Metal contamination from the Britannia Mine site: lingering problems, ongoing remediation

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What's happening with metal contamination from the old Britannia Mine site?

Despite considerable and ongoing remediation efforts, metal contamination from the Britannia Mine workings of the past lingers. The flow of contaminated water directly into Howe Sound has decreased, however sampling of the aquatic environment, including freshwater, groundwater, and marine water as recently as spring 2013 reveals metal contamination well above water quality guidelines.[1] The Britannia Mine Museum (Figure 1) now occupies part of the mine site, but the mine itself has been closed for approximately 40 years. The mine covered an area of 28 to 36.5 square kilometres consisting of a series of tunnels and some open-cast mining.[2,3] Between 1898 until 1974, over 40 million tonnes of tailings were generated and deposited onto the marine subtidal slope near Britannia Beach and four to 40 million litres of metal-laden waters (acid mine drainage) were discharged into Howe Sound every day, depending on the time of year.[4,5] Metals from rock are mobilized when large quantities of rock containing sulphide minerals are exposed to air and water, in mine tunnels for example, and sulphuric acid is created. The resulting acid rock drainage can carry high levels of heavy metals and sulphate. Acid mine drainage from the Britannia site included contaminants such as copper, aluminum, iron, zinc and manganese. Remediation efforts underway since 2001 have resulted in significant improvements in the creeks draining the area and in the nearshore environment, and ongoing efforts plan to address the remaining potential sources of metals.

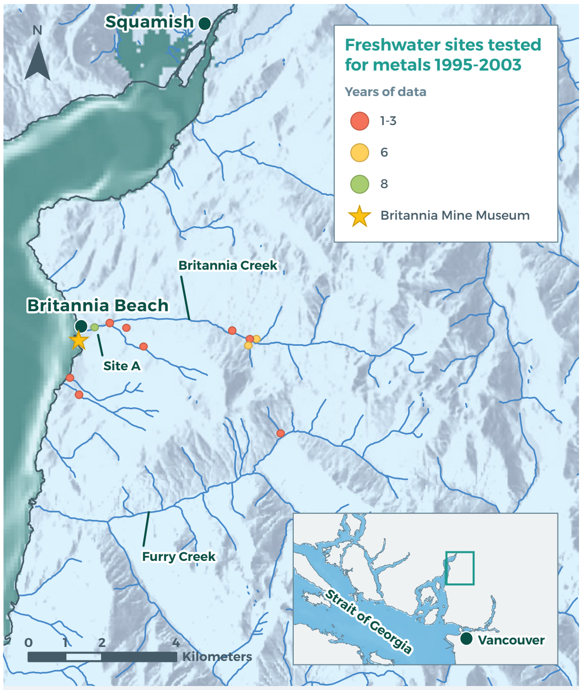

Figure 1. Britannia Beach community, Britannia Mine Museum, and freshwater sampling sites tested for metal contaminants between 1995 and 2003.

Why is it important?

Heavy metals can be toxic to many organisms, including humans. For instance, cadmium can affect humans, while copper has toxic effects on the behaviour and olfaction systems of salmonids.[6,7,8] Some metals bioaccumulate in organisms, when intake of the metal occurs at a greater rate than excretion, and these contaminated organisms are consumed by other organisms which become contaminated in turn. Water quality guidelines (WQGs) for both marine and freshwater are put in place by governments for the protection of aquatic life.[9] It is important to recognize, however, that the area geology is naturally mineral-enriched (hence the historic mining activity) which can result in naturally occurring concentrations of metals exceeding WQGs.

In the late 1990s, it became clear that contamination from the old Britannia mine was an issue that needed attention, when reports documented copper concentrations in mine drainage that were thousands of times greater than provincial water quality guidelines of the time[10,11,12] and there were clear indicators of the effects in the shoreline community. In 1999, concentrations of dissolved copper in seawater detected in near shore waters close to the mouth of Britannia Creek[13] exceeded British Columbia WQG[14] by approximately 20 times and was lethal to caged salmon and local mussels. Research on the effects of metal contamination at Britannia prior to remediation has shown impacts on salmon fry,[15] mussels, algae, and invertebrates of Howe Sound. Primary production in Howe Sound was reduced,[16] contaminated sediments in Britannia Creek were toxic to important food sources such as midge larve and amphipods, sand dollar reproduction was impaired,[17] and blue mussel growth was impaired.[18]

Historically, the site was referred to as being one of the worst sources of water pollution involving metal contamination in North America[19,20] and the worst point source of heavy metal pollution in British Columbia.[21] Remediation began in 2001.

While the construction of a water treatment plant was underway, freshwater and acid mine drainage from a point source at the mine were diverted into an outfall off Britannia Creek. This led to an immediate re-

Britannia Creek drainage (centre left) with the mine museum (white stepped building) close to the shoreline. (Photo: Gary Fiegehen) duction in acid mine drainage to Britannia Creek and nearshore areas, and allowed the beach ecosystem to start recovering.[22] Additional remediation efforts have included:

- several surface water diversions of clean water away from the mine,
- use of the mine workings as a storage reservoir to balance seasonal flows,
- a water treatment plant, operational since 2005,
- a deep-water outfall for the outflow of the treatment plant, which discharges to Howe Sound,
- a ground water management system to intercept metal-contaminated fresh ground water and direct it to the treatment plant,
- relocation of metal contaminated soils,
- surface water drainage diversions to keep metal-contaminated surface water away from intertidal areas,
- and maintenance of these operations (e.g., Figure 2).[23,24]

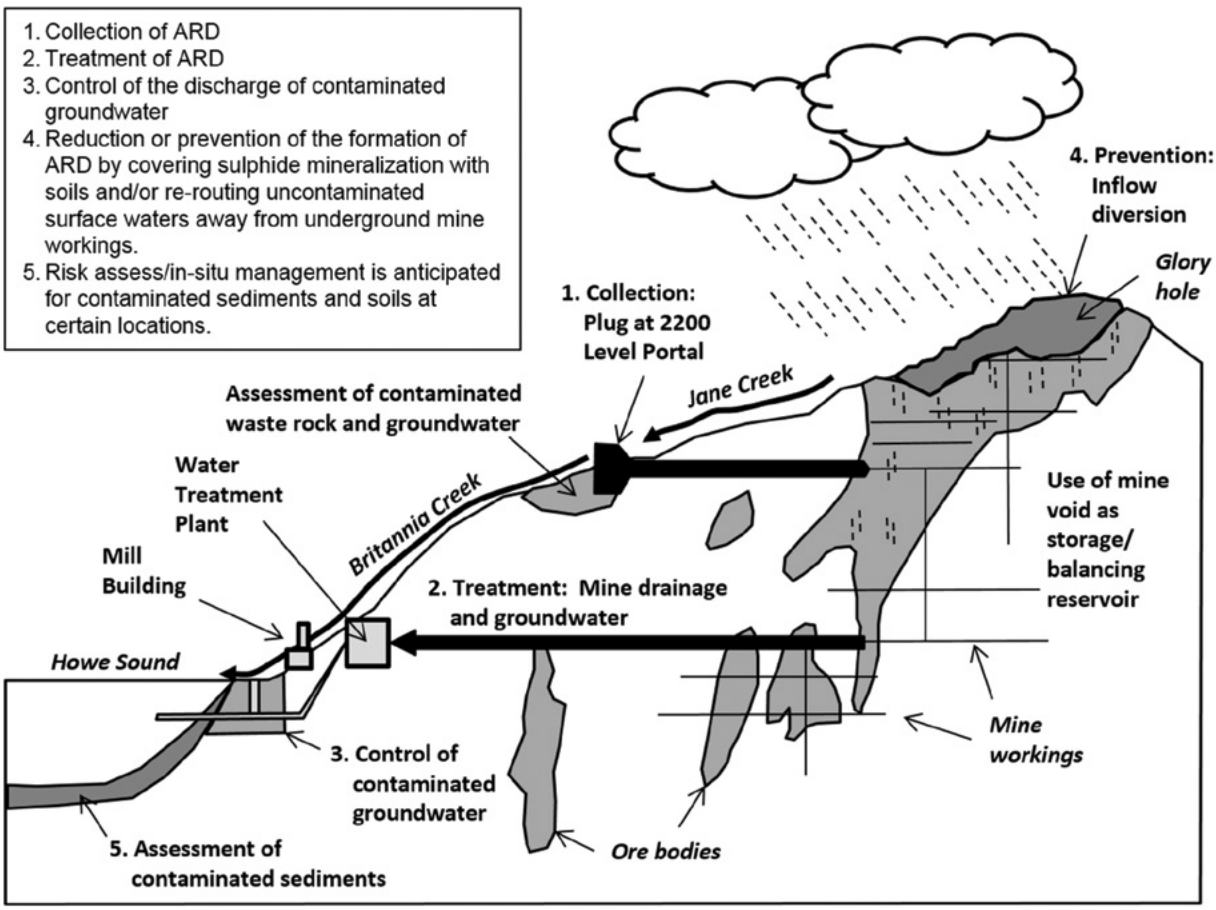

Figure 2. Some of the pollution prevention measures and remediation systems required to address and mitigate metal contamination in the coastal marine environment from Britannia Mine. ARD is Acid Rock Drainage. (drawing courtesy of Golder Associates)

What is the connection to First Nations cultural and spiritual heritage?

Contamination by acid mine drainage in Howe Sound can have and has had important implications for First Nation communities that rely on salmon and seafood from Howe Sound and the Squamish River Estuary. Salmon is not only a traditional food but holds strong spiritual and cultural significance. First Nations communities on the B.C. coast eat 15 times more seafood than the general B.C. population.[25] This fact alone puts the First Nation population at greater risk of toxic effects of contaminated seafood.

Nearshore areas all along the coast of Howe Sound are used by juvenile chum salmon, Chinook salmon, and other salmonids as they migrate from the Squamish River to the open ocean. Chum salmon fry abundance was found to be significantly lower near Britannia Creek mouth (up to 1.2 per 100 square metres) than in reference areas (between 11.5 and 31.4 per 100 square metres) in 1997 and 1998.[26] Prior to any mitigation, water quality near Britannia Creek was poor enough (e.g., dissolved copper concentrations of ~2.67 mg/L) that 100 percent of caged Chinook salmon smolts died within two days of being placed there.[27] The contamination can not only affect abundance of fish in the area, but the balance of the marine food web, upon which First Nation communities rely.

What is the current state of metal contaminants around Britannia Mine?

There is an overall closure plan in place, and remediation and risk assessment are ongoing to address residual contamination in the Britannia Fan Area.[28] Currently, most of the mine water and some of the contaminated ground water is captured, treated, and discharged to Howe Sound at a depth of 50 metres. The ecological recovery of Britannia Creek became news in 2011, when citizen scientist John Buchanan discovered pink salmon inhabiting the lower reaches of the Creek for the first time in about 80 years. Fisheries and Oceans Canada (DFO) confirmed his observation.[29] Mussels, common to Howe Sound, are now naturally colonizing the shoreline except in a few localized areas, and rockweed — a common Howe Sound seaweed which was long absent along the shoreline in the proximity of Britannia Creek — is now also present except at a few sites.[30]

However, recent monitoring, by Golder Associates and the Province of B.C., of creek water, groundwater, intertidal water and intertidal ecology show evidence of lingering metal contamination and suggest that the area will never be returned to its pre-industrial state.

In 2013, sampling efforts found that metal concentrations in some porewater (i.e., groundwater seeping from the Britannia Creek alluvial fan into the marine intertidal area) and intertidal surface and bottom water samples continued to exceed B.C. marine WQG[31] at levels comparable to years since 2004.[32] The highest copper concentration observed in porewater in March 2013 was over 4,000 times greater than the acute WQG.[33] Furthermore, copper concentrations in porewater exceeded WQGs at all locations except one reference location at the Magnesia Creek outlet,[34] about 20 kilometres to the south. At a test site in the Furry Creek intertidal area, located several kilometres south of the mine site, porewater copper concentrations increased approximately 10-fold between 2003 and 2012.[35] It is not clear why concentrations at Furry Creek were higher during parts of 2011 and 2012, as the Britannia Mine does not have an influence on intertidal porewater there. Substantial spikes in other metals in porewater were also observed in 2013 at sites in the Britannia fan area (i.e., iron concentration up 100-fold at one site and zinc concentration up approximately 10-fold at another) compared to 2005 levels.[36]

Marine intertidal water at reference locations (Magnesia and Furry Creeks) showed copper concentrations at or below WQG for the most part, which is expected, but samples from two sites in the Britannia Beach fan area showed numerous copper concentrations higher than WQG between 2003 and 2013 (Figure 3).[37]

While intertidal invertebrate community shows increasing healthy diversity at some sites in the Britannia Beach foreshore, some continue to exhibit lower diversity than comparable sites near Furry Creek and Magnesia Creek.[38] Not surprisingly, the sample site with the highest porewater metal concentrations showed the lowest intertidal species diversity.[39]

Older data (from 1995 to 2003) from the Environmental Monitoring System (EMS) at the British Columbia Ministry of Environment[40] showed variation in freshwater concentrations of most metals associated with acid mine drainage (i.e. copper, aluminum, iron and zinc) at sites around Britannia Mine. Metal concentrations at one sampling location furthest downstream on Britannia Creek (Figure 1, site A) did show a sharp decline in 2002, likely related to the diversion of a point source of acid mine drainage away from the Creek in 2001 when mitigation efforts began, but 2003 concentrations for copper and zinc were still above the Federal WQGs[41] (Figure 4).

In 2006, concentrations of copper, zinc and other metals in Britannia Creek were still at levels exceeding water quality guidelines.[42] In Jane Creek and surrounding Britannia Creek stations, water concentrations of several metals, especially copper, zinc and cadmium, exceeded WQGs by two to 149 times.[43] Since 2006, sampling in the freshwater areas of the mine site has been linked to specific studies to support remediation planning and risk assessment.

Reoccurring high metal concentrations in porewater, marine water, and in rockweed at the mine site require further investigation to elucidate the source. Groundwater could be flowing in from areas outside of the groundwater management system and becoming contaminated or metals could be leaching from mine tailings buried under beach sediments.[44] Work on these issues is continuing.

COPPER CONCENTRATIONS IN INTERTIDAL WATERS NEAR BRITANNIA CREEK AND FURRY CREEK

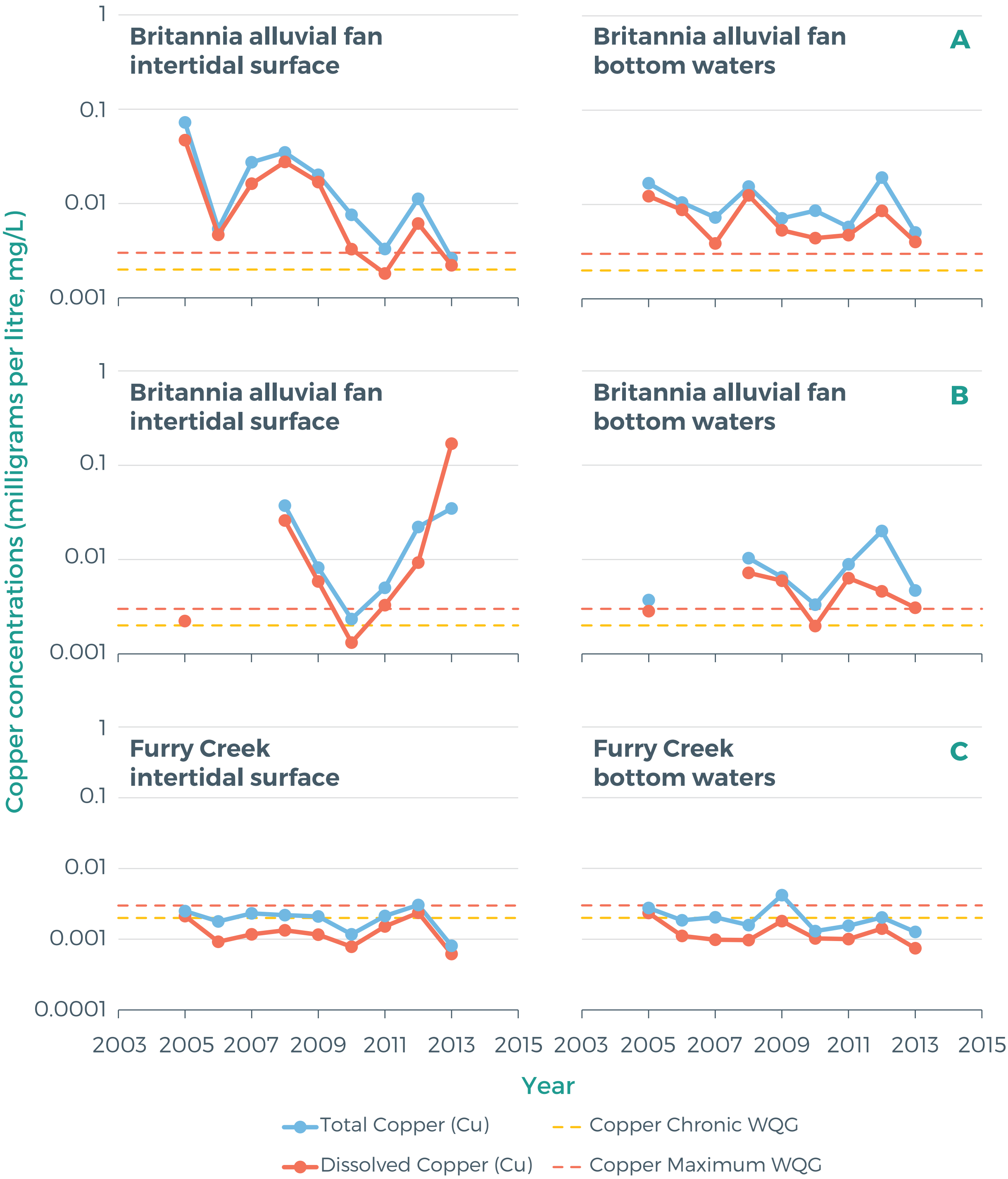

Figure 3. Annual averages of total and dissolved copper concentrations (mg/L) in marine intertidal surface and bottom waters measured at two sampling sites, from 2005 to 2013, of the Britannia Fan Area Reach, south of the Customs Wharf, Britannia Mine (rows A and B), and the Furry Creek reference site (row C). Concentration data for 2006 and 2007 were not available or measured for the second site (row B). The chronic and maximum water quality guidelines (WQGs) (dashed lines) are set for the protection of marine aquatic life in British Columbia.[45] Note the log scale on the y-axis. (Data courtesy of Golder Associates)

What is being done?

Both federal and provincial regulations have played a role in the remediation and clean-up of the former Britannia mine site. Several remediation orders were issued between the 1970s and late 1990s under the former provincial Waste Management Act,[47] replaced by the Environmental Management Act in 2004. Since 2004, an environmental monitoring program and ecological risk assessment have been underway and remediation is on-going.

Significant improvements to Britannia Creek and nearshore ecology have been achieved. For example, the waters are no longer lethal to fish. The source(s) of reoccurring high metal concentrations in porewater and intertidal water at some shore locations near the mine is under investigation, as is the feasibility of further remediation options. It is unlikely that the area around Britannia Mine will ever be returned to its pre-mine state, copper levels may never consistently meet WQG, and risk assessment will be used as a tool to determine what an acceptable end state will be. Even when closure is achieved for the Britannia Remediation Project through a closure plan, there will be on-going risk management obligations, for example the continued operation of the Water Treatment Plant.[48]

Meanwhile, development of the community at Britannia Beach has renewed interest. Residential and mixed purpose development is being planned for both North and Sound Britannia Beach in uncontaminated lands. An application for a mixed residential development of 1,000 dwelling units at Britannia Beach South (south of Britannia Beach proper where the mining infrastructure is), to be phased over 15 to 20 years, was presented to the Squamish-Lillooet Regional District Board in June 2016 (see Coastal Development article in this report). Replacement and upgrade of dilapidated infrastructure for the existing community, in Britannia Beach proper, has proceeded over recent years; private home ownership was implemented, new development lots were identified and the town is enjoying a general rejuvenation.[49]

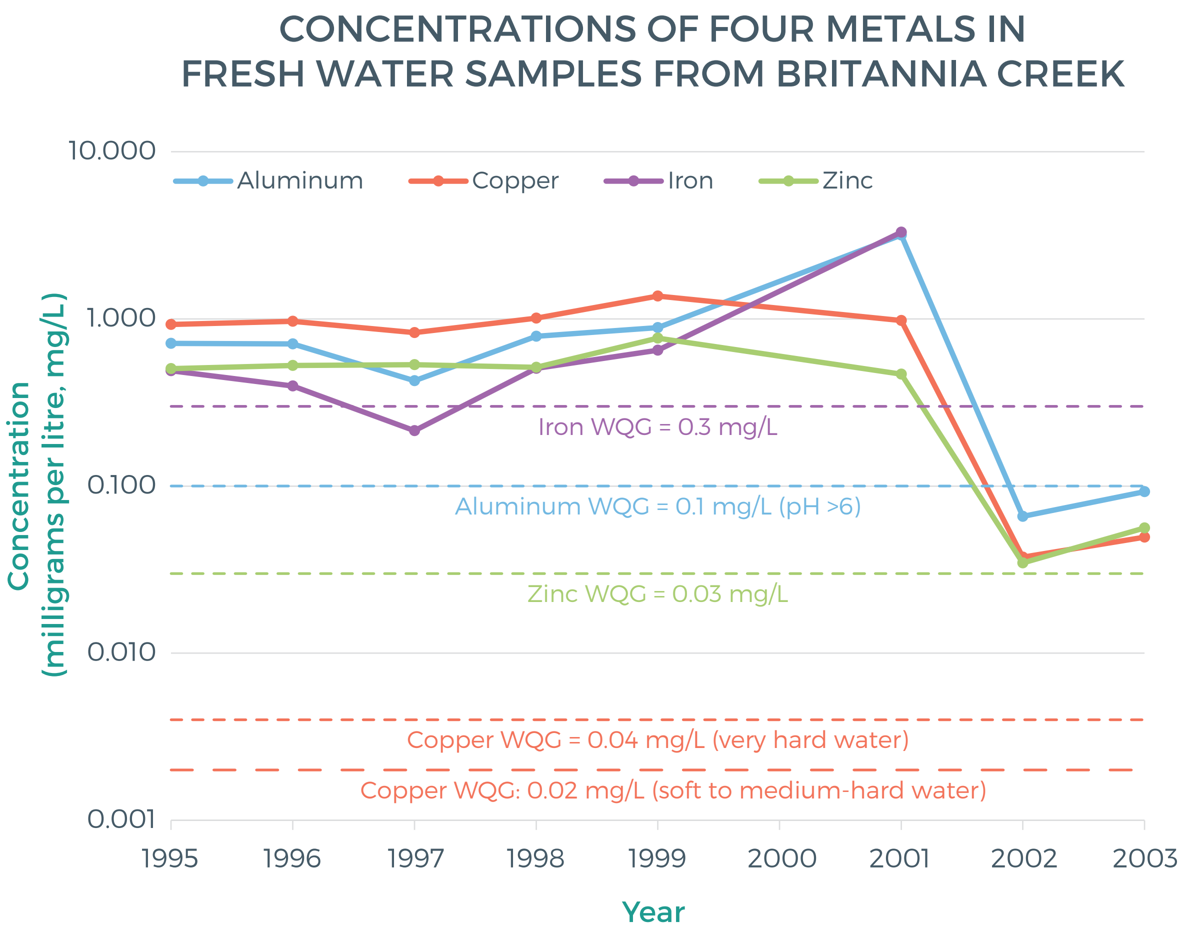

Figure 4. Concentrations of aluminum, copper, iron and zinc in fresh water samples collected from 1995 to 2003 around Britannia Mine in Britannia Creek (Site A, Figure 1). Data were retrieved from the database of the Environmental Monitoring System (EMS), British Columbia Ministry of Environment.[46] Note the log scale on the y-axis.

What can you do?

Individual and Organization Actions:

- Sources of metals in waste-water are not all industrial. Be aware that what goes down your household drain or into the street gutter almost always ends up the ocean. Water treatment facilities can remove many contaminants, but plenty of dangerous chemicals that go down your drain will still end up in rivers, lakes, and oceans. Phosphates from detergents, chlorine from bleach, and the toxins in pesticides will all wreak havoc on fragile ecosystems once they leave your local sewage treatment plant.
- Do not put paint, solvents, pesticides or other chemicals down your drain.
- Recycle all batteries.
- Help reduce the environmental impacts of mining by:
  - Reducing your consumption of minerals; reducing consumption of consumer goods in general.
  - Taking transit rather than buying a new car.
  - Using recycled materials instead of mined materials and recycling all your metals (e.g., tin cans).

Government Actions and Policy:

- Track the state of the ecosystem health using a consistent ocean pollution indicator. Identify and use a resident and an abundant biological indicator or bioindicator (i.e., an organism that can be used to monitor the state of pollution levels in the long term) to track metal contamination.
- Reach out to the community with updates on remediation in the Britannia Mine area. The community needs information about observed metal concentrations and any risk of harm they pose to human and marine life.
- Increase public education campaigns designed to educate citizens about the impact of phosphates, chlorine, and pesticides, and how to minimize their impact.
- Increase support of research focuses to asses levels of metal contamination in waterways.
- Support local recycling and zero waste initiatives.
- Protect salmon stocks against the negative health effects of copper to the salmon's olfactory system similar to that established in Washington State (http://www.seadocsociety.org/scientists-who-showed-how-copper-damages-salmons-sense-of-smell-receive-prestigious-award/), which will benefit salmon recovery by reducing the amount of toxic metals entering the Salish Sea by hundreds of thousands of pounds each year.
- Legislate against the use of phosphates in household products.

Resources

A Fact Sheet on Acid Mine Drainage
focs.ca/wp-content/uploads/2012/07/Acid-Mine-Drainage-FNEHIN.pdf

Footnotes

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