British Columbia, Canada’s Crown Contaminated Sites Program –
a 10-year review

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Abstract

The Crown Contaminated Sites Program (CCSP) leads the management of contaminated publically owned lands in British Columbia, Canada. The program was initiated in 2003 and operates within the Ministry of Forests, Lands and Natural Resource Operations (FLNR) under a Cabinet-approved policy that commits CCSP to identify and prioritise contaminated sites that are a provincial responsibility. This policy uses a science-based risk assessment approach to protect human health and the environment. Although CCSP manages a wide range of contaminated sites, the vast majority of remediation effort has been directed at closing historic mine sites. This paper focuses on these mine sites and reviews the program’s inventory, assessment, prioritisation approach to site remediation.

Over the past decade, a tremendous amount of progress has been made towards the CCSP’s goals. As the program matured, the focus shifted from developing various tools (e.g. site inventory, assessment guidance, risk-ranking methodology), to their implementation, and then to remediation and risk reduction. Since inception, the program has investigated 75 historic mine sites; eight have been fully remediated, and 15 are characterised as priority sites where ongoing assessment and remediation is occurring. Examples from these mine sites will be used to illustrate the program’s innovative and flexible approach. Of particular relevance to mine closure is that CCSP has demonstrated leadership in using a risk-based approach to assess and prioritise sites and protect human and ecological health. This approach improves the information available on contaminated sites through site research and a database of sites and activities related to them. Regular reports are made to government and the public on the progress of work and the financial burden of contaminated sites. The program works collaboratively with First Nations, communities, environmental organisations and other levels of government to tackle problems together. The end result after a decade of effort is a comprehensive and coordinated government-wide framework for managing contaminated sites on publically owned lands.

1 Introduction

British Columbia, Canada, has an active history of mining, manufacturing, forestry, agriculture and many related activities. While development activities have built a modern and vibrant province, there have been some detrimental impacts to public lands from early in the province’s history, when the impacts of these activities were not well managed.

Some historic industrial sites are contaminated with metals, acid rock drainage, hydrocarbons and other substances harmful to human and environmental health. These sites can become the responsibility of the Province of British Columbia. To protect the public interest in such sites, the province undertakes activities such as removing contaminated soils, diverting watercourses away from toxic materials, capping hazardous areas with engineered covers and replanting vegetation to create habitats for birds, animals, insects and fish.

1.1 Crown Contaminated Sites Program responsible for clean-up on provincial land

Crown lands make up 94 per cent of the total land area of British Columbia. This includes the vast majority of resource areas, wilderness, waterways, parks and ecological reserves in the province. Remediation of contaminated sites located on this land becomes the province’s responsibility if the persons or companies responsible for their clean-up cannot be found or no longer exist.
In 2002, a report by the Auditor General, *Managing Contaminated Sites on Provincial Lands* (Office of the Auditor General of British Columbia, 2002), noted that contaminated sites that fall under the jurisdiction of provincial ministries and agencies, including Crown lands, were being managed separately by diverse groups including the ministries responsible for forests, mines, sustainable resources, transportation and the environment, as well as the B.C. Buildings Corporation. The government therefore did not have the information to provide oversight, or to manage contaminated sites in a consistent manner. The Auditor General concluded that the province should establish a framework for managing work on contaminated sites, gather information to develop management plans and support resource allocations and account for its overall performance.

In response, the province established the Crown Contaminated Sites Program (CCSP) in 2003. The CCSP was developed to take appropriate actions and provide public accountability on the management of contaminated sites for which the province is responsible. The program manages high-risk contaminated sites to ensure the protection of human health and the environment. It uses a scientific risk-ranking method to determine which sites need remediation on a priority basis.

### 1.2 Meeting ministry goals and priorities

The CCSP is administered by the Liquid Natural Gas (LNG), Crown Land Opportunities and Restoration Branch of the Ministry of Forests, Lands and Natural Resource Operations (FLNR). FLNR is responsible for developing policies and programs to ensure that forests, lands and natural resources are managed in a sustainable manner so they can continue to provide environmental, social and economic benefits to all British Columbians now and into the future.

### 1.3 Guided by Cabinet policy

The CCSP operates under a policy approved by B.C.’s Cabinet: the Management of Provincial Contaminated Sites Policy.

This government-wide policy defines the guiding principles that underlie all actions to manage contaminated sites on Crown lands:

- reducing and eliminating risks to human health and the environment and minimising liabilities;
- applying standards that are cost effective, consistent and in keeping with the legislation;
- applying the “polluter pays principle” (The CCSP follows the polluter pays principle outlined in British Columbia’s *Environmental Management Act*. Under this principle, the costs associated with environmental remediation are borne by the parties responsible for the contamination when any of those parties can be identified and are still in existence.);
- working cooperatively among ministries and consulting with stakeholders and First Nations;
- acting consistently and fairly;
- acting accountably and transparently;
- using innovative strategies for managing contaminated sites, such as public-private partnerships (P3s);
- minimising the creation of future contaminated sites;
- applying sound science and technology to guide management.

### 1.4 Regulatory framework

CCSP remediates sites in compliance with the *Environmental Management Act*, contaminated sites regulation and hazardous waste regulation. This legislation is a comprehensive and prescriptive process
ensuring a consistent approach and application of numerical and risk-based approaches to the remediation of contaminated sites in the province.

1.5 Setting site priorities

For a contaminated site located on Crown land, the CCSP attempts to identify the organisations or individuals responsible for causing the contamination so that they can be held accountable for the cost of clean-up. Public funds are used only if private parties no longer exist and the site has defaulted to the province, or if the site poses an immediate unacceptable high risk to human health or the environment.

The number and variety of contaminated sites on Crown land exceeds the resources available within the CCSP to clean up all sites at once. As a result, the CCSP allocates its resources systematically to work on the highest priority sites and identify other sites for future action. Sites that present the highest risk to human health or to the environment receive priority. Sites that pose a lower risk will receive attention as higher risk sites are remediated. In some cases, investigations determine that sites do not present an unacceptable risk and do not require remediation.

Because of the potential for risks to human and environmental health, determining an appropriate methodology for assessing and prioritising the risks is one of the CCSP’s key responsibilities. The methodology determines what sites will receive action, what resources each candidate site will receive and when each site will be scheduled for attention. Sites are identified through cross-government review of existing inventories and the application of coarse filter criteria to known sites, including proximity to sensitive habitats, access by humans and nature and extent of contamination.

Program sites fall into one of four categories:

- Remediated: Crown sites where clean-up activities are completed.
- Priority: Crown sites that have been identified for action based on site investigation and potential risk to human health and the environment.
- Candidate: Crown sites on which initial investigation has begun to determine the degree of risk.
- Other: Sites that the province manages in order to fulfil obligations established under legal agreements or other commitments.

1.6 Risk-ranking methodology

In 2007, the CCSP developed a risk-ranking methodology (RRM) as its principle tool to establish program priorities and allocate the funds available for remediation (Power et al., 2010 and various guidance documents). The RRM is a scientifically based method for assessing the ecological and human health risks presented by contaminated sites in British Columbia. The process uses two components to prioritise sites:

- a risk ranking support tool, which is a data entry and calculation spreadsheet that compares contaminants in soil, water and sediment to regulatory standards;
- a risk-ranking workshop, which brings together experts on contaminated sites, including geologists, engineers, biologists and toxicologists, to review and assess the information available on candidate sites.

1.7 Key steps in assessing Crown contaminated sites

The process of assessing sites and the actions required follows these steps:

- identify potential candidate sites;
- determine land ownership and responsibility for clean-up;
- develop a list of candidate sites;
• conduct preliminary site investigations;
• enter field observations and analytical data into the risk-ranking support tool;
• hold a risk-ranking workshop to rank sites, identify priority sites and recommend next steps based on a group consensus;
• develop management action plans appropriate for priority sites, subject to available financial resources.

The site prioritisation process is shown in more detail in Figure 1.

1.8 Recommendations for action or investigation

Investigators gather available field-based data for candidate sites to populate the risk-ranking tool. The information allows workshop participants to rank sites based on risk and to make initial recommendations to CCSP on management actions for identified high-priority sites. The ranking process involves pair-wise comparison of the multiple lines of evidence. Using the expert guidance of the workshop participants, a level of action appropriate for each site is selected. The workshop participants can recommend any of the following actions:

• Immediate action: The workshop recommends immediate action for sites where health or safety risks require urgent attention.
• Detailed site investigation: Where the information indicates that a potential risk may exist, the workshop recommends a more detailed site investigation.
• Supplemental investigation: When analysis shows a need for action for a ranked site, but requires additional information to determine the most appropriate steps, the workshop recommends specific, targeted investigations. These can include further study of various risks, sample taking or other types of site analysis.
• Reduce uncertainty: Where the data in the tool are too uncertain for the site to be ranked, the workshop may recommend gathering more information or performing analyses about specific issues.
• Lower priority: Low priority sites are those with the lowest risks, where management action can be deferred.

The recommendations from the workshop guide the CCSP in planning future actions.

2 Reporting out

A formal report on the state of the CCSP is published once every two years.

The two-year report period was chosen because typically there may not be significant reportable change over an annual reporting period. In addition, remediation efforts tend to take longer than a single year, so the period of reportable change in the indicators selected is more consistent with a biennial report. The report includes an overview of principles, policy, process, governance and legislation driving the CCSP, case studies from province-wide experience as well as comparison of B.C. progress to other jurisdictions worldwide.
Figure 1  Site prioritisation process (FLNR, 2014)
The CCSP also reports out annually on financial information to meet the obligations of the Budget and Transparency Act, as well as to operate in accordance with the provincial adoption of generally accepted accounting principles. This information is prepared for inclusion in the annual public accounts report of the Office of the Comptroller General (OCG) using approved financial reporting procedures as presented in the core policy and procedures manual from the OCG, Ministry of Finance.

The information is subject to the requirements identified by OCG and may include sites identified as contingent liabilities or financial liabilities, with estimated dollar amounts for financial liabilities as well as expenditures in each fiscal year to date.

3  Project site reports

The CCSP continues important work to achieve its goal: protecting human health and the environment by returning land to a clean and usable state:

- A total of 84 sites have been investigated since the program began in 2003.
- There are currently 17 priority contaminated sites warranting further study and investigation.
- Remediation has been completed at 15 mine sites. Many of these require ongoing monitoring to ensure that the remediation is meeting the desired results and to ensure long-lasting integrity of the remedial works.

The following sections highlight a number of high-priority mine sites managed by CCSP.

3.1  Britannia Mine

Britannia Mine, located 45 kilometres north of Vancouver next to Howe Sound on the Sea-to-Sky corridor, was once the largest copper producer in the British Commonwealth. This site ranks as CCSP’s highest profile remediation program owing to its size and complexity. It occupies a very large tract of land – the entire site covers about 9,000 acres. Britannia Mine began production of copper ore more than 100 years ago and stopped producing ore in 1974. Water entering the mine site continued to leach out an average of 300 kilograms per day of copper and zinc. Until 2005, this discharge flowed directly into Howe Sound (marine) totalling approximately five million cubic metres each year, making it one of the largest metal pollution sources in North America.

The province began its environmental remediation work at Britannia Mine in 2001, after a financial settlement was reached with the former mine operators. The former operators contributed C$ 30 million toward the clean-up cost and provincial funding provided an additional C$ 45.9 million. The CCSP has ongoing responsibility for the investigation, remediation and environmental monitoring at this site.

A P3 was formed in 2005 with EPCOR Water Services Ltd. to design, build, finance and operate the new water treatment plant. This is a conventional high-density lime water treatment plant processing on average 4.2 million cubic metres of acid water annually. Other detailed technical work completed included underground mine rehabilitation, a power generation system and systems to divert surface water to reduce inflow of uncontaminated surface water.

A long-term program of environmental effects monitoring was implemented and continues each year.

In 2010, a final mine closure plan was developed that includes a hydrogeological/hydrological investigation at Jane Creek, the 2200 level of the mine and a risk assessment program for the Furry Creek watershed.

The success of the remediation work at Britannia is clearly visible, both in its creek and along the beach area. In 2011, local citizens and the B.C. Rivers Institute reported observing fish in the lower reaches of Britannia Creek. Fish have never been seen in this part of this creek. The B.C. Institute of Technology confirmed the presence of fish through independent studies. Along the shoreline, the changes are equally dramatic – what was bare rock covered with sporadic patches of copper-tolerant algae is now bristling with life. Much of the shoreline is covered with fucus (rock-weed), barnacles, mussels and a host of other plants.
and animals. New life is also visible under the water. Previously barren sediment is now sporting crabs, sea cucumbers and anemones.

3.2 Atlin Ruffner Mill and tailings site

The Atlin Ruffner Mill and tailings site is located approximately 28 kilometres northeast of Atlin, B.C., on the northwest slope of Mount Vaughan. The Atlin Ruffner Mine was developed following discovery of mineralisation in an outcropping within the Crater Creek drainage in 1899. Mining operations commenced in 1900 and continued intermittently until 1981. A total of 3,535 tonnes of ore were milled, with recovery of 138,493 kg lead, 13,540 kg zinc, 2,079 kg silver, 920 kg copper, 15 kg cadmium and 3.4 kg gold.

The Atlin Ruffner Mill and tailings area was identified as posing risks to human health and the environment and was prioritised for remediation. Other Atlin Ruffner mine workings, including numerous adits further up the mountain, were determined to pose lower risks and were not included as part of the remediation plan.

The mine site included the following:

- An upper pad, which included the mine adit, a flat working area with metals-contaminated soils and minor mining equipment debris, an ore chute, an ore cart track and several small surface stockpiles and subsurface volumes of residual ore and waste rock.

- A lower pad area encompassing the mill building, a large flat working area around the north end of the mill with a shack and contaminated soils with high metal concentrations (primarily arsenic, lead and zinc) and two trailers (main trailer and single trailer). High levels of total and leachable metals are present in the milling dust and debris that cover the inside surfaces of the mill building and associated residual equipment such as the ball mill. Within and around buildings and debris areas of the lower pad, there are small amounts of hazardous waste materials that include hydrocarbon liquids and solids, asbestos-containing materials (ACM) and miscellaneous hazardous materials.

- A tailings area, upper sedimentation pond and lower sedimentation pond comprising sand and gravel dams with deposits of low permeability tailings behind them. The tailings pond was partially covered with shallow water cover due to snowmelt and precipitation. The filled or saturated sedimentation ponds are consistently refilled with overland and subsurface flows, predominately originating as groundwater exiting the mine adit. The adit water reportedly originates as a subsurface flowing borehole that was formerly used as the mill water supply. Water emanating from the sedimentation ponds infiltrated into the ground immediately down slope of the ponds.
Presently:

- A total of 84 sites have been investigated since the program began in 2003.
- There are currently 17 priority contaminated sites warranting further study and investigation.
- Remediation has been completed at 17 sites. Many of these require ongoing monitoring to ensure that the remediation is meeting the desired results and to ensure long-lasting integrity of the remedial works.

Figure 2  Provincial distribution of priority and remediated Crown contaminated sites (FLNR, 2014)
Test results on soil samples indicated that much of the soil beneath the upper and lower pads and within the tailings and sedimentation ponds contained concentrations of metals that exceeded the numerical standards of the B.C. contaminated sites regulation, including those classified as high risk. Leachability tests on some of the higher concentration samples indicate some of the soil would also be classified as “leachable toxic waste” and hence hazardous waste under B.C. hazardous waste regulations. Variability in the physical distribution of metal concentrations meant that soils classified as hazardous waste or exceeding CSR numerical standards could not be constrained to an area or depth suitable for ex situ remediation efforts. Site remedial efforts were therefore directed at risk management, risk mitigation or (for some media) source removal.

Following detailed site investigations, a preliminary remedial plan was developed that detailed potential suitable remedial actions for the site. These included demolition of all buildings and capping the site with glacial till.

Access to the site for public recreation was discouraged by placing rocks and earthworks across entry routes. Water will be monitored and the cover will be inspected once a year for the first five years, and every five years after that.

3.3 Howard Mine tailings site

Howard Mine in B.C.’s West Kootenays, about 30 kilometres south of Nelson, produced gold, silver and lead during its operation from 1937 to 1938. The mine transported ore over a 7.5-kilometre aerial tramway to a processing mill at the confluence of the Salmo River and Porcupine Creek. The mill operation left behind many tonnes of mine tailings, much of which has since been washed away by the river.

Between 2009 and 2013, the CCSP commissioned a series of studies to assess the extent of mine tailings and their potential risk to human health and the environment. The investigations showed that the mine wastes contained lead and other metals at concentrations that pose a potential risk. Groundwater and surface water in the Salmo River directly adjacent to the tailings deposit contained elevated concentrations of cadmium and zinc. However, Porcupine Creek and the main channel of the Salmo River have not been affected by the mine wastes.

The results showed that management of the mine wastes was necessary. In order to determine the best approach, the CCSP analysed a number of different management options in late 2012 and early 2013 and evaluated them against specific environmental, practical, social and cost criteria. Leachability tests on tailings samples indicate that these mine wastes were leachable hazardous wastes and needed to be contained in an approved hazardous waste facility. A conceptual plan to manage the wastes was presented at an open house in August 2013, and local community members agreed with the recommended remedial option.

Remedial work commenced in the summer of 2014 and will be completed in spring 2015. The remediation plan includes consolidation of mine tailings capped by a bituminous engineered cover to reduce water and oxygen ingress into the mine waste.

3.4 Toquaht Bay marina and campground

Toquaht Bay recreation site includes a wilderness campground, marina and kayak launch site on the west coast of Vancouver Island. The site became popular for public recreation use after the nearby Brynnor iron ore mine closed in the late 1960s. Sheltered from the open ocean in Barkley Sound near Ucluelet, it was transferred under the 2011 Maa-nulth Treaty to the Toquaht Nation.

In the treaty, British Columbia agreed to undertake environmental investigations and, if necessary, clean up any contamination. Preliminary investigations in early 2013 found arsenic, selenium and cobalt in soil at unacceptable levels, and also identified iron as a concern. The site was closed to assess the risks to humans. The contaminants were found to be associated with mine tailings produced from the former Brynnor mine, an unexpected result because iron mine tailings typically contain little arsenic.
The CCSP began detailed site investigations of all media at the site and adjacent beach to determine the extent of contamination. The CCSP is also working in partnership with the federal Pacific Region Interdepartmental Shellfish Committee to analyse clam, oyster and geoduck tissues from around Toquart Bay (the body of water has a different spelling).

The CCSP is communicating closely with Toquaht Nation officials to share information and plans. In late summer of 2013, the Toquaht Nation opened a campsite nearby to provide a replacement for the recreation facilities, and in 2014, temporary measures were taken to allow the boat launch and marina to re-open.

3.5 Emerald Glacier Mill and tailings site

First staked in 1915, the steep slopes and alpine meadows of the Emerald Glacier mine site produced over three million pounds of lead and zinc, and smaller amounts of gold, silver, copper and cadmium. Active work on the site ended in 1971, leaving a tailings pile and reservoir at a mill site in an adjacent valley about 2.5 kilometres from the mine.

The mining activity resulted in metals-contaminated soils and waste rock around the mill, an upstream reservoir dam that had supplied water to the mill but had not been maintained since mining ended, and metals-contaminated tailings beside a creek that flowed from the reservoir. The mill site’s remote location, approximately 120 kilometres by road from the nearest town of Houston (430 kilometres from the larger city of Prince George), made it particularly challenging.

Investigations between 2008 and 2011 identified a potential risk from derelict buildings, erosion from the tailings pile and the possibility that the reservoir dam could breach and further erode the tailings pile. Using a phased remediation strategy, buildings were first demolished in summer 2012, allowing safe access for detailed assessments.

The second phase in fall 2013 involved capping all of the areas of the mill and tailings that had high concentrations of metals. The capping material, consisting of a one-metre cover of compacted glacial till, will protect the site from further erosion and prevent people and animals from being exposed to the metals-rich tailings. Owing to the remote site location, an onsite source of the glacial till was developed for use during remediation and then decommissioned. A berm was also constructed between the creek and the tailings to prevent any future floods from reaching the tailings.

To remove the risk of the dam breaching, contractors pumped water out to lower the reservoir level and then built a spillway in the middle of the dam to maintain the new lower level. The spillway mimics a natural drainage channel and returns the reservoir to pre-mining levels.

The roads to the dam, ore pile and tailings were decommissioned by placing fallen trees on the road surface and creating a ditch and berm at the road entrance. To begin revegetation, contractors planted willow stakes on the berms and reseeded disturbed areas.

The CCSP will continue monitoring the former reservoir, the covers, the creek and groundwater. The new vegetation will be monitored and enhanced as needed.

3.6 Bralorne Takla historic mercury mine

In 1942, prospectors discovered an outcropping of cinnabar, the ore from which mercury is produced, in B.C.’s north-central region, about 180 kilometres northeast of Fort St. James. Bralorne Mines operated a mercury mine on the site for about nine months in 1943 and 1944. One of only a few mercury mines in Canada, it produced almost 60 tonnes of mercury.

Since the mine closed, its workings and wastes have produced a variety of contaminants, including mercury, antimony, arsenic, cadmium and chromium. Mercury is a particular concern because it can change its form and become concentrated through biological processes – called biomagnification – and its effects on wildlife become more serious as the concentration increases. In addition, the region is rich in many
minerals, and the naturally high levels of several metals exceed the standards for permitted contaminants. This posed challenges in assessing the mine contaminants and in designing an appropriate remediation strategy. The remoteness of the site, almost 400 kilometres by road from Prince George, B.C., added to the logistical difficulties.

The mine site is located within the traditional territory of the Takla Lake First Nation (TLFN). The Province of British Columbia and the CCSP have been working with the TLFN to identify contaminants and assess the site. TLFN technicians worked as members of the sampling team to assist with sample collection in 2012, 2013 and 2014. A technical working group made up of government and TLFN representatives, supported by expert consultants, worked to identify and select a clean-up option that is effective, practical and acceptable to the TLFN and the province. At community meetings in Takla Landing and Prince George from 2012 through 2014, the technical working group reported its findings to the members of the First Nation and asked for their input.

By the end of 2013, objectives for the clean-up had been developed, and several options for remedial actions were identified. The joint working group selected a preferred remedial option in the spring of 2014. Power and Baker (2015) touch on the findings of an ecological risk assessment of the preferred remedial option. Clean-up work is scheduled to begin in summer 2015.

4 Conclusions

When it was established in 2003, British Columbia’s CCSP inherited a legacy of contaminated sites – land, water and air – from previous times when the impacts of industrial development were not well managed. Compounding the problem, information on many of these sites was wanting, opening questions such as which were the most highly contaminated, which required immediate attention and what kinds of remediation would be needed.

This situation required (1) a system for gathering information, and (2) a way of ranking the urgency of the sites and the related actions that needed to be taken.

Ten years later, a tremendous amount of progress has been made – but more remains to be done. To date, we have identified and managed risks to human health and the environment at sites across the province. Our innovative and flexible approach has created a comprehensive and coordinated government-wide framework for managing contaminated sites on publicly owned lands.

Since the program was established in 2003, leadership has been demonstrated in:

- using a risk-based approach to assess and prioritise sites and protect ecological health;
- improving the information available on contaminated sites through site research and developing inventories;
- reporting regularly to government and the public on the progress of work and the financial status of contaminated sites;
- working collaboratively with First Nations, communities, environmental organisations and other levels of government to tackle problems together.

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References


