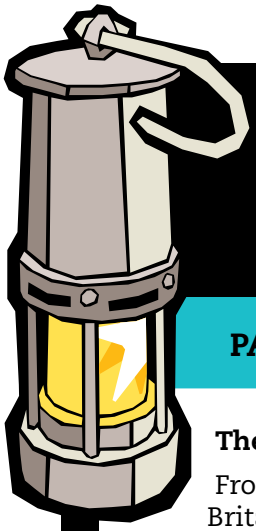

BRITANNIA'S ENVIRONMENT

A look into the 20th century environmental legacy of the Britannia Mine and its 21st century clean up

PAST • PRESENT • FUTURE

The Britannia Mine

From 1904 to 1974, a mine operated at Britannia Beach, extracting the ores of copper, lead, zinc, gold, silver and cadmium. At its peak, the mine was the biggest copper producer in the British Commonwealth. The miners extracted enough ore to produce around 800,000 tonnes of metal, with most of that being copper. That 800,000 tonnes is roughly equal to the weight of 4000 jumbo jets.

There were 210 km (150 miles) of tunnels dug, and the vertical shafts stretch from around 1300 m above sea level to around 650 m below sea level. During the life of the mine, pollution from mining was not tackled. On closing, Anaconda (the then owners), took steps to divert the pollution from the most sensitive environments – in line with the environmental standards of the day, but it did not stop the pollution. Over the next thirty years, with no mine owners to improve conditions, the pollution problem only grew worse.

Acid Rock Drainage

Acid Rock Drainage (ARD) is a natural process that happens when metal sulphides are exposed to oxygen and water – air and rain - though bacteria (*Thiobacillus ferrooxidans*) also play a big part in ARD production. The biggest ARD producer is pyrite (iron sulphide), though at Britannia, others include chalcopyrite (the copper ore), galena (lead) and sphalerite (zinc). A chemical reaction happens that produces sulphuric acid and dissolves metals, both of which pollute the local environment when they get into the groundwater and local water sources.

The site of the Britannia Mine. Circa 1960

ARD production is a very complicated process, but the main reaction is:

$$2FeS_2(s) + 7O_2(g) + 2H_2O(l) \rightarrow 2Fe^{2+}(aq) + 4SO_4^{2-}(aq) + 4H^+(aq)$$

pyrite + oxygen + water --> ferrous iron + sulphate + hydrogen

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The local creeks eventually became contaminated with iron hydroxide coatings called 'yellowboy'

The Size of the Problem

Because the ARD-forming chemical reaction needs air and water to work, ARD generation increases as surface area of the metal sulphides increases. ARD formed at Britannia before the mine ever existed, but only within exposed surface and near surface mineralized rock. The mine created surface area from 210 km of tunnels. High snow and rainfall has sent large volumes of water flowing through the old tunnels and seeping through the fractured rock that has been shattered by mining operations. This has resulted in the formation of ARD - the water can flow from the mine at up to 3600 cubic metres per hour. When the ARD exited the mine, it flowed into local creeks and Howe Sound. This led to Britannia Beach becoming seriously polluted – an average of 600 kg of dissolved metals were being washed into Howe Sound each day, making it harmful to aquatic life.

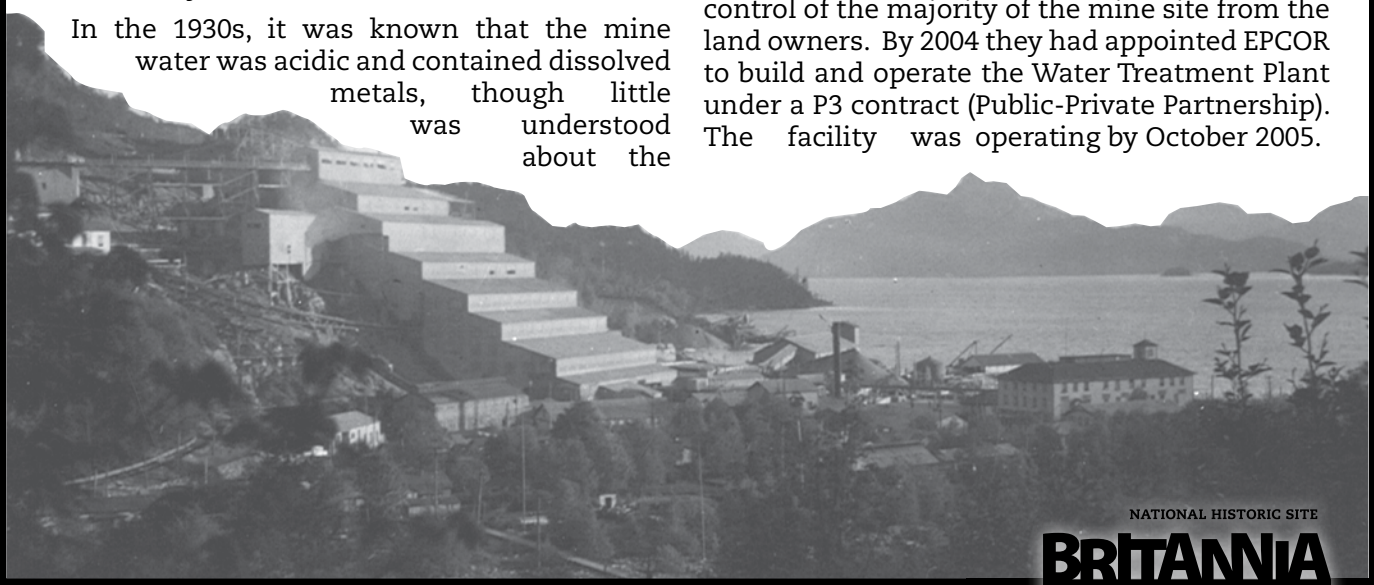
The History of the Problem

In the 1930s, it was known that the mine water was acidic and contained dissolved metals, though little was understood about the environmental impacts. From the 1930's to the 1970's, copper launders helped, but these were for economic, not environmental reasons. The launders were long timber or concrete troughs containing iron scraps. The mine water was fed through these before being discharged. An iron-copper exchange happened; copper coated the iron scraps and dissolved, relatively non-toxic iron flowed with the water out of the troughs. The copper flaked off from the scraps and was collected to be sold. So it did help reduce the amount of copper entering Howe Sound, but after the mine closed in 1974, the use of the launders soon stopped.

Anaconda, the last operating owners, had planned to build a lime treatment plant, but it was never built as the mine closed. On closure, they installed an outflow pipe that discharged the water 50 m below sea level. The water was not treated, but was taken away from the intertidal zone, the most vulnerable area for aquatic life. They also installed an underground mud/earth dam near the 2200 Level portal, to prevent water exiting the mine at this point. This stopped mine water entering Britannia Creek, though the dam failed sometime in the 1980's/90's.

The BC Province Intervenes

In 1997 with the introduction of the Contaminated Sites Regulation, the Province began the site's remediation. In 2001, they secured $30 million from 'Potentially Responsible Persons' – former owners and the present owners of former owners. In the same year they appointed Golder Associates to assess and plan the remediation. In 2003, in a mutual agreement, the Province took control of the majority of the mine site from the land owners. By 2004 they had appointed EPCOR to build and operate the Water Treatment Plant under a P3 contract (Public-Private Partnership). The facility was operating by October 2005.



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Water sampling from Britannia Creek

Water Treatment In Action - Collecting Water

Even though there were 210 km of tunnels, there were only ever a few portals and shafts (mine entrances). These are now blocked or orientated in a way that all the water is diverted to the 4100 Level portal next to the Water Treatment Plant. The mine now acts as a giant reservoir, capable of storing up to 430,000 cubic metres of water. At this portal, an 8 m thick concrete plug, outflow pipes and a valve system carefully control water flow from the mine to the treatment facility.

EPCOR Britannia Mine Water Treatment Plant

Water Treatment In Action - Treating the Water

On arrival at the facility, the water is first treated with lime slurry (a mixture of lime and water) in two reactor tanks. The alkaline lime neutralizes the acidic water, quickly raising the pH from 3.8 (ARD) to 9.3. At pH 8.5, the dissolved metals naturally come out of solution and precipitate as tiny particles. The most amount of metals precipitate at pH 9.3. The water is then fed into a large 'clarifier' tank where a customized, man-made polymer is added. This electrostatically attracts the metal particles, forming clumps that sink through their own weight, creating a dense sludge at the bottom of the tank. This is removed, and the clean water is discharged into Howe Sound. By the time the water reaches the sea, its pH has naturally decreased to around neutral. Some of the metal-rich sludge is added back into the lime and ARD mix. The sludge particles are a catalyst, encouraging the newly precipitated metals to stick to them – speeding up the precipitation/ clumping process. The rest of the sludge is dewatered in a large filter press (to 45% dry), then stored until it is taken back up to the original mining pit (Jane Basin) high on the mountain.

The Metal Sludge

The water treatment process removes around 600 – 700 kg of metal sludge every day. The main metals removed are aluminum, zinc, copper, manganese, iron and cadmium. This is around 95% of the metal in the water.

The sludge is stored on site until it can be taken up to the Jane Basin mining pit, where it helps cap the pit. As the metals are no longer in the form of a metal sulphide, they won't react with air and water to form ARD. Also, as the pH is now slightly alkaline, any water runoff into the mine will help to neutralize the acidic water in the mine.

Storing the metal sludge before transport to the Jane Basin pit

Drilling groundwater pumping wells at the Museum

Contaminated Soils

The soils around the 2200 Level portal at the old Mount Sheer townsite and on the fan at Britannia Beach, have been badly contaminated by mining operations. The alluvial fan area at Britannia Beach is largely overlain by tailings (waste rock) from the Mill operations. This has contributed to the contamination of the ground here. The worst of the soil has been removed to the original Jane Basin mining pit. Here, any ARD it generates will be captured in the mine and then cleaned by the water treatment plant. Currently about 50% of the ARD generated by the remaining contaminated soils is captured by the wells on the foreshore and pumped to the water treatment plant. Ongoing work aims to take this to over 90%.

There are also tailings located offshore in Howe Sound at Britannia Beach. These are considered to be low risk because of the lack of oxygen needed for the chemical reactions, and because they are slowly being covered by silt flowing into Howe Sound from the Squamish River.

The Outcome

As long as the Water Treatment Plant is operating and the 2200 Level plug is in place, the water that flows from the mine into Howe Sound will be clean. The operators run daily tests on the treated water, and weekly tests go to an independent lab. To date, no results have failed the stringent levels set by the Province.
Statistically, there is a long term, small chance that extreme weather/climates could prove too much for the facility. In such a case it may be necessary to discharge some of the water to Howe Sound quickly, treating it only with lime; this would need to be authorized by the Province. To avoid such an event, the operators make allowances for likely conditions. For example, before freshet, they process as much water as possible to lower the level of the reservoir.

Monitoring life on the shores of Howe Sound

Life Returns

In the few short years that the remediation campaign has been taking place, Golder Associates have been monitoring the shoreline at Britannia for dissolved metal levels and for its ecology. There are currently still some hot-spots - the focus for future work, but the shoreline and sea water quality has improved greatly and life has returned. In 2011, both Pink and Coho salmon were also found to be swimming in the lower reaches of Britannia Creek.

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Britannia Creek - clean once again

More Information

www.epcor.com

www.britanniamine.ca

To find out more about the Britannia Mine's history, visit - www.britanniaminemuseum.ca

Acknowledgment goes to EPCOR and Golder Associates (on behalf of the Britannia Remediation Project) for permission to use their photographs

Key Dates

1904	Mine opens
1920's	Largest copper mine in British Empire: mine operators are aware of pH levels and metal contaminants but not required to take action
1974	Mine closes; Anaconda build discharge pipe below sea level and small dam at 2200 portal to direct water to 4100 portal
1970's	Late 70's, concrete plug and outflow pipe built at 4100 portal to flow through plug in controlled manner
1979	Mine sold to real estate developer (Copper Beach Estates)
1981	Pollution control not being maintained; start of monitoring and studies
1997	Start to test and design treatment plant
1997	Contaminated Sites Regulation effective
2001	$30 million settlement
2001	UBC installs concrete plug at 2200 portal
2002	Golder Associates appointed Province to assess situation and plan remediation
2003	Agreement with new land owner (MacDonald Development Corporation) to take control of site
2005	EPCOR awarded contract; construction begins in April and operating in October

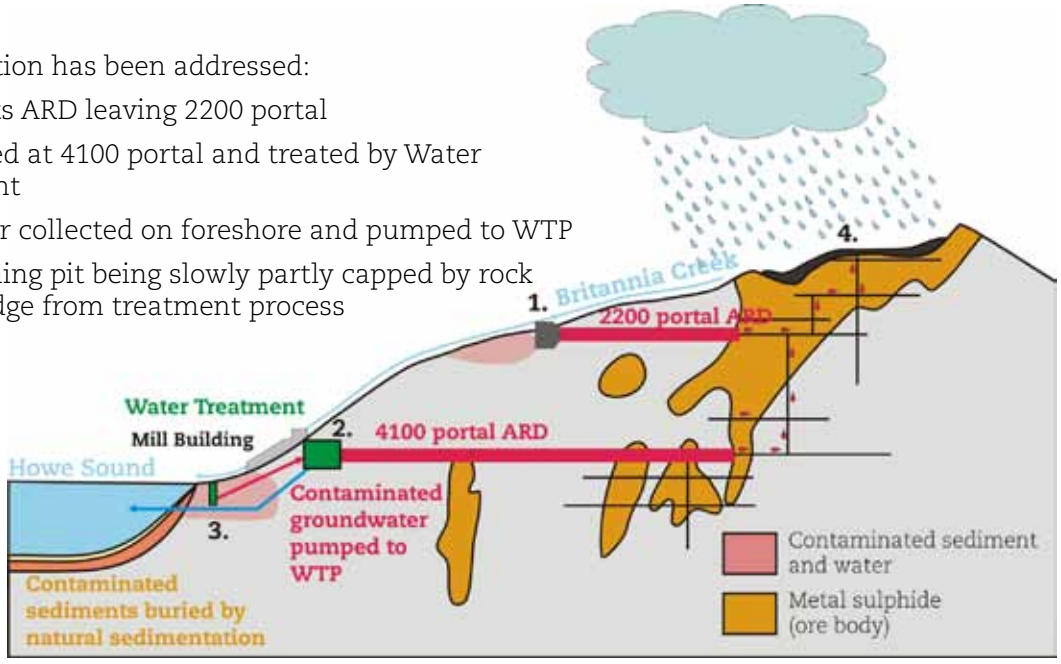
How the pollution has been addressed:

1. Plug prevents ARD leaving 2200 portal

2. ARD collected at 4100 portal and treated by Water Treatment Plant

3. Groundwater collected on foreshore and pumped to WTP

4. Original mining pit being slowly partly capped by rock waste and sludge from treatment process



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