MOUNT WASHINGTON MINE REMEDIATION PROJECT - CONSTRUCTION PHASE

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ABSTRACT

After a very short history of mining (1964 to 1966), the Mount Washington copper mine has been a major source of acid rock drainage entering the Tsolum River near Courtenay, BC. Previous remediation projects have been partially successful at controlling the ARD generation at the site and treating the copper bearing discharge from the site (Pyrrhotite Creek).

The current project includes placement of a bituminous liner over the North Pit, covering the liner with soil for revegetation, improvement of the surface water diversions and, if necessary, treatment of the drainage from under the cover while groundwater recovers. The Ministry of Energy, Mines and Petroleum Resources retained Quantum Environmental, SRK Consultants (Canada) Inc and Stantec to carry out the work. The Tsolum River Partnership, a coalition of community, industry and government were also involved in the planning and implementation of this project.

The project is ongoing. Site preparation, liner installation and partial placement of the soil cover were completed during the summer of 2009. The placement of the remaining soil cover on top of the liner and revegetation of the site will be completed during the summer of 2010. Post-construction monitoring will be conducted by the Tsolum River Restoration Society and the Ministry of Environment for at least two years to determine if lime treatment will be required.

Key Words: Copper mine, acid rock drainage, Tsolum River, bituminous liner, water quality, fisheries impact

INTRODUCTION

The Mount Washington Mine, on Vancouver Island 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 was formed between industry, government and the local community with the objective to seek long-term solutions to the impacts from the mine and to ensure a healthy ecosystem and a rehabilitated sustainable fishery on the Tsolum River.
The Tsolum River Partnership retained SRK Consulting (Canada) Inc. (SRK) to develop an ARD remediation plan for the abandoned mine. Remedial alternative and related cost benefits were proposed, reviewed and evaluated by Tsolum River Partnership and third party reviewers. A detailed plan was developed and was presented to BC government for evaluation. On April 14, 2008, British Columbia Environment Minister Barry Penner and Minister of State for Mining Kevin Krueger announced funding of $4.5-million for the mine remediation project.

The mine remediation was planned in three phases to occur between 2008 and 2010. The project involves the placement of a bituminous liner over the North Pit, covering the liner with soil for revegetation, improvement of the surface water diversions and, if necessary, treatment of the drainage from under the cover while groundwater recovers. The soil cover is to be 0.5m thick and vegetated to stabilize and protect the material from the elements. The Ministry of Energy, Mines and Petroleum Resources will lead the remediation.

This paper describes the final design and implementation of the remediation plan.

**HISTORY**

Beginning in 1987, federal and provincial agencies funded studies, monitoring and on-site works to address the ARD problem at the Mount Washington Mine. Between 1988 and 1992, the Ministry of Energy, Mines and Petroleum Resources (MEMPR) contributed $1.5 million for 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, 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 there had been 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 onsite works.

To address continuing toxicity issues, the Tsolum River Partnership was formed and 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. The focus shifted back to remediation of the major copper sources at the mine site and in 2005, the Tsolum River Partnership was expanded to include:

- The Mining Association of British Columbia
- The B.C. Ministry of Energy, Mines and Petroleum Resources
- NVI Mines and
- Natural Resources Canada.

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

**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 by DFO. 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.

**Geochemical Assessment**

The primary objective 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 assessment included the collection of field and
water quality data from three weirs during the freshet starting in April and ending in July, by representatives of the Tsolum River Restoration Society and the B.C. Ministry of Environment (BCMoE).

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 north-westerly direction towards Piggott Creek (Figure 1). 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 1).

In addition to the above, a detailed water quality sampling program was completed on July 9, 2007 by representatives from SRK, the Tsolum River Restoration Society and Environment Canada. SRK inspected the site and identified 23 potential surface water sampling locations and four groundwater monitoring locations.

The following was concluded from this work:

- 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;

- A 90 percent reduction in load will require roughly a 95 percent reduction in flow.
FINIAL DESIGN

The planned remediation work was designed in three phases:

- The first phase was to include all the major earthworks involving installation of underdrains, placement of the till buttresses against the pit high walls, installation of the bituminous geomembrane, placement of the soil cover over the geomembrane, construction of surface drainage channels in the soil cover and the work associated with an uphill diversion of run-off.

- The second phase would involve placement of growth medium, 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 subject to results of the post cover monitoring program. If water treatment is required, Phase 3 would involve a 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.
The overall project remediation measures are shown in Figure 2.

**Figure 2**

**FROM THE PLAN TO THE CONTRACT**

The plan was received by the Tsolum River Partnership in December, 2007, and in January, 2008 the Partnership began its lobbying and fundraising efforts. The Partnership was successful in securing funding of the project from the provincial government without the need to canvas the local community and corporations within the membership of the Partnership.

Once the provincial government announced the funding for the implementation of the remediation plan in April, 2008, a Request for Proposals was developed by the Ministry of Energy, Mines and Petroleum Resources, in consultation with the Tsolum River Partnership. The selection process took place over the summer of 2008 and the contract for remediation construction was awarded to a consortium of Quantum Environmental Group (Quantum), SRK and Stantec (previously CE Jones and Associates) in September, 2008 and construction work started in summer of 2009.
REMEDIATION CONSTRUCTION

The following sections outline the work completed in 2009 and ongoing work in 2010.

Upgrade Site Access

The access road to the mine site was upgraded to meet BC Mine regulations for use of haul trucks and other vehicles. SRK and Quantum determined the work required to meet the minimum road width and remediate fall hazard. The B.C. Mines Act states that a single lane haul road should have a minimum width of twice the occupying vehicle, which in this case is 6 m. The Act also states that safety berms should be in place if the road is elevated or has fall hazard more than 3 m adjacent to the road and should be minimum ¾ of the wheel height from the said vehicle.

Due to terrain limitation, sections of the road had fall hazard more than 3m and did not have adequate space for an appropriate safety berm. A variance from the MEMPR was requested which involved the installation of “No Post” barriers, similar to the highway dividers, in lieu of the berm. These barriers were backed by 140 mm dia. metal posts drilled into bedrock/competent ground and cemented in place. A 38 mm steel cable linked all the barriers with the posts to join all components as one unit. This level of safety is similar to the approved variance implemented on the haul road up to Jane Basin at the Britannia Mine, Squamish, BC.

Borrow Pit Development

Development of the borrow area was estimated to be about 3 ha to provide required construction quantity. The development included clearing the trees and grubbing the remaining scrub and low profile vegetation. Diversion ditches and culverts were constructed to control runoff.

The upper layer of organic soil was stripped and stockpiled at the borrow area and at the mine site for use as the topsoil layer for re-vegetation. The development of the borrow area was staged to minimize double handling when accessing the deeper unweathered till material for buttresses and bedding material.

Uphill Diversion

The existing diversion above the pit was founded in bedrock and was originally constructed to divert runoff from the catchment above the pit into the Piggott Creek catchment. However, the diversion had deteriorated over time and water was ponding in multiple sections.

In Phase I of the project, the old diversion was widened and graded at various sections as necessary to ensure natural drainage. The sideslopes were flatten to 2H:1V where overburden was exposed and at 0.5H:1V in bedrock. Riprap was placed over the overburden sections to minimize erosion. A new diversion ditch was constructed around the eastern perimeter of the pit to direct surface runoff to the dry pond. The new diversion was excavated in bedrock and overburden and armoured as required.
Underdrains Installation

A series of underdrains were installed around the mine site to collect and route seepage from the highwall and groundwater. There are two different types of underdrains utilized for the project: geosynthetics drains and rock drains.

Geosynthetic drains consisted of a combination of Geocomposite, Geonet and Geotextile material. The Geocomposite is a GSE 200 mil FabriNet with NW8 geotextile component. Geonet is a GSE 200 mil HyperNet and the geotextile is a GSE NW16. The three layers of geonet were deployed as base layer and geocomposite were deployed on top. The layers were then sandwiched between two layers of geotextile is to act as a filter layer. All geosynthetic drain tied into the rock drains leading to the central seepage collection manhole located below the pit.

Drain rock (19 mm minus) was used in underdrains over the existing shotcrete lined seepage collection channels. Geotextile filter fabric was deployed around the drain rock to reduce clogging from migration of the finer fraction in the overlying till material. The maximum flow through the drains is estimated to be no more than 10 L/s.

The underdrain flow is collected in two sumps located at the edge of the cover. A 150 mm dia. HDPE pipeline conveys the seepage to the central manhole prior to discharge into the Dry Pond. The sumps were lined and tied into the liner cover. The pipes were sealed into the liner with bitumen. The two pipes feed into the manhole allowing for flow monitoring and water quality sampling.

Pit Wall Buttress and Subgrade Preparation

To facilitate the placement of the bituminous geomembrane liner and soil cover over the steep pit wall areas, buttresses constructed from compacted till from the borrow area was placed against the pit wall areas at a slope of about 4H to 1V (Horizontal to Vertical).

In the original remediation plan, only the two major washed areas of the pit floor with exposed bedrock required backfilling with till to provide a suitable bedding surface for the bituminous geomembrane liner. However during the installation of the liner, an unexpected design change dictated by the liner manufacturer required the placement of additional bedding material in more areas than previously expected prior to the liner deployments.

West Dump was re-graded to minimum 4H:1V slope and covered with a minimum of 0.3 m of till material for preparation of liner deployment. This till bedding layer was required as the exposed angular waste rock did not provide an acceptable subgrade for the liner.

Vibrating Wire Piezometer Installations

Ten vibrating wire piezometers were installed during construction at the bottom of selected underdrains in buttress that are higher than 3m and along the drain rock underdrains. The purpose of the piezometers was to monitor the pore water pressure inside the buttress post construction prior to the fill achieving
long-term equilibrium and to monitor the performance of the drains. These piezometers will provide information on any unexpected pressure build up and local underdrain performance. If the underdrains are working as intended, then there should be no pressure build up inside the buttress and the piezometers will register normalized pressures. If the data indicates a build up of excess pore pressure over long periods of time, remedial measures such as wick or horizontal drains can be installed before slope stability is compromised. Surges of high pore water pressure are predicted during freshet and high precipitation seasons.

The installation of the vibrating wire piezometers were done by wrapping the instrument with geotextile for protection and placing them directly on the original ground. Calibration was done for initial readings. The cables were routed through the liner and sealed according to manufacturer’s recommendations. The cables will be protected during the soil cover construction and will be encased in a steel post on the soil liner cover when construction is completed.

**Bituminous Geomembrane (BGM) Liner Deployment**

The BGM liner is a 4mm thick Coletanche NP4 membrane or equivalent and as placed from 5 m wide rolls with a hydraulic beam. Each section of the liner was manually welded with a gas burner. The liner was anchored around the edges and along the top of the steeper slope area.

The BGM liner was delivered and stored on site according to manufacturer’s recommendations. Anchor trenches were dug along the proposed limit to secure the liner. The anchor trench excavation advances slightly ahead of the liner deployment to prevent water seep into the ground and ponding in the trench. The panel laid out paralleled to the length of the slopes with transverse seam restricted within 5 m of toes of the slopes. The deployment was done on the slopes first, prior to the flats, to prevent water seeping underneath the liner and saturating the subgrade during rain events. If and when the subgrade degraded due to rain or other means, the deployment was suspended until the subgrade was dried or repaired.

Vacuum testing and manual peel testing were performed on the seams on periodically basis. The frequency of the tests started at every 5 m systemically reduced to 25 m based on continuous success rates.

**Soil Cover on Liner**

The soil cover is a combined 0.5 m thick layer of compacted till and loose organic soil over the BGM liner to both protect the liner and to provide suitable growth medium for revegetation. In the steeper areas where the geomembrane has been placed over the pit wall buttress, the cover will be placed to a slope of 3.8H:1V to ensure long term stable conditions.

The soil cover construction was not completed in 2009 but is expected to be completed by the end of 2010 summer. Compact till will form the bottom 0.35 m and organic soil will form the top 0.15 m of the cover. Sorting was done at the borrow area to ensure oversize boulders (>0.5 m) was rejected from the till portion to prevent damage to the liner. The till material will be compacted by vehicular traffic on the flat areas and vibratory compaction on the buttresses areas to 95% standard Proctor to increase slope
stability. Organic soil will be spread and scarified to promote vegetation growth. The final liner cover configuration will be sloped to provide free drain to the surface drain channels.

**Surface Drainage Channels**

Runoff from the cover will be collected in riprap lined channels constructed on the surface of the cover. With the design change to the soil cover thickness from the original concept, the surface drainage channels designs are currently under review. The general design features of the channels will include a trapezoidal configuration with 1.5H to 1V side slopes, and be built within the soil cover over the liner. A geotextile filter fabric will be deployed beneath the channel to protect the bituminous geomembrane liner. A 0.3 m thick layer of riprap will line the channels as erosion protection.

The surface drainage channels will be constructed concurrent to the soil cover.

**Borrow Area Reclamation**

The borrow area will be reclaimed once materials are no longer required for the project. The upper layer of organic soil, windrowed and stockpiled at the borrow area, will be spread back over the borrow area for revegetation. The borrow area will be replanted with commercial conifer tree species appropriate for the site and seeded with a light cover of grasses/legumes for erosion control and invasive plant species control.

The borrow area is currently contributing to TimberWest’s productive forest land base and every effort will be made to ensure production of a second crop of commercially viable trees.

**Site Revegetation**

The reclamation of the mine site will include the entire area of the covered pit and the currently till capped East Dump and the flat areas of the West Dump. A layer of 0.15 m of organic topsoil/material will be spread over the till cover to provide a growth medium for site revegetation

The revegetation process will involve seeding with a grass/legume seed mix to establish a fast growing ground cover that will provide erosion control. Alder seed will be incorporated into the seed mix in order to establish a long term vegetation cover for the sites. The sites will be fertilized at the time of seeding.

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.
WATER TREATMENT

The current plan includes a provision for short-term treatment of the underdrain flow from beneath the cover, if required.

A water quality monitoring program would be initiated following the construction of the cover in Year 1 (2009). This program would include the minesite, Pyrrhotite Creek and the Tsolum River. In the spring of Year 2 and Year 3 (2010 and 2011), water quality samples would be collected from the underdrain discharge and from the seeps at the toe of the East Dump. Monthly sampling and analysis would continue through the summer and fall of 2010. The data will be reviewed and discussed with the Tsolum River partnership to determine the need for pipeline construction and lime treatment.

LONG TERM MONITORING

Groundwater monitoring would be initiated following completion of the cover and will include recording of water levels and collection of samples for water quality analysis. During the first five years after cover installation, groundwater samples and water level measurements will be collected twice yearly, once in the winter and once in the summer. After five years, sampling will be reduced to once yearly, during the summer. Sampling analyses will include the same parameters as have been historically collected.

In addition to the groundwater monitoring, water quality will be monitored of the flow in the underdrains, in the surface drainages, in Pyrrhotite Creek and the Tsolum River.

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