Mount Washington Mine Remediation Project

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INTRODUCTION

The Mount Washington Mine, on Vancouver Island near the community of Courtenay, BC, 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 $xx per year. In 2003, a unique partnership committee was formed between industry, government and the public 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 Canadian Pacific 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.

Mount Washington Partnership Progress Report

HISTORY

The Mount Washington Mine, on Vancouver Island near the community of Courtenay, BC, was a small, open-pit copper mine that began operations in 1964. Mt. Washington Copper and Cumberland Mining Company, in a joint venture, leased the base-metal rights from the Esquimalt and Nanaimo (E&N) Railway and the precious metal rights from the province. The pit is located approximately 18 kilometers northwest of Courtenay at an elevation of 1350 metres.

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

Large piles of ore and waste rock were left on the mine site, and mill tailings were left at the mill site 4 km southeast of the mine site. The pyrite-bearing ore and sulphidic waste rock, left exposed to air and water, began generating acid mine drainage (AMD) and leached dissolved copper into Pyrrhotite, McKay, and Murex Creeks, all tributaries to the Tsolum River. The dissolved copper was then carried downstream, to the fish spawning and rearing grounds of the lower Tsolum River. The problem of AMD was exacerbated in 1979 when Esso Resources Limited added sulphuric acid and iron-oxidizing bacteria to the waste rock dump to try to extract metals. The high levels of copper, however, were not discovered until water sampling was done in 1983.

The Tsolum River historically had large salmon runs. In the 1950s runs of 100 000 pink salmon, 15000 coho, 11000 chum and 3500 stealhead were reported. Since that time several factors have affected the river and its aquatic life: development and logging along the banks of the Tsolum increased sedimentation in the river and its tributaries; the removal of gravel from the streambed for an airstrip at CFB Comox destroyed fish habitat; and water removal for irrigation for agriculture affected water flows and temperatures.

Although the community was aware of the decline of fish in the river, it wasn't until 1982, when a pilot 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. The source of the contamination was the Mount Washington mine, which had been abandoned almost 20 years earlier. The issue became public at a meeting in Campbell River in, 1984 with a subsequent newspaper article by Francis Bula declaring the "Tsolum River Dead".

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 in1983, through to 1997, the local branch of the Steelhead Society of BC (Comox Valley Chapter) began to look at the reclamation of the mine site and the enhancement of the Tsolum River as a major project. A campaign of letter writing, media outreach, and working with federal and provincial ministries brought community attention to the mine problem and helped to bring about partial remediation for the mine site.

Assessments by the Ministry of Environment, Lands and Parks in 1985 and 1987 estimated that for the Tsolum River to meet the water quality objectives stated above during the spring freshet, the reclamation should reduce copper loading from the mine site by 95%.

Hydrology and Water Quality

The North Pit is the main source of ARD which typically has pHs 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.

In contrast, the Tsolum River receives most of its flow from low elevation streams fed mainly by 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 therefore peak at over 20 µg/L in the Tsolum during the spring. 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 when Tsolum River flows are 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, 15000 coho, 11000 chum and 3500 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 increased sedimentation in the river and its tributaries; the removal of gravel from the streambed for an airstrip at CFB Comox destroyed fish habitat; and water removal for irrigation for agriculture affected water flows and temperatures.

REMEDIATION OBJECTIVES

In response to the observed near extinction of salmonid stocks in the Tsolum River in 1993, the British Columbia Ministry of Environment, Lands and Parks (now the Ministry of Environment) set water quality objectives for the Tsolum River to establish the needed reduction in copper loadings (Densiger 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.

A mass loading study completed in 2000 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 in1983, through to 1997, the local branch of the Steelhead Society of BC (Comox Valley Chapter) began to look at the reclamation of the mine site and the enhancement of the Tsolum River as a major project. A campaign of letter writing, media outreach, and working with federal and provincial ministries brought 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 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 which 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 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, by 1998 and subsequently water quality monitoring has shown sustained reductions of approximately 50% in the copper loading probably as 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 BC's Urban Salmon Habitat Enhancement Program and most of the funding was directed towards their goals, rather than mine reclamation. TRTF produced the final report entitled *State of the Tsolum River: A Comprehensive Report on Work Completed by the Tsolum River Task Force, April 1997-March 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 MoE and Environment Canada on water quality monitoring of the Tsolum since that time though funding for the monitoring program were on-going concerns.

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

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

Spectacle Lake Wetland

2003 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. The concern is that this form of passive treatment is time limited and the wetland will become less effective at reducing copper over time.

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 followed by release 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.

Covers 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

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	• Relative 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	• Require subgrade preparation • Relatively higher material cost than GCL • susceptible to long term traffic if left expose
GCL 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 compare to Bituminous Liner • Might requires 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

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 bit 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.

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 2000 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.

Preferred Remediation Plan

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 would be by a lime addition system located at Branch 126 or Pyrrhotite Lake.

- 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 years 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

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. The partners are well on the way to securing funding needed to implement the preferred alternative. The current schedule envisages construction activities in the summer of 2008.

Acknowledgements

The Tsolum River Partnership gratefully acknowledges the support of the agencies and individuals that have contributed funding and in-kind support to the project. These include BC Ministry of Environment, BC Ministry of Energy Mines and Petroleum Resources, Fisheries and Oceans Canada, Environment Canada, the Mining Association of BC, and a Tsolum River Restoration Board Member.

References

J. Deniseger, Larry W. Pommen. 1995. Water Quality Assessment and Objectives for Tsolum River Basin, Vancouver Island: Overview. Report Prepared by BC Ministry of Environment.

SRK Consulting 2000. Hydrogeological and Hydrological Evaluations for Development of Remediation Options for Mt Washington, Courtenay, B.C. March 2000. Report Prepared for Environment Canada.

Mt. Washington Copper Mine Reclamation Milestones

May, 2006	- First $50,000 from Min. of Environment ($80,000 total)
June 9, 2006	- Closing Date for RFP based on our Terms of Reference
June 9, 2006	- SKR and two other firms submit proposals.
July, 2006	- Panel selects SRK.
Sept 14, 2006	- SRK site visit.
Sept 28, 2006	- SRK kick off meeting at Mt. Washington Ski Resort.
Nov 1, 2006	- Brainstorming secession at SRK Vancouver office.
Dec, 2006	- Phase 1 Progress Report.
March, 2007	- Phase 1 Report.
April/May, 2007	- $123,500 additional funding approved for Phase II
March 19, 2007	- First Phase II proposal from SRK.
April 17, 2007	- Phase II meeting requesting additions to Phase II Proposal
May 7, 2007	- Revised Phase II Proposal received by PSF from SRK.
July, 2007	- Peer review comments received by PSF.

July 19, Aug 23 & Sept 20, 2007- Technical Committee progress meetings.

Oct 18, 2007	- Partnership Progress Report Meeting.
Nov 30, 2007	- Final Report Due.
Jan – Mar, 2008	- Government funding decisions and industry/community fund raising.

PHASE II – DETAILED COSTING & SITE-SPECIFIC DESIGNS FOR SELECTED OPTION

Phase II will involve the development of a feasibility level remediation plan of the mine site based on the outcome of the Phase I Study. The scope of the work for Phase II would involve:

- A detailed review of the cover and treatment options developed in Phase I;
- A Feasibility level design of the elements of the preferred option or combination of options including design drawings,
- An estimate of material quantities;
- A feasibility level cost estimate of the capital, labour, monitoring and maintenance requirements for implementing the remediation plan.
- The preparation of a draft and final remediation plan report for submittal to the Partnership.
- Attendance at meetings with the Partnership to present the finding of Phase II

As discussed in the Phase I report, the preferred remediation option would include a cover over the entire pit area that would eventually reduce, by at least 90 percent over the 2001 to 2003 Cu loading from the mine site. The function of the cover would be to separate clean runoff water from the contaminated water, minimize further oxidation reduce infiltration and provide a growth medium for future revegetation of the site.

Options for the cover that would be evaluated in Phase II would include till only, a bituminous liner plus till, an asphalt impregnated geotextile plus till and the incorporation of a compacted peat layer next to the rock. Phase II would also include evaluating the possibility of re-introducing marmot habitat.

Surface diversions would also be considered as part of the overall plan. The diversions that would be considered would include improvements to the existing uphill diversion above the pit and surface runoff diversion channels on the pit cover. The design would also include an underdrain seepage collection system below the liner. The preferred approach to seepage collection would be to provide a granular drain beneath the liner that would direct seepage beneath the liner to a perforated piping system along the western perimeter of the pit. The flow in the pipe would be fed to a new sump located at the low point of the cover. An HDPE/Steel pipeline would convey this contaminated seepage to a proposed water treatment system that would be located at either Branch 126 or Pyrrhotite Lake.

Due to the high cost of constructing a conventional (High Density Sludge) HDS plant, SRK would evaluate alternative methods such as in-stream application of dry hydrated lime using portable units for remotes sites sucg as Aquafix or Earth System machines. SRK would also consider construction of berms in Branch 126 wetland area to provide a settling pond for the sludge. One idea is to construct a berm at the eastern end of the wetland to raise the water level and one at the midpoint to segment the reservoir. The treatment would continue to rely on Pyrrhotite Lake and Spectacle Lake wetland as polishing ponds. It is expected that it may take between 5 to 10 years for the new pit cover to reach optimum efficiency. Therefore SRK believes that some form of water treatment will be required at completion of the cover. However, depending on the outcome of the cover evaluation, which would provide an estimate of the residual loading from the mine with a cover in place, the existing wetlands at Pyrrhotite Lake and Spectacle lake may reduce the overall residual loading to the Tsolum to an acceptable level that would allow deferral of the implementation of the lime addition water treatment. 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 would be needed prior to implementing the construction program would include monitoring of this years 2007 freshet, treatability tests, identification of till and gravel borrow sources.

Proposed Schedule

SRK expects that the final design phase would be carried out in 2007. It is expected that preparation of a tender bid package, which is not part of the work scope of this phase would be scheduled in early 2008 with construction over the summer of 2008. A proposed Phase II schedule is provided in Figure 1.

Project Funding Sources to date

The following fully funded Phase 1

Ministry of Environment	$50,000
Fishers and Oceans Canada	$4,000
Mining Association of BC	$3,500
Tsolum River Restoration Board Member	$7,500
Total	**$65,000**

The following have contributed funds to Phase II

Ministry of Environment	$50,000
Ministry of Energy Mines and Petroleum Resources	$50,000
Fishers and Oceans Canada	$15,000
Mining Association of BC	$5,000
Residual Funds from Phase 1	$24,000
Tsolum River Restoration Board Member	$17,000
Total	**$161,000**

Appendix A
Partial List of Mt Washington Reports

1. 'Water Quality assessment and Objectives: Tsolum River', **Denisger**, John H., British Columbia Ministry of Environment, Lands and Parks, 1996.

2. 'Report to Environment Canada on the Drilling Program at the Mt Washington Mine Site', **Golder** Associates Ltd, January 1989.

3. 'Final report on 1988 Construction Activities, Mt Washington Minesite Reclamation', **Steffen, Robertson and Kirsten** (BC) Ltd, November 1989.

4. 'Mt Washington Mine reclamation Project: 1990 Post-Construction Report', **Galbraith**, D.M.; British Columbia Ministry of Energy and Mines, November 1990.

5. 'Washington Mine reclamation Project: 1991 Post-Construction Report', **Galbraith**, D.M.; British Columbia Ministry of Energy and Mines, March 1992.

6. 'Washington Mine reclamation Project: 1992 Post-Construction Report', **Galbraith**, D.M.; British Columbia Ministry of Energy and Mines, March 1993

7. 'Impact Assessment of Acid Drainage from an Abandoned Copper Mine on Mt Washington', **Erickson**, Lloyd L. and John H. **Deniseger**; British Columbia Ministry of Environment, Lands and Parks, December 1987.

8. 'Determination of Copper Reduction Needed at the Mt Washington Minesite to Meet Tsolum River Water Quality Objectives', **Hansen**, Debbie; British Columbia of Environment, Lands and Parks, August 1994.

9. 'Review of the Mt Washington Mine Reclamation Project', **SENES Consultants** December 1993.

10. 'Acid Mine Drainage Abatement Study, Mt Washington', **Steffen Robertson and Kirsten** (BC) Inc, July 1987.

11. 'A Preliminary Assessment of Acid mine Drainage from an Abandoned Copper mine on Mt Washington', **Kangasniemi**, B.J, and Lloyd J. **Erickson**; British Columbia Ministry of Environment, Lands and Parks, July 1985.

12. 'Report... on a Piezometer Installation Program, Mt Washington Mine Site', **Golder** Associates Ltd, February 1990.

13. 'Opportunities Relating to the Remediation of Acid Mine Drainage and the Restoration of the Tsolum River Watershed', **AGRA** Earth and Environmental Ltd, July 1996.

14. 'History of Pink Salmon Enhancement on the Tsolum River - Impact of Copper and Low Summer flows', **McLean**, W.E.; File Report, Department of Fisheries and Oceans, January 3, 1996.

15. 'Passive or Wetland Treatment Options for Acidic Mine Drainage at the Mt Washington mine Site', **Golder** Associates Ltd, April 1997.

16. 'Pipeline Routing and Conceptual Design Study for Diversion of Mt Washington VAcid Rock Drainage', **Golder** associates Ltd, April 1997.

17. 'Remediation of Mt Washington mine site to restore Tsolum River fishery', Letter report by Dr André **Sobolewski**, DOE File 4484-37/B490, August 1997.

18. 'Mount Washington Copper mine data review and recommendations on Mitigative Measures', Wendling, Dr Gilles and Dr Sue Baldwin; **Levelton** Engineering Ltd, July 1998.

19. 'Preliminary Assessment of Conditions at the Mt Washington Mine Site', **O'Kane**, Mike and Dr Moir Haug; M.D. **Haug** and Associates Ltd, August 1998.

20. 'State of the Tsolum River', Campbell, Kathy; **Tsolum River Task Force**, jointly funded by Fisheries and Oceans, Ministry of Environment, Environment Canada, Ministry of Energy Mines and Petroleum Resources and the Regional District of Comox-Strathcona, March 1999.

21. Letter Report by Dr Tom **Lundgren** of Miljoteknik, Link6ping, Sweden, DOE File, 4484-37/B490, August 1999.

22. Notes and letter regarding the proposal of Mr.Cliff **Rennie** to add a strong base to the exposed rock in the Mt. Washington open pit.

23. Copies of borehole logs (BH89-1 to BH89-14) for piezometers installed by **Golder** Associates.

24. Copies of borehole logs (BH88-1 to BH88-6) for temperature and gas monitoring installations installed by **Golder** Associates.

25. "Report Evaluation of BC MINE for application to Acid Mine Drainage Regulations at Mt. Washington", **CB Research** International Corporation, April 3, 1992.

26. "Interim Report on the Leachability of Mt. Washington Ores", **BC Research**, prepared for Imperial Oil Canada Ltd., Vancouver, BC, August, 1978.

27. Water Quality sampling results of the monthly sampling program at Mt Washington by Mac **Chaudhry** sent to Murray Galbraith on September 26, 1991

28. Hydrogeological Site Characterization by D **Edwards** and Rick **Lawrence**,