02	2.01	62.8	193.8	131.0	3.1	Strong
-	96-B2S-06 (subsurface)	-	7.5	7270	-	-	-	-	-	-	-	-	-	-
5	96-B2N-56	8.6	7.8	706	16.21	368.4	1.19	<0.01	1.19	37.2	262.4	225.2	7.1	Strong
6	SRK-BOS-WR-01	8.5	7.9	1265	15.69	356.6	2.56	0.02	2.54	79.4	263.9	184.5	3.3	Strong
7	96-B2N-32	8.3	7.6	2960	18.26	415.0	1.33	<0.01	1.33	41.6	292.3	250.7	7.0	Strong
8	96-B2S-09S	8.4	8.1	244	15.51	352.5	1.00	<0.01	1.00	31.3	207.4	176.2	6.6	Strong
9	96-B2S-10	8.8	8.0	356	15.84	360.0	3.09	<0.01	3.09	96.6	210.2	113.7	2.2	Strong
10	96-B2N-52	8.5	7.2	9300	14.52	330.0	1.37	<0.01	1.37	42.8	270.2	227.4	6.3	Strong
-	96-B2N-52 (subsurface)	-	8.0	1355	-	-	-	-	-	-	-	-	-	-
11	96-B3S-12	8.8	7.7	486	18.41	418.4	0.59	<0.01	0.59	18.4	269.6	251.1	14.6	Strong
12	96-B2-NR-1/2	8.4	7.5	1047	11.95	271.6	3.18	0.01	3.17	99.1	191.3	92.2	1.9	Strong
-	96-B2-NR-1/2 (subsurface)	-	7.5	526	-	-	-	-	-	-	-	-	-	-
13	97-CX3(02)-08	8.3	7.8	2190	11.73	266.6	2.71	0.01	2.70	84.4	260.1	175.7	3.1	Strong
14	SRK-BOS-WR-02	8.6	7.9	790	15.22	345.9	2.34	<0.01	2.34	73.1	212.8	139.6	2.9	Strong
15	SRK-BOS-WR-03	8.5	8.2	475	16.39	372.5	0.73	<0.01	0.73	22.8	205.2	182.4	9.0	Strong
16	SRK-BOS-WR-04	8.4	7.6	1550	10.74	244.1	2.01	0.01	2.00	62.5	214.0	151.5	3.4	Strong
17	SRK-BOS-WR-05	8.1	7.5	3600	15.29	347.5	1.52	0.01	1.51	47.2	239.9	192.7	5.1	Strong
18	96-B2N-67	8.5	7.8	612	8.95	203.4	2.37	<0.01	2.37	74.1	178.7	104.6	2.4	Strong
-	96-B2N-67 (subsurface)	-	8.0	353	-	-	-	-	-	-	-	-	-	-
19	SRK-BOS-WR-08	8.4	7.8	1386	14.01	318.4	0.46	<0.01	0.46	14.4	264.5	250.1	18.4	Strong
20	97-B2-3865-S22	8.3	7.8	1041	8.18	185.9	2.87	0.01	2.86	89.4	135.1	45.7	1.5	Strong
21	SRK-BOS-WR-06	9.1	8.7	135	16.79	381.6	0.46	<0.01	0.46	14.4	310.0	295.6	21.6	Strong
22	97-B2S-32S	8.4	7.9	759	16.39	372.5	1.16	<0.01	1.16	36.3	289.8	253.5	8.0	Strong
23	97-CX3(02)-06	8.6	8.4	441	15.44	350.9	0.13	<0.01	0.13	4.1	261.4	257.3	64.3	Strong
24	SRK-BOS-WR-07	8.4	8.2	837	14.92	339.1	0.61	<0.01	0.61	19.1	268.3	249.2	14.1	Strong
25	SRK-BOS-WR-09	8.9	8.3	197	12.76	290.0	0.38	<0.01	0.38	11.9	270.8	259.0	22.8	Strong
26	SRK-BOS-WR-10	8.9	-	-	18.00	409.1	1.95	<0.01	1.95	60.9	307.4	246.5	5.0	Strong
27	SRK-BOS-WR-11	9.1	8.65*	129*	15.62	355.0	0.15	<0.01	0.15	4.7	312.5	307.8	66.7	Strong
28	SRK-BOS-WR-12	8.7	8.23*	502*	16.06	365.0	2.25	<0.01	2.25	70.3	251.3	181.0	3.6	Strong

Detection Limits	*0.1*	*0.1*	*1*	*0.02*	*0.5*	*0.02*	*0.01*	*0.02*	*0.6*				
CANTEST SOP No:	7160	7190		LECO	Calculation	LECO	7410	Calculation	Calculation	7150	Calculation	Calculation	7150

Notes:

Rinse pH and EC done on 50g of -2mm sample: 70ml of DI water.

*Rinse pH and EC were measured in the field with the exception of two samples: SRK-BOS-11 and SRK-BOS-12.

**Based on difference between total sulphur and sulphate-sulphur.

***Based on sulphide-sulphur.

Total Sulphur and Carbonate Carbon (CO2) by LECO.

Reference for Mod ABA NP method (SOP No. 7150): MEND Acid Rock Drainage Prediction Manual, MEND Project 1.16.1b (pages 6.2-11 to 17), March 1991.

Appendix B.2

ABA Results for Fine Fraction Samples

Appendix B.2
ABA Results for Fine Fraction Samples

S. No.	Sample ID	Paste pH	CO2 (Wt.%)	CaCO3 Equiv. (Kg CaCO3/tonne)	Total Sulphur (Wt.%)	Maximum Potential Acidity* (Kg CaCO3/Tonne)	Modified Sobek Neutralization Potential (Kg CaCO3/Tonne)	Net Neutralization Potential (Kg CaCO3/Tonne)	NP/AP	Fizz Rating
1	96-B2N-02	8.1	9.39	213.4	3.90	121.9	137.0	15.1	1.1	Strong
2	96-CX2-05	8.1	13.16	299.1	1.26	39.4	219.0	179.6	5.6	Strong
3	96-B2S-06	8.9	14.52	330.0	2.08	65.0	171.4	106.4	2.6	Strong
4	96-B2N-32	8.2	13.49	306.6	1.78	55.6	220.2	164.6	4.0	Strong
5	96-B2S-10	8.5	14.12	320.9	3.54	110.6	205.3	94.6	1.9	Moderate
6	97-CX3(2)-08	8.2	11.00	250.0	2.59	80.9	204.6	123.7	2.5	Strong
7	SRK-BOS-WR-02	8.6	13.35	303.4	2.54	79.4	187.7	108.3	2.4	Strong
8	SRK-BOS-WR-03	8.3	14.19	322.5	0.89	27.8	152.3	124.4	5.5	Strong
9	SRK-BOS-WR-05	8.0	13.02	295.9	2.05	64.1	192.7	128.7	3.0	Strong
10	97-B2-3865-S22	8.2	8.73	198.4	2.86	89.4	140.0	50.6	1.6	Strong
11	97-CX3(2)-06	8.5	11.07	251.6	0.20	6.3	235.3	229.1	37.7	Strong
12	SRK-BOS-WR-07	8.3	15.80	359.1	0.40	12.5	237.8	225.3	19.0	Strong
13	SRK-BOS-WR-11	8.9	15.00	340.9	0.13	4.1	264.0	260.0	65.0	Strong
14	SRK-BOS-WR-12	8.5	14.23	323.4	2.16	67.5	216.5	149.0	3.2	Strong
Detection Limits		*0.5*	*0.02*	*0.5*	*0.02*	*0.6*				
CANTEST SOP No:		7160	LECO	Calculation	LECO	Calculation	7150	Calculation	Calculation	7150

Notes:

All Analysis done on pulverized <2mm fraction.

Total sulphur and Carbonate carbon (HCl method) by LECO furnace (done at Acme Labs).

Sulphate sulphur not requested.

*Maximum Potential Acidity (MPA): Is based on total sulphur.

Reference for Mod ABA NP method (SOP No. 7150): MEND Acid Rock Drainage Prediction Manual, MEND Project 1.16.1b (pages 6.2-11 to 17), March 1991.

Appendix C

Elemental Analysis Results

Appendix C.1

Elemental Analysis Results for Bulk Samples

S. No:	**Sample ID**	**Ag ppm**	**Al %**	**As ppm**	**Au ppb**	**B ppm**	**Ba ppm**	**Bi ppm**	**Ca %**	**Cd ppm**	**Co ppm**	**Cr ppm**	**Cu ppm**	**Fe %**	**Ga ppm**	**Hg ppm**	**K %**	**La ppm**	**Mg %**	**Mn ppm**	**Mo ppm**
1	96-B2S-02	1.4	0.31	757.6	15020.4	<20	7.0	<0.1	5.06	0.6	43.1	46	202.9	9.56	1.0	<0.01	0.04	1	2.00	1933	3.1
2	96-B2N-02	3.1	0.24	745.7	37203.5	<20	5.0	<0.1	3.91	0.1	35.2	102	198.5	6.55	<1	0.01	0.03	<1	1.55	1269	5.3
3	96-CX2-05	0.8	0.84	693.7	699.4	<20	3.0	<0.1	6.78	0.1	41.6	160	98.8	5.94	2.0	<0.01	0.01	<1	2.62	1613	2
4	96-B2S-06	0.9	0.24	2943.3	4892.2	<20	5.0	<0.1	5.53	0.1	49.5	30	129.2	10.27	1.0	<0.01	0.04	1	2.09	2189	2
5	96-B2N-56	3.3	0.2	846.6	4517.6	<20	4.0	<0.1	7.04	2.0	50.8	60	112	5.48	<1	<0.01	0.03	<1	2.42	1677	2.2
6	SRK-BOS-WR-01	0.6	0.2	1127.1	2396.6	<20	5.0	<0.1	6.31	<0.1	61.8	82	108.1	6.19	<1	<0.01	0.02	<1	2.84	1516	2.3
7	96-B2N-32	1.1	0.39	612.9	2508.5	<20	5.0	<0.1	7.65	0.2	47.1	65	109.8	6.74	1.0	0.01	0.02	<1	2.59	1831	1.2
8	96-B2S-09S	0.3	0.23	362.7	571.8	<20	5.0	<0.1	5.85	0.1	39.4	13	148.5	10.08	1.0	<0.01	0.03	<1	2.12	2149	1.4
9	96-B2S-10	1.0	0.26	645.6	3773.5	<20	6.0	<0.1	5.63	0.1	37.2	49	137.4	8.8	1.0	<0.01	0.03	<1	1.90	1839	3.3
10	96-B2N-52	0.6	0.91	555.3	891.7	<20	6.0	<0.1	6.42	0.8	54.1	148	127.9	6.41	2.0	<0.01	0.04	<1	2.49	1751	1.9
11	96-B3S-12	0.1	0.25	979.8	187.4	<20	6.0	<0.1	6.69	<0.1	65.2	93	84.2	6.51	<1	<0.01	0.03	<1	2.97	1665	1.1
12	96-B2-NR-1/2	2.5	0.31	731.2	13392.2	<20	5.0	<0.1	5.03	0.1	34.2	55	109.8	7.11	1.0	<0.01	0.03	1	1.98	1405	3.4
13	97-CX3(02)-08	1.3	0.65	777.3	2095.9	<20	6.0	<0.1	5.91	1.0	50.3	116	165	6.11	2.0	0.01	0.02	<1	2.60	1358	1.2
14	SRK-BOS-WR-02	0.4	0.31	655.3	1015.2	<20	5.0	<0.1	5.57	<0.1	67.6	94	104.9	7.19	<1	<0.01	0.02	<1	2.82	1647	0.9
15	SRK-BOS-WR-03	0.2	0.59	268.6	368.7	<20	5.0	<0.1	5.27	<0.1	42.4	100	117.7	9.6	1.0	<0.01	0.02	1	2.21	2027	0.9
16	SRK-BOS-WR-04	1.8	0.17	199.3	18024.1	<20	5.0	<0.1	5.23	0.3	37.9	52	135.4	4.91	<1	<0.01	0.02	<1	1.63	1167	2.8
17	SRK-BOS-WR-05	0.5	0.27	312.5	1843.1	<20	4.0	<0.1	5.94	0.1	50.8	48	121.6	7.51	<1	<0.01	0.03	<1	2.21	1708	1.4
18	96-B2N-67	2.1	0.24	753.2	8652.3	<20	4.0	<0.1	4.53	0.1	37.5	68	102.5	5.11	<1	<0.01	0.02	<1	1.55	1226	2.8
19	SRK-BOS-WR-08	0.2	1.13	269.4	127.7	<20	22.0	<0.1	5.98	<0.1	57.3	290	89.1	6.16	3.0	<0.01	0.02	<1	3.27	1374	0.9
20	97-B2-3865-S22	1.4	0.12	216.7	8999.3	<20	2.0	<0.1	3.50	0.4	22.7	41	116.9	4.23	<1	<0.01	0.02	<1	1.10	921	2.7
21	SRK-BOS-WR-06	<0.1	0.84	167.9	161.4	<20	92.0	<0.1	6.37	<0.1	40.7	220	73	5.27	2.0	<0.01	0.01	<1	3.51	1484	0.7
22	97-B2S-32S	0.3	0.4	412.8	432.3	<20	4.0	<0.1	6.32	0.1	36.4	98	78.1	5.62	1.0	<0.01	0.02	<1	2.42	1607	1.1
23	97-CX3(02)-06	0.1	1.34	258.3	23.4	<20	6.0	<0.1	5.48	<0.1	56.5	343	84	5.61	4.0	<0.01	0.02	<1	2.51	1346	0.7
24	SRK-BOS-WR-07	<0.1	0.87	285.7	191.5	<20	26.0	<0.1	5.51	<0.1	55.7	266	79	6.25	2.0	<0.01	0.02	<1	2.99	1423	0.6
25	SRK-BOS-WR-09	<0.1	1.85	168.9	53.3	<20	9.0	<0.1	5.50	0.1	49.6	427	119.7	5.53	4.0	<0.01	0.01	<1	3.08	1260	0.6
26	SRK-BOS-WR-10	0.5	0.75	929.5	1728.5	<20	3.0	<0.1	6.39	0.2	45.8	266	66.3	6.84	2.0	<0.01	0.01	<1	3.86	1582	1
27	SRK-BOS-WR-11	<0.1	1.64	115.6	23.8	<20	8.0	<0.1	6.50	0.1	48.7	400	98.3	5.81	4.0	<0.01	0.02	<1	3.16	1472	0.9
28	SRK-BOS-WR-12	0.9	0.8	730.8	3970.1	<20	6.0	<0.1	5.65	0.6	37.7	100	152.5	7.57	2.0	<0.01	0.03	<1	2.44	1746	1.7
QA/QC (Duplicates)																					
19	SRK-BOS-WR-08	0.1	1.11	263.9	183.9	<20	26	<0.1	5.93	0.1	58.6	291	92.1	6.08	3	<0.01	0.02	<1	3.15	1366	1
28	SRK-BOS-WR-12	1	0.77	693.7	3857.7	<20	6	<0.1	6.03	0.7	39.6	103	161.2	7.87	2	<0.01	0.03	<1	2.56	1891	1.9
STANDARD DS7		0.8	1	48.1	56.1	45	367	4.7	0.91	5.5	8.9	186	131.4	2.38	5	0.19	0.46	11	1.04	621	20.5
STANDARD DS7		0.9	0.92	49.5	58.1	43	368	4.8	0.86	6.4	9	175	102.5	2.26	4	0.2	0.45	11	0.97	584	19.6
STANDARD DS7		0.8	0.98	49.5	62	40	400	4.1	0.9	5.9	9.2	193	103.9	2.33	5	0.21	0.44	11	1.03	609	20.9
STANDARD DS7		0.9	0.94	50.3	54.1	36	382	4	0.9	5.6	8.9	188	103.3	2.28	5	0.2	0.44	11	1.01	601	19.9
True Value STD DS7		0.89	0.959	48.2	70.0	38.6	370.3	4.51	0.93	6.38	9.7	163	109	2.39	4.6	0.20	0.44	12.7	1.05	627	20.92
Percent Difference		1.1	2.2	2.7	-11.4	3.6	8.0	4.2	-2.2	-7.5	-5.2	7.4	-4.7	-2.5	8.7	0.0	0.0	-13.4	-1.9	-2.9	-0.1
Detection Limits		0.1	0.01	0.5	0.5	20	1	0.1	0.01	0.1	0.1	1	0.1	0.01	1	0.01	0.01	1	0.01	1	0.1
Group		1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX

Note:

Analysis done at Acme Labs

Analytical Methods:

ICP-MS Package: 0.5 gram sample digested in hot reverse aqua regia (soil, silt) or hot aqua regia (for rocks).

S. No:	Sample ID	Na %	Ni ppm	P %	Pb ppm	Sb ppm	Sc ppm	Se ppm	Sr ppm	Th ppm	Ti %	Tl ppm	U ppm	V ppm	W ppm	Zn ppm
1	96-B2S-02	0.032	50.0	0.045	3.7	1.1	10.5	3.1	25	0.3	<0.001	<0.1	<0.1	26	17.20	90
2	96-B2N-02	0.025	54.1	0.027	5.2	0.7	7.3	4.8	31	0.2	<0.001	<0.1	<0.1	14	2.00	45
3	96-CX2-05	0.013	152.0	0.01	3.1	3.3	10.4	0.9	31	<0.1	<0.001	<0.1	<0.1	41	60.30	57
4	96-B2S-06	0.049	60.2	0.047	4.1	1.1	11.9	4.7	35	0.3	<0.001	<0.1	<0.1	23	0.40	77
5	96-B2N-56	0.013	186.1	0.021	19.9	3.9	6.5	1.4	41	<0.1	<0.001	<0.1	<0.1	14	>100	291
6	SRK-BOS-WR-01	0.027	256.3	0.022	9.6	3.2	11.0	1.2	54	<0.1	<0.001	<0.1	<0.1	17	1.90	39
7	96-B2N-32	0.021	157.3	0.014	6.8	0.9	9.8	1.2	48	<0.1	<0.001	<0.1	<0.1	23	5.30	65
8	96-B2S-09S	0.017	37.6	0.048	2.6	0.7	11.1	1.3	32	0.3	<0.001	<0.1	<0.1	20	0.40	68
9	96-B2S-10	0.025	42.7	0.041	3.3	0.9	9.6	2.6	29	0.2	<0.001	<0.1	<0.1	19	0.60	51
10	96-B2N-52	0.027	195.1	0.019	8.8	1.1	10.3	1	38	<0.1	<0.001	<0.1	<0.1	33	0.50	161
11	96-B3S-12	0.022	299.4	0.017	4.9	1.4	9.9	<0.5	44	<0.1	<0.001	<0.1	<0.1	18	0.20	41
12	96-B2-NR-1/2	0.015	66.6	0.065	13.4	4.3	8.1	2.2	38	0.2	<0.001	<0.1	<0.1	28	7.70	49
13	97-CX3(02)-08	0.021	185.7	0.02	16.8	2.5	11.6	0.7	55	<0.1	<0.001	<0.1	<0.1	31	15.10	221
14	SRK-BOS-WR-02	0.020	269.6	0.012	3.9	1.3	13.2	<0.5	45	<0.1	<0.001	<0.1	<0.1	21	1.20	48
15	SRK-BOS-WR-03	0.015	80.6	0.041	3.4	1.0	12.4	0.5	36	0.3	<0.001	<0.1	<0.1	31	0.40	97
16	SRK-BOS-WR-04	0.026	45.5	0.028	5	1.3	8.8	1.3	36	0.2	<0.001	<0.1	<0.1	15	0.30	96
17	SRK-BOS-WR-05	0.018	89.2	0.022	4.1	0.9	10.1	1.6	37	0.1	<0.001	<0.1	<0.1	19	0.40	86
18	96-B2N-67	0.010	81.1	0.019	10.4	1.8	6.7	1.7	29	<0.1	<0.001	<0.1	<0.1	15	8.80	46
19	SRK-BOS-WR-08	0.020	240.3	0.015	3.3	0.7	13.2	<0.5	64	<0.1	0.0	<0.1	<0.1	53	0.60	54
20	97-B2-3865-S22	0.010	30.2	0.017	3.1	1.4	4.5	2.4	19	0.1	<0.001	<0.1	<0.1	10	0.60	129
21	SRK-BOS-WR-06	0.012	167.5	0.014	2.5	0.4	11.5	<0.5	59	<0.1	<0.001	<0.1	<0.1	48	1.40	44
22	97-B2S-32S	0.009	140.3	0.01	2.3	1.1	7.9	0.8	32	<0.1	<0.001	<0.1	<0.1	28	63.30	48
23	97-CX3(02)-06	0.021	233.6	0.012	2.9	1.4	12.0	<0.5	37	<0.1	<0.001	<0.1	<0.1	71	0.30	56
24	SRK-BOS-WR-07	0.017	261.1	0.013	3	0.7	11.5	0.6	53	<0.1	<0.001	<0.1	<0.1	50	0.40	47
25	SRK-BOS-WR-09	0.011	234.3	0.013	2.2	0.5	12.1	0.5	50	<0.1	0.0	<0.1	<0.1	85	0.80	56
26	SRK-BOS-WR-10	0.009	308.3	0.017	12.1	2.2	9.9	1.4	59	<0.1	<0.001	<0.1	<0.1	42	0.50	57
27	SRK-BOS-WR-11	0.017	223.3	0.012	6.3	0.7	12.1	<0.5	40	<0.1	<0.001	<0.1	<0.1	82	0.20	69
28	SRK-BOS-WR-12	0.018	109.4	0.031	7.4	1.5	9.1	2.5	35	0.2	0.0	<0.1	<0.1	42	35.30	156
QA/QC (Duplicates)																
19	SRK-BOS-WR-08	0.022	236.8	0.016	5.3	0.7	13.5	<0.5	60	<0.1	0.002	<0.1	<0.1	53	0.6	52
28	SRK-BOS-WR-12	0.019	116.6	0.033	8.3	1.9	9.7	2.6	38	0.2	0.001	<0.1	<0.1	42	35.1	167
STANDARD DS7		0.096	55.9	0.074	67.5	4.4	2.2	3.4	69	4	0.112	3.9	4.8	82	3	409
STANDARD DS7		0.082	53.6	0.075	71.7	4.7	2.1	3	66	4.1	0.105	4.1	4.8	78	3.2	391
STANDARD DS7		0.083	57.1	0.073	72	4.2	2.2	4.4	67	3.9	0.111	4.5	4.7	86	2.4	413
STANDARD DS7		0.083	58.4	0.073	67.7	4.0	2	4	65	3.8	0.108	4.3	4.5	86	2.7	401
True Value STD DS7		0.073	56.0	0.08	70.6	5.9	2.5	3.5	69	4.4	0.124	4.19	4.9	86	3.8	411.0
Percent Difference		12.3	2.0	-8.8	2.0	-19.8	-12.0	-2.9	-2.5	-6.8	-9.7	-2.1	-4.1	0.0	-15.8	0.5
Detection Limits		0.001	0.1	0.001	0.1	0.1	0.1	0.5	1	0.1	0.001	0.1	0.1	2	0.1	1
Group		1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX

Note:

Analysis done at Acme Labs

Analytical Methods:

ICP-MS Package: 0.5 gram sa

Appendix C.2

Elemental Analysis Results for Fine Fraction Samples

Appendix C.2
Elemental Analysis Results for Fine Fraction Samples

S. No.	Sample ID	Ag ppm	Al %	As ppm	Au ppb	B ppm	Ba ppm	Bi ppm	Ca %	Cd ppm	Co ppm	Cr ppm	Cu ppm	Fe %	Ga ppm	Hg ppm	K %	La ppm	Mg %	Mn ppm	Mo ppm
1	96-B2N-02	3.1	0.26	611.7	40622	<20	10	<0.1	3.58	0.1	38.8	88	198.3	6.05	<1	0.06	0.05	2	1.31	1116	5.1
2	96-CX2-05	1.5	1.04	919.9	2006	<20	8	<0.1	5.76	0.3	64.2	213	138.4	5.45	3	0.02	0.04	<1	2.22	1189	3.8
3	96-B2S-06	1.2	0.43	2941.4	5260	<20	11	<0.1	4.86	0.2	63.1	53	174.2	8.92	2	0.05	0.07	2	1.80	1772	3.1
4	96-B2N-32	1.3	0.64	879.0	2425	<20	14	<0.1	5.78	0.4	80.4	92	153.0	5.56	2	0.03	0.07	<1	1.91	1188	2.4
5	96-B2S-10	1.9	0.61	675.7	9314	<20	20	<0.1	5.30	0.2	51.6	72	202.4	8.25	2	0.05	0.11	1	1.70	1540	5.0
6	97-CX3(2)-08	1.8	0.87	1058.1	2020	<20	15	<0.1	5.03	0.9	70.1	157	229.4	5.77	2	0.02	0.05	<1	2.16	1006	1.7
7	SRK-BOS-WR-02	0.6	0.36	798.7	1934	<20	12	<0.1	4.42	<0.1	84.4	112	137.8	6.26	1	0.03	0.03	<1	2.20	1205	1.5
8	SRK-BOS-WR-03	0.4	0.89	351.7	550	<20	14	<0.1	4.13	0.2	63.8	132	166.2	8.31	2	0.02	0.05	2	2.00	1592	1.7
9	SRK-BOS-WR-05	0.6	0.56	464.9	2700	<20	13	<0.1	4.92	0.2	72.6	75	179.2	6.45	1	0.05	0.08	1	1.78	1311	3.0
10	97-B2-3865-S22	2.1	0.24	326.8	17655	<20	10	<0.1	3.77	0.5	38.0	106	200.2	4.73	<1	0.06	0.05	1	1.12	997	7.8
11	97-CX3(2)-06	0.3	1.84	383.2	58	<20	14	<0.1	6.01	0.1	82.2	433	137.9	6.37	6	0.04	0.03	<1	2.56	1256	0.8
12	SRK-BOS-WR-07	0.1	1.40	461.6	190	<20	65	<0.1	5.66	0.1	90.6	356	154.8	6.92	4	0.03	0.04	<1	3.06	1306	1.0
13	SRK-BOS-WR-11	0.2	2.21	234.4	126	<20	24	<0.1	6.57	0.3	84.4	501	185.7	6.48	6	0.03	0.04	<1	3.04	1248	1.0
14	SRK-BOS-WR-12	2.1	1.19	981.1	11019	<20	22	<0.1	5.58	0.5	64.4	161	226.0	7.59	3	0.06	0.09	1	2.30	1500	3.7
QAQC																					
Reference Material																					
STANDARD DS7 (1)		0.9	0.99	55.9	68.3	39	422	4.4	0.87	6.3	8.7	149	101.0	2.36	5	0.17	0.48	11	1.03	605	18.9
STANDARD DS7 (2)		0.8	1.00	56.1	63.3	34	425	4.7	0.89	6.6	9.1	153	106.1	2.42	5	0.19	0.48	12	1.04	615	20.2
True Value STD DS7		0.9	1.0	48.2	70.0	38.6	370.3	4.5	0.9	6.4	9.7	163.0	109.0	2.4	4.6	0.2	0.4	12.7	1.1	627.0	20.9
Percent Difference (1)		1.1	3.2	16.0	-2.4	1.0	14.0	-2.4	-6.5	-1.3	-10.3	-8.6	-7.3	-1.3	8.7	-15.0	9.1	-13.4	-1.9	-3.5	-9.7
Percent Difference (2)		-10.1	4.3	16.4	-9.6	-11.9	14.8	4.2	-4.3	3.4	-6.2	-6.1	-2.7	1.3	8.7	-5.0	9.1	-5.5	-1.0	-1.9	-3.4
Detection Limits		0.1	0.01	0.5	0.5	1	1	0.1	0.01	0.1	0.1	1	0.1	0.01	1	0.01	0.01	1	0.01	1	0.1
Method		1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX

Note:

Analysis done on pulverized <2mm fraction.

Analysis done at Acme Labs.

S. No.	Sample ID	Na %	Ni ppm	P %	Pb ppm	S %	Sb ppm	Sc ppm	Se ppm	Sr ppm	Th ppm	Ti %	Tl ppm	U ppm	V ppm	W ppm	Zn ppm
1	96-B2N-02	0.038	45.6	0.035	10.4	3.68	1.0	6.7	5.0	25	0.3	<0.001	<0.1	<0.1	15	2.1	53
2	96-CX2-05	0.041	227.6	0.014	12.6	1.40	3.1	9.2	0.7	31	<0.1	<0.001	<0.1	<0.1	44	>100.0	76
3	96-B2S-06	0.108	72.0	0.056	10.1	2.26	1.1	11.4	4.8	34	0.4	<0.001	<0.1	<0.1	28	2.0	83
4	96-B2N-32	0.056	244.1	0.021	17.2	1.88	1.2	9.0	1.6	40	0.1	<0.001	<0.1	<0.1	26	39.5	85
5	96-B2S-10	0.075	54.1	0.054	17.5	3.58	0.6	9.7	2.4	33	0.3	<0.001	<0.1	<0.1	29	1.1	82
6	97-CX3(2)-08	0.045	231.7	0.029	31.1	2.72	3.6	11.3	0.6	52	<0.1	<0.001	<0.1	<0.1	36	41.8	184
7	SRK-BOS-WR-02	0.045	316.8	0.013	13.1	2.41	1.7	12.1	<0.5	39	<0.1	<0.001	<0.1	<0.1	23	1.3	51
8	SRK-BOS-WR-03	0.042	109.8	0.051	10.6	0.93	0.8	11.8	<0.5	31	0.4	<0.001	<0.1	<0.1	40	4.4	93
9	SRK-BOS-WR-05	0.056	123.2	0.033	12.1	2.00	0.7	9.3	1.7	41	0.2	<0.001	<0.1	<0.1	24	1.2	90
10	97-B2-3865-S22	0.040	47.6	0.024	14.1	2.91	1.1	5.9	2.8	30	0.2	<0.001	<0.1	<0.1	14	1.2	145
11	97-CX3(2)-06	0.047	288.5	0.019	8.0	0.22	2.3	15.2	<0.5	49	<0.1	<0.001	<0.1	<0.1	81	0.3	83
12	SRK-BOS-WR-07	0.057	371.0	0.016	10.8	0.46	1.0	14.1	<0.5	65	<0.1	<0.001	<0.1	<0.1	60	2.3	75
13	SRK-BOS-WR-11	0.066	291.1	0.017	12.8	0.16	1.0	15.0	<0.5	49	<0.1	<0.001	<0.1	<0.1	96	0.1	98
14	SRK-BOS-WR-12	0.078	160.6	0.037	20.8	2.24	1.6	10.8	2.1	46	0.3	<0.001	<0.1	<0.1	51	12.3	130
QAQC																	
Reference Material																	
STANDARD DS7 (1)		0.075	48.3	0.079	62.8	0.2	4.8	2.2	3.6	69	3.8	0.119	4.0	4.6	73	3.0	387
STANDARD DS7 (2)		0.079	50.0	0.077	70.5	0.2	5.2	2.3	2.9	72	3.9	0.127	4.4	5.2	78	3.6	394
True Value STD DS7		0.1	56.0	0.1	70.6	0.2	5.9	2.5	3.5	68.7	4.4	0.1	4.2	4.9	86.0	3.8	411.0
Percent Difference (1)		2.7	-13.8	-1.3	-11.0	-14.3	-18.1	-12.0	2.9	0.4	-13.6	-4.0	-4.5	-6.1	-15.1	-21.1	-5.8
Percent Difference (2)		8.2	-10.7	-3.8	-0.1	-9.5	-11.3	-8.0	-17.1	4.8	-11.4	2.4	5.0	6.1	-9.3	-5.3	-4.1
Detection Limits		0.001	0.1	0.001	0.1	0.05	0.1	0.1	0.5	1	0.1	0.001	0.1	0.1	2	0.1	1
Method		1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX	1DX

Note:

Analysis done on pulverized <

Analysis done at Acme Labs.

Appendix D
Shake Flask Extraction Results

Parameter	Units	Method	Detection Limit	Sample ID							
				96-B2N-32	96-B2N-52	96-B2S-02	96-B2S-06	96-B2S-10	SRK-BOS-WR-01	SRK-BOS-WR-05	SRK-BOS-WR-08
Wt. of sample used	g	Weighing Scale	0.01	250	250	250	250	250	250	250	250
Vol. of DI water used	ml	Graduated Cylinder	0.01	750	750	750	750	750	750	750	750
pH (24h)	pH Units	Meter	0.5	8.2	8.1	8.2	8.2	8.3	8.1	8.1	8.1
Conductivity (24h)	µs/cm	Meter	0.5	711	548	490	1617	373	640	1078	576
Alkalinity (to pH 4.5)	mg CaCO3/L	Titration/ Calculation	1	100	80	112	99	129	82	91	73
Sulphate	mg/L	Auto Turbidity	1.0	54	110	108	238	53	231	176	69
Dissolved Chloride Cl	mg/L	IC	0.20	56	30.3	9.78	158	2.33	12	157	74.4
Dissolved Nitrate N	mg/L	IC	0.05	28.6	9.52	4.74	67.4	0.1	2.93	10.5	7.57
Nitrite N	mg/L	Colorimetric	0.002	0.003	0.004	0.02	0.003	0.006	0.006	< 0.002	0.003
Total Ammonia	mgN/L		0.01	4.52	2.56	0.17	6.74	0.08	0.14	1.46	0.13
Dissolved Metals (Cantest)											
Dissolved Aluminum Al	mg/L	ICP-MS	0.005	0.237	0.217	0.154	0.121	0.152	0.256	0.111	0.204
Dissolved Antimony Sb	mg/L	ICP-MS	0.001	0.012	0.013	0.004	0.003	0.003	0.021	0.004	0.008
Dissolved Arsenic As	mg/L	ICP-MS	0.001	0.211	0.254	0.014	0.037	0.007	0.41	0.029	0.111
Dissolved Barium Ba	mg/L	ICP-MS	0.001	0.005	0.003	0.002	0.007	0.001	0.003	0.006	0.03
Dissolved Beryllium Be	mg/L	ICP-MS	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Dissolved Bismuth Bi	mg/L	ICP-MS	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Dissolved Boron B	mg/L	ICP-MS	0.05	0.25	0.2	0.19	0.19	0.14	0.26	0.39	0.15
Dissolved Cadmium Cd	mg/L	ICP-MS	0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002
Dissolved Calcium Ca	mg/L	ICP-MS	0.05	46.8	46.4	56	111	40.4	61.2	124	44.4
Dissolved Chromium Cr	mg/L	ICP-MS	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Dissolved Cobalt Co	mg/L	ICP-MS	0.001	0.002	0.001	0.001	0.005	0.001	0.003	0.0072	0.002
Dissolved Copper Cu	mg/L	ICP-MS	0.001	0.002	0.002	0.009	0.007	0.003	0.004	0.004	0.002
Dissolved Iron Fe	mg/L	ICP-MS	0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Dissolved Lead Pb	mg/L	ICP-MS	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	0.003	< 0.001
Dissolved Lithium Li	mg/L	ICP-MS	0.001	0.003	0.003	0.002	0.006	0.001	0.003	0.035	0.01
Dissolved Magnesium Mg	mg/L	ICP-MS	0.05	23.1	16.6	21	62.2	17.3	22.9	27.3	23.5
Dissolved Manganese Mn	mg/L	ICP-MS	0.001	0.018	0.015	0.033	0.074	0.028	0.01	0.085	0.013
Dissolved Molybdenum Mo	mg/L	ICP-MS	0.0005	0.008	0.0052	0.0017	0.0042	0.001	0.0014	0.0043	0.0016
Dissolved Nickel Ni	mg/L	ICP-MS	0.001	0.016	0.009	0.002	0.008	0.001	0.021	0.018	0.009
Dissolved Phosphorus P	mg/L	ICP-MS	0.15	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15	< 0.15
Dissolved Potassium K	mg/L	ICP-MS	0.15	14.6	13.4	8.8	20.8	5.3	6.12	17.6	3.5
Dissolved Selenium Se	mg/L	ICP-MS	0.001	0.004	0.003	0.014	0.012	0.003	< 0.001	0.004	0.004
Dissolved Silicon Si	mg/L	ICP-MS	0.15	1.1	1.2	1	1	0.8	1.44	0.93	1.1
Dissolved Silver Ag	mg/L	ICP-MS	0.00025	0.0003	< 0.00025	0.0005	0.0005	0.0004	0.0004	0.0003	< 0.00025
Dissolved Sodium Na	mg/L	ICP-MS	0.25	42.5	26.4	22.6	105	9.28	35.2	28.1	22.5
Dissolved Strontium Sr	mg/L	ICP-MS	0.001	0.158	0.119	0.064	0.375	0.039	0.153	0.881	0.304
Dissolved Tellurium Te	mg/L	ICP-MS	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Dissolved Thallium Tl	mg/L	ICP-MS	0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001	< 0.0001
Dissolved Thorium Th	mg/L	ICP-MS	0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Dissolved Tin Sn	mg/L	ICP-MS	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Dissolved Titanium Ti	mg/L	ICP-MS	0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001	< 0.001
Dissolved Uranium U	mg/L	ICP-MS	0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Dissolved Vanadium V	mg/L	ICP-MS	0.001	0.002	0.002	< 0.001	0.002	< 0.001	0.002	0.002	0.002
Dissolved Zinc Zn	mg/L	ICP-MS	0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Dissolved Zirconium Zr	mg/L	ICP-MS	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Dissolved Mercury Hg	µg/L	CVAF	0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02

Extraction Method Used: Using Rotary Extractor for 24h.
Liquid:Solid Ratio Used = 3:1; 750ml DI H2O:250g cone crushed (<9.5 mm) sample.

Parameter	Units	Method	SRK-BOS-WR-11	SRK-BOS-WR-12
Wt. of sample used	g	Weighing Scale	250	250
Vol. of DI water used	ml	Graduated Cylinder	750	750
pH (24h)	pH Units	Meter	8.2	8.3
Conductivity (24h)	μs/cm	Meter	220	392
Alkalinity (to pH 4.5)	mg CaCO3/L	Titration/ Calculation	102	132
Sulphate	mg/L	Auto Turbidity	10	58
Dissolved Chloride Cl	mg/L	IC	1.21	9.3
Dissolved Nitrate N	mg/L	IC	0.07	0.12
Nitrite N	mg/L	Colorimetric	0.015	< 0.002
Total Ammonia	mgN/L		0.02	0.05
Dissolved Metals (Cantest)				
Dissolved Aluminum Al	mg/L	ICP-MS	0.292	0.19
Dissolved Antimony Sb	mg/L	ICP-MS	0.01	0.007
Dissolved Arsenic As	mg/L	ICP-MS	0.1	0.056
Dissolved Barium Ba	mg/L	ICP-MS	0.002	0.003
Dissolved Beryllium Be	mg/L	ICP-MS	< 0.001	< 0.001
Dissolved Bismuth Bi	mg/L	ICP-MS	< 0.001	< 0.001
Dissolved Boron B	mg/L	ICP-MS	0.1	0.21
Dissolved Cadmium Cd	mg/L	ICP-MS	< 0.0002	< 0.0002
Dissolved Calcium Ca	mg/L	ICP-MS	17.4	37.8
Dissolved Chromium Cr	mg/L	ICP-MS	< 0.001	< 0.001
Dissolved Cobalt Co	mg/L	ICP-MS	< 0.001	0.001
Dissolved Copper Cu	mg/L	ICP-MS	0.002	0.001
Dissolved Iron Fe	mg/L	ICP-MS	< 0.05	< 0.05
Dissolved Lead Pb	mg/L	ICP-MS	< 0.001	< 0.001
Dissolved Lithium Li	mg/L	ICP-MS	0.002	0.003
Dissolved Magnesium Mg	mg/L	ICP-MS	10.3	17.3
Dissolved Manganese Mn	mg/L	ICP-MS	0.004	0.024
Dissolved Molybdenum Mo	mg/L	ICP-MS	< 0.0005	0.0015
Dissolved Nickel Ni	mg/L	ICP-MS	< 0.001	0.011
Dissolved Phosphorus P	mg/L	ICP-MS	< 0.15	< 0.15
Dissolved Potassium K	mg/L	ICP-MS	1.4	4.3
Dissolved Selenium Se	mg/L	ICP-MS	< 0.001	< 0.001
Dissolved Silicon Si	mg/L	ICP-MS	1	0.9
Dissolved Silver Ag	mg/L	ICP-MS	0.0003	0.0003
Dissolved Sodium Na	mg/L	ICP-MS	9.9	9.11
Dissolved Strontium Sr	mg/L	ICP-MS	0.048	0.09
Dissolved Tellurium Te	mg/L	ICP-MS	< 0.001	< 0.001
Dissolved Thallium Tl	mg/L	ICP-MS	< 0.0001	< 0.0001
Dissolved Thorium Th	mg/L	ICP-MS	< 0.0005	< 0.0005
Dissolved Tin Sn	mg/L	ICP-MS	< 0.001	< 0.001
Dissolved Titanium Ti	mg/L	ICP-MS	< 0.001	< 0.001
Dissolved Uranium U	mg/L	ICP-MS	< 0.0005	< 0.0005
Dissolved Vanadium V	mg/L	ICP-MS	< 0.001	< 0.001
Dissolved Zinc Zn	mg/L	ICP-MS	< 0.005	< 0.005
Dissolved Zirconium Zr	mg/L	ICP-MS	< 0.01	< 0.01
Dissolved Mercury Hg	μg/L	CVAF	< 0.02	< 0.02

Extraction Method Used: Using Rotary Extractor for 24h.
Liquid:Solid Ratio Used = 3:1; 750ml DI H2O:250g cone crushe

Supporting Document B

Water and Load Balance

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Memo

To:	File	**Date:**	July 27, 2009
CC:		**From:**	Christina James Kelly Sexsmith
Subject:	Boston WRMP Task 2: Water and Load Balance	**Project #:**	ICH008.022

1 Introduction

Geochemical characterization of the ore and waste rock at Boston indicates that all of the waste rock and the majority of the ore is non-acid generating. A small proportion of the ore has an uncertain potential for acid rock drainage (ARD). However, even if localized ARD were to develop in this material, the presence of non-acid generating waste rock in the underlying pad is expected to maintain neutral pH conditions. Although pH conditions are expected to remain neutral, seepage monitoring indicates that concentrations of arsenic, and to a lesser extent, nickel and selenium may be somewhat elevated in comparison to CCME guidelines for aquatic life. To evaluate the significance of these findings, and to determine whether further controls are required to mitigate the effects of the seepage on the downstream environment, SRK has prepared a water and load balance to estimate water quality at various points in the downstream environment. Information on the potential downstream habitats and receptors was also compiled for this evaluation.

The water and load balance model was developed as a 'box' model in Microsoft Excel. It is a simple dilution model with a fundamental assumption that all parameters behave conservatively. In other words, it is assumed there is no attenuation or degradation of contaminants as water flows over the tundra. In reality, considerable attenuation of the metals, and some degradation of nutrients is likely to occur along the flow paths. Therefore, the results of this assessment are expected to provide a conservative indication of the potential effects of the ore and waste rock on the downstream environment.

2 Input Assumptions and Calculations

2.1 Flows

2.1.1 Delineation of Catchment Areas and Seepage Flow Paths

As shown in Figure 1, the majority of the ore and waste rock is located at the high point of land that is bounded to the west and north by the open portion of Aimaokatalok (Spyder) Lake and bounded to the east by a relatively narrow inlet located at the outlet of the stream draining Stickleback and Fickleduck Lakes (referred to as East Bay). Seepage and runoff from the camp pad area flows along poorly defined pathways to the North, East and West before entering Aimaokatalok Lake (Figure 1). Waste rock was also used to construct an airstrip south of the main pad area. Seepage and runoff from the airstrip is expected to flow towards both East Bay and Stickleback Lake, which eventually discharges into East Bay.

The ‘Rain Drop’ function in AutoCAD Civil 3D was used to identify catchments and possible stream channels in this area based on the pre-mine topography. The catchment areas were divided into source areas (areas A1 through E1), and dilution zones (areas A2 through E2). In several places around the camp pad, seeps and runoff flow paths converge and create short, ephemeral streams (ES). A total of 5 distinct ephemeral streams (ES-A through ES-E) were identified visually through a combination of topographical maps and aerial photographs. A portion of the camp pad was drained by non-converging flows (area U). The ephemeral streams were later confirmed in the field in June 2009 (Attachment 1). Flows were found in ES-C, ES-D, and ES-E, while ES-A and ES-B were dry.

The majority of the ore and waste rock is contained within the eastern catchments (C, D and E), which are expected to discharge towards East Bay. Within East Bay, these flows will mix with inflows from Stickleback and Fickleduck Lakes before eventually discharging into the main part of Aimaokatalok Lake. Wind-driven circulation between the inlet and the main part of Aimaokatalok Lake is also expected to result in further dilution within East Bay. Discharges from the remaining catchments (A, B and U) will also discharge directly into the main part of Aimaokatalok Lake. This assessment addresses potential impacts to the ephemeral streams, East Bay, and the main part of Aimaokatalok Lake.

Dramatic changes in water level through the hydrological cycle have been documented in Aimaokatalok Lake (Golder 2008a; Golder 2008b). In the location map in Figure 1, two aerial photographs were used: a smaller image with high resolution and a large image with low resolution. In the west corner of the small image, the water level is demonstrated to be much higher (~3m higher) than in the large image. As runoff calculations were based on the drainage area, calculations of seepage flow volumes will be affected by fluctuations in water level. A higher lake water level would result in a smaller dilution zone and therefore higher concentrations as seepage reaches the lake shoreline. Calculations included in this memo were based on drainage areas depicted by the high resolution image because it provides information for the entire shoreline.

2.1.2 Seepage Flows

The amount of seepage in the Boston Camp area is small, and originates from precipitation (rain and snow) in the local catchment area. Water flows were based on the surface area and mean monthly runoff. Flows were assumed to be zero during months when water in the Hope Bay area is frozen (*i.e.,* October through April).

Water flow, Q, for each of the catchments was calculated using:

$$Q = Catchment\ Area\ x\ \ Precipitation\ x\ Runoff\ Factor$$

Derived monthly precipitation data for the Doris area was used to represent precipitation at the site. The available records for the Doris site cover a reasonably long time-span (1974 to 2001), and the site is in relatively close proximity to Boston (AMEC 2003). A comparison of the Doris results with 2006 data from the Boston weather station (Golder 2008a) indicated the two sites had comparable precipitation. Precipitation that fell as snow was assumed to accumulate over the winter months, and contribute to flows during freshet (*i.e.*, in June).

The generic runoff factor was assumed to be 0.4, comparable to runoff coefficients calculated for the Stickleback and Fickleduck Lake catchment areas.

2.1.3 Stream Flows

Flows in the combined outlet of Stickleback and Fickleduck Lakes and in the inflow to Aimaokatalok Lake were based on direct streamflow measurements collected in 2006 and 2007 (Golder, 2008b).

2.1.4 Volume and Residence Times within the East Bay of Aimaokatalok Lake

Lake volumes can have an important influence on the modelling results in situations where there are transient loadings or changes in the seasonal inputs, particularly where the volumes are large relative to the amounts of inflow, i.e. where residence times are long. In general, longer residence times result in longer delays in the build-up and removal of concentrations. However, steady state concentrations are not generally affected. For this model, there were seasonal differences in the amounts of flow from the camp pad versus Stickleback/Fickleduck catchments, suggesting that the model should be constructed using monthly time steps. However, because these flows will discharge into East Bay where there will be some averaging of the monthly inputs, it was not clear whether these monthly time steps would be warranted in the modelling. The volume and residence time in the East Bay of Aimaokatalok Lake were estimated in order to assess if there would be sufficient averaging to justify an annual model.

Bathymetry data was not available for East Bay. Bathymetry surveys conducted in Aimaokatalok Lake likely did not cover this bay because it is very shallow and boat access would likely have been problematic. The closest contour to the mouth of the bay is 2m. Although there are some deeper sections of the bay visible from aerial photographs, most of this area appears to be very shallow, with average depths on the order of 1m. The volume of the bay was determined to be 132,777 m^3 based on the assumed average depth and the bay's surface area.

Flow contributions were considered from each of the ephemeral streams flowing into East Bay (ES-C, ES-D and ES-E) as well as inflows to the bay from Stickleback and Fickleduck lakes.

The residence time of East Bay varied throughout the year. During freshet (June), the residence time was on the order of 6 days, with the bay being entirely flushed nearly 5 times in one month. During the remaining open-water season months (July through September), the residence time in the bay was on the order of 100 days. Given the relatively short residence time, it appears that a monthly model is warranted. However, in reality, some averaging of inputs is likely to occur in the latter part of the summer.

2.2 Water Quality

2.2.1 Seepage Chemistry

Source concentrations for the waste rock and ore stockpiles were based on data from seep surveys and routine monitoring programs as documented in SRK (2009). The parameters carried forward into this assessment are ones that had previously been flagged as having potential for concern, including arsenic and, to a lesser extent, iron, nickel and selenium (SRK 2009). Copper was also included because it has been identified as a potential issue in previous studies, and sulphate, chloride, nitrate and nitrite were also included based on the findings of the geochemical assessment (SRK 2009).

The temporal and spatial resolution of seepage data for the Boston camp pad is limited. Seepage was collected only during one year (2008), and samples have only been collected from two seeps and one surface pond (Figure 1). No seasonal variability in concentrations was observed in the data, but most of the data was collected from the latter part of the summer.

Base case load calculations were completed using both average and maximum concentrations measured from seepage. Where dissolved metals data were not available, total metals data were used in calculating the average concentrations. The input values for each parameter are presented in Table 1.

2.2.2 Background Chemistry

Fickleduck Lake water quality was used to represent the quality of background runoff from the undisturbed catchments, including the Aimaokatalok Lake Inflow, and the Fickleduck and Stickleback Lake inflows. Data from Fickleduck Lake was available for an approximately 4 year period from 1994 to 1998, with two samples collected each year, typically in July and August. Median background data for select parameters are presented in Table 1.

Table 1: Average and Maximum Concentrations for Seepage Quality and Background Runoff

Parameter	Average Seepage Concentration (mg/L)	Maximum Seepage Concentration (mg/L)	Background Runoff Concentration (mg/L)
Sulphate	377	650	1.1
Chloride	467	1890	10.5
Nitrate	18.6	49.7	0.005
Nitrite	0.132	0.54	0.001
Arsenic	0.164	0.341	0.0003
Copper	0.0069	0.011	0.0016
Iron	0.61	3.23	0.36
Nickel	0.51	1.75	0.0011
Selenium	0.006	0.017	0.0005

2.3 Load Calculations

Water quality parameter loadings from the camp pad areas and background areas were estimated for open-water season months (*i.e.*, May through September) by multiplying seepage or runoff concentrations by area-based or measured flow estimates:

$$Load = Flow\ x\ Concentration$$

Cumulative loads were considered when calculating loadings to the bay to the east of the Boston camp peninsula and the inflow to Aimaokatalok Lake to the west of the peninsula. Loadings were assumed to be conservative and additive.

2.4 Downstream Water Quality Calculations

Downstream water quality was calculated based on the following equation:

$$Concentration = \frac{\sum Loads}{\sum Flow}$$

Concentrations of water quality parameters were calculated for each of the ephemeral streams where they meet the Aimaokatalok Lake shoreline (i.e. before the flows enter Aimaokatalok Lake), within East Bay after the discharges from the ephemeral streams mix with the inflows from Stickleback/Fickleduck Lake, and within the main part of Aimaokatalok Lake after discharges from the ephemeral streams, outflows from East Bay, and inflows from the Aimaokatalok River mix and reach steady state.

Runoff from undisturbed areas in the local watershed was considered the basis for dilution for seeps originating from the camp pad. This assumption may overestimate dilution in the small ephemeral streams as runoff from the lower reaches of the drainage area is more likely to flow directly into the lake as opposed to converging with flow that originated in the upper reaches.

In contrast, calculations for East Bay only consider the dilution provided by the Stickleback/Fickleduck catchment and neglect the additional runoff from other undisturbed catchments and from direct precipitation to this part of the lake. They also neglect circulation between the bay and with the main part of the lake. These assumptions are likely to conservatively underestimate dilution in East Bay.

Similarly, calculations for the main part of Aimaokatalok Lake only consider the dilution provided by the Aimaokatalok River inflows, again resulting in conservative estimates of dilution. In addition, they do not consider storage effects within the lake. The latter feature would result in a significant delay in the build-up of concentrations within the lake, but has no effect on the long-term steady state concentrations that could develop in the absence of attenuation effects.

2.5 Environmental Receptors

The presence of important aquatic habitats and/or aquatic receptors should be considered in defining where water quality guidelines should be applied.

Baseline studies have shown that Aimaokatalok Lake supports an ecosystem including photoplankton, zooplankton, benthic invertebrates and fish populations including lake trout, lake whitefish, cisco, Arctic grayling and ninespine stickleback (Golder 2008b). However, there was limited information available for fish habitat in East Bay and shoreline of the Boston camp peninsula, and no information available for the ephemeral streams.

Each of the ephemeral streams shown in Figure 1 were visited in June 2009 to establish whether they were flowing, and if so, to collect samples for characterization of water quality. Photos of all of these stations are provided in Attachment 1. Streams from catchments C, D and E were flowing, while streams from catchments A and B were not flowing. As shown in the photos, none of the streams have distinct channel characteristics, and none appear to provide clear passage to the lake.

In July 2009, an aquatic specialist from Rescan was asked to visit the site and to provide a preliminary assessment of these areas. The ephemeral streams were no longer flowing, and they were characterized as having no stream channelization, no substrate/stream bed, and no aquatic vegetation. Therefore, they were not considered to be fish habitat. However, the margins of Aimaokatalok Lake, including the mouths of the ephemeral streams were considered to be important fish habitat for ninespine sticklebacks and other small or juvenile fish (*pers comm*. Rescan, 2009).

2.6 Model Validation

The samples collected at the mouths of each of the flowing ephemeral streams were submitted for a full suite of water quality analyses. The results are presented in Attachment 1. The results were used to validate the results of the modelling, as discussed in Section 4.

3 Results and Discussion

3.1 Base Case

Estimated concentrations based on average and maximum seepage concentrations for each of the ephemeral streams, East Bay, and the main part of Aimaokatalok Lake are presented in Table 2. The results for each of these areas are discussed as follows:

Table 2 Estimated Concentrations of Select Parameters at the Shoreline of Aimaokatalok Lake and Within Aimaokatalok Lake for Average and Maximum Concentration in Seepage Water Quality

Parameter	**Location**	**Predicted Monthly Average Concentrations (mg/L) in Receiving Environment**								*CCME Guideline for Protection of Aquatic Life*
		Average Seepage Concentration				**Maximum Seepage Concentration**				
		Jun	Jul	Aug	Sep	Jun	Jul	Aug	Sep	
Sulphate	ES-A Shoreline	70	70	70	70	121	121	121	121	*n/a**
(Seepage Conc:	ES-B Shoreline	13	13	13	13	21	21	21	21	
Ave = 377 mg/L	ES-C Shoreline	111	111	111	111	190	190	190	190	
Max = 650 mg/L)	ES-D Shoreline	128	128	128	128	220	220	220	220	
	ES-E Shoreline	15	15	15	15	25	25	25	25	
(Background:	**Aimaokatalok Lake**	**1.1**	**1.1**	**1.1**	**1.1**	**1.1**	**1.1**	**1.2**	**1.2**	
1.1 mg/L)	**East Bay**	**1.4**	**4.4**	**4.7**	**3.0**	**1.7**	**6.7**	**7.3**	**4.3**	
Chloride	ES-A Shoreline	95	95	95	95	357	357	357	357	*n/a**
(Seepage Conc:	ES-B Shoreline	24	24	24	24	68	68	68	68	
Ave = 467 mg/L	ES-C Shoreline	144	144	144	144	559	559	559	559	
Max = 1890 mg/L)	ES-D Shoreline	164	164	164	164	644	644	644	644	
	ES-E Shoreline	27	27	27	27	79	79	79	79	
(Background:	**Aimaokatalok Lake**	**11**	**11**	**11**	**11**	**11**	**11**	**11**	**11**	
11 mg/L)	**East Bay**	**11**	**15**	**15**	**13**	**12**	**27**	**28**	**20**	
Nitrate	ES-A Shoreline	3.4	3.4	3.4	3.4	9.2	9.2	9.2	9.2	*2.93*
(Seepage Conc:	ES-B Shoreline	0.6	0.6	0.6	0.6	1.5	1.5	1.5	1.5	
Ave = 18.6 mg/L	ES-C Shoreline	5.4	5.4	5.4	5.4	14.5	14.5	14.5	14.5	
Max = 49.7 mg/L)	ES-D Shoreline	6.3	6.3	6.3	6.3	16.8	16.8	16.8	16.8	
	ES-E Shoreline	0.7	0.7	0.7	0.7	1.8	1.8	1.8	1.8	
(Background:	**Aimaokatalok Lake**	**0.006**	**0.006**	**0.007**	**0.007**	**0.007**	**0.007**	**0.009**	**0.011**	
0.005 mg/L)	**East Bay**	**0.02**	**0.17**	**0.18**	**0.10**	**0.05**	**0.44**	**0.48**	**0.25**	
Nitrite	ES-A Shoreline	0.025	0.025	0.025	0.025	0.101	0.101	0.101	0.101	*0.06*
(Seepage Conc:	ES-B Shoreline	0.005	0.005	0.005	0.005	0.017	0.017	0.017	0.017	
Ave = 0.132 mg/L	ES-C Shoreline	0.039	0.039	0.039	0.039	0.159	0.159	0.159	0.159	
Max = 0.542 mg/L)	ES-D Shoreline	0.045	0.045	0.045	0.045	0.183	0.183	0.183	0.183	
	ES-E Shoreline	0.006	0.006	0.006	0.006	0.021	0.021	0.021	0.021	
(Background:	**Aimaokatalok Lake**	**0.0010**	**0.0010**	**0.0010**	**0.0010**	**0.0010**	**0.0010**	**0.0010**	**0.0011**	
0.001 mg/L)	**East Bay**	**0.0011**	**0.0021**	**0.0022**	**0.0017**	**0.0015**	**0.0057**	**0.0061**	**0.0037**	
Arsenic	ES-A Shoreline	0.030	0.030	0.030	0.030	0.063	0.063	0.063	0.063	*0.005*
(Seepage Conc:	ES-B Shoreline	0.005	0.005	0.005	0.005	0.011	0.011	0.011	0.011	
Ave = 0.164 mg/L	ES-C Shoreline	0.048	0.048	0.048	0.048	0.100	0.100	0.100	0.100	
Max = 0.341 mg/L)	ES-D Shoreline	0.056	0.056	0.056	0.056	0.115	0.115	0.115	0.115	
	ES-E Shoreline	0.006	0.006	0.006	0.006	0.013	0.013	0.013	0.013	
(Background:	**Aimaokatalok Lake**	**0.0003**	**0.0003**	**0.0003**	**0.0003**	**0.0003**	**0.0003**	**0.0003**	**0.0003**	
0.0003 mg/L)	**East Bay**	**0.0004**	**0.0017**	**0.0019**	**0.0011**	**0.0006**	**0.0033**	**0.0035**	**0.0020**	
Copper	ES-A Shoreline	0.0026	0.0026	0.0026	0.0026	0.0033	0.0033	0.0033	0.0033	*0.002*
(Seepage Conc:	ES-B Shoreline	0.0018	0.0018	0.0018	0.0018	0.0019	0.0019	0.0019	0.0019	
Ave = 0.0069 mg/L	ES-C Shoreline	0.0031	0.0031	0.0031	0.0031	0.0043	0.0043	0.0043	0.0043	
Max = 0.011 mg/L)	ES-D Shoreline	0.0034	0.0034	0.0034	0.0034	0.0048	0.0048	0.0048	0.0048	
	ES-E Shoreline	0.0018	0.0018	0.0018	0.0018	0.0019	0.0019	0.0019	0.0019	
(Background:	**Aimaokatalok Lake**	**0.0016**	**0.0016**	**0.0016**	**0.0016**	**0.0016**	**0.0016**	**0.0016**	**0.0016**	
0.0016 mg/L)	**East Bay**	**0.0016**	**0.0017**	**0.0017**	**0.0016**	**0.0016**	**0.0017**	**0.0017**	**0.0017**	
Iron	ES-A Shoreline	0.41	0.41	0.41	0.41	0.89	0.89	0.89	0.89	*0.3*
(Seepage Conc:	ES-B Shoreline	0.37	0.37	0.37	0.37	0.45	0.45	0.45	0.45	
Ave = 0.61 mg/L	ES-C Shoreline	0.43	0.43	0.43	0.43	1.20	1.20	1.20	1.20	
Max = 3.23 mg/L)	ES-D Shoreline	0.44	0.44	0.44	0.44	1.33	1.33	1.33	1.33	
	ES-E Shoreline	0.37	0.37	0.37	0.37	0.46	0.46	0.46	0.46	
(Background:	**Aimaokatalok Lake**	**0.36**	**0.36**	**0.36**	**0.36**	**0.36**	**0.36**	**0.36**	**0.36**	
0.36 mg/L)	**East Bay**	**0.36**	**0.37**	**0.37**	**0.36**	**0.36**	**0.39**	**0.39**	**0.38**	
Nickel	ES-A Shoreline	0.095	0.095	0.095	0.095	0.323	0.323	0.323	0.323	*0.025*
(Seepage Conc:	ES-B Shoreline	0.017	0.017	0.017	0.017	0.054	0.054	0.054	0.054	
Ave = 0.51 mg/L	ES-C Shoreline	0.150	0.150	0.150	0.150	0.511	0.511	0.511	0.511	
Max = 1.75 mg/L)	ES-D Shoreline	0.173	0.173	0.173	0.173	0.591	0.591	0.591	0.591	
	ES-E Shoreline	0.020	0.020	0.020	0.020	0.065	0.065	0.065	0.065	
(Background:	**Aimaokatalok Lake**	**0.0011**	**0.0011**	**0.0011**	**0.0012**	**0.0012**	**0.0012**	**0.0012**	**0.0013**	
0.0011 mg/L)	**East Bay**	**0.0016**	**0.0055**	**0.0059**	**0.0036**	**0.0027**	**0.016**	**0.018**	**0.010**	
Selenium	ES-A Shoreline	0.0015	0.0015	0.0015	0.0015	0.0035	0.0035	0.0035	0.0035	*0.001*
(Seepage Conc:	ES-B Shoreline	0.0007	0.0007	0.0007	0.0007	0.0010	0.0010	0.0010	0.0010	
Ave = 0.006 mg/L	ES-C Shoreline	0.0021	0.0021	0.0021	0.0021	0.0053	0.0053	0.0053	0.0053	
Max = 0.017 mg/L)	ES-D Shoreline	0.0024	0.0024	0.0024	0.0024	0.0061	0.0061	0.0061	0.0061	
	ES-E Shoreline	0.0007	0.0007	0.0007	0.0007	0.0011	0.0011	0.0011	0.0011	
(Background:	**Aimaokatalok Lake**	**0.0005**	**0.0005**	**0.0005**	**0.0005**	**0.0005**	**0.0005**	**0.0005**	**0.0005**	
0.0005 mg/L)	**East Bay**	**0.0005**	**0.0006**	**0.0006**	**0.0005**	**0.0005**	**0.0006**	**0.0007**	**0.0006**	

Notes: Pink highlighting indicates concentrations that exceed their respective CCME guideline for the protection of aquatic life.
Bolded values indicate concentrations calculated in Aimaokatalok Lake (where freshwater aquatic life has been observed).
* No CCME guideline for the protection of aquatic life exists for sulphate or chloride. However, guidelines stipulate that TDS is not to exceed background concentrations by more than 10%.

Concentrations in Ephemeral Streams at the Shoreline of Aimaokatalok Lake

The results for the ephemeral streams indicate that there is relatively little dilution occurring between the camp pad and the shoreline of the lake. Under assumptions of average seepage concentrations, predicted concentrations of nitrate, arsenic, iron, nickel and selenium would exceed CCME guidelines for the protection of aquatic life in catchments A, C and D, and predicted concentrations of arsenic, and iron would exceed CCME guidelines in catchments B and E. Under assumptions of maximum seepage concentrations, predicted concentrations of all modelled parameters would exceed the CCME guidelines in catchments A, C and D, and concentrations of arsenic, iron, nickel and selenium would exceed the CCME guidelines in catchments B and E.

Concentrations of arsenic and nickel showed the greatest magnitude of exceedance, with concentrations in the catchments C and D exceeding the guidelines by factors of approximately 10 and 20 for the estimates based on average and maximum seepage concentrations respectively.

Although predicted concentrations of iron consistently exceeded the guidelines, the background concentrations for iron also exceeded the guidelines and the magnitude of increase above those values was relatively small. Therefore, these results for iron should be interpreted with caution.

Concentrations of sulphate and chloride are predicted to be appreciably higher than background concentrations. However, there are no specific aquatic life guidelines for these parameters.

Although CCME guidelines are referenced in the preceding discussion, the ephemeral streams are not considered to be aquatic habitat, and are therefore not directly applicable to these sites. However, they may be applicable in the shoreline area that is immediately adjacent to these streams, particularly during times of the year when mixing in the lake is restricted by ice cover. Further assessment of the mixing zone may be needed to address this issue.

Concentrations in the East Bay of Aimaokatalok Lake

Estimated concentrations of all modeled parameters in East Bay were consistently below the CCME guidelines for the protection of aquatic life, reflecting the much larger amounts of dilution provided by the Stickleback/Fickleduck inflows. As discussed previously, the calculations neglect mixing with the main part of Aimaokatalok Lake and other inflows to East Bay. Therefore, these results are considered to be quite conservative for the bay as a whole. However, locally elevated concentrations could occur along the shoreline immediately adjacent to the ephemeral streams.

Estimated concentrations of most parameters were either below their respective CCME guideline by an order of magnitude, or were only marginally above background concentrations. However, estimated concentrations of arsenic and nickel were appreciably above background levels and were approaching the CCME guidelines. Sensitivity analyses for these parameters are presented in Section 3.2.

Fish have been captured in both Stickleback and Fickleduck Lakes, and it is presumed that they would make use of the aquatic habitats present in East Bay. Therefore, in the absence of site specific guidelines, CCME guidelines are considered to be applicable in this location.

Concentrations in Aimaokatalok Lake

Estimated concentrations of all modeled parameters in the main part of Aimaokatalok Lake were all well below the CCME guidelines for protection of aquatic life and were very close to background concentrations. These results reflect the very high rates of inflow from the Aimaokatalok River.

3.2 Sensitivity Analyses

The base case results indicated that arsenic and nickel concentrations were close to CCME guidelines for freshwater aquatic life within the East Bay of Aimaokatalok Lake. Given the potential ecological significance of this location, sensitivity analyses were completed to assess the effects of key variables in the model. Two key variables, the source areas, and the source concentrations are expected to have the most significant effect on the results, and are assessed as follows:

3.2.1 Sensitivity to Source Concentrations

In the recent geochemical assessments of ore stockpile material at Boston, seepage concentrations were compared to both humidity cell data and leach extraction test results. Nickel concentrations were consistently higher in the seepage, indicating that seepage concentrations provide a reasonable upper bound on the potential nickel concentrations from this site. However, maximum arsenic concentrations in two of the humidity cell tests and one of the shake flask tests were higher than the highest seepage results, and one of the humidity cell results had arsenic concentrations up to an order of magnitude higher than observed in the seepage, i.e. 3.3 mg/L (SRK 2009).

There are several reasons why the laboratory results could be higher than the seepage data. These include variations in the mineralogy, differences between temperatures and grain sizes in the field versus the lab, and attenuation reactions that occur in the field but not in the lab. However, since source concentrations of this magnitude have been observed at other geologically similar sites in the north, it is worthwhile to consider the possible impacts of higher arsenic concentrations on the downstream environment. Results of a sensitivity analysis using a source concentration of 3.3 mg/L arsenic as the source concentration are provided in Table 3.

The results indicate that concentrations of arsenic in the East Bay of Aimaokatalok Lake could conceivably exceed CCME guidelines during low flow months (July through September). Given that there would be some delay in the build-up of concentrations at this location as well as some mixing with the main part of the lake, these results are considered to be somewhat conservative. However, further monitoring is warranted to ensure that any changes in source concentration can be addressed in an appropriate manner.

There are several other variables that are not considered in the model that are considered to be conservative assumptions. In particular, attenuation of contaminants, additional inflows from other undisturbed areas draining to East Bay, and the averaging effects that will occur within this part of the lake during the latter part of the summer are all expected to result in reduced concentrations in both the ephemeral streams and in East Bay.

Table 3 Estimated Concentrations of Arsenic based on Highest Recorded Laboratory Results

		Monthly Averaged Concentrations in Receiving Environment (mg/L)				*CCME Guideline for the Protection of Aquatic Life*
		Maximum Seepage Concentration				
Parameter	**Location**	Jun	Jul	Aug	Sep	
Arsenic (Seepage Conc. = 3.3 mg/L)	ES-A Shoreline	0.61	0.61	0.61	0.61	*0.005*
	ES-B Shoreline	0.10	0.10	0.10	0.10	
	ES-C Shoreline	0.96	0.96	0.96	0.96	
	ES-D Shoreline	1.11	1.11	1.11	1.11	
	ES-E Shoreline	0.12	0.12	0.12	0.12	
	Aimaokatalok Lake	**0.0004**	**0.0005**	**0.0006**	**0.0007**	
	East Bay	**0.0033**	**0.029**	**0.032**	**0.017**	

Notes: Pink highlighting indicates concentrations that exceed their respective CCME guideline for the protection of aquatic life.
Bolded values indicate concentrations calculated in Aimaokatalok Lake (where freshwater aquatic life has been observed).

3.2.2 Sensitivity to Source Areas

The water and load balance was constructed primarily to assess the impacts of the camp pad and ore stockpile areas. The base case assessment conservatively assumes that the source concentrations measured in the vicinity of the ore stockpiles would be applicable to the entire camp pad. Although ore has been used as surfacing material over a large portion of the camp pad, concentrations from this material are not expected to be as high as in the ore stockpiles due to the much smaller ratios of ore to waste present on the remainder of the camp pad.

Ore has also been used as a surfacing material on the roads and airstrip, and these areas have not been included in the current base case assessment. To assess the potential significance of the airstrip on predicted concentrations in East Bay, the source area reporting to East Bay was increased to include both the road and airstrip (i.e. an increase in source area from 2.4 to 3.6 ha). Results are provided in Table 4. It is noted that some of the seepage and runoff from the airstrip is expected to report to Stickleback Lake before reaching East Bay. However, Stickleback Lake is not included in this assessment. Separate calculations to assess the ratios of source flows to receiving water flows in Stickleback Lake (which only receives water from part of the airstrip) and East Bay (which receives water from both the camp pad and the airstrip) indicate that there is relatively more dilution in Stickleback Lake than in East Bay. Therefore, concentrations in Stickleback Lake would be expected to be lower than those predicted for East Bay.

The sensitivity analyses indicate that maximum concentrations of arsenic and nickel could slightly exceed CCME guidelines in East Bay if loads from the airstrip are considered in the assessment.

Table 4: Estimated Concentrations in East Bay Including Contributions from the Airstrip

	Predicted Monthly Average Concentrations (mg/L) in East Bay								*CCME Guideline for Protection of Aquatic Life*
	Average Seepage Concentration				Maximum Seepage Concentration				
Parameter	Jun	Jul	Aug	Sep	Jun	Jul	Aug	Sep	
Sulphate	1.6	6.0	6.4	3.9	2.0	9.5	10.3	5.9	
Chloride	11	17	17	14	62	157	167	112	
Nitrate	0.03	0.25	0.27	0.14	0.07	0.65	0.71	0.37	*2.93*
Nitrite	0.001	0.003	0.003	0.002	0.002	0.008	0.009	0.005	*0.06*
Arsenic	0.0005	0.0024	0.0026	0.0015	0.0008	0.0047	0.0051	0.0028	*0.005*
Copper	0.0016	0.0017	0.0017	0.0017	0.0016	0.0017	0.0018	0.0017	*0.002*
Iron	0.36	0.37	0.37	0.36	0.36	0.40	0.41	0.38	*0.3*
Nickel	0.002	0.008	0.008	0.005	0.003	0.024	0.026	0.014	*0.025*
Selenium	0.0005	0.0006	0.0006	0.0005	0.0005	0.0007	0.0007	0.0006	*0.001*

4 Model Validation

Ephemeral streams downgradient of the site were sampled in June 2009 to verify whether there are any current impacts on water quality at these locations. The results are provided in Attachment 1. The results indicate that metal concentrations are all very low, suggesting that there is considerable attenuation of these parameters occurring along the flow paths.

Concentrations of sulphate and chloride were within the range predicted by the dilution model. This indicates that the model is valid for parameters that are less strongly affected by attenuation processes. Over time, the effectiveness of the attenuation processes may diminish, resulting in increased concentrations in the ephemeral streams. The timing of breakthrough will be difficult to establish through predictive modelling. Therefore ongoing monitoring of both source and downstream concentrations is recommended.

Nutrient levels were lower those than predicted by the model, suggesting that some degradation of nutrients is occurring. However, the rate of degradation is not sufficient to completely remove nitrate from solution.

5 Summary and Conclusions

A water and load balance has been developed to assess the potential impacts of seepage from the ore and waste rock at key locations downstream of the site, including ephemeral streams downgradient of the stockpile area, the East Bay of Aimaokatalok Lake, and the main part of Aimaokatalok Lake.

The results showed that concentrations of nitrate, nitrite, arsenic, copper, iron, nickel and selenium in the ephemeral streams could exceed the CCME water quality guidelines for the protection of aquatic life. However, these guidelines are not applicable at these locations due to the lack of aquatic habitat.

East Bay is semi-enclosed which may limit the extent of wind driven mixing with the main lake basin, particularly when water levels in Aimaokatalok Lake are at their minimum. The residence time in the bay is relatively short, ranging from 6 days during freshet to 100 days in the latter part of the summer. Therefore, concentrations in the bay can be reasonably modelled by simple mixing of the inflows. Seepage that reports to this location is effectively diluted to below CCME guideline concentrations for all modelled parameters. Most parameters were estimated to be an order of magnitude below their respective CCME guideline, with the exceptions of arsenic and nickel. These parameters were close the CCME guidelines and are sensitive to the assumptions of source concentrations. Sensitivity analyses indicate that higher arsenic concentrations in seepage from the Boston camp could result in exceedances of the CCME guideline for aquatic life in East Bay. Similarly, sensitivity analyses indicate that concentrations of arsenic and nickel could result in exceedances of the CCME guidelines in East Bay if loadings from the airstrip are considered in the assessment.

Seepage that reports to Aimaokatalok Lake is effectively diluted by large inflow volumes entering the lake through the Aimaokatalok River. As a result, predicted concentrations in Aimaokatalok Lake are close to background levels for all scenarios considered.

6 Recommendations

Based on the findings of this evaluation, continued monitoring of seepage and ephemeral streams downgradient of the site are recommended. If arsenic and/or nickel concentrations in the seepage increase relative to 2008 levels, further controls on seepage chemistry may be warranted. Monitoring of the ephemeral streams would help to establish the rate of contaminant breakthrough from the site. If possible, the seepage monitoring should include some locations that reflect seepage from areas of the stockpile that do not contain the larger ore stockpiles as this would likely provide a more realistic indication of seepage quality from other areas of the site.

Although the modelling shows that impacts to water quality in East Bay would be unlikely to occur unless the source concentrations or the source areas change appreciably, there is some potential for less dilution to occur in the immediate vicinity of the ephemeral streams. A conductivity survey[1] in these areas would help to establish the extent of mixing in these areas.

To address the potential for impacts to water quality in East Bay, some further controls on seepage from the ore stockpiles should be considered in the development of a long-term closure plans for this site. In addition, some consolidation of the ore used as surfacing material at this site should be considered.

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[1] A conductivity survey would entail field conductivity readings during spring freshet and then later in the summer in a grid pattern in the shoreline areas around the outlets of Ephemeral Streams C and D. The spring survey would ideally be completed during a period when there is open water along the shore, but not in the main part of the bay, and the summer survey should be completed following a period of rainy weather, and ideally on a calm day. Results would be compared to concentrations in the outlet of Stickleback Lake and to concentrations in the ephemeral streams. The intent would be to define the area that could be potentially impacted by imperfect mixing along the shoreline.

7 References

AMEC 2003. *Meteorology and Hydrology Baseline Doris North Project Revision 1 Supporting Document 'D' to the Final Environmental Impact Statement*. Prepared for Miramar Hope Bay Ltd. by AMEC. November 2003.

Canadian Council of Ministers of the Environment (CCME). 1999 updated 2007. *Canadian Environmental Quality Guidelines*. Winnipeg, Manitoba.

Golder 2008a. *Boston and Madrid Project Areas 2006 – 2007 Aquatic Studies Draft Report.* Prepared for Hope Bay Mining Company by Golder Associates Ltd. May 2008.

Golder 2008b. *Aquatic baseline studies Boston project data compilation report 1992 – 2000 Draft Report.* Prepared for Miramar Hope Bay Ltd. by Golder Associates Ltd. July 2008.

Rescan 2009. Personal communication: Email dated July 25, 2009 from Kevin Esseltine to Bill Patterson regarding fish habitat near Boston.

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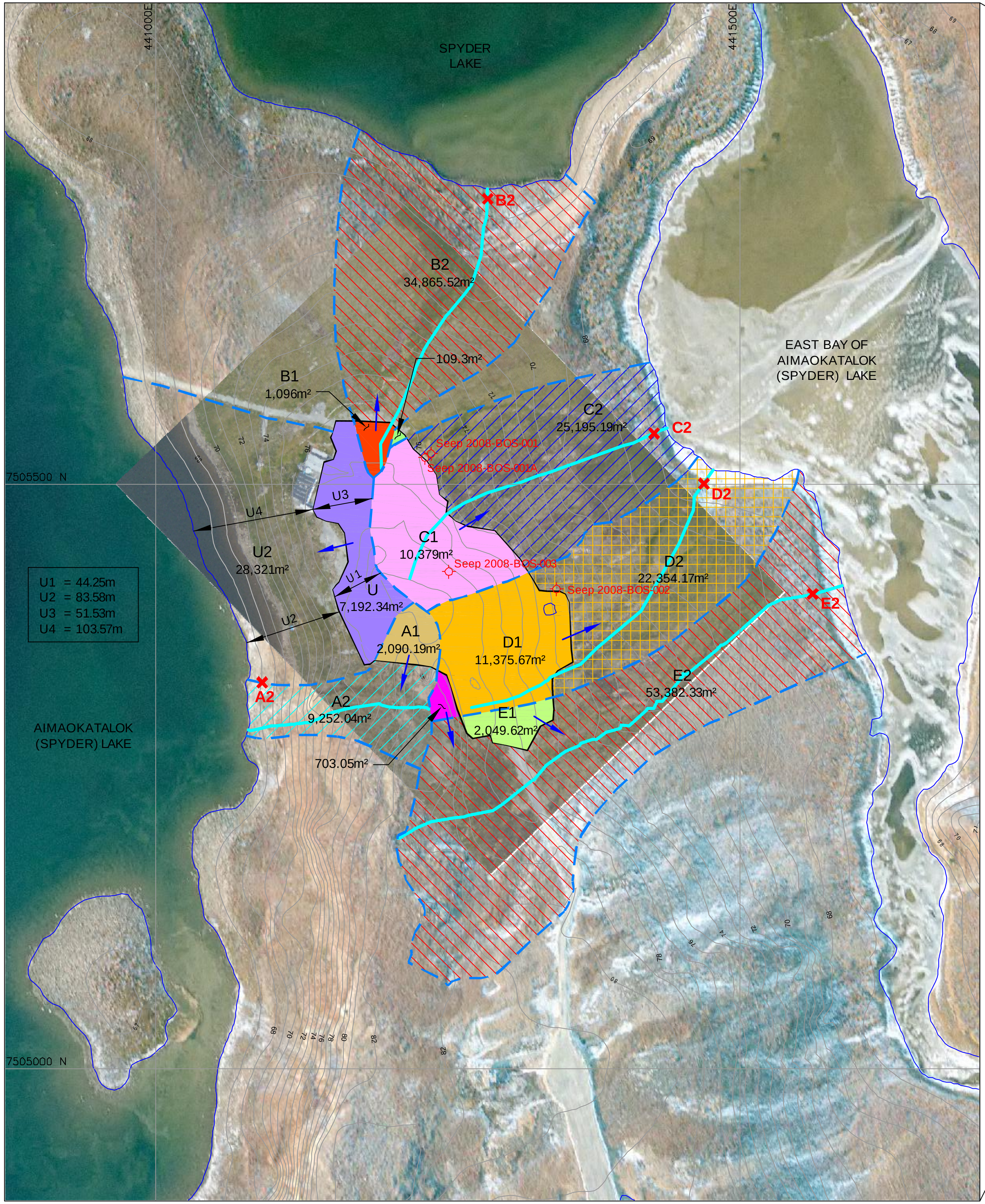

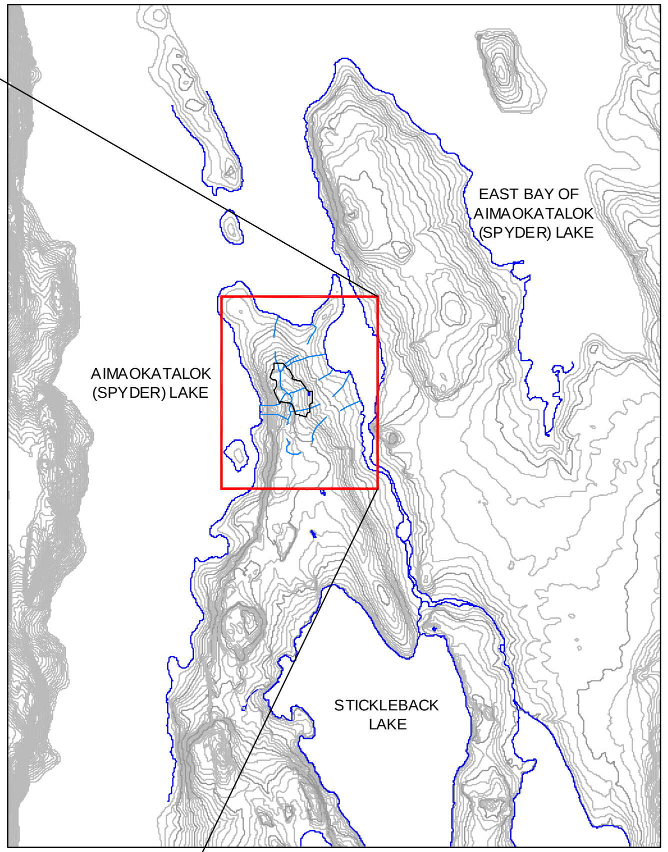

SITE LOCATION

Legend

—	Contours (1m)	– –	Catchment Boundary
—	Ephemeral streams	←	Flow direction
—	Camp pad perimeter	⌖	Seepage Sampling Station
A2, B2, C2, D2, E2, U2	Dilution Zone (Hatch)	25,195.19m²	Catchment Areas

1:4000

0 50 100 150 200 Metres

SRK Consulting
Engineers and Scientists
Vancouver B.C.

SRK JOB NO.: 1CH008.022
FILE NAME: Boston Catchments.dwg

HOPE BAY MINING LTD.

Hope Bay Project

Boston Waste Rock Management Plan

Boston Camp Drainage Aeas

DATE: July 2009
APPROVED:
FIGURE: A

J:\01_SITES\Hope.Bay\ACAD\2009 Drawings\Boston Catchments.dwg

Attachment 1

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Memo

To:	Kelly Sexsmith	**Date:**	July 14, 2009
cc:		**From:**	Madeleine Corriveau
Subject:	Ephemeral Streams at Boston Camp	**Project #:**	1CH008.023

Five ephemeral streams have been identified downgradient of the ore stockpile areas. These are shown in Figure 1. On June 30 2009, streams C2, D2 and E2 were sampled (Attachment 1). There was no flow present in A2 and B2 streambeds. Samples were submitted to ALS-Chemex, Vancouver BC for analysis of nutrients (ammonia, nitrate, and orthophosphate), total and dissolved metals, and routine parameters (pH, alkalinity, sulphate and chloride).

Field parameters for the three streams sampled are summarized in Table 1. A summary of water quality results in provided in Table 2. It should be noted that there are old drill sites upstream of all sampling locations.

Photos of streams A2, B2, C2, D2, and E2 are provided in Figures 1 through 5, respectively.

Table 1. Field Parameters

Sample ID	**Field pH**	**Field Cond**	**ORP**	**Temp**	**Flow**	**Comments**
Units	s.u.	uS	mV	°C		
C2	6.76	831	268	12.5	Trace	Abundant organic matter.
D2	6.53	1651	302	11.3	Trickle	Abundant bird waste in flow path.
E2	7.27	727	322	10.1	Trace	Algae growth.

Table 2. Summary of Water Quality Results

Sample ID	**C2**	**D2**	**E2**
Anions and Nutrients (mg/L)			
Alkalinity, Total (as CaCO3)	43.2	25.1	42.2
Ammonia as N	0.022	0.024	<0.020
Chloride (Cl)	210	455	166
Nitrate (as N)	2.15	4.03	<0.0050
Ortho Phosphate as P	<0.0010	0.0010	<0.0010
Sulfate (SO4)	137	196	47.7
Total Metals (mg/L)			
Aluminum (Al)-Total	0.0193	0.0155	0.0329
Arsenic (As)-Total	<0.0020	<0.0030	<0.0020
Cadmium (Cd)-Total	0.000032	<0.000085	0.000077
Copper (Cu)-Total	0.00166	0.00132	0.00167
Lead (Pb)-Total	0.000075	<0.00025	0.000563
Mercury (Hg)-Total	<0.000010	<0.000010	<0.000010
Nickel (Ni)-Total	0.00640	0.0067	0.00373
Selenium (Se)-Total	<0.0020	<0.0080	<0.0020
Zinc (Zn)-Total	<0.0040	<0.0080	<0.0060
Dissolved Metals (mg/L)			
Aluminum (Al)-Dissolved	0.0157	0.0115	0.0138
Arsenic (As)-Dissolved	<0.0020	<0.0020	<0.0015
Cadmium (Cd)-Dissolved	0.000063	<0.000085	<0.000017
Copper (Cu)-Dissolved	0.00300	0.00155	0.00170
Lead (Pb)-Dissolved	0.000068	<0.00025	<0.000050
Mercury (Hg)-Dissolved	<0.000010	<0.000010	<0.000010
Nickel (Ni)-Dissolved	0.00610	0.0053	0.00299
Selenium (Se)-Dissolved	<0.0010	<0.0060	<0.0010
Zinc (Zn)-Dissolved	0.0055	<0.0050	0.0014

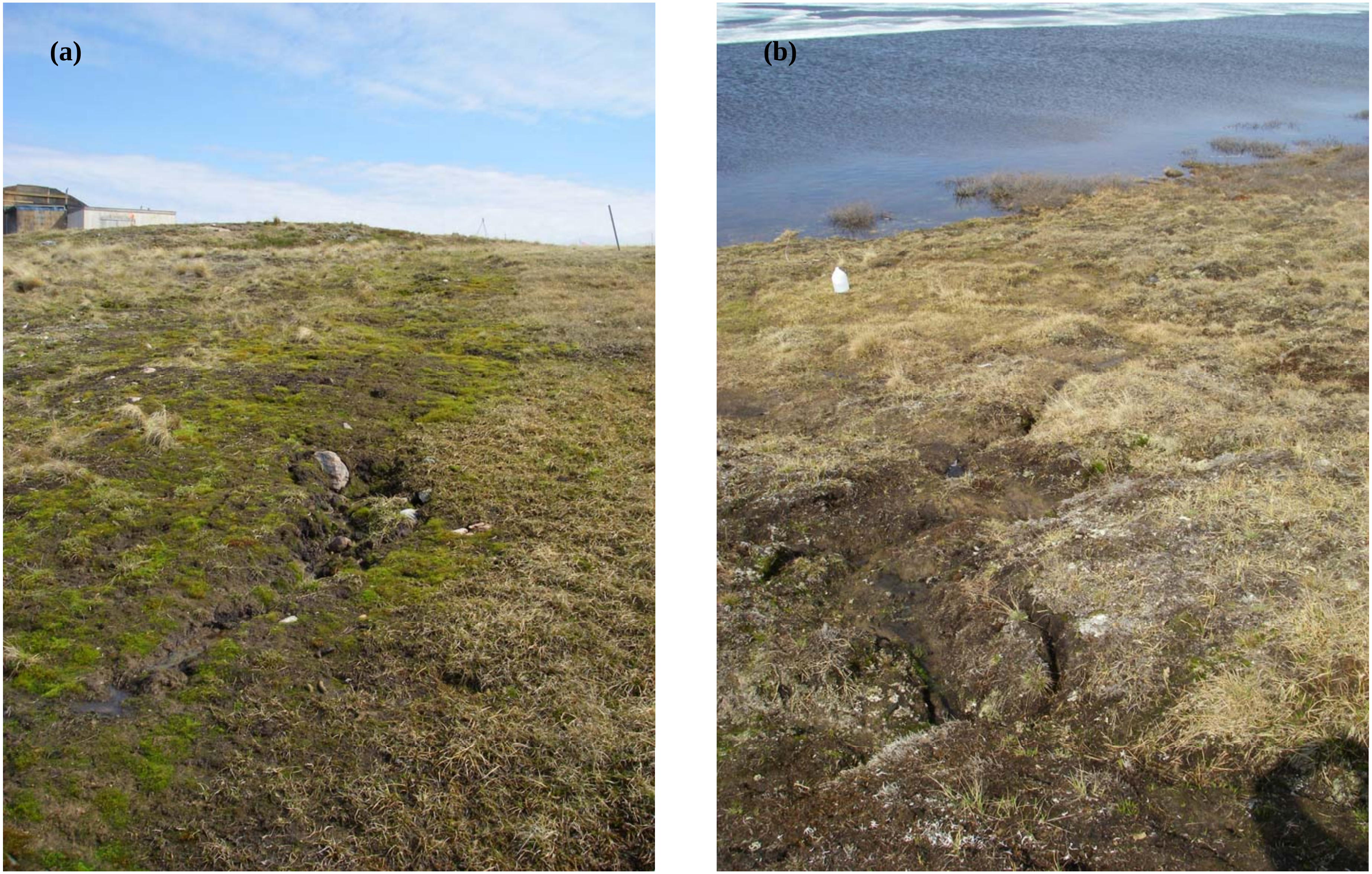

Figure 1. Photos looking upstream (a) and downstream (b) at A2.

Figure 2. Photo looking upstream at B2.

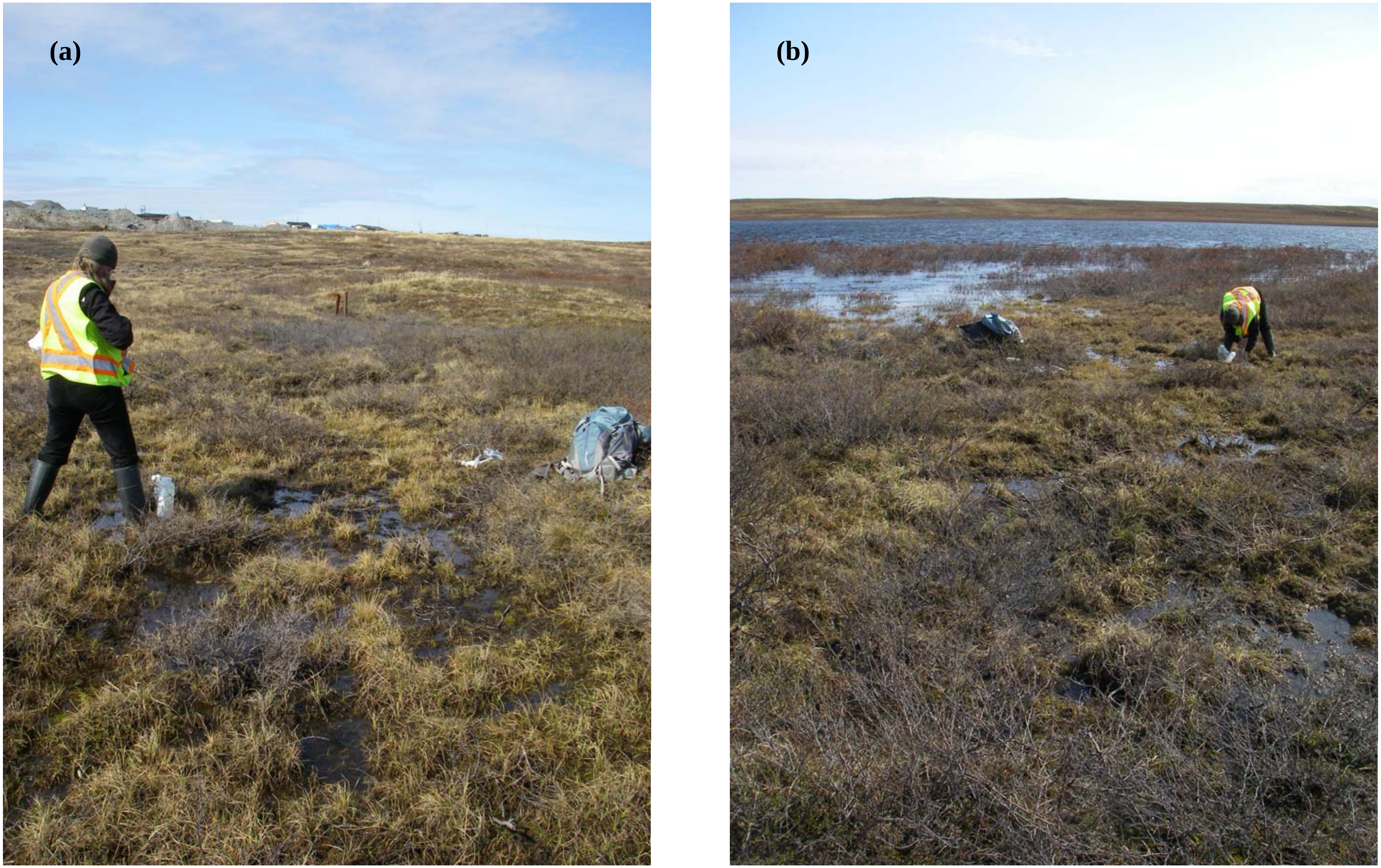

Figure 3. Photos looking upstream (a) and downstream (b) at C2.

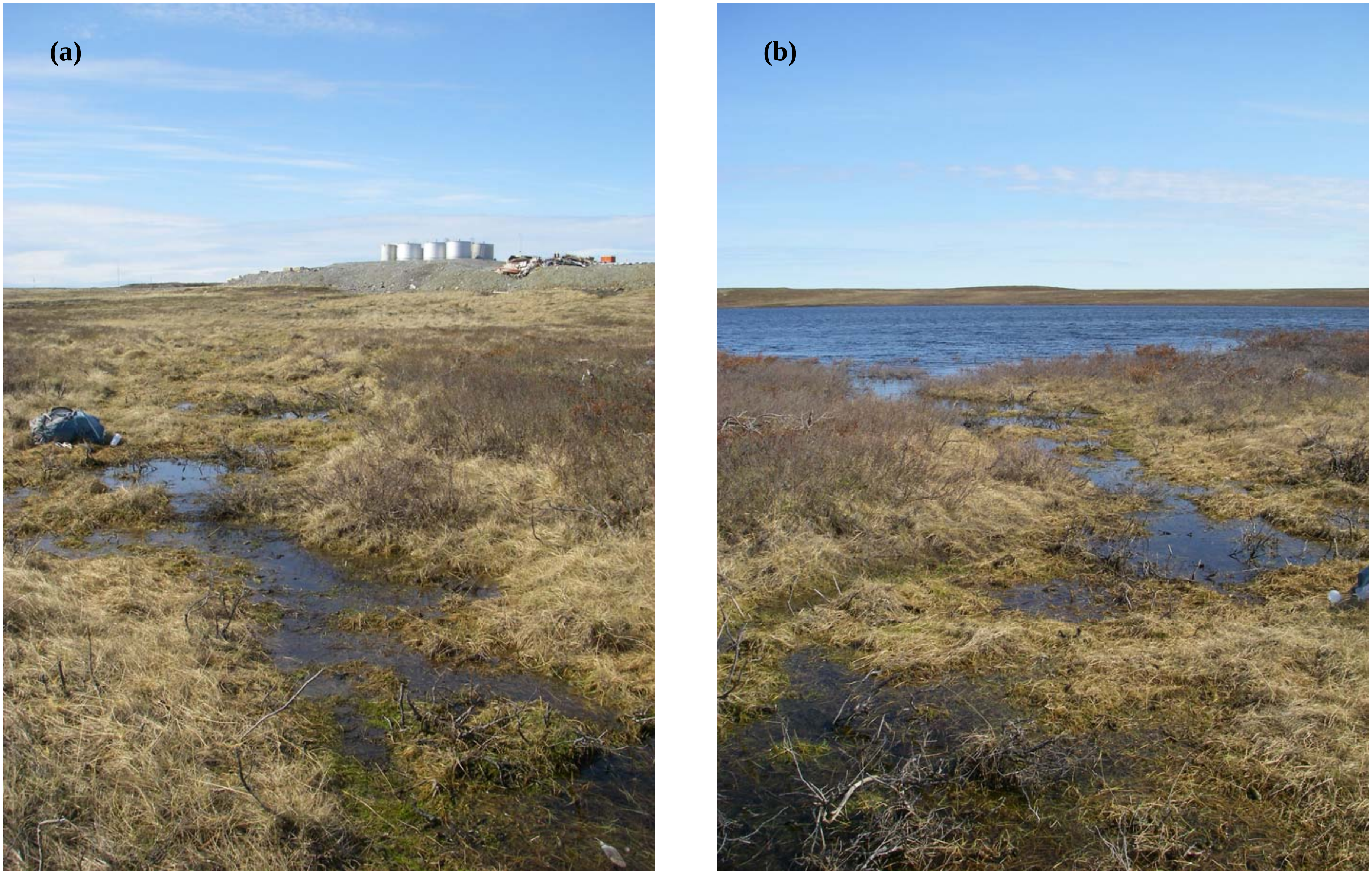

Figure 4. Photos looking upstream (a) and downstream (b) at D2.

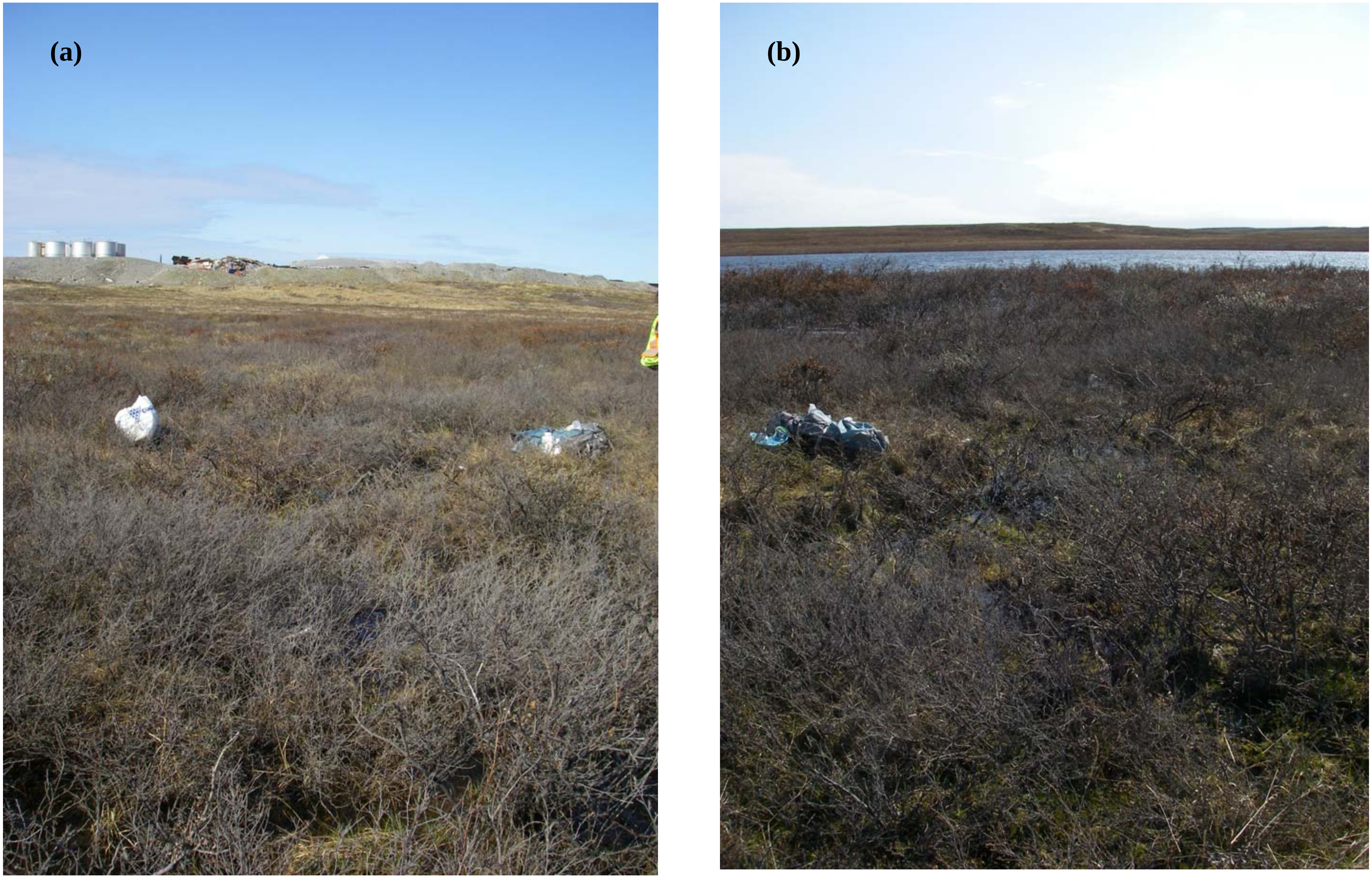

Figure 5. Photos looking upstream (a) and downstream (b) at E2.

Supporting Document C

Closure Options

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Technical Memorandum

To:	Kelly Sexsmith	**Date:**	June 27, 2009
cc:		**From:**	Lowell Wade, Peter Mikes, and Maritz Rykaart
Subject:	Hope Bay Project – Boston Ore Stockpile Closure Options	**Project #:**	1CH008.010.600

1 Introduction

A bulk sampling program completed by BHP from 1996 to 1997 at Boston. This program produced 27,000 tonnes of ore and 106,000 tonnes of waste rock. The ore was crushed on site and stockpiled on a rockfill pad constructed from waste rock. The waste rock was also used for other infrastructure components such as camp pads and airstrip (SRK, 2009b).

This memo provides an assessment of potential closure options for the site, including a discussion of the potential advantages and disadvantages of each option.

2 Comparative Summary

Table 1 below provides a summary of the potential options, including a description of the option, and the advantages and disadvantages of each, including the relative costs. Those options worthy of further consideration were identified for use in developing a closure plan for the site.

3 Recommendations

All of the options recommended for further consideration include consolidation of the ore and resloping of the ore stockpiles. This will facilitate construction of covers or reprocessing of the ore. If an opportunity to process the ore at a processing facility somewhere on the Hope Bay project site arises, the ore would likely be reprocessed. Otherwise, the stockpiles would be covered with either a simple waste rock cover, a thicker rock cover to promote freezing, or with a geomembrane to reduce infiltration and oxidation of the sulphides. Further monitoring of the seepage water quality will be used as the basis for determining what degree of control is required.

Table 1: Closure Option Comparative Summary

Option	Description	Advantages	Disadvantages	Relative Cost	Carry Forward
1	**Do Nothing:** The ore stockpiles are left as is with an existing footprint of 7,833 m^2.	• Least effort	• No reduction in contaminant loadings. • Inconsistent with corporate policies	negligible	No
2	**Reslope and cover (0.3 m):** The original footprint of the ore stockpile remains the same at 7,833 $m^{2.}$ The stockpiles are resloped to promote drainage. A cover consisting of 0.3 m thick, locally sourced material (likely waste rock) will be placed over the resloped stockpiles.	Minimal effort.	• Does not address ore material used for camp pad and airstrip maintenance • Only a modest reduction in contaminant loadings	small	No
3	**Consolidate and reslope:** The ore stockpiles are consolidated to 2/3 of the original footprint. Ore material used throughout the camp pad and airstrip, for maintenance, will be scalped and consolidated with the ore stockpiles. The consolidated footprint is estimated to be 5,222 m^2. The consolidated stockpile is resloped to promote drainage and left uncovered.	• Footprint of ore is reduced • Preserves option to process ore in future • Reduces both direct exposures to terrestrial receptors and contaminant loadings through footprint reductions and resloping	• Still appreciable contaminant loadings from the stockpile areas	Moderate, but appreciably higher than previous	No
4	**Consolidate, reslope, and cover (0.3m):** The ore stockpiles are consolidated to 2/3 of the original footprint [5,222 m^2]. Ore material used throughout the camp pad and airstrip, for maintenance, will be scalped and consolidated with the ore stockpiles. The consolidated stockpile is resloped to promote drainage. A cover, 0.3 m thick, of locally sourced material (likely waste rock) would be placed over the resloped stockpiles.	• As above with further reduction in direct exposures	• Still moderately appreciable contaminant loadings from the stockpile areas	Similar to previous	Yes
5	• **Consolidate, reslope, and thermal cover (1.5m):** The ore stockpiles are consolidated to 2/3 of the original footprint [5,222 m^2]. Ore material used throughout the camp pad and airstrip, for maintenance, will be scalped and consolidated with the ore stockpiles. The consolidated stockpile is resloped to promote drainage and a thermal cover consisting of 1.5 m thick locally sourced material would be placed over the resloped stockpiles. This cover will create a thermal barrier to promote freezing of reactive materials and provide a buffer between the PAG ore and the environment	• As above with potential to eliminate contaminant loading from the ore stockpiles	• Would need to implement thermal monitoring to demonstrate effectiveness. • May not be sufficient non-PAG waste rock available for construction • More costly and difficult to recover the ore for processing in future.	Moderate to High, appreciably higher than previous	Yes
6	**Consolidate, reslope, encapsulate, and cover (0.3 m):** The ore stockpiles are consolidated to 2/3 of the original footprint [5,222 m^2]. Ore material used throughout the camp pad and airstrip, for maintenance, will be scalped and consolidated with the ore stockpiles. The consolidated stockpile is resloped to promote drainage and an HDPE liner is placed over the consolidated and resloped stockpile. A cover consisting of 0.3 m thick locally sourced material would be placed over the resloped stockpiles.	• As for consolidation option. • Minimizes seepage • Minimizes rate of sulphide oxidation • Substantial reduction in contaminant loading	• Potential maintenance requirements • Questionable durability over very long term. • May be a requirement to commit to replacing HDPE every 100 years.	Similar to previous	Yes
7	**Relocate underground:** All ore stockpile material and ore material used throughout the camp pad and airstrip, for maintenance, will be picked up and relocated to the underground workings in the portal entrance and vent shaft.	• Promotes freezing of reactive materials. • Eliminates potential for exposure or contaminant loading to the environment	• This option is not favourable due to the presences of a frost plug at the portal entrance and unconfirmed reports of an ice dam are noted in SRK (2009b). • Eliminates future access to the underground workings • Limits potential opportunities to recover metals	High, moderately higher than previous	No
8	**Relocate to Doris Mining Area:** All ore stockpiles material is picked up and transported to a mill located at the Doris Mine Area for processing and recovery of the gold. A total distance of approximately 60 km	• Contained value of ore is \$10 to \$13 million, sufficient to offset haulage and processing costs. • Eliminates source of contaminants • No further monitoring or maintenance requirements	• This option will require the ore to be transported by ice road from Boston to the Doris Mining Area. • May require further permits and approvals	Revenue neutral	Yes
9	**Process at Boston:** A portable mill will be barged from Hay River to Roberts Bay then transported to the Boston Mining Area by winter road. The ore stockpiles and ore material used throughout the camp pad and airstrip from maintenance will be processed. The concentrate will be transported by winter road to Roberts Bay were it will shipped off site by barge	• Value as above may offset direct and indirect costs of this option. (Historical studies have shown the cost of transporting a mill to Boston to process the ore is revenue neutral).	• Transportation of mill modules to Boston may be price prohibitive depending on the current price of gold • Deposition of tailings has to be considered	Unknown	No

4 References

SRK Consulting (Canada) Inc. (2009a). *Scope of Work and Cost estimate for Preparing a Waste Rock Management Plan for Ore and Waste Rock at the Boston Site, Hope Bay Project*. Technical Memorandum submitted to Hope Bay Mining Ltd., Project No. 1CH008.010, May 14, 2009.

SRK Consulting (Canada) Inc. (2009b). *2008 Annual Geotechnical Inspection, Boston Advanced Exploration Project, Hope Bay, Nunavut.* Report submitted to Hope Bay Mining Ltd., Project No. 1CH008.006, March, 2009.