BC CROWN CONTAMINATED SITES PROGRAM REMEDIATION OF THE HISTORIC MINE TAILINGS AT TWO MILE CREEK, NEAR HAZELTON, BC

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ABSTRACT

Mine tailings were deposited in Two Mile Creek from mining operations in the 1910s and 1920s. Preliminary investigations in 2006 found elevated metals concentrations in tailings, sediment and surface water. Two Mile Creek was observed flowing over areas of exposed tailings, eroding them into the creek.

The creek is a source of drinking water for local communities and is designated as a community watershed. Although no exceedances of dissolved metals were identified, management of downstream ecological and human health risks associated with the tailings was necessary. Tailings were removed from the floodplain and placed into an upland quarry and covered with an engineered cover.

Project challenges included ensuring there were no negative impacts on water quality during and after construction. A temporary drinking water by-pass pipe to the downstream water treatment plant and a temporary ditch to divert Two Mile Creek were used during construction. A higher-than-expected volume of tailings required design modifications during construction.

Reclamation also involved re-channelling Two Mile Creek and the installation of a new culvert under Nine Mile Mountain Road. Water quality monitoring is ongoing.

Key Words: Reclamation, mine tailings, water quality, lessons learned

INTRODUCTION

The Crown Contaminated Sites Program (CCSP) is part of the Crown Land Opportunities and Restoration Branch of the BC Ministry of Agriculture and Lands. The CCSP was established in 2003 to assume a lead role for government to take actions toward creating a provincial strategy that reflects stronger leadership and public accountability with respect to the management of contaminated sites for which the province is responsible. The program was developed in response to a report "Managing Contaminated Sites on Provincial Lands, 2002/2003: Report 5" issued by the Auditor General.

CCSP provides clear, accountable cross-government policy for the management of Crown contaminated sites. The program improves the information available on Crown contaminated sites, and institutes a provincial framework to establish accountabilities for liabilities and progress. CCSP manages identified priority contaminated sites on provincial lands, to ensure protection of human health and the environment, using a risk-based approach. This role differs from that of the BC Ministry of Environment (MOE),

which is charged with the regulatory role related to all contaminated sites under the *Environmental Management Act* and Contaminated Sites Regulation.

The Two Mile Creek tailings site was brought to CCSP's attention in the summer of 2006 when a representative of the Regional District of Kitimat-Stikine became aware that CCSP was conducting an investigation of mining disturbances nearby. The tailings and associated former mill from the 1910s and 1920s are located along Two Mile Creek, where Nine Mile Mountain Road crosses the creek, a few kilometres from Hazelton, BC. CCSP undertook a reconnaissance site visit and conducted some preliminary sampling at the newly identified site (Figure 1).

Figure 1: The tailing in Two Mile Creek, adjacent to Nine Mile Mountain Road. Two Mile Creek flows from left to right across the photo.



The preliminary environmental investigation was conducted in October 2006. The results of this investigation indicated elevated concentrations of several metals and metalloids relative to applicable environmental quality standards in samples of tailings, sediment and surface water. Concentrations of arsenic, cadmium, copper, lead, and mercury in sediment exceeded the Contaminated Sites Regulation sediment standards. Concentrations of cadmium, arsenic, iron, manganese, and zinc exceeded surface water guidelines for protection of aquatic life. The tailings had elevated concentrations of antimony, arsenic, cadmium, cobalt, copper, lead, silver, tin, and zinc. In addition, leachable cadmium and lead were present in the tailings. Sulphide sulphur concentrations (up to 5.19%) and low net neutralization potential ratios (as low as 0.33) suggested that portions of the tailings deposit were potentially acid generating.

During the 2006 program, Two Mile Creek was observed to be flowing over areas of exposed tailings and eroding these materials into the creek. Downstream of the site, Two Mile Creek is used as a source of drinking water and irrigation water for the Village of Hazelton and Gitanmaax Band communities. A water treatment plant is located about 800 metres downstream of the tailings and treats water through slow sand filtration and chlorination.

Photo 1: Looking upstream towards Nine Mile Mountain Road, Two Mile Creek on right, tailings on left.



Photo 2: Ponded water with high metals concentrations at south end of tailings area.



Water sampling adjacent to the water treatment plant intake indicated that dissolved metals concentrations met the Health Canada drinking water quality objectives for all parameters analyzed. Two samples from ponded water on the tailings deposit had concentrations of dissolved iron and manganese greater than the drinking water standards. The sand filter removes suspended solids and thereby addressed concerns around elevated total concentrations for aluminum, arsenic, cadmium, iron, lead, and manganese found in creek samples.

Although no exceedences at the water supply intake were identified, rapid action was necessary to reduce potential downstream risks associated with the tailings and related suspended solids. CCSP requested our consultants to develop and implement a plan for the tailings. The goal was to arrest the potential for direct erosion into Two Mile Creek and to protect the drinking water intake. Additional information was required to complete a remedial plan. The work plan was phased – data collection and planning, design and permitting, and construction. The initial remedial work plan involved pull back of tailings from the creek and low lying areas. The material was to be pulled back to an upland location but still in the floodplain of the creek. The creek was planned to be realigned. Seasonal timing constraints prevented this plan from being implemented in 2007.

PROJECT CHALLENGES AND SUCCESSES

There were a number of challenges and successes during the course of the remediation project. This paper illustrates some of the lessons learned and highlights successes, with a focus on lessons and successes that can be applied to other projects.

Data collection and planning in 2007 included a scoping reconnaissance, test pit investigation and sampling program, identification of downstream water users, topographic survey of the Site, fisheries baseline monitoring and habitat assessment, and benthic sampling and analysis. The design and permitting involved a meeting with regulatory agencies, including BC MOE and Department of Fisheries and Oceans Canada (DFO) and remedial options analysis. The subsequent investigations (June, September, and December 2007) confirmed elevated concentrations of several metals relative to applicable environmental quality standards in samples collected from the tailings deposit, surrounding sediment, and surface water.

One of the first project challenges was scheduling the physical remediation. Results of the initial site investigation were not available until relatively late in 2006, resulting in planning being delayed until early 2007. Even though the data collection and planning occurred as early as possible following snow melt, the design and permitting didn't commence until summer 2007. MOE required a Notice of Independent Remediation to be filed and a Section 9 Approval under the *Water Act* to work in the creek. The turnaround time for an approval is 90 days. The proposed work also required fish salvage, construct works upon highways, and Forestry Licence to Cut permits. Although there were no documented direct water users downstream, door to door notification was made to all local residents along the creek as well as a water user notice in the local papers (*The Bulkley Browser* and *Smithers Interior News*). The Village of Hazelton, Regional District of Kitimat-Stikine, and Gitanmaax Band Council were also notified. Permitting in combination with tendering requirements pushed the construction period back to the late fall. Some equipment was mobilized to site, but weather conditions postponed the program.

LESSON: Good planning and understanding of all permit requirements and timing is critical. Had CCSP understood the additional data and permitting requirements early in 2007, the project may have developed differently. Develop and regularly update a schedule. Communicate with all local officials early and often.

When the remedial works were delayed in 2007, it allowed time for further evaluation of remedial options and the development of a revised remediation plan. Leaving the tailings in the floodplain as originally planned was not ideal in the long term as the creek is known to flood and to experience dramatic changes in flow related to upstream beaver activities. The delay allowed consideration of other options and development of a longer term solution.

LESSON: Sometimes slower is better. The risks of delay need to be understood and accepted. The tailings had been in place for decades (since the 1920s) so it was unlikely that a major event would change conditions in the spring of 2008. The initial rush to move forward, subsequent changes in plans, and projects delays challenged the project communication with local officials.

More initial planning on this front would have benefitted the project. Communication improved as the reclamation plan was implemented, but first impressions are critical.

The remediation goal to reduce downstream risk remained, but the objectives for remediation were revised to:

- Protection of the drinking water supply for the Village of Hazelton and Gitanmaax Band;
- Prevention of further erosion of the tailings into Two Mile Creek;
- Minimize the potential for further metal and trace element leaching into the creek and improving water quality for ecological receptors; and
- Minimize human and ecological physical exposure/contact with the tailings deposit.

The remediation goal was not to obtain a regulatory instrument from the MOE for the site but to manage risks related to the tailings in the creek.

Our consultants characterized the key design constraints for the remediation program as:

- Construction works timing, specifically with regards to fish spawning, scheduled replacement of the water treatment plant sand filter, and rainfall events;
- Satisfying DFO and MOE requirements regarding fish habitat; and
- Maintaining surface water quality, including total suspended solids loading, for the downstream water treatment plant and for downstream users and habitat.

The revised remediation plan involved removal of tailings materials from the Two Mile Creek floodplain and placement into an adjacent former quarry area and capped with an engineered cover. A temporary drinking water by-pass pipe to the downstream water treatment plant and a temporary ditch to divert Two Mile Creek were used during construction. The original Two Mile Creek alignment at the Site was enhanced to improve ecological values. A new culvert was installed under Nine Mile Mountain Road to increase flow capacity and reduce flooding.

A quarry area adjacent to the tailings area was identified as a potential repository for the tailings. It was surveyed in the spring 2008 early enough to allow remedial design and go out to bid. Plans to manage the creek flows were also improved due to additional time allowance. The Section 9 Approval was renewed instead of reissued which saved time. Work was able to progress earlier in the fall than the previous year (work commenced September 29, 2008). As it was, the snow was flying during the last few days of construction, for capping of the stockpile and final backfilling of the excavation. Construction needed to be completed prior to the water treatment plant operator's scheduled replacement of the sand filter to ensure maximum longevity of the new filter.

SUCCESS: Timelines still limited the construction window, so work was designed to be completed quickly. Construction was completed within the 2008 construction season. Investigations and remedial works were completed and risks were addressed within two years of the site being brought to CCSP's attention.

The remedial design had to ensure there were no negative impacts on water quality during and after construction. The water treatment plant operators were concerned that work would increase turbidity in the creek, requiring them to change their sand filter earlier than planned or would increase sediment in the settling pond (both which would add cost to them). CCSP needed to ensure there were no spikes in metals concentrations, particularly dissolved concentrations, which could potentially impact the drinking water quality. Options had to balance costs and risks.

A temporary diversion pipe (150 mm HDPE) was installed from upstream of the construction area directly into the water treatment plant intake. The pipe extended about 1.2 kilometres along the east bank of the river, using a former road that ran adjacent to the creek. Small perforations were made along the top of the pipe to prevent a vapour seal. While the diversion pipe was in place, the gate of the treatment plant intake was closed, allowing the creek to run past the treatment plant without entering the plant.

SUCCESS: Sometimes simple is best. While innovative approaches for instantaneous or rapid monitoring of metals concentrations in the creek were considered along with detailed contingency plans for providing bottle water to residents in the event of an issue, it was ultimately the simple solution to avoid any potential problems that was chosen. While the piping option was costly, it was less expensive that an emergency response for contaminated drinking water, and ensured a higher degree of safety for the drinking water supply.

Numerous steps such as lining the diversion ditch and installing silt fencing were taken to reduce impacts on the creek during construction and to protect the ecosystem. Fish were removed from the section of the creek where remedial work occurred prior to in-stream construction works. A surface water monitoring and sampling plan, part of the environmental project plan, was implemented before, during, and after construction activities. General parameters (pH, temperature, electrical conductivity, dissolved oxygen, and turbidity) were measured daily. Water samples were collected and sent to the lab as per the environmental monitoring protocol. Dissolved metals concentrations did not exceed Health Canada standards or BC Approved and Working Water Quality Guidelines for drinking water during any of the sampling events. Elevated total metals concentrations were noted and were directly related to increased total suspended solids, which are removed by the slow sand filter. Several water samples collected during the construction program exceeded the BC Approved and Working Water Quality Guidelines for freshwater aquatic life (but not wildlife), including arsenic, cadmium, copper, and iron. Concentrations of all but cadmium met the guidelines immediately following completion of in stream works. Cadmium concentrations also exceeded the guideline at the upstream station.

SUCCESS: Drinking water quality in the creek was maintained throughout the construction period. Water quality for ecological receptors, while showing a few spikes during construction, returned to background conditions immediately following construction.

During excavation, it became apparent that the tailings extended further into the original creek bed than had been anticipated. Tailings were deeper in areas than was evident during the site investigation. The change in volume required a redesign of the repository during construction. The redesign also took into account that the contractor had over excavated the tailings repository area during site preparation. A total of approximately 2,350 m³ of tailings and soil were excavated and stockpiled compared to the original estimate of 1,200 m³. The final extent of the main excavation was approximately 120 m by 5-to-40 m. Average tailings thickness was approximately 0.8 m, with the excavation extending approximately 0.3 m below the base of the tailings. Tailings at the south end of the creek were buried beneath approximately 30 cm of mud, and were approximately 60 cm thick. At the north end they were typically less than 5 cm thick and at the surface of the creek bed. The excavation of additional tailings also required additional backfill material to bring the excavation up to an appropriate level for the creek realignment.

LESSON/SUCCESS: Expect the unexpected. Have a contingency in place. Based on the limited data available during design, a change in volume was not unexpected, although the magnitude of the change was larger than anticipated. Our consultants had staff available to do the redesign immediately.

The contractor had anticipated using material excavated from the quarry as backfill, although prior permission was not obtained to do this. The expectation that clean, certified backfill be used was not communicated clearly in the tender package. Fortunately, the over excavation contributed to the quarry area being large enough to hold the higher volume of tailings. The excavated material from the quarry was tested and later used as additional fill for the excavated floodplain area.

LESSON: The quality of tender packages can impact the overall success of project. Ensure requirements, expectations, and lines of communication are clearly laid out along with the change order process and associated pricing.

Another challenge on working at this site was the limited area for stockpiling of materials and equipment. Fortunately some materials were sourced from close by and some of the work could be completed in phases. In addition, the contractor was able to make arrangements to use neighbouring land.

LESSON: A mandatory site tour as part of the tender package can help identify contractor concerns prior to completion of the tender, when it is easiest and least costly to make revisions.

Safety concerns and accessibility required removal of standing trees, mostly standing dead wood, to be removed from the work area adjacent to the creek. The removal of these trees hadn't been communicated well and resulted in some locals being upset. In the end, the creek enhancements helped offset the concern around the loss of vegetation.

LESSON: Communicate early and often and include all aspects of the project in those communications. Drawings are particularly useful.

The remediation plan called for engineered cover material on both the tailings impoundment and over the excavated area. An erosion control blanket was also required for the temporary diversion ditch. While all of these materials were specified in the construction bid package, alternative materials were used based on availability and cost.

Based on the increased volume of tailings, the shape and size of the impoundment were altered. Instead of a large mound that drained in all directions at a 3:1 slope, the impoundment was piled highest closest to the quarry wall and was sloped downwards towards the northwest. The slope was lower (approximately 12.5 degrees) than the designed 3:1 angle due to the friction angle of the interface between the unbounded geonet and geotextile of the stockpile cap. Originally, non-woven geotextile bonded to geonet in factory was specified, but the approved alternative was Armtec 250 and Layfield Geo-Net (not bonded). Covering the impoundment involved placing a geomembrane (EnviroLine 404 (40 mil LLDPE) instead of 40 mil HDPE) over the stockpile and installation of a drainage trench along the quarry wall. A 100 mm Ø perforated HPDE drainpipe was installed to facilitate drainage. The geonet was placed over the geomembrane using zip ties to keep the net in place and then the geotextile was fit over the net. A layer of subsoil was placed on the geotextile. The same geotextile was used to cover the excavated area, and was covered with approximately 30 cm deep pit run material.

SUCCESS: Engineer authorized substitution of the engineered materials based on availability and cost allowed the project to continue on schedule with no negative impact on the final project success or budget.

Soil samples collected from the extents of the remedial excavation exceeded regulatory standards postexcavation, although they were significantly reduced. Maximum concentrations measured in tailings materials placed in the stockpile and remaining at the base and walls of the excavation are presented in Table 1.

Metal	Stockpile Tailings	Confirmation Sample	CSR standard
(mg/kg)	Maximum	Maximum	wildlands/urban park
			(ranges are pH dependent)
Antimony	1,040	633	20
Arsenic	12,600	4,860	15
Cadmium	870	528	1.5-70
Copper	2,210	1,410	90-150
Lead	16,700	6,900	100-1,000
Manganese	3,110	1,540 (meets standard)	1,800
Silver	197	135	20
Tin	92.7	0.9 (meets standard)	50
Zinc	51,600	32,900	150-450

Table 1 Maximum concentrations in tailings and confirmation samples for metals that exceeded Contaminated Sites Regulation (CSR) standard for wildlands/urban park land use.

The excavated area was covered with a geotextile and imported pit run and quarry material were placed on top. This isolated the remaining soils from runoff and reduced the potential for both erosion of contaminated soils in the creek and increased siltation from the site into the creek. This also reduced the potential for leaching from three small locations were tailings materials were left in place:

• beneath Nine Mile Mountain Road. Tailings from either side were excavated. The remaining tailings are located under the road bed, above the creek level. Excavation would have required

reconstruction of a section of the road, additional permits, and significant disruption to local access.

- a thin layer at the top of slope on the west excavation boundary along the forest boundary. Removal of these tailings would have required removal of a significant number of healthy trees and elimination of undergrowth.
- in areas between the enhanced section of Two Mile Creek and the location of the temporary ditch. Earlier investigation had suggested tailings weren't present in this area and excavation would have potentially undermined the temporary ditch.

SUCCESS: Risks were managed without having to remove every trace of contaminated soil from the site and thereby saving time and money. Placement of the geotextile both reduced risks of erosion of remaining contaminated material and risks of siltation from the excavated floodplain area (a significant concern of the water treatment plant operators).

A long term management challenge is the annual flooding of Two Mile Creek, especially above the road crossing. The existing culvert was inadequate for spring flows, as well as being very poor for fish passage, with a drop off at the downstream end. Instead of replacing the culvert, a second culvert was added. Not only did this help manage the flood concern, it also improved fish passage. An added benefit was that it facilitated construction, requiring only limited road closures.

SUCCESS: Sometimes more is better and does not add any additional cost. Installation of the second culvert instead of replacement of the existing culvert both addressed concerns and facilitated construction. As the culvert needed to be addressed as part of the Section 9 approval, there was no additional cost.

Reclamation also involved realignment of Two Mile Creek. The creek bed was rebuilt and raised to establish a proper gradient. Boulders, fallen trees and root wads that had been saved during the excavation process were places along the creek as enhancement features. Flow was gradually re-established on October 25, 2008 and the creek was subsequently monitored closely to ensure banks and structures were stable. This met the Section 9 Approval deadline of October 31, 2008 for the completion of in stream works.

SUCCESS: Although improvement of aquatic habitat along the creek corridor was not one of the project objectives, it became one of the requirements of the Section 9 Approval. It also received support from the local community and was an immediately visible improvement post-remediation.

As the construction work was completed late in the year, re-vegetation occurred in the following spring. Spruce, hemlock, and alder seedlings were planted along the banks of the creek in June 2009. Topsoil was placed as needed and a local seed mixture was applied to the impoundment, the creek banks, and the excavated area. Water was applied numerous times during plantings and again a few weeks later. Photo 3 shows the creek and excavated area in August 2009, about two months after planting. Photo 4

shows the impoundment at the same time. Western toads were noted adjacent to the creek in the reseeded area during this site visit.

Following completion of the mine tailings excavation, a one year post construction monitoring and sampling program was implemented. The program assessed water quality in Two Mile Creek and evaluated changes in water quality. Site inspections were also completed at the Site to monitor performance of construction works and to determine if further work is required.

Photo 3: Looking downstream from Nine Mile Mountain Road post remediation and 2 months after reseeding August 2009.



Photo 4: View from the top of the tailings impoundment, August 2009.



CONCLUSION

A year and a half of post remediation monitoring at the site confirms that remedial actions continue to successfully mitigate the risks posed by the tailings material. Although a number of challenges were encountered during the course of the project, the outcome was successful and met the remediation objectives within about two years of the site being brought to the program's attention. Site monitoring is ongoing to ensure water quality remains acceptable and engineered works remain stable and functioning.

Further information on the Crown Land Opportunities and Restoration Branch can be obtained at http://www.al.gov.bc.ca/clad/ccs/index.html.