MOUNT WASHINGTON MINE REMEDIATION TO SUPPORT RECOVERY OF THE FISH STOCKS IN THE TSOLUM RIVER

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ABSTRACT

On April 14, 2008, British Columbia Environment Minister Barry Penner and Minister of State for Mining Kevin Krueger announced a $4.5-million remediation of the abandoned Mount Washington open pit copper mine in an effort to support the recovery of Vancouver Island fish stocks. The mine remediation will take place in three phases, between 2008 and 2010. The project will include the installation of a bituminous geomembrane that will cover the entire site. This will be covered by a one metre thick glacial till layer, which will be planted with vegetation to stabilize and protect the material from the elements. The Ministry of Energy, Mines and Petroleum Resources will lead the remediation. Historically, the Tsolum River had large salmon runs. Since that time, several factors are believed to have affected the river and its aquatic life, reducing the salmon runs. While these factors include development and logging along the banks of the Tsolum, the dominant impact has been copper leaching from the abandoned mining operation from the mid-sixties. The old copper mine started up in 1964 and extracted ore for less than two years. It milled the ore for just a few months longer, shutting down after the mining company went bankrupt in 1967.

INTRODUCTION

The Mount Washington Mine, on Vancouver Island (see Figure 1) near the community of Courtenay, B.C., was a small, open-pit copper mine that operated from 1964 to 1966. Pyrite-bearing waste rock is generating copper-bearing acid rock drainage (ARD) and impacting the Tsolum River, which historically had large salmon runs valued at over $2 million per year in 1995 dollars. In 2003, a unique partnership committee was formed between industry, government and the local community with the objective to seek long-term solutions to the impacts from the mine and ensure a healthy ecosystem and a rehabilitated sustainable fishery on the Tsolum River.

This paper summarizes the problem, remediation history and the proposed remediation and reclamation. An aerial photograph of the site in its current condition is shown in Figure 2.
Figure 1: Vicinity Map

Figure 2: Aerial View of the North Pit
THE PROBLEM

Historically, the Tsolum River had large salmon runs. In the late 1940’s, runs of up to 200,000 pink salmon, 15,000 coho, 11,000 chum and 3,500 steelhead were reported. Since that time, several factors are believed to have affected the river and its aquatic life, reducing the salmon runs. While these factors include development and logging along the banks of the Tsolum, the dominant impact has been copper leaching from the abandoned mining operation from the mid-sixties.

Although the community was aware of the decline of fish in the river, it was not until 1982 that the severity of the problem was discovered. After operating for four years with very low returns, the Headquarters Creek Hatchery released 2.5 million pink fry into the Tsolum River and none returned. Subsequent water monitoring in 1983 revealed high copper levels originating from the mine.

Several community members, concerned about watershed issues in the Comox Valley, began a campaign of letter writing, media outreach, and working with federal and provincial ministries to bring community attention to the mine problem. This helped to bring about partial remediation of the mine site between 1988 and 1993.

Figure 3: Location Map
BACKGROUND

Beginning in 1987, federal and provincial agencies funded studies, monitoring and on-site works to address the ARD problem. Between 1988 and 1992, the Ministry of Energy, Mines and Petroleum Resources (MEMPR) put $1.5 million into remediation at the site. Steffen Robertson and Kirsten (Canada) Ltd. (SRK) was hired to design and install a till cover, the primary focus of the remediation work at that time. The cover was placed over waste rock in the East Dump. The purpose of this till cover was to prevent the ingress of oxygen and infiltration of water to the waste rock. Other smaller scale MEMPR activities included the application and testing of an experimental asphalt emulsion/geotextile cover, power washing of certain areas of the pit floor and the application of calcium hydroxide to the pit walls and floor to attempt to raise the pH and reduce metal loading. Since the initial work done by SRK in 1988 and 1989, the site has been the subject of numerous government, consultant and academic reports and assessments.

Water monitoring results from 1993 to 1996 revealed little reduction in copper levels. However, since 1998, water quality monitoring has shown sustained reductions, approximately 50%, in the copper loading from the mine, which is believed to be the result of the on-site works.

To address continuing toxicity issues, the Tsolum River Partnership was formed. The Partnership initially included:

- B.C. Ministry of Environment;
- Environment Canada;
- Fisheries and Oceans Canada;
- Pacific Salmon Foundation;
- TimberWest; and
- Tsolum River Restoration Society.

In 2003, this Partnership developed the Spectacle Lake Wetland Project to achieve water quality which was no longer acutely toxic at the compliance point downstream of the triple confluence of Pyrrhotite, McKay and Murex Creeks that drain the upper watershed. The wetland has been successful in achieving this goal to date, as copper levels in the Tsolum have been reduced by a further 40%. The concern is that this form of passive treatment is time limited and the wetland will become less effective at reducing copper over time.

With the improved water quality in the Tsolum River, the health of the fishery has gradually improved, but a longer-term solution was required. In 2005, the Tsolum River Partnership was expanded to include the Mining Association of British Columbia and the B.C. Ministry of Energy, Mines and Petroleum Resources as the focus shifted back to remediation of the major copper sources at the mine site. Recently, Natural Resources Canada has also joined the partnership.

In 2006, the Partnership initiated a process with SRK Consulting to develop a long term remediation plan for the site, which would incorporate remedial measures to sufficiently reduce the Cu loading from the
mining site, so that the water quality objectives for Pyrrhotite Creek and the Tsolum River would be achieved.

On April 14, 2008, British Columbia Environment Minister Barry Penner and Minister of State for Mining Kevin Krueger announced $4.5-million funding for the remediation of the site in an effort to support the recovery of the fish stocks in the Tsolum River. The mine remediation will take place in three phases, between 2008 and 2010. The project will include the installation of a bituminous geomembrane liner or equivalent that will cover the entire north pit. A one metre thick glacial till layer be placed over the liner and planted with vegetation to stabilize and protect the material from the elements.

**GEOCHEMICAL ASSESSMENT**

The primary purpose of the remediation plan is to reduce copper loadings from the site that impact water quality in the Tsolum River. A geochemical assessment of the mine site was carried out by SRK in 2007 to support development of the final remediation plan.

The North Pit, which is considered to be the main source of ARD, typically has pH levels below 4 and contains typical copper concentrations of 10 mg/L. The ARD originates as runoff from the shallow pit floor and waste rock on the pit floor, as well as the two waste rock dumps in the North Pit. The majority of the drainage from the North Pit flows northwards, feeding the headwaters of Pyrrhotite Creek. Part of the West Dump also contributes, but flows in a northwesterly direction towards Piggott Creek (Figure 2). The South Pit in contrast has non-acidic drainage containing lower copper concentrations (1 mg/L), and flows towards McKay Lake and McKay Creek, eventually reaching the Tsolum River via Murex Creek (Figure 2).

SRK’s geochemical assessment concluded the following:

- Copper loads originate mainly from the pit floor and more specifically in the eastern part of the pit, including the bench of highly fractured rock on the eastern edge of the pit;
- Distribution of loads, shown by weir monitoring and pit area sampling in 2007 were consistent with load distribution calculated in 2000;
- Reduction of water contact with the pit floor is not expected to result in a directly proportional decrease in loads because copper concentrations in water beneath a cover will increase due to a predicted decrease in pH. A 90% reduction in load will require roughly a 95% reduction in flow.

**REMEDIAION ALTERNATIVES**

One of the key remediation alternatives considered during the planning stages of the project was the concept of a flow equalization reservoir located at Pyrrhotite Lake. This lake is already affected by ARD from the mine site and therefore it was considered to be suitable for storage of contaminated water. We know that the highest copper loads are released from the site when dilution capacity in the Tsolum River is low. The concept would involve storage of snow melt water containing high copper load in the spring. The stored water would then be released into the river the following winter when flows in the river peaked due to rainfall.
However, during the evaluation of the option, it was found that even if the load could be perfectly optimized to make use of dilution in the river, the water quality objectives would not be met because the site produces more copper load than can be assimilated by the river.

A number of alternative pit cover options were considered to reduce contact of water with the oxidized pit floor and waste rock. Table 1 summarizes benefits and disadvantages for each option. The Bituminous Geomembrane was selected as the preferred cover option.

### Table 1: Options Evaluation Pros and Cons

<table>
<thead>
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<th>Option</th>
<th>Pros</th>
<th>Cons</th>
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| Till Cover only            | • Long-term durability  
                           • no skilled labour or equipment required  
                           • Growth Medium  
                           • Minimal to no subgrade preparation | • Locally available material has relatively high permeability     |
| Bituminous Geomembrane    | • Long term durability  
                           • Minimal subgrade preparation  
                           • panels can be welded by locally trained personnel  
                           • relatively low permeability (< 10⁻¹⁴ cm/sec)  
                           • easy to repair if liner damaged during installation  
                           • Can be deployed in wet weather  
                           • less susceptible to traffic  
                           • Flexible with most subgrade conditions  | • Relatively higher material cost than Bentomat CL (GCL)  
                           • Not recommended for cold weather installation  
                           • Higher unit weight than GCL (transportation issues) |
| (NTP2)                    |                                                                      |                                                                     |
| GCL Liner                 | • Ease of installation  
                           • Low permeability (< 10⁻⁹ cm/sec)  
                           • Self healing if punctured or cut  
                           • Self seaming at overlaps  
                           • Flexible with some subgrade conditions  
                           • Damaged liner easy to repair  | • Requires soil cover for confining stress  
                           • Extra care required during placement  
                           • Susceptible to poor weather conditions  
                           • Requires more subgrade preparation  |
| Concrete Liner            | • Very low permeability  
                           • Long term durability  
                           • Not susceptible to erosion  | • More expensive material unit cost  
                           • Require more subgrade preparation  
                           • Susceptible to cracking and settlement  
                           • Requires skilled labour  
                           • Difficult to build on steep slopes  
                           • Differential settlement an issue failure  |

### IMPLEMENTATION OVERVIEW

The mine remediation is currently scheduled to take place in three phases between 2008 and 2010. The first phase, which is scheduled for the summer of 2008, will include borrow area development, upgrading of the access roads to the site, major earthworks such as the installation of underdrains, placement of till buttresses against the pit high walls, subgrade preparation where required on areas of the pit floor, installation of a bituminous geomembrane liner over the entire area of the north pit, placement of a 1m thick till cover over the geomembrane, construction of surface drainage channels in the till cover and work associated with an uphill diversion of runoff. The second phase, which is currently scheduled for 2009, would involve placement of the 0.5 m till cover on the flat areas of the west dump, site revegetation, reclamation of the borrow areas and instrumentation installation. The third phase of the project is subject to the need for a water treatment system. The current design includes a provision for treatment but a decision on whether it is required will be made in the spring of 2010 subject to the results of a post-construction monitoring program. If water treatment is required, Phase 3 would involve final design and procurement of a lime addition water treatment system, installation of the pipeline to
Branch 1200, construction of the settling ponds and the Pyrrhotite diversion at Branch 1200. The overall project remediation measures are shown in Figure 4. A computer generated rendering of the proposed pit remediation is shown in Figure 5.

**Figure 4: Proposed Remediation Measures (Phases 1 and 2)**

**Figure 5: Rendering of the Proposed Bituminous Geomembrane, Surface Drains and Revegetation**
SITE PREPARATION

A detailed borrow source investigation for the liner cover material (till) will be conducted on a 3 ha site northeast of McKay Lake (see Figure 3). All timber will be felled and stacked on the side of the haul road for possible later transport by TimberWest. A BC registered professional forester as requested by TimberWest, will be contracted to create a silvicultural prescription prior to the test pit investigation and till excavation. This prescription will be used to ensure the area will be brought back to a state suitable for secondary commercial timber production growth.

After investigation, approximately 500 mm of overlying soil and forest duff will be excavated and stockpiled adjacent to the borrow area to allow access to underlying till. Stockpiled soil will be cover seeded for interim erosion protection and invasive plant infestation control until later use during Phase 2 borrow area restoration.

Concurrently during the borrow source investigation, the gravel roads leading to the site and borrow area will be upgraded to allow the safe and efficient passage of vehicles and equipment. Whenever possible, locally sourced granular aggregate will be used for road upgrades.

To facilitate the placement of the bituminous geomembrane liner, till sourced from the borrow area will be transported via articulated rock truck for tracked excavator placement of buttresses at the pit walls areas where the existing grade forms steep vertical contours. In areas of the pit floor that were power washed during earlier experiments with different pit floor treatments, till will be placed and compacted using both a smooth and sheeps foot roller to a uniform grade in 300 mm lifts (see Figure 5). In pit wall areas involving the placement of the soil buttress and on the east side of West Dump slope (see Figure 5), till will be placed on a 2H to 1V slope in 300 mm lifts and compacted to greater than 95% Modified Proctor maximum dry density (see Figure 6).

![Figure 6: Typical Section Detail of the Pit Wall Buttress](image-url)
UNDERDRAINS

To facilitate the collection and transport of residual leachate seepage from groundwater upwelling in the pit, a number of seepage collection drains will be installed along the alignment of the existing drainage patterns prior to placement of the liner and the cover (See Figure 7). A geotextile (Layfield Geo-comp 5 or similar) and filter fabric (LP16 or equivalent) and or drainrock will be placed on the subgrade surface. To meet required filter criteria two 150 mm layers of uncompacted till will be placed on top of the base with a filter fabric layer sandwiched between layers. Filter fabric will be wrapped over the top of both till layers. Till will be sourced from the borrow area and transported to site via articulated rock trucks (see Figure 8).

Three other underdrains will be constructed along the alignment of the existing shotcreted drainage channels. One 500 mm thick layer of uncompacted 19 mm minus aggregate will be placed on filter fabric, which will be wrapped around the sides and top of the aggregate. Aggregate will be transported from the Comox Valley via truck and trailer if no suitable material can be found locally.

Figure 7: Plan View of Underdrains
LINER PLACEMENT

After construction of the underdrains and subgrade till, the Bituminous geomembrane (a 4 mm Coletanche NTP2 geomembrane (or similar)) will be placed directly over the underdrains and the prepared subgrade. An excavator with spreader bar attachment and labour crew will be used for placement under the initial direction of an onsite manufacturer’s representative. A manufacturer’s recommended overlap will be left between rolls for welding using a gas burner (tiger torch). Panel overlaps will be oriented perpendicular to the down gradient slope to allow for maximum membrane impermeability. The liner perimeter will be keyed into either soil or bedrock using either a 1 m vertical anchor trench or rock anchor/pressure plates respectively. The extent of the liner placement is shown on Figure 7.

TILL COVER

After installation of geomembrane, a 1 m thick layer of compacted till cover, sourced from borrow area, will be placed in two 500 mm lifts. The initial lift will be compacted using both a sheeps foot and smooth drum compactor to greater than 95% Modified Proctor maximum dry density. The secondary lift will be track compacted only to allow for a looser vegetative growth media. If final lift becomes too compacted for vegetative growth, machine scarification will occur. In steeper areas (buttresses), the till cover will be placed at a 3H to 1V slope.

SURFACE DRAINS

Riprap lined surface drainage channels will be constructed on top of the till cover to facilitate surface water runoff. Trapezoidal channels will be excavated to a minimum of 550 mm below grade with 2H to 1V sidewalls. Geotextile filter fabric will be placed on top of channels prior to placing the riprap.
SITE REVEGETATION

The reclamation of the mine site areas will include the entire area of the covered pit and the capped areas of the East and West Dumps. The capping material will consist of locally available silt loam soil or glacial till.

Once the sites are capped, they will be seeded with a grass/legume seed mix to establish a fast growing ground cover that will provide erosion control. Consideration will be given to commercially available non-palatable (for ungulates) legume species with an assortment of bunchgrass and creeping grasses (erosion control) and possibly “pockets” of organic soil for site diversification and aesthetics. A shrub based cover will also be considered for the medium term.

Machine scarification of till cover in areas to be revegetated will be carried out using a dozer with ripper attachment. Scarification of East Dump slope will occur along or parallel to slope contours to prevent formation of preferential drainage pathways and for erosion protection.

After scarification, fertilizer and seed mix would be applied using an agricultural tractor with a broadcast spreader attachment. If there are slopes too steep for the tractor, mix will be applied by hand or ATV equipped with broadcast spreaders. The seed mix will contain fast growing erosion control grass species, nitrogen fixing legume species and native alder seed for long term establishment. Alder seedlings will be hand planted in areas with erosion potential (i.e. East Dump slope) or where prescribed by the revegetation specialist.

Borrow pit area would be regraded using a dozer to standardize slope and drainage. A tracked excavator would then place stockpiled soil and duff over the regraded surface to form an approximate 500 mm growth media. Reforestation of the borrow pit area would include any timber replanting following the silvicultural prescription conducted in Phase 1.

WATER TREATMENT

The current plan includes a provision for short-term treatment of the underdrain flow from beneath the cover subject to the results of post construction water quality monitoring. A schematic of the treatment concept is shown on Figure 9. The underdrain flow would be collected and transported via a pipeline to Branch 1200 for treatment. An alignment of the proposed pipeline is shown on Figure 10. At Branch 1200, the flow would be treated with lime and discharged into sludge settling ponds. Clean water in Pyrrhotite Creek would be diverted around the ponds and over to Pyrrhotite Lake.
Figure 9: Schematic of the Water Treatment System

Figure 10: Proposed Pipeline Alignment from Minesite to Branch 1200
The treatment system would be based on hydrated lime addition operating 90 days per year. It is expected that about 5 tonnes of lime would be consumed each year and would produce about 60 tonnes of sludge.

A water quality monitoring program would be initiated following the construction of the cover in Year 1. The results of the monitoring program will be collated and in the spring of Year 3, a decision will be made as to the need for pipeline construction and lime treatment. This decision will be based on the establishment of copper loadings and concentration “triggers”.

STAGING

The construction season for Mt Washington is normally mid June to late October. It is currently planned to complete the remediation over a three year period with placement of the cover, water quality monitoring and associated works in Year 1. The work in Year 2 would involve revegetation of the site; borrow area reclamations and instrumentation installation. If required, final design and procurement of the lime addition water treatment system, the installation of the pipeline to Branch 1200, construction of the settling ponds and the Pyrrhotite diversion at Branch 1200 would be carried out in Year 3.

REFERENCES


