CANADIAN CONSULTING engineer

AECOM

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Giant Mine Roaster Complex Decontamination and Deconstruction

Contaminated arsenic waste outside Roaster Complex

75 Word Summary

PWGSC and AANDC needed to deconstruct the Giant Mine Roaster Complex buildings which were at risk of collapsing, potentially releasing asbestos, arsenic trioxide, cyanide and other hazardous materials into the environment. AECOM and sub-consultant Golder completed assessment, project design and contractor supervision. Multi-faceted work control standards were developed to: minimize exposure to asbestos, arsenic, cyanide, and arsine gas by on-site workers; to protect the public and the environment; and to confirm when decontamination was complete.

Introduction

Giant Mine, located within the city limits of Yellowknife, Northwest Territories, operated from 1948 to 1999, producing more than seven million ounces of gold during its lifespan. This orebody was such that it required an oxidation process to extract the gold from arsenopyrite, a mineral containing arsenic, iron and sulphur. Chemical roasting was the only efficient oxidation process available when Giant Mine was developed. Roasting operations began in 1949, converting raw ore into calcine, which was further processed, creating sulphur dioxide and arsenic vapour, which were vented directly to the atmosphere. The first air emissions controls were introduced in 1951 and captured arsenic in the form of arsenic trioxide.

The roaster complex was the group of buildings and associated infrastructure whose purpose was to separate the gold from the Giant Mine ore and treat the air emissions to reduce the release of arsenic trioxide into the atmosphere. The complex expanded over time as more efficient technologies became available and were incorporated into the process train. According to some estimates, the roaster complex released as much as 20,000 tonnes of arsenic trioxide into the atmosphere, whereas 237,000 tonnes were collected by the emissions controls measures and are currently stored underground. The complex footprint including surrounding laydown areas was approximately 7,800 m^2 (slightly smaller than a football field). The roaster complex consisted of the following ore process facilities, as depicted in Figure 1:

- Allis-Chalmers (AC) roaster building (1400 m^2)
- Calcine plant (600 m^2)
- Dorrco roaster building (750 m^2)
- Cottrell precipitator building (510 m^2) (part of air emission controls)
- Baghouse building (part of air emission controls)
- Stack fan building (80 m^2)
- 46 m tall exhaust stack
- Exterior flues and other ancillary infrastructure
- 425 m^3 capacity silo
- Weight scale house (150 m^2)

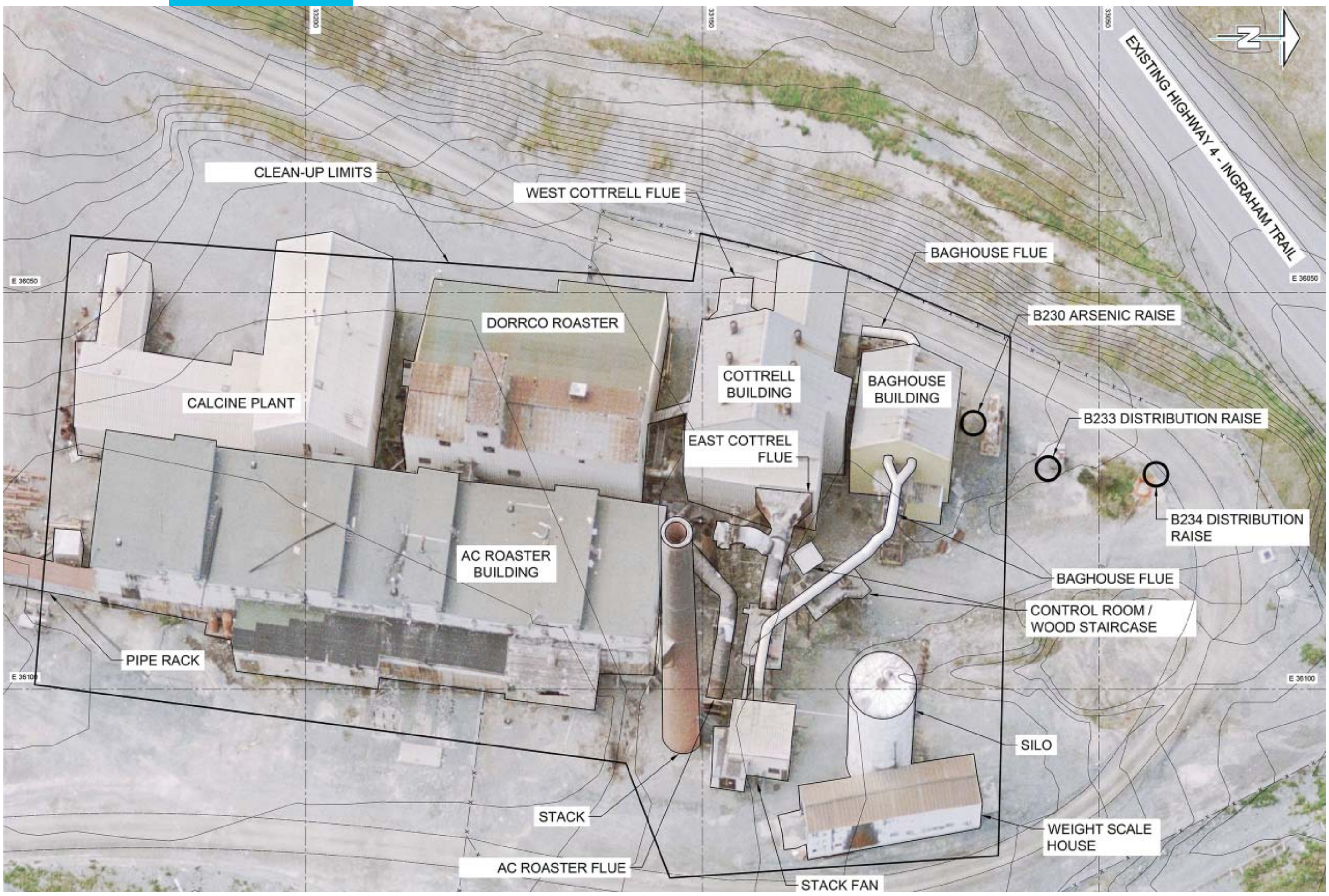

Figure 1: Site Plan – Overall Giant Mine and Roaster Complex

The silo and weight scale house were not part of the process train, but were added to the complex at a time when the mine operator was attempting sell arsenic trioxide commercially.

In 1999, the mine operator declared bankruptcy, and care, custody and liability of the site were transferred to the federal department of Indian Affairs and Northern Development (later known as Aboriginal Affairs and Northern Development Canada [AANDC]) as land administrator by default. At the time of the transfer, the roaster complex, which was locked up and no longer maintained, was known to contain large amounts of arsenic containing dust and asbestos containing materials to differing levels, as well as other hazardous materials. Several structural assessments also identified a number of building structural integrity concerns. In September 2011, the structural observations, evaluations and concerns from multiple reports were compiled by AECOM and formalized in an engineer's letter report.

The report identified noticeable structural degradation in the roaster complex and recommended that deconstruction of the flues and stack be planned within one year, and the other structures be deconstructed within 2-3 years. The likelihood of building and associated infrastructure failure was increasing with time, with increasing risks to the public, on-site workers and the environment for releases of arsenic, asbestos and cyanide in the event of failure. The risk of failure of these structures was particularly acute because the roaster complex was located, at its closest point, approximately 50 m from Highway 3 (Ingraham Trail), which is highly used by motorists as well as cyclists and runners. The project team was already seeking regulatory approval to implement the overall Giant Mine remediation plan at this time. However, the risks of structural failure and of contaminant release at the roaster complex were deemed serious enough that a separate regulatory review process and approval was sought under emergency circumstances.

AECOM was retained by Public Works and Government Services Canada (PWGSC) to complete a detailed hazardous material survey and waste audit, as well as to prepare specifications and contract documents for the decontamination and deconstruction of the roaster complex. Following contract award, AECOM was also retained to provide construction oversight and quality assurance (QA) services to inspect the work completed by the contractor and to verify methodologies and procedures utilized in industrial hygiene and ambient air monitoring programs. For this multi- year assignment, Golder Associates was a sub-consultant to AECOM.

Innovation

The technical aspects of assessing and demolishing such a highly contaminated complex were a significant source of difficulties, and multiple measures, programs, plans and procedures were put into place to protect workers, the public and the environment. The urgent nature of the work also introduced its own challenges to the planning, contracting, community engagement, regulatory and execution requirements for the project. A functioning project team, consisting of individuals from across governmental departments, communications officers, health and safety officers, managers, consultants and contractors, was critical to successfully meeting the multifaceted demands of this project.

The timing of the waste audit and the circumstances under which the work had to be completed were a challenge. Because of the need to have the work completed as soon as possible, the assessment was completed in March of 2012, during which time the average temperature was approximately -20 degrees Celsius (^{0}C). This limited the duration in which the assessment workers could be safely inside the buildings, in the required PPE, on a daily basis. Furthermore, there was limited lighting, because there was no power supply to the complex. The buildings were sealed and could not be opened up due to the risk of release of asbestos and arsenic-containing dust, and setting up inside lighting would have required a considerable effort and cost in terms of additional support worker training to enter the complex to set-up power supply and equipment. As such, the assessment work was completed using flashlights and headlamps.

Some areas could not be safely accessed due to previously identified structural issues. Finally, in some buildings, particularly the Cottrell precipitator and the Baghouse buildings, the internal structures and equipment containing arsenic waste were sealed and coated with asbestos insulation impregnated with arsenic dust, which did not allow for them to be safely opened up due to the risk of air quality issues beyond the capacity of the provided respiratory protection for workers (for example arsine gas could be created from heat generated by cutting). The trade-off between project delay to enable contractor logistical support to complete a more thorough assessment versus proceeding to design and tender with a limited assessment and waste quantity uncertainty had to be addressed in the contractual set-up of the decontamination and deconstruction work.

To that end, AECOM worked closely with PWGSC to develop a two-phase contracting process and means for evaluation of the bids for the decontamination and deconstruction work so that only a qualified contractor undertook this work. The first phase was to pre-qualify contractors by outlining the scope of work, risks, and evaluation criteria, with an evaluation completed based on the bidding contractor's qualifications. Only firms that met the criteria in the first phase were invited to the next phase. During the second phase, multiple bidders' conferences were held in addition to tours lead by AECOM. This enabled contractors to obtain a better understanding of the project, and subsequently produce higher quality proposals. A rigorous evaluation and scoring procedure was implemented for evaluation of bids: the proposals were evaluated on the basis of the "Assessed Best Value" of the highest combined rating of technical merit (70%) and price (30%).

The results of the detailed waste assessment revealed that: large volumes of arsenic waste remained in process vessels and air handling infrastructure; asbestos insulation (including amosite, chrysotile,and crocidolite) covered almost all internal structures and building interiors; asbestos insulation was coated in arsenic-containing dust; asbestos insulation was delaminating and mixed with arsenic-containing dust on floors and other surfaces; and that in some buildings, sodium cyanide was also present mixed in with process waste and surface dust. In addition to dust and process waste solids, porous structural materials such as wood and brick had become impregnated with arsenic over time, such that they were also contaminated with hazardous levels of arsenic. Finally, multiple other hazardous materials were identified such as mercury containing equipment, potentially PCB containing equipment, hydrocarbons, chemical reagents, and other miscellaneous hazardous waste.

The overall conclusion of the waste assessment was that building decontamination would need to be completed in such a manner that there would be simultaneous removal of arsenic, asbestos, and cyanide-impacted materials. Furthermore, because of the arsenic-hazardous waste classification of structural elements such as wood and brick (which included the entire outer structures of the AC Roaster building and stack) decontamination work would have to be completed in two stages. There were no existing guidance documents or regulations for addressing this type of complicated abatement work.

Multi-faceted decontamination work control measures, plans, and procedures therefore needed to be developed to protect the public and the environment, as well as to monitor the health and safety risks to on-site workers. This required a mix of inside and outside building air monitoring while decontamination was proceeding. To further complicate the situation, the control measures also needed to account for the fact that the soil surrounding the roaster complex was also highly contaminated with arsenic, so the sources of arsenic were both inside the buildings as well as outside on the ground.

Contract specifications were developed and written to provide multiple levels of protective controls under which the work must be done and with several important considerations in mind:

1. Regulators (and stakeholders) needed to be sufficiently satisfied that the levels of controls that were being specified would be sufficient to have the work proceed in a manner that protected the public, the environment, workers and met the required regulatory requirements; and
2. The controls were not so specific as to dictate to a contractor how the work must be done, thereby losing the value of the contracting method outlined above that provided for only highly qualified and experienced contractors being awarded the work.

The overall goal of the specifications was to set-up sufficient controls but also to allow the work to proceed essentially as a design-build contract. The controls had to be clear and measurable to allow for specification enforcement. Regarding item 1 above, AECOM worked closely with the client and regulators to provide the specification information in clear language to allow for regulator and stakeholder review and approval in support of obtaining the necessary water licence under which the work was allowed to proceed.

In addition to controls regarding how decontamination work proceeded, clear, measurable, and achievable multi-contaminant clean-up standards also needed to be developed to confirm when decontamination was complete, such that remaining structural elements of the buildings could be classified as non-hazardous waste. The measures had to account for the fact that some of the structural building envelope items – such as wood – had impregnated arsenic within the porous structural elements; surface wipe sampling would therefore not be appropriate. They also had to account for the inevitable amount of dust that always remains in buildings embedded within the structure, even after thorough decontamination, but that in this case, the dust was highly toxic and the public was a nearby receptor. In that sense, the procedures needed to be highly conservative. An "air clearance" sampling method was implemented, similar to that used for asbestos abatement when a building will remain in use following asbestos removal. The specific details regarding both decontamination work control measures as well as decontamination cleanup criteria are discussed further below, under "Complexity".

As an added level of protection against the remaining dust present in buildings during deconstruction,an ambient air monitoring program – to protect the public - was developed by AECOM for implementation along the perimeter of the roaster complex work area. This same monitoring program was also implemented at the overall Giant Mine property boundaries and was tied to a community air monitoring system. Risk-based action levels were developed for arsenic, total suspended particulates (TSP), and particulate matter with a diameter of 10 microns or less (PM_{10}) (which is considered inhalable). Real-time monitoring as well as discrete sample collection sampling was implemented. Because it was not possible to measure arsenic airborne concentrations in real-time, PM_{10} real-time monitoring was used as a surrogate to guard against potential arsenic exposure.

While designing specifications under which the work had to proceed were sufficiently complicated, the implementation and effective use of the control measures required a high level of QA oversight in that the arsenic contaminated soil outside of the structures made interpretation of data problematic. In particular, it was difficult to determine if the outside building air monitors were detecting arsenic being released from inside the enclosed buildings or from outside dust arising from contaminated soil being disturbed by equipment traffic. AECOM therefore worked closely with the contractor to provide suggestions on where best to position outside and inside air monitors, and in particular during decontamination confirmation air clearance sampling, to best document the source areas. AECOM also provided input on procedures to implement during the air clearance sampling – such as completely sealing the buildings – so that air monitoring inside the buildings was not being influenced by outside dust coming inside. While challenging to implement, in the end, the selected work control and clean-up standards did prove achievable and effective in protecting the public, environment and workers.

Complexity

While the abatement work control methods, completion standards and medical monitoring required for high-risk asbestos abatement are well established and regulated, developing similarly appropriate controls for dealing with multiple contaminants was a new endeavour. This was further complicated by the fact that the contaminants present and risks varied depending on the actual building being abated within the complex.

For example, the concentration and type of arsenic present within dust and process residuals increased according to where the building was located in the ore process chain. In the AC roaster, Dorrco roaster, and calcine plant buildings, arsenic was not necessarily in the form of arsenic trioxide and not present in as high a concentration. Whereas in the Cottrell precipitator, Baghouse, silo and weight scale buildings the form of arsenic was primarily highly concentrated arsenic trioxide dust. Asbestos-containing materials were also present in different forms in different buildings: the calcine plant, Dorrco roaster and Cottrell precipitator building envelopes were constructed of transite (asbestos-containing cement board) with spray-applied insulation on the building interiors (impregnated with arsenic dust); within the Cottrell precipitator building, the type of asbestos insulation present included both chrysotile and crocidolite, the latter of which has much higher health risks for exposure, thereby requiring more control during abatement work.

Finally, cyanide exposure risk was highly variable between buildings. It was not clear from old drawings and process train maps where exactly sodium cyanide had been added into the process system: the overall process systems had changed tremendously over the operational years of the mine and nothing was clearly labelled. It was clear that sodium cyanide had been added in the AC roaster building, as residuals had been identified during sampling and a circuit was present within the complex. However, that circuit configuration had changed with time. Sodium cyanide residuals were also identified in dust in the calcine plant and the Dorrco roaster building but no clear source area was identified. This represented a significant risk to how work proceeded, as the use of typical water for dust suppression during abatement of arsenic and asbestos particulates could generate hydrogen cyanide gas – a contaminant with acute health and safety risks – which required an entirely different type of respiratory protection than when dealing with particulates. In addition to hydrogen cyanide gas, the use of heat – such as for cutting structures either coated with arsenic or containing arsenic waste – carried the potential to generate arsine gas, which is also a contaminant with an acute risk, not protected by the typical respiratory protection that would be utilized for the primary arsenic and asbestos particulate risks.

The project adopted the same control standards and procedures as for high-risk asbestos abatement work, but increased the level of air monitoring to account for the higher risk and more dispersible nature of arsenic-containing dust and to account for hydrogen cyanide and arsine gases. The increased level of air monitoring also helped address interpreting arsenic dust sources to account for the inside and outside contaminated soil sources. The primary control measures specified to address these risks included the following:

- A sealed, contained environment (“containment” or “enclosure”) needed to be established within each building, with negative air establishment, and two-staged entry/exit points for personnel and/or waste containers. For the buildings constructed of transite with spray-applied insulation impregnated with arsenic on the inside, this required a full scaffolding system to be installed outside of the building with a shrink-wrap containment installed on the external scaffolding. For other buildings, all openings had to be sealed off.
- A three-stage worker decontamination unit (DCU) was required, consisting of a clean room, a shower room, and a dirty room, with set PPE donning and doffing procedures within each stage.
- Inside enclosure air quality monitoring samples were to be collected, with a sample collection frequency of two samples per shift for every 10 workers inside the enclosure for each building being worked in. Samples were analyzed for asbestos and arsenic, and were to be representative of worker breathing space, and collected for comparison to the published threshold limit values (TLVs) for a full shift, and 15-minute ceiling limits established by American Council of Government Industrial Hygienists (ACGIH), with consideration of the protection factor supplied by the respirator in use. It was particularly important that regardless of the number of workers

in each building, each crew (up to 10 people) have occupational air monitoring to address the issue of contaminant risk variability and uncertainties between buildings.

- In addition to the above, a set coverage of one personal data logging monitor for hydrogen cyanide was required for each separate work crew, with alarm set to sound at 50% of the ceiling limit for hydrogen cyanide. Because of the uncertainty regarding where cyanide may be detected, this was, in practice, applied to each building.
- Where arsine gas might be generated by heat via cutting procedures where arsenic trioxide was present, the primary worker involved with cutting was required to wear a personal data logging device to monitor for arsine gas exposure, which was set to alarm at 50% of the ceiling limit for arsine.
- Outside enclosure air quality monitoring was required with a minimum of:
    - One air sample for arsenic and asbestos within the clean room of each DCU.
    - One air sample for arsenic and asbestos and one hydrogen cyanide gas datalogging monitor equipped with alarm adjacent to each enclosed area entrance.
    - One additional air sample for arsenic and asbestos adjacent to the enclosure for every 450 m^2 of enclosure area to provide additional control monitoring for large enclosures. This was the additional level of air monitoring implemented to cover the additional risk of exposure posed by arsenic but also to provide input regarding potential outside sources.
- If asbestos fibre levels, arsenic or hydrogen cyanide contaminants were detected inside enclosures above 50% of the protection factor of respirators in use, abatement work was to be stopped, with further dust control measures put in place and/or the use of a higher safety factor in respiratory protection for personnel implemented inside the enclosure or work area. The use of 50% of the respiratory protection factor is considered the action level by ACGIH for implementing corrective measures.
- Abatement work was to be stopped and dust controls implemented if measurements outside of the abatement work area exceeded half of the TLV for asbestos and arsenic or if hydrogen cyanide was detected. Corrective measures had to be implemented. Half of the TLV is the concentration at which respiratory protection needs to be implemented. Because hydrogen cyanide has an acute response in terms of health and safety, as recognized by it having a 15-minute ceiling limit versus an 8-hour time weighted average TLV, any detection of hydrogen cyanide outside of enclosure was considered a particular concern.
- All air monitoring results for asbestos had to be available within 24 hours of sample collection, consistent with the Workers Safety and Compensation Commission (WSCC) Code of Practice for Asbestos Abatement. Asbestos samples could be analyzed under a short turnaround as they could be analyzed on-site or in Yellowknife.
- In consideration of the need to send arsenic to an actual laboratory for analysis, the reporting timeline for arsenic was increased to 48 hours.
- All air monitoring results had to be both reported to AECOM and also made available in a location to abatement workers to confirm to them that they were wearing the required respiratory protection.

For almost all buildings, other regulatory concerns also had to be addressed in the specifications and monitored

Giant Mine Roaster Aerial View

in terms of QA for adherence to regulations: these include working from heights and working in confined space. In particular, most of the large internal ducts and exterior flues, given their large sizes, required that abatement workers enter into them to remove waste from within through scaffolding platforms. These requirements, while closely regulated, required that AECOM provide particular QA oversight, given how common they were on the job, to confirm contractor compliance with regulations.

A measurable standard needed to be developed to document when abatement work for arsenic, asbestos and cyanide had been completed. In particular, a standard needed to be adopted for arsenic. While there are some limited surface wipe standards for decontamination of arsenic, none of these were appropriate in the case of the roaster complex, given the elevated level of total arsenic concentrations present throughout the Giant Mine site, and the widespread presence of porous structural items that were also classified as arsenic hazardous waste. The continued presence of arsenic-impacted dust within the overall building structures, even after a comprehensive visual inspection, that could be released during deconstruction also needed to be recognized. The project therefore adopted the same procedure as for high-risk asbestos abatement for where buildings will continue to be used following abatement – an aggressive air clearance sampling program. This program included the following:

- After the abatement work area had passed a visual inspection confirming no visible dust remained, a coat of lock down agent (encapsulant) was to be applied to all surfaces to seal down any residual remaining dust and allowed to dry.
- Prior to collection of air clearance samples, all surfaces were to be agitated with forced air, such as using a leaf blower.
- After surface agitation, air monitoring samples and a hydrogen cyanide monitor were to be set-up to run with a spacing of one sample for each contaminant for every 110 m^2 of enclosed space.
- Air monitoring samples were to be run for a sufficient time period to allow for analytical confirmation that airborne concentrations were less than 10% of the TLV for asbestos and arsenic (0.01f/cc asbestos and 0.001 mg/m^3 arsenic) and that no hydrogen cyanide had been detected.

Air clearance sampling was the measure of what was classified in the specifications as “stage 1 decontamination.” Almost all buildings also required “stage 2 decontamination” in that they contained or were constructed of structural elements that were also classified as arsenic hazardous waste. These included: all wooden structures, including the entire building envelope of the AC roaster building, wood and brick structures within the calcine plant and the Dorrco roaster building that could not be accessed for internal dismantling by heavy equipment within the buildings, structural steel elements with adhered arsenic scale within the Dorrco roaster, the Cottrell precipitator building, the Baghouse, and the Silo, and the entire Stack. For these buildings, decontamination needed to proceed simultaneously with deconstruction, but using the same air monitoring requirements to document worker breathing space air quality as well as outside work area sampling.

As an added precaution beyond the dust and exposure control measures, air monitoring and PPE requirements, all workers involved with the roaster complex decontamination and deconstruction work underwent medical monitoring to monitor for exposure to arsenic. The contractor initiated their medical monitoring program at the start of the project, collecting urine samples and using an action level of 100 ug/m^3, in accordance with the protocol in place before the mine ceased operations which had been continued by the mine care and maintenance contractor.

However, the urine concentration at which workers were assessed as being potentially occupationally exposed with work restrictions imposed was also re-assessed by the WSCC during the course of the project. The ACGIH recommends a biological exposure index (BEI) for inorganic arsenic plus methylated metabolites concentrations in urine of 35 ug/m^3. A concentration above this level suggests that there has been a risk of arsenic exposure, and it is a level that should not be exceeded routinely on a long term, chronic basis. However, the measurement of this concentration is fraught with interpretation challenges in that inorganic arsenic is present in many foods and such lifestyle choices such as smoking or chewing tobacco will also contribute to a measured exposure in urine and there is no way of distinguishing between occupational and non-occupational exposure. Studies have demonstrated that the BEI can be exceeded routinely in a percentage of the population through lifestyle choices. Indeed, the ACGIH cautions against the use of the BEI as an enforcement standard, partially for that reason.

Late in the first season of the Roaster Complex work, the WSCC began enforcing that an Employer Report of Injury must be submitted for any worker whose urine sample results exceeded the BEI. As a consequence, documentation of diet in the 48 hours preceding the submission of urine sample became a standard part of the medical monitoring. Investigations were conducted by the contractor for each instance of worker urine sample exceedances to try to identify the source of the exposure and AECOM reviewed each report to confirm that all potential exposure routes had been identified, with reference to relevant abatement and ambient air quality monitoring data. In that regard, AECOM also followed up on each investigation and provided additional input regarding potential exposure routes as part of our QA role. Through this process, AECOM assisted the contractor in identifying potential non-abatement exposure routes related to exposure due to contaminated soil surrounding the complex. This resulted in the contractor applying more rigorous housekeeping measures inside heavy equipment cabs as well as throughout the temporary work trailers on the site and implementing a strict procedure regarding workers needing to wear dedicated on-site outerwear that was changed into and out of each day.

Social and/or Economic Benefits

Work at Giant Mine is subject to review and approval by the Mackenzie Valley Land and Water Board (MVLWB). Any work within the jurisdiction of the MVLWB that requires either the drawing of water or the deposition of waste requires a water licence. This water licence is the instrument by which the MVLWB authorises projects. For certain projects, the federal requirement for a comprehensive environmental assessment under the Canadian Environmental Assessment Act (CEA) is also required prior to issuing a water licence. This environmental assessment is designed to identify potential impacts of the project, as well as measures to mitigate these impacts, the latter of which then become conditions of the water licence.

At the time of project inception, all remediation at Giant Mine was subject to an ongoing CEA Environmental Assessment because of significant concern from the community and regulators regarding how to safely address chemical and physical hazards at the site; however, an application was submitted to the MVLWB to proceed to the licensing phase for the roaster decontamination and deconstruction work without preliminary screening or environmental

Worker Removing Bulk Arsenic from Inside Flue

impact assessment review pursuant to paragraph 119(b) (response to an emergency circumstance) of the Mackenzie Valley Resource Management Act (MVRMA). The application was accepted, and the project went through a concentrated and rigorous licensing process so the deconstruction work could start as soon as possible. This work was arguably the highest risk surface remediation component because of the large quantity of arsenic trioxide within the structures, in close proximity to a highway utilized by motorists, cyclists and runners. This project was therefore closely scrutinized and setting the bar to demonstrate that Giant Mine remediation could be completed safely. As a consequence, the Roaster Complex decontamination and deconstruction work was conducted in a fully transparent manner. The following documents some of the key measures that were implemented in that regard:

- As noted above, the specification control measures were all provided to regulators during submission for project approval and subject to review and questioning by regulators and public stakeholders.
- The specifications had also called for the contractor to provide detailed plans to document how decontamination and deconstruction would proceed at each building, with specific considerations for dust control and management. The conditions of the water licence, upon which the project approval had been obtained, required that these plans be submitted, reviewed, and accepted by regulators and stakeholders, with the opportunity for reviewers to ask questions.
- All ambient air monitoring results were compiled and published weekly to a public registry for review by regulators and stakeholders, with the opportunity for questioning of any data that appeared problematic.
- A webcam was set-up on-site to allow the public to monitor how work proceeded. The project team

moved the webcam as needed to provide ongoing coverage of where work was proceeding.

- Public stakeholder tours were held during work progression where work could be witnessed from a safe distance outside of the contractor's work area.
- A local film producer was allowed access to document the dismantling of the stack as well as other activities on-site as the time, for historical documentation purposes; and
- A Global crew from the documentary program "16 x 9" was allowed to film during work activities, including by overhead drone.

At the start of the project, the WSCC was highly concerned about how the decontamination work was proceeding and the risk to workers. Inspectors visited the site regularly and required that the contractor provide all health and safety procedures to them for review and acceptance. While they were generally satisfied with the decontamination work control methods, there were concerns regarding potential incidental exposure by workers outside of containment that were being reflected in medical monitoring results, discussed above. AECOM worked closely with the contractor and participated in WSCC meetings to develop revised procedures and documentation regarding the evaluation of any workers exceeding the medical monitoring guideline level discussed above to satisfy their concerns.

When the roaster complex project began, it was frequently discussed and scrutinized in local news in an unfavourable manner, and anything posted on the public registry for review was intensely scrutinized by local stakeholder environmental activists.

By the end of the project, however, WSCC had significantly eased up on their scrutiny of how work was proceeding as they had been convinced that work was proceeding safely. This has carried on to subsequent work being conducted at Giant Mine; they do not inspect additional site work with the same level of zealous concern that work will be implemented safely. Furthermore, the level of criticism by local stakeholders and negative coverage in the local press has eased up. The transparency under which this project proceeded has resulted in a much higher level of trust with regulators, stakeholders, and the community at large.

Environmental Benefits

Aside from the environmental benefits of removing the pressing physical and contaminant exposure hazards posed by the Roaster Complex buildings and contents, because this work was proceeding in advance of the overall site remediation, the work was designed to account for interim waste storage requirements and to minimize future work and costs to the project.

In particular, a very large quantity of arsenic hazardous waste had to be stored in a safe manner on-site, until it will be eventually disposed of according to the disposal provisions for arsenic waste on-site covered under the EA submission. As well, other hazardous waste, such as PCBs, potentially needed to be stored for the duration of the roaster complex deconstruction and decontamination project. A hazardous waste storage area was therefore designed and constructed on-site. The selected location was on a tailings pond that had been previously assessed geotechnically for feasibility of equipment trafficking and waste loading placement. The waste area was therefore designed with a previously identified recommended fill thickness overlying the tailings to provide the necessary firm base for heavy equipment trafficking and long storage on the tailings without subsidence of waste. Furthermore, there was an existing drainage collection system passing through the far side of the tailings pond that collected any water from the pond and fed it into the existing mine effluent treatment plant, where it was treated for arsenic as well as other metals.

There is no source of clean granular material at Giant Mine or in the Yellowknife area that is appropriate for pad construction. All clean fill therefore requires quarrying from a local source and comes at a considerable expense. It was recognized by AECOM that any clean fill placed on top of the tailings would essentially become contaminated because the clean granular fill would both sink into the fine-grained tailings, but also that contaminated pore water in the tailings would rise up into the fill. In consideration of the above, AECOM designed the storage area pad to utilize an existing on-site stockpile of contaminated soil as a base layer with only clean fill derived from a commercial quarry on the top surface of the pad to allow trafficking of equipment without the need for decontamination of equipment once it exited the area.

The constructed storage area pad was designed with a gradual grade to drain into the tailings pond drainage collection system. Any spills from the storage area would be therefore be collected and eventually treated. While there were territorial guidelines for hazardous waste storage, because of the high risk of the arsenic waste being stored there, and because of the potential for temporary storage of other non-arsenic containing hazardous waste from the complex prior to shipment off-site (including PCBs), the storage area was designed to be consistent with the strict regulatory requirements under CEA for PCB storage, as no specific regulatory requirements are in place for arsenic trioxide. Fences were erected around the storage area, with signage alerting that it was a hazardous waste storage area. Operational specifications were put in place which required that it be kept locked with access only allowed by hazardous materials trained workers, and regular inspections were required. Spill kits and fire extinguishers were also erected throughout the storage area. Because of the regulatory need to keep PCBs stored separately, a small separate fenced area within the overall storage area was also erected for short-term PCB storage.

The arsenic hazardous waste that was being derived from the roaster complex was a complete mixture of different waste forms, ranging from granular, dust like materials to structural elements such as wood and steel with adhered arsenic trioxide scale. As a consequence, a variety of appropriate different hazardous waste containers would be required for containerization and storage of waste. To provide a broad but clearly regulated standard, it was specified that all hazardous waste had to be placed in containers approved under the Transportation of Dangerous Goods Act and Regulations standards, even though most of the waste would not be transported off-site.

The contractor elected to use 1 and 3 m^3 waste bags as their primary waste containment measure for most of the loose waste. As a consequence, the need was identified to provide additional containerization to protect the waste bags from the elements over the longer term. Several methods were considered, but in the end, marine shipping containers were procured, and utilized for providing additional protection from the elements of waste bags.

The overall Giant Mine site remediation plan calls for the construction of a non-hazardous waste landfill on-site. As such, specifications were developed that would preclude any additional processing needs for non-hazardous waste from the roaster complex being placed in the on-site landfill. The specifications included requirements for waste type segregations, size reduction to set lengths that would allow for placement on a haul truck, and cutting open of any waste with voids. Waste was stored in a location that would minimize hauling requirements down the road, based on the anticipated location of the non-hazardous waste landfill.

Meeting Clients' Needs

The clients' primary driver of this project was to mitigate physical and chemical risks and complete the project safely.

To guard against chemical risks to workers, AECOM developed strict control measures to address the potential for exposure to arsenic and asbestos particulates as well as hydrogen cyanide and arsine gases during decontamination work.

To guard against chemical risk to the public and the environment, stringent control standards for building containment, outside containment air quality monitoring, and ambient air quality monitoring at the fenceline were developed for the project. In consideration of continued risk for release of dust embedded into the structure upon deconstruction, a very strict standard was implemented for identifying when the decontamination was complete. Ambient air monitoring at the fenceline, including in real-time, was also implemented.

Unintended physical collapse was a real risk for some of the structures during work. AECOM therefore specified multiple protective measures: the contractor was required to have a registered structural engineer assess all buildings and ancillary structures to identify structural risks in advance of any work proceeding in the building; and any temporary mitigative measures such as shoring had to be designed by a structural engineer and were also reviewed by AECOM for acceptance.

Finally, for actual deconstruction, the contractor was required to submit a detailed plan identifying the building dismantling procedures and dust control procedures, in consideration of the existing building structural deficiencies and potential areas where dust might remain. This plan also required review and approval by a structural engineer.

In the end, the project safely dismantled all structures and containerized just over 9000 m^3 of arsenic hazardous waste without adverse effect to workers, the public and the environment.

About AECOM

AECOM is built to deliver a better world. We design, build, finance and operate infrastructure assets for governments, businesses and organizations in more than 150 countries. As a fully integrated firm, we connect knowledge and experience across our global network of experts to help clients solve their most complex challenges. From high-performance buildings and infrastructure, to resilient communities and environments, to stable and secure nations, our work is transformative, differentiated and vital. A Fortune 500 firm, AECOM had revenue of approximately $18 billion during fiscal year 2015. See how we deliver what others can only imagine at aecom.com and @AECOM.