MOUNT WASHINGTON MINE REMEDIATION PROJECT

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ABSTRACT

After a very short history of mining (1964 to 1966), the Mount Washington copper mine has been the major source of acid rock drainage entering the Tsolum River near Courtenay, B.C. since that time. 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 present project is to develop a final closure plan for the mine site. SRK was retained by the Tsolum River Partnership, a coalition of community, industry and government, to develop the closure plan. The preferred option is to place a bituminous liner over the North Pit, improve the diversion works and to treat the drainage from under the cover while groundwater recovers.

Phase II of the project, the detailed design of the cover system, drainage and treatment, is ongoing. Detailed engineering plans should be delivered to the Tsolum River Partnership before December 2007.

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 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 describes the history of remediation efforts at the Mount Washington Mine and progress toward implementing a closure plan which will finally achieve the goals of the partnership.

BACKGROUND

Geology

The Mount Washington Copper deposit is classified as a porphyry deposit subsequently superimposed by epithermal mineralization. The major rock types in the area are quartz diorite, and siltstones and argillites of the Nanaimo Group. The mineralization occurs as stockwork of chalcopyrite-pyrite-quartz veins along the contact between the intrusive and sediments.

Mining History

The mine operated from 1964 until the fall of 1966. Ore was milled until 1967, after which time Mt. Washington Copper and Cumberland Mining Company went into receivership and the site was abandoned. Today, Better Resources owns the precious metal rights, TimberWest has surface rights, and Esquimalt and Nanaimo Railway held the subsurface rights until 2005 when they reverted back to the Crown.

The mine has two main pits—the North and the South Pits—and three waste rock dumps: the East and West Dumps adjacent to the North Pit, and the South Dump adjacent to the South Pit. The layout of the mine is presented in Figure 1.

Hydrology and Water Quality

The North Pit is the main source of ARD which typically has pH’s 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 flow northwestward toward Piggott Creek (Figure 2). The South Pit on 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).

The hydrology of Pyrrhotite Creek and the Tsolum River present a significant challenge to remediation of the site due to the difference in timing of peak flows and copper loadings in the creek and river.

Pyrrhotite Creek experiences two peak flows. The first peak occurs in May in response to melting snow on Mount Washington. This event causes copper concentrations to increase in the drainage due to flushing of oxidation products. As a result, copper loads increase. Flows and copper concentrations are lower in the summer months. In the fall, a second flow and copper loading peak occurs in response to rainfall prior to accumulation of snow at the mine site elevation.

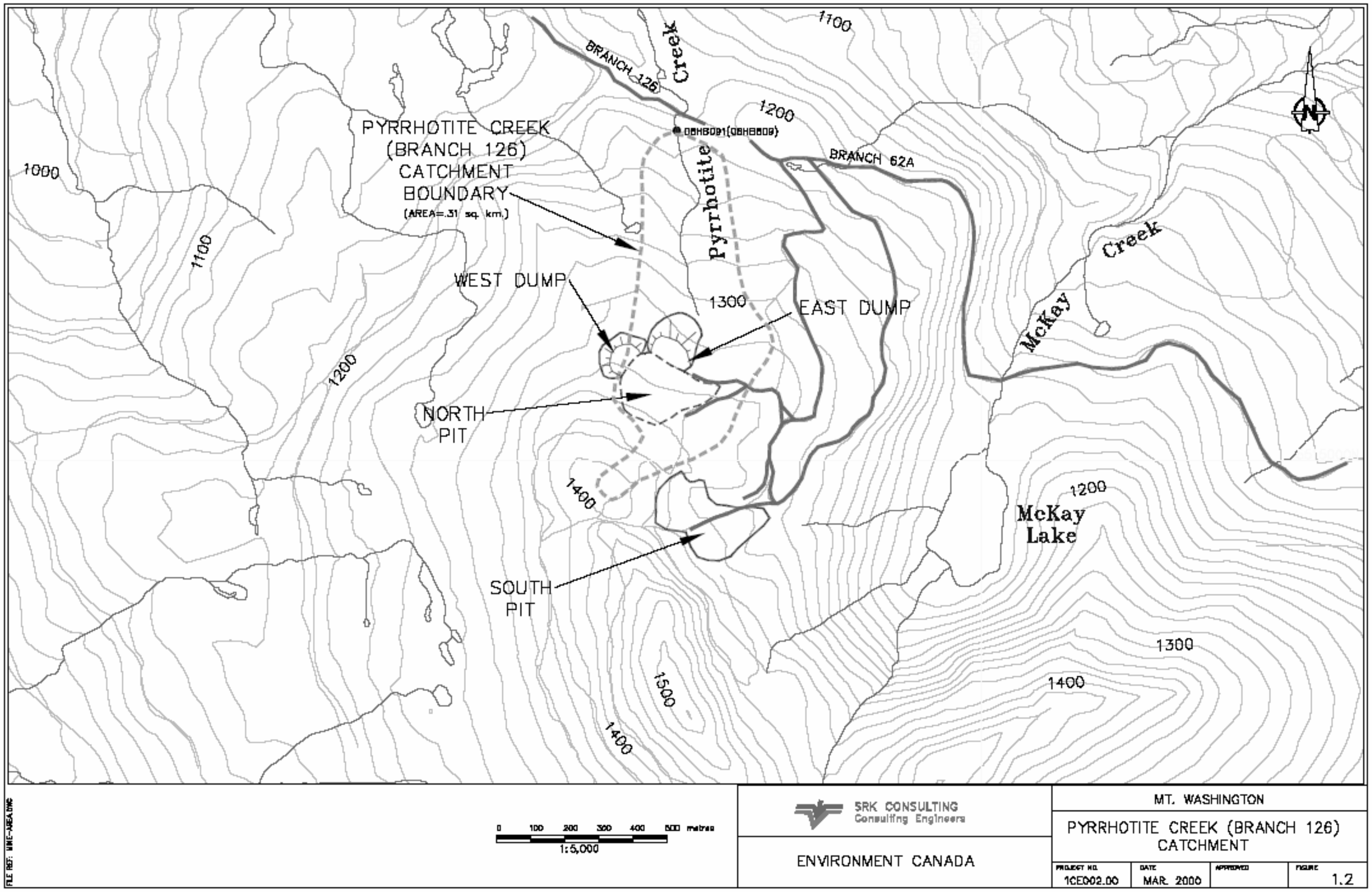

Figure 1: General Features of the Mount Washington Mine Site (from SRK 2000)

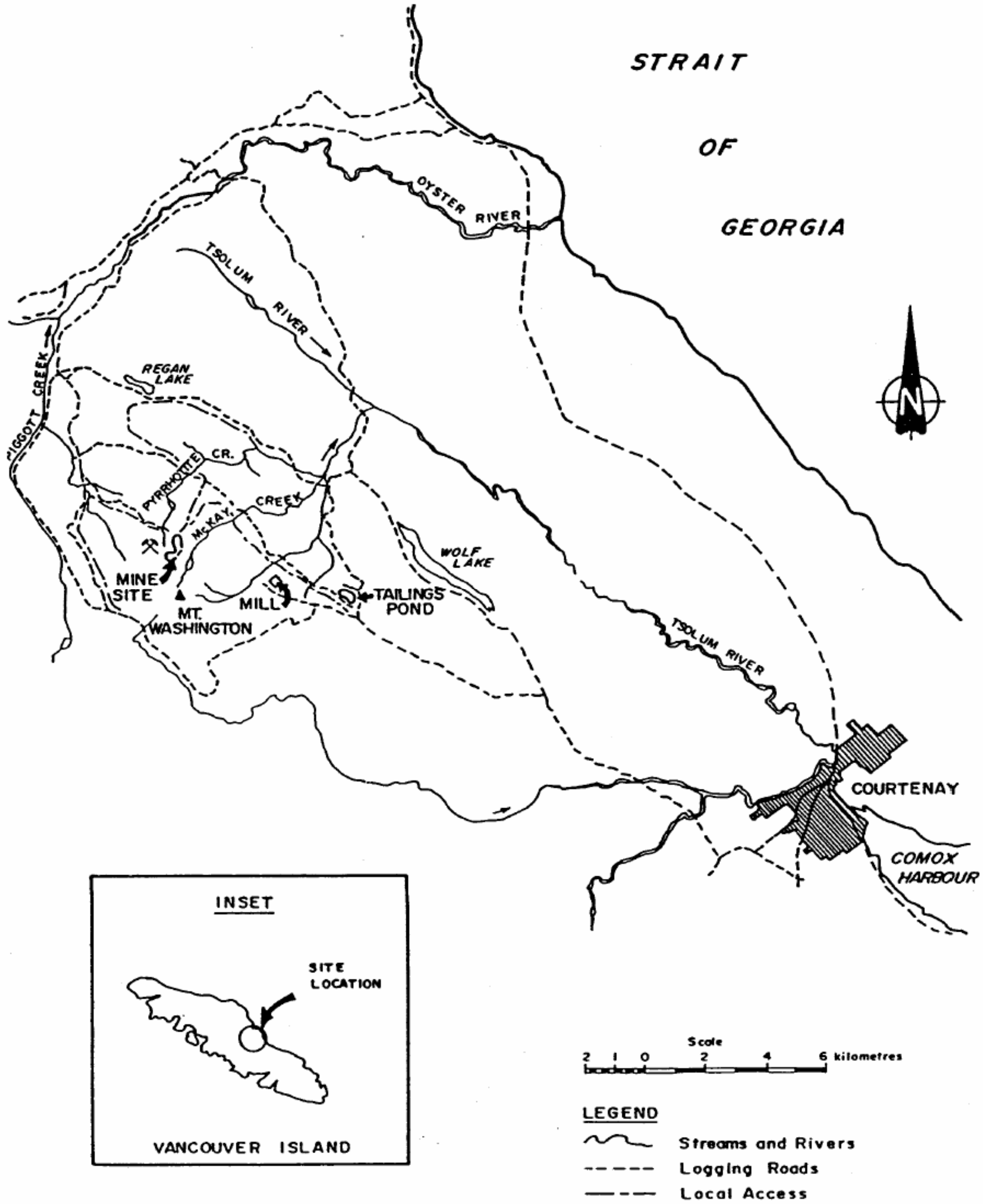

Figure 2: Drainage System Downstream of Mount Washington Mine

In contrast, the Tsolum River receives most of its flow from low-elevation streams fed mainly by fall and winter rainfall. Flows increase slightly in the spring due to melting of snow on Mount Washington, but flows are not sufficient to dilute copper load from the mine site. Copper concentrations currently peak at over 20 µg/L in the Tsolum during the spring (70 to 90 µg/L historically). A second concentration peak at the same levels occurs in the fall. Peak discharges in the Tsolum are observed in the winter due to rainfall events.

In summary, peak flows in Pyrrhotite Creek occur in the spring when Tsolum River flows are decreasing and relatively low, which thereby maximizes impact on the river water quality at the times when salmonids are most sensitive. Remediation efforts at the site must achieve a high level of effectiveness because dilution cannot be used to a significant degree.

Tsolum River Fishery

The Tsolum River historically had large salmon runs. In the late 1940s, 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 have affected the river and its aquatic life, including development and logging along the banks of the Tsolum, which increased sedimentation in the river and its tributaries; the removal of gravel from the streambed for an airstrip at CFB Comox, which destroyed fish habitat; and water removal for irrigation for agriculture, which affected water flows and temperatures.

REMEDIATION OBJECTIVES

In 1993, the British Columbia Ministry of Environment set water quality objectives for the Tsolum River to establish the needed reduction in copper loadings (Deniseger and Pommen, 1995). The objectives set two limits on dissolved copper concentrations in the Tsolum River below Murex Creek: i) the 30-day average concentration should not exceed 0.007 mg/L; and ii) the maximum concentration should not exceed 0.011 mg/L.

The water quality objectives report further showed that in order to achieve the water quality objectives in the Tsolum River at peak loading periods, it would be necessary to reduce overall loadings from the mine area by at least 95%. This translates to an upstream target of a 30-day average copper concentration at Branch 126 of 0.257 mg/L, and a maximum of 0.5 mg/L.

HISTORICAL REMEDIATION EFFORTS

Community Awareness

Although the community was aware of the decline of fish in the river, it was not until 1982, when, 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, that the seriousness of the problem was discovered. Subsequent water monitoring in 1983 revealed high copper levels originating from the mine.

Several community members were concerned about watershed issues in the Comox Valley, particularly the loss of the fishery in the Tsolum River. From the time of the discovery of high copper levels in 1983, the local branch of the Steelhead Society of British Columbia (Comox Valley Chapter) began a campaign of letter writing, media outreach, and working with federal and provincial ministries to bring community attention to the mine problem and helped to bring about partial remediation for the mine site.

Remediation in the 1980s

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 cover was placed over waste rock, which had been consolidated in the East Dump and lower North Pit. The purpose of this till cover was to prevent the ingress of oxygen and infiltration of water to the waste rock. Other MEMPR projects included application and testing of an experimental asphalt emulsion/geotextile cover; and calcium hydroxide was applied 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 no reduction in copper levels, and the reclamation efforts were considered to be a failure at that time. However, since 1998, water quality monitoring has shown sustained reductions of approximately 50% in the copper loading from the mine, which is thought to be a result of the on-site works.

Formation of the Tsolum River Task Force

In 1995, a focus group called the “Tsolum Team” was formed in response to ongoing concerns raised about the health of the Tsolum River. The Tsolum Team held a “Healing the Tsolum” workshop at the Comox longhouse in April 1997, which was attended by over 200 local residents. The next day, the Tsolum River Task Force (TRTF) was formed with the mission of “restoring the Tsolum River watershed to historic levels of health and productivity.” The Tsolum River Task Force was one of the first efforts to bring all levels of government (including First Nations), the industry and the local conservation community together to address the mining legacy.

The Task Force’s main funding source was DFO’s Habitat Restoration and Salmon Enhancement Program and B.C.’s Urban Salmon Habitat Enhancement Program, and most of the funding was directed towards their goals, rather than mine reclamation. A comprehensive report on work completed by the Tsolum River Task Force was published in 1999 (Campbell, 1999). However, the issue of minesite reclamation remained unresolved.

The Tsolum River Restoration Society (TRRS) was formed (in the fall of 1998) to administer the TRTF funding and, when that ran out, to continue the work of restoring the river. TRRS has worked with the B.C. Ministry of Environment and Environment Canada on water quality monitoring of the Tsolum since that time, although funding for the monitoring program was ongoing concern.

Formation of the Tsolum River Partnership

In June 2001, after the Task Force disbanded, Environment Canada issued a direction under section 38(6) of the *Fisheries Act* to the owners of record of the surface and mineral rights. Esquimalt and Nanaimo Railway had owned the land since the original land grant of 1884. In 1992, the railway severed and sold the surface rights to a forest products company, so both parties were named. The parties were directed to prevent the deposit of deleterious substances into fish habitat at the confluence of Pyrrhotite Creek and Murex Creek, upstream of the Tsolum River.

One indirect result of this direction was the formation of the first Tsolum River Partnership. The Partnership included:

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

Spectacle Lake Wetland

In 2003, this Partnership developed the Spectacle Lake Wetland Project to achieve non-toxic water quality 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 approx 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.

Mine Site Reclamation

With the improved water quality in the Tsolum River, it was expected that the health of the fishery would improve and 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.

Other Objectives

As part of the reclamation strategy, the Partnership has set a related goal which will be to produce suitable habitat for the Vancouver Island marmot, Canada's most endangered mammal. The Partnership will work closely with the Marmot Recovery Foundation to make sure reclamation prescription meets the animals' habitat needs.

PLANNING FINAL REMEDIATION

Overall Process

In 2006, the Partnership initiated a process with SRK Consulting to develop a final closure plan for the site, which will result in achieving the water quality objectives in Pyrrhotite Creek and the Tsolum River. The steps in this process are as follows:

- A series of site meetings and workshops involving all stakeholders to identify all possible remediation technologies, reduction of the list of technologies to remedial options for the site, and combination of the options into the preferred remediation plan.
- Initial evaluation and costing of the short list of alternatives.
- Selection and evaluation of the feasibility of the preferred alternative.
- Development of detailed designs.
- Construction.
- Monitoring.

A workshop held in November 2006 concluded with development of a preferred method. However, in order to evaluate these methods, it was agreed that additional information would need to be obtained and further analysis would need to be carried out in order to demonstrate the practicality and effectiveness of the methods selected. The main options under consideration are:

- Flow equalization.
- Placement of engineered covers to the mine area.
- Clean water diversions
- Water treatment.

These options are described below.

Flow Equalization

One of the key options that the workshop group felt was worth pursuing was the concept of a flow equalization reservoir located at Pyrrhotite Lake. This lake is already affected by ARD from the mine site and would therefore be suitable for storage of contaminated water. As described above, 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.

To evaluate this option, a mass loading model was developed to calculate the required storage volume and the timing of release to the Tsolum River. Initial calculations demonstrated 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.

Further calculations showed that the water quality objectives could be met if the copper load from the mine were reduced by 60% and the storage capacity of Pyrrhotite Lake was increased to 500,000 m^3 with an embankment averaging 9 m high. Several variants were considered, including construction of surface water diversions around Pyrrhotite Lake and piping of contaminated seepage from the pit to the flow equalization reservoir at Pyrrhotite Lake.

The cost of various options evaluated ranged from $960,000 to $3.4 million. For various technical reasons and the high cost resulting from combination of this method with source control measures, the flow equalization concept is not being pursued.

Cover Options

A number of alternative cover options were considered to reduce contact of water with the oxidized pit floor and waste rock. This is expected to result in a proportionate reduction in acidity and copper load. The estimated area of the North Pit that would be covered is 38,000 m^2. The following sections present an overview of each of the cover options considered. Table 1 considers benefits and disadvantages for each option.

Low Permeability Soil Cover

A low permeability soil cover would consist of 1 m thick compacted till similar to the cover placed over the East Dump in 1988. This cover appears to have been successful in reducing loads from this source. The main limitation of this option is the lack of suitable material.

The approximate total capital cost for the soil/till cover is $2 million.

Bituminous Liner

The next cover option considered for the North Pit was a geosynthetic bituminous liner similar to the asphalt impregnated geotextile installed in 1992. As shown in Table 1, this type of liner is easily installed, highly durable and is less expensive than a soil cover. The total capital cost for this option was estimated to be about $1.44 million.

Concrete Cap

A concrete cap at least 50 mm thick would require extensive engineering work for both design and quality control during construction. The subgrade will need to be compacted to minimize settlement. The total capital cost for this option was estimated to be about $2 million.

Geosynthetic Clay Liner

An alternative to the bituminous liner cover is a Geosynthetic Clay Liner (GCL) cover. The installation of a GCL is similar to the bituminous liner but would require more quality control and engineering. The total capital cost for this option was estimated to be about $1.9 million.

Table 1: Cover Options Benefits vs. Disadvantages

Option	Pros	Cons
Till Cover	• Long Term Durability • Ease of construction, require no special technicians or equipment for installation • Minimum subgrade requirements	• Relatively High permeability with soil available on site • Long haul distance hence increase cost • Volume of suitable material maybe difficult to find
Bituminous Liner	• Long Term Durability • Ease of installation • Very low permeability • Cheaper unit cost relative to till	• Requires subgrade preparation • Relatively higher material cost than GCL • susceptible to long term traffic if left expose
Geosynthetic Clay Liner	• Ease of installation • Low permeability • Cheapest material unit cost	• Requires confining stress to perform • Susceptible to weather if exposed • Requires relatively more subgrade preparation compared to Bituminous Liner • Might require an extra layer of geogrid for poor subgrade condition • Strict construction weather conditions
Concrete Liner	• Very low permeability • Long Term Durability	• Expensive material unit cost • Require extensive subgrade preparation and installation process • Susceptible to long term cracking and settlement • Strict construction weather conditions

Surface Water Diversion

Existing surface diversions up gradient of the pit would be improved to channel clean water away from the acidic rock in the pit. The estimated cost of these improvements was $250,000.

Water Treatment

Although it is believed that source control measures (diversions and covers) will eventually reduce the copper loading from the mine area by 90% and hence meet the water quality objective in the Tsolum River, water treatment will likely be required in an interim period until the cover achieves its optimum effectiveness. This can be expected to occur as shown by the delay before water quality improvements were observed following placement of the cover on the North Dump in the late 1980s.

Operation of a water treatment plant near the site is expected to be challenging due to the remoteness, high snow pack, lack of nearby power and limited storage space for sludges. In concept, a small portable lime system would be operated where Branch 126 logging road crosses Pyrrhotite Creek. A small wetland is located downstream of the bridge and could be used to settle the resulting sludges. It is estimated that based on a lime consumption of 25 tonnes a year, and assuming 3 percent solids by weight, the system would generate about 2,000 m^3 of sludge every year.

The capital cost of the plant is estimated to be between $75,000 and $200,000. Annual lime costs were estimated to be $15,000 per year.

<u>Preferred Remediation Plan</u>

A preferred plan was selected during discussions at a meeting held on January 23, 2007. It will include:

- A cover over the entire pit area to reduce the loading by at least 90 percent of the current load from the site. Several options for the cover are being carried forward for detailed costing purposes. These include till only, a bituminous liner plus till or an asphalt impregnated geotextile plus till.

- Surface diversions would also be considered as part of the overall method.

- Short-term treatment of the mine site water will be necessary .

- A monitoring and maintenance program would be developed to monitor the improvement of the water quality both in Pyrrhotite Creek and the Tsolum River.

Additional work that will be needed prior to implementing the construction program would include monitoring of this year’s (2007) freshet, treatability tests, identification of till and gravel borrow areas, assessing the requirements for vegetation and marmot habitat, the completion of detailed engineering and a review of the final construction cost estimates.

The total estimated cost of the preferred option is $2,650,000.

CONCLUDING REMARKS

After over 40 years since the brief history of mining at Mount Washington, the Tsolum River Partnership has initiated a process to achieve the water quality objectives and restore the salmon fishery in the Tsolum River by remediating the mine site. The partners are confident necessary funding needed to implement the preferred alternative will be secured. The current schedule envisages construction activities in the summer of 2008.

ACKNOWLEDGEMENTS

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The authors of this report wish to acknowledge Father Charles Brandt, who instigated the original letter writing campaign by the Steelhead Society in 1984, for his notes on the history of the mine and the community effort in its remediation.

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