REGULATORY CONSIDERATIONS FOR HISTORIC MINE REMEDIATION IN BC: ATLIN RUFFNER MILL AND TAILINGS CASE STUDY

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ABSTRACT

A large number of historic mine sites across British Columbia are no longer operating and no responsible person exists or can be found. The clean-up of historic mine sites is undertaken as per provisions within the *Environmental Management Act* (EMA), and particularly the Contaminated Sites Regulation (CSR) and the Hazardous Waste Regulation (HWR).

The Crown Contaminated Sites Program (CCSP) of the BC Ministry of Forests, Lands and Natural Resource Operations leads the management of contaminated provincial lands where the province has accepted responsibility. The CCSP identifies and prioritizes sites using a science-based and risk assessment approach to reduce risks to human health and the environment.

Using the Atlin Ruffner Mill and Tailings Site as a case study, the application of the CSR and the HWR to the remediation of a historic mill and tailings will be discussed. The site is approximately 20 km from Atlin, BC and produced silver, lead, and zinc as well as gold, copper, cadmium, molybdenum, and tin. Prior to remediation, the mill and tailings site included a mill building with machinery and ore storage bins, two leveled areas (upper and lower mill pads), two trailers, a shack, an explosives shed, a tailings pond, two settling ponds, and an adit with flowing drainage.

Prior to remediation, the site was classified as High Risk under the CSR and metals in soils and mine wastes were classified as leachable hazardous waste under the HWR, requiring special permitting to be managed on site. The paper will focus on the application of the CSR and HWR to the mine site.

REGULATORY CONTEXT

The Crown Contaminated Sites Program (CCSP) is part of the LNG, Crown Land Opportunities and Restorations Branch (CLORB) within the British Columbia Ministry of Forests, Lands and Natural Resource Operations (FLNR). Within the FLNR, the CCSP leads the management of contaminated provincial lands to reduce risks to human health and the environment. The CCSP works under a Cabinet approved policy that commits the FLNR to identify and prioritize contaminated sites that are a provincial responsibility using a science-based and risk assessment approach.

The CCSP uses a number of criteria to identify and prioritize sites. One criterion is there are no one who may hold liability for the clean-up, i.e. there are no Responsible Persons, as defined in the *Environmental Management Act* (EMA). Metrics used for this criterion is the absence of any *Mines Act* permit which

approves mineral production as well as the mine is located on Crown Land. If a *Mines Act* permit has existed, the permit holder and/or the BC Ministry of Energy and Mines may be Responsible Persons.

Most of the historic mine sites in British Columbia were active prior to development of the Health Safety and Reclamation Code for Mines in British Columbia and were never permitted. They do not meet the definition of an "abandoned mine" under the *Mines Act*, which "means a mine for which all permit obligations under this Act have been satisfied and in respect of which the mineral claims have reverted to the government." They are better defined as a "historic mine site" under EMA, which "means an area (a) where mechanical disturbance of the ground or any excavation has been made to produce coal or mineral bearing substances, including a site used for processing, concentrating or waste disposal, and (b) for which a *Mines Ac*t permit does not exist and no identifiable owner or operator is taking responsibility for contamination at the site."

Further, while owners and operators may be jointly and separately liable under EMA, a person is not responsible for remediation of a historic mine site if "the person acquired the mineral or coal rights at the site for the purpose of undertaking mineral or coal exploration activities and the exploration activities have not exacerbated any contamination that existed at the site at the time the person acquired those mineral or coal rights." Historic mine sites that the CCSP address are therefore cleaned up under EMA provisions, including but not limited to the Contaminated Sites Regulation (CSR) and Hazardous Waste Regulation (HWR), not under reclamation provisions of the *Mines Act*.

SITE DESCRIPTION

The Atlin Ruffner Mill and Tailings site is located approximately 28 kilometres northeast of Atlin, BC on the northwest slope of Mount Vaughan. The site is location near the end of Ruffner Mine Road, 17 kilometres from the junction with the Atlin Highway. The mine covers a relatively large area with the mill situated at an elevation of 1180 metres above sea level (masl) and a number of adits and works ranging in elevation from 1190 to 1760 masl located at distances up to 4.8 km from the mill. Site drainage flows towards Vulcan Creek and other tributaries of Fourth of July Creek. The uninhabited McDonald Lake Indian Reserve is located approximately 2 km west and downgradient of the Site.

The Ruffner mining area was developed following discovery of mineralization in 1899. Lead, zinc, silver, copper, cadmium, and gold were mined and milled intermittently until 1981 from a series of mineralized veins, shears and lamprophyre dykes cutting granodioritic rocks of the Middle Jurassic Fourth of July Creek batholiths. The mineralization consists predominant of sphalerite, galena, aresenopyrite, pyrrhotitite, and chalocopyrite in a quartz-calcite gangue. Mining and exploration activities are currently inactive after a brief period of surface exploration in the late 1980's. There is no *Mines Act* permit associated with the mine.

The mill and tailings area was developed by cutting into an esker formation on the side of Mt Vaughn. At least 3,535 tonnes of ore were milled at the site. Prior to remediation, the mill and tailings site included a mill building with machinery and ore storage bins, two leveled areas (upper and lower mill pads), two trailers, a shack, an explosives shed, a tailings pond, two settling ponds, and an adit with flowing drainage (Figure 1, Photos 1 through 3).

SITE CHARACTERIZATION

In 2008, the CCSP risk ranking process identified the mill and tailings area as a priority due to very high concentrations of arsenic, cadmium and lead in soils and concerns of direct exposure to both ecological receptors and recreational users. The mine workings area was ranked lower, human use is less frequent than at the mill site, and options for remediation of this area are limited; it was assessed through assessment of risks to the local environment. Remediation efforts focused on the higher risk mill and tailings area.

Phased environmental investigations between 2008 and 2011 identified that throughout the site, including in surface soils on the upper and lower mill pads, arsenic, lead, zinc, antimony, copper, silver, and cadmium concentrations were found to exceed CSR Wildlands Land Use standards. Concentrations in soils on the upper and lower mill pads, tailings, and settling ponds also exceeded the Upper Cap Concentration, classifying the site as a high risk site under the CSR. High risk sites have specific reporting requirements under the CSR, triggering BC Ministry of Environment (MOE) involvement into the independent remediation process.

In addition, a number of soil and tailings samples exceeded the HWR Leachate Quality Standards for various metals, classifying the material as Leachable Toxic Waste and triggering the HWR requirements. The mill building also contained hazardous waste including friable asbestos, painted debris with leachable lead concentrations exceeding 5 mg/L, and small quantities of residual fuel, grease blocks, batteries and other chemicals. Given the presence of Leachable Hazardous Waste, the age of the mill, and the lack of activity after 1981, the site is classified as a Historical Hazardous Waste Contaminated Site under the HWR. (See next section.)

Water draining from the adit at the mill site is believed to be from a single borehole groundwater source within the workings. Adit drainage was found to have relatively stable and low flow volume (<10L/s) and above the tailings, had concentrations of fluoride and arsenic only slightly higher than local streams. The adit drainage flows approximately 150 metres before entering the settling ponds. Downgradient of the lower settling pond, the drainage quickly infiltrated back into the highly porous ground without connecting to another surface water body. This water is believed to daylight 800 metres away in a wetland area before draining to Fourth of July Creek. There was no surface water pathway to a receiving environment or aquatic habitat.

Over three years and four sampling events, metal concentrations in groundwater at source areas at the site, with the exception of cadmium and zinc, met applicable CSR standards for freshwater aquatic life. Concentrations of cadmium and zinc attenuated to within 100 metres downgradient of the source areas (contaminated soils and tailings), and all groundwater receptors are located a significant distance away. Groundwater conditions suggested any metal leaching that was occurring was being attenuated quickly and metals were not being transported to receiving environments through leaching. Despite the groundwater conditions that suggested metal leaching wasn't a major concern at the site, the exceedance of HWR leachate quality standards defined some site soils as Leachable Toxic Waste.

Wastes are classified as Leachable Toxic Wastes if they produce an extract with contaminant concentrations greater than those proscribed in Table 1 of Schedule 4, when subject to the US EPA Method 1311 Toxicity Characteristic Leaching Procedure (TCLP) test. This test seeks to replicate

potential acidic conditions that waste material may be subject to under typical landfill conditions, and thus uses acetic acid/ sodium hydroxide as the reagent. This test does not do a good job of representing leachate under normal atmospheric weather conditions and may account for the difference between the test results and the observed site conditions. Leachable Toxic Wastes require permitting under the HWR.

The leachate testing completed (31 TCLP tests and 17 shake flask tests (3:1 solid to water; 24hr)) found the following.

- 6% exceed HWR leachable arsenic
- 22% exceed HWR leachable cadmium
- 33% exceed HWR leachable lead
- 4% exceed HWR leachable zinc

Sample selection was biased towards the highest total metal concentrations, so the testing may have overestimated the percentage of leachable material.

Based on the results, there was an estimated 4,500m^3 (i.e. one third of upper cap soil volume estimate) of Leachable Toxic Waste (soil and mill dust) present at the Site that needed to be accommodated in the remedial plan.

REMEDIAL PLAN AND PERMITTING

The objective of remediation was to provide a robust, long term solution that was cost-effective and achievable, reducing the long term risk related to chemical contaminants. The selected remedial plan focused on reducing exposure to contaminated soils by placement of a permeable, erosion resistant cap over all of the contaminated materials. The proposed remedial actions at the Site involved construction of landfill and cover facilities, creating a Secure Landfill. The Secure Landfill encompassed soil covers on the Settlement and Tailings Ponds, the Upper and Lower Pads and the constructed landfill facility at the Mill location. The remedial plan included:

- upgrading the access road;
- removal of Hazardous Wastes building materials to an approved off-site disposal site;
- diversion of adit drainage from the settling ponds to an infiltration area and drainage of the ponds;
- building demolition and compaction on the existing mill building footprint;
- consolidation of waste rock/ore concurrently with layers of compacted demolition debris on the mill building footprint;
- on-site isolation and capping of building debris, mill equipment and associated metals contaminated soils with a minimum of one metre of clean compacted sand and gravel;
- *in-situ* isolation and capping, with a minimum of one metre of clean compacted sand and gravel, of the tailings pond, settling ponds, and high risk contaminated soils on the upper and lower pads; and
- risk management of remaining contaminated soils.

Under the CSR, this risk based approach was acceptable remediation approach, but did not eliminate the need for a permit under the HWR.

The HWR primarily focuses on generation, transportation and disposal of hazardous wastes, but contains specific exclusions if only mine tailings or mine waste rock are managed at the facility or if the site is a Historical Hazardous Waste Contaminated Site. Historical Hazardous Waste Contaminated Sites are defined as “any land or groundwater which (a) was contaminated with hazardous waste on or before April

1, 1988, and (b) is no longer used for any activity which adds new hazardous waste contamination to the land at that location." The Atlin Ruffner Mill and Tailings area met the definition of a Historic Hazardous Waste Contaminated Site. While exclusions applied to the tailings, residual ore and waste rock, the metal contaminated soils on site, a result of mining operations, were not excluded from specific HWR requirements.

The remedial plan met the definition of an In Situ Management Facility which "means a facility used to (a) prevent or control the movement or release of hazardous waste contaminants, or (b) treat or destroy hazardous waste contaminants in soil or groundwater at an historical hazardous waste contaminated site in such a way that the physical location of the hazardous waste contaminants and the soil is not substantially altered." A director's prior approval is required for construction and operations of an In Situ Management Facility.

The remedial action, through construction of an on-site Secure Landfill, provided protection to human or ecological receptors equal to the protection offered by the HWR. The remedial actions were designed to account for site-specific levels of risk and to allow remediation to proceed under suitable cost and time frames. However, the remedial plan did not meet some of the HWR requirements for a Secure Landfill, even given the Historical Hazardous Waste Contaminated Site exclusions.

Given the proposed approach and the unique circumstances at the site, we submitted an Application for a Change in Requirements under Section 51 of the HWR related to the Secure Landfill. Section 51 allows the director to approve site specific requirements that vary from the regulation. The hazardous building materials and fuels, including the friable asbestos containing materials, the painted debris with leachable lead, and the small quantities of residual fuel, grease blocks, batteries and other chemicals were managed, transported and disposed of at off-site approved facilities in accordance with the HWR and therefore were not part of the Section 51 application.

The application requested changes to the following sections to reflect the site conditions and risk managed remedial approach: Part 4 Division 6 – Secure Landfills and Sections (26) Operational Requirements and (27) Performance Standards. The requested changes to the HWR requirements were primarily related to requirements for a Secure Landfill for the Leachable Toxic Waste, such as a change in the requirement for a liner as wastes were remaining *in situ*, and a change in the frequency in monitoring to reflect the level of risk, location, and climate of the site. The site is remote and only snow free and accessible from May to September, making the standard HWR monitoring frequency requirements overly onerous. A specified but reduced monitoring frequency was proposed due to the passive nature of the on-site Secure Landfill facility and the remote location. Another example was a change in the requirement to construct the Secure Landfill under a cover or roof, given the material had been exposed to precipitation for many decades already. The Section 51 application required each changed line in the regulation to be replaced by wording applicable to the site.

OUTCOME

An approval for creation of an In Situ Management Facility and a change in requirements under the HWR was granted in August 2012. This approval jointly met both CSR and HWR requirements and was the first of its kind issued by the BC Ministry of Environment. It was based on four key criteria of the remedial plan:

1. the hazardous wastes (contaminated soils and mine wastes) remained in place and were covered with a minimum "one metre of clean gravel that is naturally erosion resistant";
2. as a contingency measure, the cover design allowed for potential installation of a geomembrane system at a later date if evidence arises that infiltration of rainfall is resulting in groundwater contamination issues due to leaching from the facility;
3. surface water was diverted away from the facility; and
4. access to the facility for public recreational use was discouraged by the placement of earthwork features and rocks.

Upon receipt of the approval, the following remedial works were undertaken in August and September of 2012:

- Upgrading the access road including installation of a temporary bridge over Trident Creek and subsequent decommissioning following remediation (required a *Water Act* authorization);
- Removal of specific Hazardous Wastes from the buildings (residual fuel, chemicals and asbestos building materials) with approved off-site disposal (required tracking as per the HWR);
- Permanent diversion of the adit drainage from the settling ponds to an infiltration area constructed to the north and east of the settling ponds and drainage of the ponds;
- Building demolition and compaction on the existing mill building footprint;
- Consolidation of waste rock concurrently with layers of compacted demolition debris on the mill building footprint;
- On-site isolation and capping of building debris, mill equipment and associated metal-contaminated soils with a geotextile and a minimum of one metre of clean compacted sand and gravel from onsite borrow areas;
- In-situ isolation and capping, with a geotextile and minimum of one metre of clean compacted sand and gravel, of the tailings pond, settling ponds, and high risk contaminated soils on the upper and lower pads; and
- Decommissions of access roads through berms and ditching and signage restricting access.

In consultation with the mineral tenure holder, two small low-grade ore piles were consolidate near the edge of the capped area, capped, and surveyed. This allows the potential for the ore to be accessed in the future with minimal need for cap repairs.

Salvage was looked as an option for the mill equipment remaining on site but was not economic. The mill building was demolished, compacted, and capped in its original footprint. The remedial plan made use of the existing topography of the site. Removal of a waste rock retaining adjacent to the former mill and natural, uncontaminated hills used as borrow sources on either side of the mill allowed the area to be reformed into a continuous slope over the demolished mill building (Figure 2, Photos 4 and 5).

Given the remote location, clean sand and gravel from three undisturbed hills was used as a borrow source for the cover material. Given the source of the cover material, it was difficult to visually differentiate contaminated soils from the clean cover. A geotextile liner was used to cover all contaminated material prior to capping to ensure the two materials weren't mixed. It also proved to be invaluable to prove the cover thickness following a survey error, as it clearly showed the cap thickness in test pits.

Monitoring as per the requirements of the approval is ongoing. The cover must be inspected for overall integrity and performance at least once a year for the first five years and once every five years subsequently. Groundwater monitoring and sampling of compliance wells for dissolved metals is required on the same schedule, with reports provided to MOE annually. The groundwater monitoring is particularly important to ensure attenuation continues as expected. The monitoring frequency density has been higher than required under the authorization. Revegetation efforts will commence once it is confirmed that the addition of an impermeable cover is not required.

SUMMARY

Remediation of Historic Mine Sites must comply with the requirements of the British Columbia *Environmental Management Act*, the Contaminated Sites and Hazardous Waste Regulations and associated Protocols, Policies, Procedures, and Technical Guidance Documents issued by the Ministry of Environment. Remedial plans need to be developed taking site specific conditions into account. At Atlin Ruffner mill and tailings site, a remedial plan that successfully risk managed contamination under the CSR still required permitting under the HWR. Site specific conditions suggested a variance from the regulated conditions could provide equal protection to human or ecological receptors as offered by the HWR. Application for specific changes to the regulation was made and approval was granted.

The optional remedial solution for any historic contaminated site needs to be assessed on a site-specific basis with clear objectives and an understanding of the regulatory requirements. Investigating options for site specific regulatory changes may allow completion of remediation in a timelier and more cost effective manner, freeing up resources for the remediation of other sites.

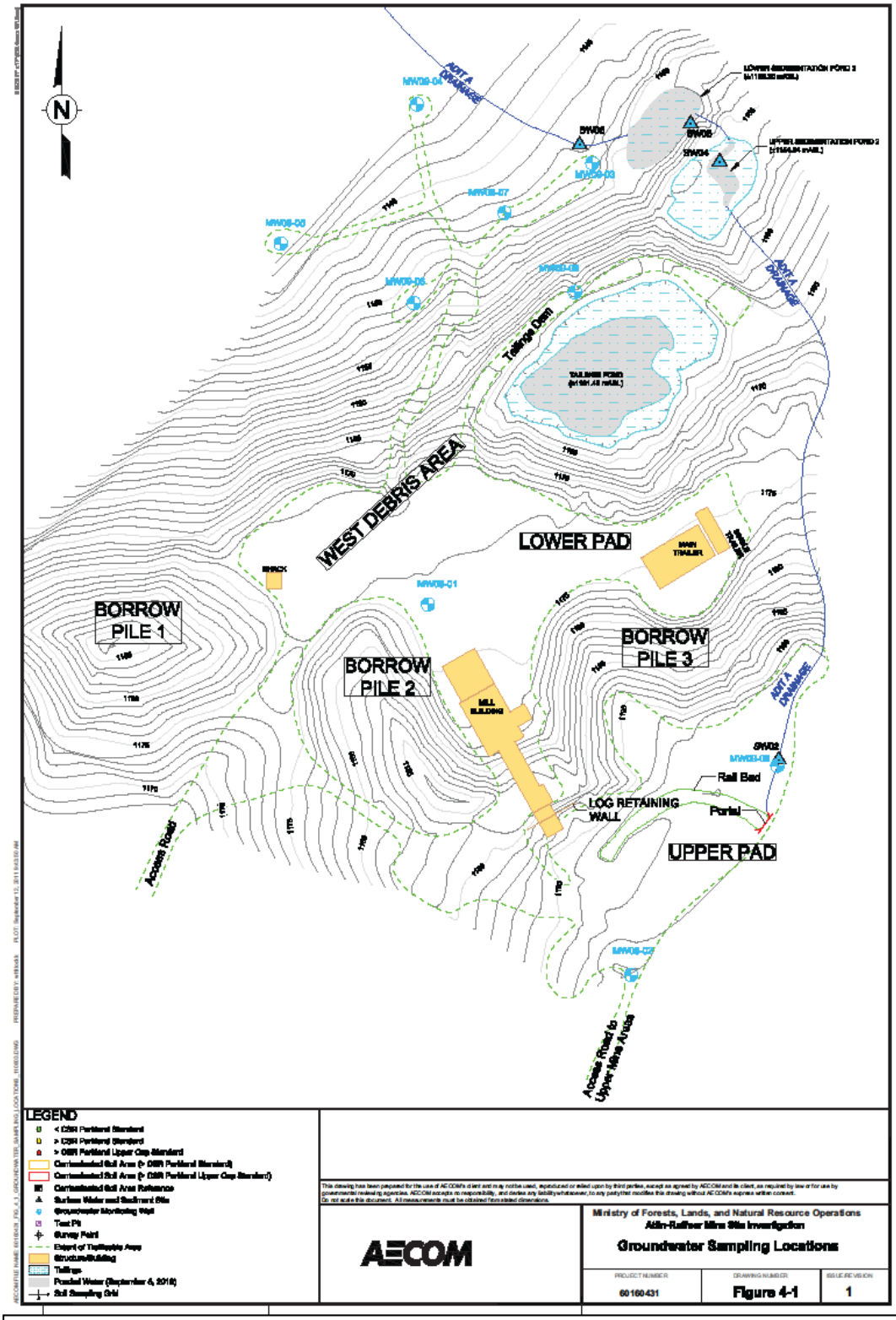
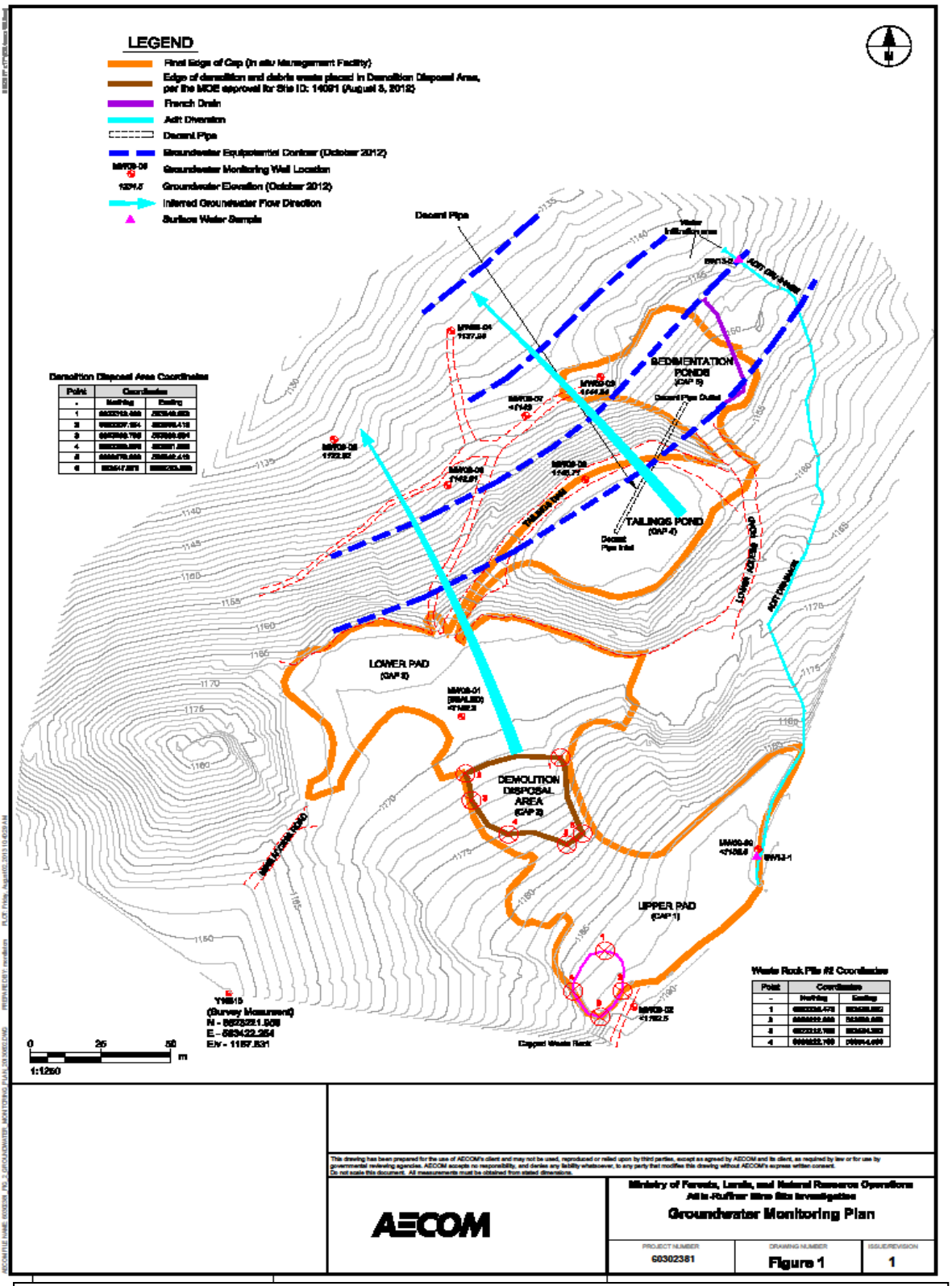


Figure 1: Site Plan Prior to Remediation of Atlin Ruffner Mill and Tailings



AECOM

Ministry of Forests, Lands, and Natural Resource Operations
Atlin Ruffner Mine Site Investigation

Groundwater Monitoring Plan

PROJECT NUMBER	DRAWING NUMBER	ISSUE/REVISION
60302381	Figure 1	1

Figure 2: Site Plan Following Remediation of Atlin Ruffner Mill and Tailings

Photo 1: Adit, mill building, trailers, upper and lower mill pads, and portion of tailings pond prior to remediation (October 2008).

Photo 2: The settling ponds seen from the top of the tailings dam, prior to remediation (October 2008).

Photo 3: The lower mill pad, with the tailings and lower settling pond in distance prior to remediation (October 2008).

Photo 4: The site post-remediation, with the tailings area in the centre. (June 2013)

Photo 5: The site post-remediation, with the former mill area and access road in the foreground. (June 2013)