

**CASE STUDY: DEVELOPMENT OF A REHABILITATION PLAN FOR THE ABANDONED ARCTIC
GOLD AND SILVER MINE SITE**

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ABSTRACT

The Arctic Gold and Silver mine is situated between Carcross and the BC-Yukon border. The mine, which included primarily underground workings, a processing plant and a tailings impoundment, operated intermittently over a period of less than 2 years in the late 1960's before being abandoned. An environmental assessment conducted in 1997 revealed that tailings seepage has a low pH and high metal concentrations, and is discharging into a small lake adjacent to the impoundment.

The Arctic Gold and Silver Working Group was established in 1997 with the objective of guiding the development and selection of a rehabilitation plan for the abandoned mine facilities. The Working Group comprises representatives of affected stakeholders, including the Carcross-Tagish First Nation and various government departments.

The development of a detailed rehabilitation plan commenced in 1998 with a detailed assessment of the environmental conditions at the site. A series of options for remediating the tailings were subsequently developed and each of the options underwent an evaluation to determine its probable effectiveness. Based on this evaluation, two options were "short-listed" for further consideration. The first consisted of consolidation and covering of the tailings, a well established technological approach. The second consisted of chemical amendment by heap leaching and reprocessing of the tailings, a technology that has become common in recent years although there are relatively few such cases in the North.

The two short-listed options were compared on the basis of factors such as environmental benefits, estimated costs and the level of certainty associated with each of the cost estimates. The results of these comparative evaluations were submitted to the Arctic Gold and Silver Working Group who, following a review of all the options, selected the consolidation and cover option. The rehabilitation activities were implemented during summer 1999.

1.0 INTRODUCTION

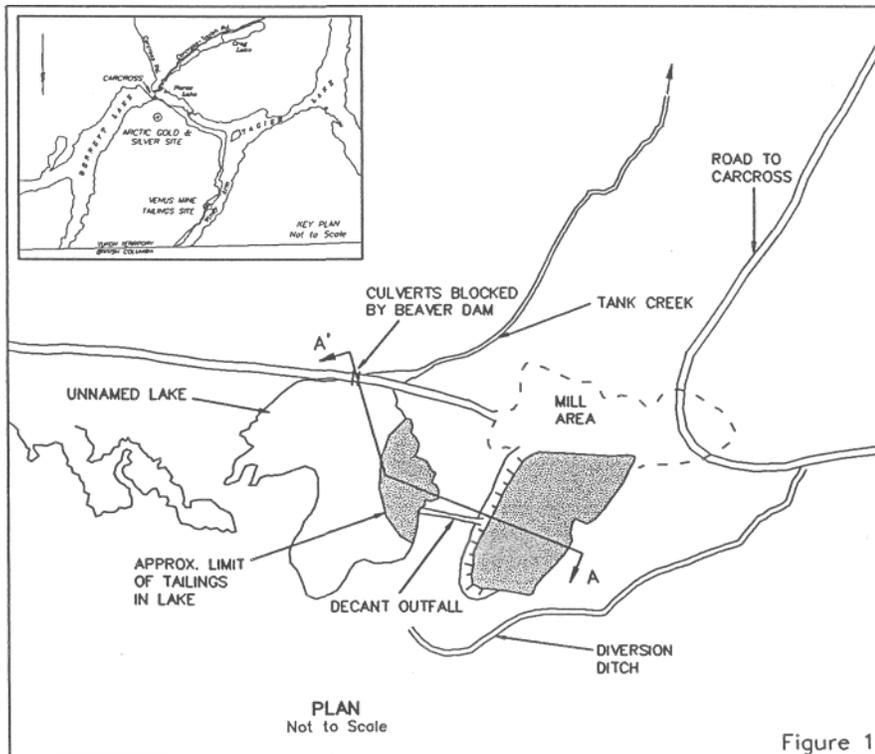
In June 1998, Public Works and Government Services Canada (PWGSC) commissioned Steffen Robertson and Kirsten (Canada) Inc. (SRK) to provide scientific and geotechnical services related to the remediation of the abandoned Arctic Gold and Silver (AG&S) mine facilities near Carcross in the Yukon Territory. The principal concerns to be addressed by the rehabilitation plan were the threats posed to

human health and the environment by contaminants, such as arsenic, in tailings, mine rock and water which comes into contact with either of these materials.

1.1 Mine Setting and History

The AG&S mine is located approximately 4 km south of Carcross (Figure 1). The surface facilities, comprised principally of a processing plant and tailings impoundment, are up-slope of a small, unnamed lake that formed when beavers dammed culverts through a service road spanning Tank Creek and adjacent marshy areas. The unnamed lake, which is fed by a few small creeks, discharges over the beaver dam and into Tank Creek. In turn, Tank Creek flows into Bennett Lake.

The deposit that eventually led to the development of the AG&S mine was discovered in 1905. Ore was processed intermittently at the AG&S plant between May 1968 and October 1969 using a basic flotation process, i.e. without the use of cyanide. Approximately 51,000 tonnes of ore were processed before the mine closed due to unsatisfactory recoveries. All tailings were deposited in the impoundment, although some tailings washed through decant structures into the unnamed lake during operations and others were blown by wind to areas adjacent to the impoundment ground (Figure 1).



1.2 Environmental Assessment History

In 1976, Environment Canada published a survey report that showed that seepage from the AG&S tailings impoundment was of poor quality. In 1993, following completion of Phase I environmental assessments at 49 abandoned exploration and mine sites in the Yukon Territory under the Arctic Environmental Strategy - Action on Waste Program, the AG&S site was identified by Department of Indian Affairs and Northern Development (DIAND) as requiring further assessment of the environmental impacts and potential remediation.

Field studies performed at the AG&S site in 1996 and 1997 addressed various technical issues. These studies indicated that additional geochemical or geotechnical information was required in order to make decisions regarding site rehabilitation. Subsequent site work confirmed that the tailings were generating acid and that discharge from these tailings, which contains significant metals concentrations, was seeping into the unnamed lake. It was recommended that remediation be undertaken to minimize further generation of ARD and reduce contaminant transport.

During a site visit by representatives of PWGSC, Indian and Northern Affairs Canada (INAC), the Carcross-Tagish, and SRK in July 1998, it was concluded that further investigation and evaluation of remediation options was required before deciding on the most appropriate remediation plans. The recommended fieldwork was carried out in August and September, 1998 and the results were used to formulate and evaluate seven remediation options (SRK 1999).

1.3 Definition of Issues

The site is abandoned and has defaulted to the responsibility of the federal government. It is situated on land claimed by Carcross-Tagish First Nation, who prefer a "zero risk" rehabilitation option and the involvement of First Nation contractors.

Technically, the key issue is the high arsenic level in the tailings, which makes them a hazard to human health. This requires definition of the significant contaminant transport mechanisms, i.e. surface runoff, storage of precipitation and seepage, groundwater seepage or a combination of the previous. Another issue was whether the known low pH in and high metal concentrations in the tailings would cause a significant impact. An understanding of the groundwater regime in and below the tailings impoundment and the in-lake tailings are essential to understand these issues.

With respect to potential rehabilitation activities, the key issues were the lack of suitable borrow material in the area and the logistics of removing in-lake tailings. In particular, the removal of in-lake tailings would be influenced by the removal procedures and hydrology issues such as the upstream lakes and the removal of the beaver dam and road, i.e. the in-lake tailings would be exposed if the road/dam fails.

2.0 ARCTIC GOLD & SILVER WORKING GROUP

The Arctic Gold and Silver Working Group (AGSWG) was established in 1997 with the objective of guiding the development and selection of a rehabilitation plan for the abandoned mine facilities. The AGSWG comprised representatives of affected stakeholders, including the Carcross-Tagish First Nation, Environment Canada, Indian and Northern Affairs Canada and Yukon Territorial Government.

3.0 DEVELOPMENT OF REHABILITATION OPTIONS

3.1 Visit by Technical Specialists

Technical specialists with expertise in site contamination and geotechnique reviewed relevant background documents and attended a site visit in July 1998. During the visit, a series of rehabilitation options were defined. It was concluded that further investigation and evaluation of rehabilitation options were required before a recommendation on the most appropriate rehabilitation plans could be finalised.

3.2 Investigation Staging

A list of options was developed along with a two-stage plan for data collection. The first stage of the investigation would define the basis for eliminating most of the investigation options from further consideration. The second stage of activities, if required, would provide information needed for final design of the plan.

3.3 Description of Options

The seven alternatives considered worthy of further consideration were:

1. Do nothing;
2. Control access to the site;
3. Reduce contact with surface and ground water;

4. Cover the tailings;
5. Consolidate tailings and other into a smaller area;
6. Chemically amend the tailings; and,
7. Reprocess the tailings.

It was important to consider all possible alternatives so that the two-stage investigation would provide the information needed to select and develop the optimum rehabilitation plans.

4.0 TECHNICAL ASSESSMENT OF OPTIONS

4.1 Overview of Results

The investigation was completed in August and September 1998 and comprised the following components: topographic mapping; surface water sampling; tailings investigations; delineation of other sources of contamination; hydrogeologic investigation; lake sediment evaluation; metallurgical testing; borrow source characterization; and cost estimation.

The implication of the investigation results on the seven options listed previously is provided below.

Do nothing

The "do nothing" alternative, which was included as a baseline, was rejected because of the human health hazard, continuing dispersion of tailings, and the potential for future deterioration of surface water quality.

Control access to the site

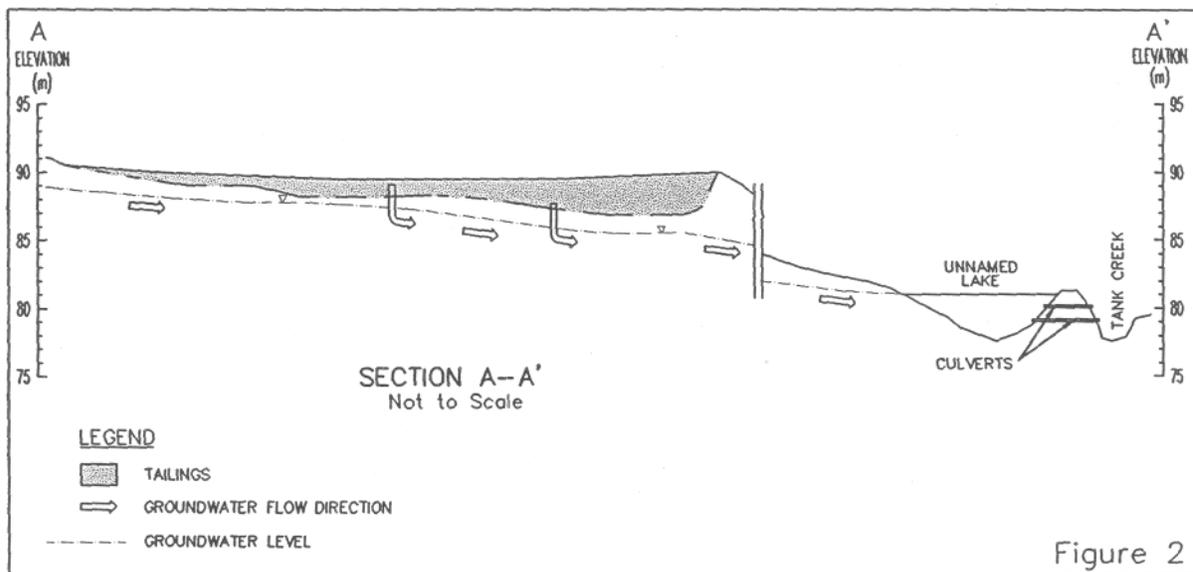
Controlling access to the tailings, probably by means of fencing and warning signs, would minimize direct contact of people with the tailings. However, it would control neither dispersal of the tailings nor groundwater contamination. This option was therefore rejected from further consideration.

Reduce contact with surface and groundwater

Tailings are present in unnamed lake, but are apparently not causing arsenic levels in the lake to exceed CCME criteria. Since the tailings had been present for some time, it is likely that the situation at that time

was stable and would not lead to future increases in contamination. The in-lake tailings would not need to be removed, as long as the lake remains in place. However, it was noted that a large portion of the unnamed lake only existed because beavers had blocked the culvert that once drained the area. If that situation were to change, all or part of the currently submerged tailings would be exposed to oxygen, and could become a more significant source of contamination. In that case, removal of the exposed tailings from the watercourse would be necessary.

The results of the groundwater investigation at the tailings impoundment showed that the water table is below the tailings (Figure 2). Hence, there are no groundwater inputs to the tailings, and any measures to further control groundwater inputs would be pointless.



Consolidate tailings in a smaller area and cover

Consolidation of wastes to the tailings impoundment and construction of a soil cover over the consolidated material remained under consideration. This alternative would prevent human contact and further dispersion of the tailings, and could reduce the risk of future surface water contamination.

Chemically amend the tailings

Chemical amendment of the tailings through the addition of alkali would neutralize acidity and convert soluble metals to less soluble mineral forms. However, as shown by the results of the metallurgical tests,

a substantial amount of alkali, approximately 48 kg Ca(OH)₂ per tonne of tailings, is required to attain alkali conditions. Furthermore, after the chemical amendment, the tailings would still be able to produce acidity in future, and would therefore need to be covered or further treated. Chemical amendment alone would be prohibitively expensive and would not provide sufficient assurance that the current environmental problems would not recur.

Reprocess the tailings

Chemical amendment would be more attractive as part of a re-processing option. Testing had shown there was significant recoverable metal value (gold and silver) in the tailings. The costs of reprocessing would depend on the method used, of which the following three were considered viable: heap leaching; vat leaching on site; and, regrinding followed by cyanide leaching at the nearby Venus Mill (Figure 1).

4.2 Assessment Conclusions

The additional investigations at the AG&S site clarified remediation objectives and lead to the conclusion that the two alternatives described below remained worthy of consideration.

Consolidate and Cover Alternative

The main benefits of the "consolidate and cover" alternative would be prevention of human contact and further dispersion of the tailings, and the reduction of future surface water contamination downstream of the tailings impoundment. This alternative could proceed to final design with limited additional investigation. A class "C" ($\pm 25\%$) cost estimate of the cost of this option was prepared on the assumption that:

- In the absence of low permeability material in the immediate vicinity of the mine site, low permeability material from Carcross would be hauled to site and used to develop a compacted cover over the tailings;
- The road/dam at the north limit of the unnamed lake would be lowered by as much as 2 m and any tailings exposed as a consequence of this action would be hauled to the tailings impoundment and covered with the low permeability cap;
- Additional material would be placed on the upstream side of this structure to bolster its stability;
- A spillway would be installed to pass extreme flood events.

The uncertainty associated with the estimated cost of this alternative was relatively low, i.e. $\pm 25\%$. Furthermore, the technology associated with this alternative would be such that the work could be undertaken using labour and conventional earthmoving equipment available in the region. Most of the work would be undertaken over a single construction season. The removal of the tailings exposed at the east margin of the lake would be done during the subsequent winter and the low permeability cap would be placed over these tailings the following summer. Multiyear funding would, therefore, be required but the amount required in the second year would be relatively minor.

Amend and Process Alternative

The "amend and reprocess" alternative would be attractive from an environmental perspective because it would allow neutralization and complete encapsulation of the tailings, as well as a net reduction in the area impacted. The general site cleanup and modifications to the road/dam adjacent to the unnamed lake would also be required as part of this alternative. A preliminary cost estimate showed that there was potential to recover most of the costs of this alternative. However, several significant issues, such as the need for more metallurgical tests and the "handlability" and "stackability" of the reprocessed tailings, would have to be resolved. Therefore, unlike the "consolidate and cover" alternative, the "amend and process" alternative could not proceed to design without significant further investigation. Subject to the determination of positive economic feasibility, the reprocessing alternative would then need to enter a regulatory approval process that could be expensive and protracted. Furthermore, uncertainty associated with the cost of this alternative was judged to be very high due to factors such as the northern climate, the small size of the "ore body", the inability of laboratory testing to properly model the realities of a full scale leach pad and potential changes in gold and silver prices.

The technology associated with the earthworks portion of this alternative is similar to the "consolidate and cover" alternative and could, therefore, be undertaken using labour and conventional earthmoving equipment available in the region. Importation of specialist technical skills would likely be required for other aspects of the alternative. Support personnel could likely be obtained from the local work force and would be in the order of 10 to 12 man-months.

The feasibility assessment could proceed in the current year and, depending on the results of that assessment, the alternative could be implemented the following year. Detoxification of the leached tailings would likely be done the same year, but the final capping of the heap and revegetation would likely have to be done the following year. Multiyear funding over a 2 to 3 year period would be required.

5.0 FINAL ASSESSMENT BY WORKING GROUP

The AGSWG concluded that the "consolidate and cap" alternative was preferred for the tailings impoundment due to the unknown financial risk and reliance on multi-year funding associated with the "amend and process" alternative. In particular, further feasibility work would be required to minimize the risk associated with the quantity of the recoverable gold and silver. The uncertainty inherent in the market value of precious metals over a 2-year period would be high. Lastly, access to multi-year funding would have significant risk due the project's reliance on unpredictable federal funding.

6.0 SUMMARY

The process developed to evaluate and select an acceptable rehabilitation plan for the Arctic Gold and Silver Abandoned Mine site was quite successful. A Working Group composed of stakeholders, including representatives from regulatory agencies and the local First Nation, was established at the outset of the project to guide the technical program. As a result, substantial resources were not wasted in pursuing a potentially unacceptable rehabilitation program. All technically feasible options were considered by the Working Group and evaluated for their ability to satisfy the regulatory requirements, as well as those of the First Nation. The result of the evaluation lead to the selection of two meritorious alternatives and, based on the associated implementation risks, a final option was selected and successfully implemented.

7.0 REFERENCE

SRK Consulting Inc., 1999. Final Report - Assessment of Remedial Measures for Arctic Gold and Silver Tailings Site. Prepared for Public Works and Government Services Canada, Environmental Services, February 1999.