AECOM

CANADIAN CONSULTING ENGINEERING **AWARDS**

COLOMAC MINE REMEDIATION

ENVIRONMENT

APRIL **2013**

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Colomac Mine after (2011)

Colomac Mine before (2004)

1. PROJECT **BACKGROUND**

The Colomac Mine site is located 220 km north of Yellowknife. The open pit mine was developed in 1988-89, with gold production commencing in 1990. In 1999, the mine operator abandoned the Colomac Mine site and the Contaminated Sites Office (CSO) of Aboriginal Affairs and Northern Development Canada (AANDC) assumed responsibility for the site. Mine operations had left the Colomac site with many environmental and physical hazards.

A Remedial Plan was developed for the Colomac Mine site in 2004, which identified environmental concerns, physical hazards and the remediation method to be implemented. AECOM was retained in 2009 by Public Works and Government Services Canada (PWGSC), on behalf of AANDC, to prepare engineering design drawings and specification documents for the final site remediation contract to address all remaining remedial work at the site. In addition to detailed design work, AECOM's role included provision of resident engineering services, construction contract administration and technical support during the implementation of the remediation contract.

The final remediation construction contract was awarded to Tlicho Engineering and Environmental Services Ltd. in joint venture with Aboriginal Engineering Ltd. (TEES-AEL).

2. ENVIRONMENTAL **GOALS**

The environmental goals of the Colomac Mine remediation were to protect fish, wildlife and vegetation, as well as *protect* water quality, *minimize environmental impacts* during remediation, and return the site to its original condition where possible or, to provide an *alternative productive ecosystem*. This was achieved through addressing the environmental impacts in each area of the site. The major components of the remediation were addressed as follows:

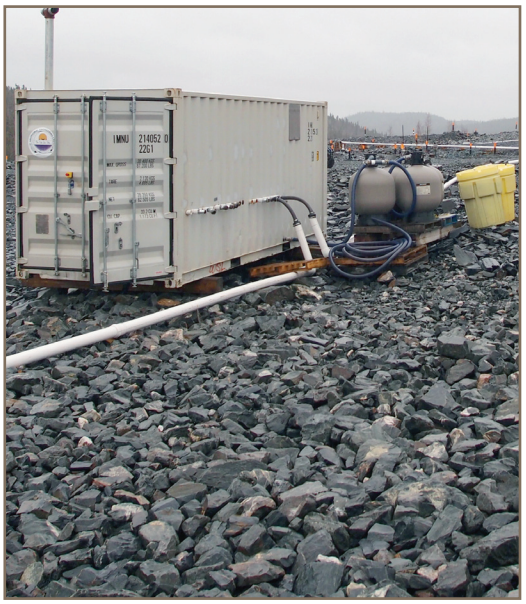
Petroleum Hydrocarbon Contamination

Several small fuel spills and one major fuel spill, estimated at 30,000 litres, occurred during the operation of the mine, which resulted in widespread contamination of soil and lake sediments and the presence of petroleum hydrocarbon free product within the fractured bedrock.

Over 17,000 m^3 of soil and overburden contaminated with petroleum hydrocarbons was excavated and treated in a landfarm on site. Free product within the fractured bedrock was extracted via monitoring/recovery wells using a Multi-Phase Extraction (MPE) system. Free product migrating out of the bedrock fractures at known seep areas on the shoreline of Steeves Lake was captured in two constructed seepage collection systems. A trench filled with peat was created along the shoreline to trap and attenuate free product and impacted water not controlled by the seepage collection systems.

Building upon a challenging remedial concept, AECOM designed an innovative 750 m long cap for hydrocarbon contaminated lake sediments using only on-site materials and requiring no dewatering of the laterally extensive and deep water work area. Coarse-grained waste rock was used to build the new erosion resistant shoreline, serve as a causeway during construction, provide filtration to finer grained capping material deposited on the inshore side, and provide shade and shelter for fish. Contaminated sediments were capped with a mix of native low-permeability silt till and peat to provide adsorption and increased attenuation. A trench was cut into the perimeter berm, filled with peat and silt till, and planted with locally sourced willow stakes and alder seeds to create natural erosion control and improve the new shoreline for fish habitat. The cap was finished with the placement of a surface layer of peat and seeded with natural grasses and alder seeds. In total, the construction of the sediment cap required 6,700 m^3 of natural silty till, 3,500 m^3 of natural peat, 22,000m^3 of rock fill and over 6,500 m^3 of geotextile.

"Over 17,000 m^3 of soil and overburden contaminated with petroleum hydrocarbons was excavated and treated in a landfarm on site."



Multi-Phase Extraction System

"In total, the construction of the sediment cap required 6,700 m^3 of natural silty till, 3,500 m^3 of natural peat, 22,000m^3 of rock fill and over 6,500 m^3 of geotextile."

Steeves Lake Sediment Cap

Demolition Team (main)
Demolition of Main Mine Complex (inset)

Building Demolition and Debris Removal

Buildings and infrastructure remaining on the site following mine operations presented a hazard to humans, wildlife and the environment. Hazardous materials remaining on-site presented a risk of exposure to humans, wildlife and the environment.

In total, four large buildings, a camp complex, five above ground conveyors, two underground conveyors, 21 large tanks and all related infrastructure was demolished. Prior to demolition, each building was assessed for hazardous materials and then decontaminated. Cyanide contaminated dust was prevalent in many of the on-site buildings and extensive decontamination work was completed to eliminate the hazard to site workers and to the environment. Removal of the cyanide contaminated dust had to be completed without allowing the dust to come into contact with water, as cyanide gas would have been created. The dust was removed by large vacuums with HEPA filters.

In addition to the debris created during the demolition of infrastructure, non-hazardous debris was present over much of the mine site. The non-hazardous waste landfill was constructed in one of the open pits, blasted out during mine operations. This area was previously disturbed as non-hazardous waste had been placed in this location previously. A reduction of physical hazards was achieved by completing and capping a landfill in this location as the previously placed waste was covered and the pit depth was greatly reduced.

All hazardous material was shipped to an off-site disposal facility. Contaminated dust and mill process waste derived from building decontamination and spilled tailings around the buildings were placed within a disposal cell in a pre-existing tailings containment area. The open cell was capped with clean overburden to eliminate exposure to the contaminated tailings. Segregation of contaminated waste from hazardous waste resulted in a substantial savings in time, effort and funds as the material did not need to be packaged and transported to an off-site disposal facility.

Borrow Material

A large volume of borrow material was required to compete final remediation of the site. The main source of the borrow material on site was the waste rock piles, and screening equipment was used to produce the required granular material types. By using the waste rock, the amount of granular material to be removed from the natural environment was greatly reduced. For material types that could not be produced from the waste rock, including organic peat material, three existing borrow areas were identified for sourcing material.

Waste Rock Piles and Open Pits

The waste rock piles left over from mine operations were identified as physical hazards to caribou and other wildlife. The Colomac area is home to an identified 22 species of mammals including caribou, moose, black bears and fox. The Bathurst caribou herd migrates annually through the area to access its calving grounds. It was important to identify and eliminate these hazards as Caribou are a critical wildlife resource for the Tlicho community as a primary food source, but also as part of their spiritual and cultural identity. Waste rock berms (called "caribou berms") were designed in consultation with Tlicho Elders and strategically placed to prevent caribou migration into these areas.

Several large open pits exist on the site following ore removal and borrow source development during mine operations. Some of the high vertical walls left by this blasting and excavation were located in areas that could not be effectively isolated from human and wildlife movement. To mitigate the hazard posed by these large drop offs, large boulders were placed along the ridge of the drop offs. These boulders were intended to serve as a visual warning and a physical barrier.

Aquatic Habitat and Protection of Water Quality

Several areas of natural drainage were impacted during mine activities by placement of roads and mill building pads over natural waterways. Drainage restoration was completed to create or restore fish habitat and fish migration pathways in accordance with the requirements of the Fisheries Authorization obtained for the remediation work.

Restoration was completed at areas where haul roads had restricted the natural drainage by excavation of the roadway and re-establishment of the natural drainage pathway. More complex drainage restoration activities that included creation and enhancement of riparian habitat and fish passageways were completed at the Steeves Lake to Truck Lake channel and the Tailings Lake drainage channel.

Tailings Lake Discharge Channel

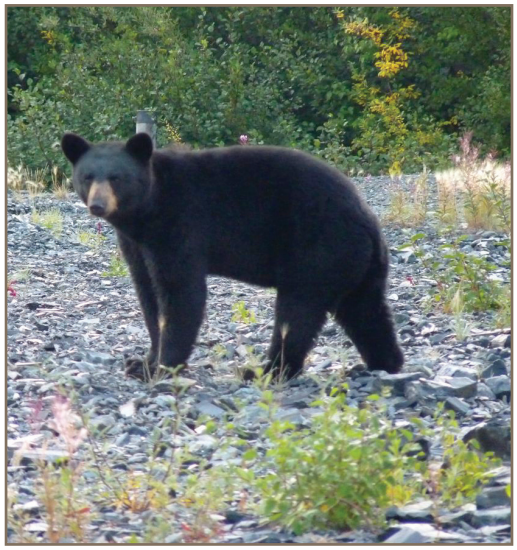
The discharge channel, a wide flat channel, was previously completed to allow passive drainage from Tailings Lake to L-Shaped Lake but was not amenable to fish passage. The channel was improved by adding a terraced section to the channel base to create a small meandering stream suitable for fish passage and lowering grades in areas of hydraulic drops.

Tailings Lake Discharge Channel

Tailings Lake Discharge Channel

Bull Moose at Tailings Lake Discharge Channel

"The Colomac area is home to an identified 22 species of mammals including caribou, moose, black bears and fox."



Black Bear in the Main Camp Area

Successful growth of willow stakes

Re-vegetation was completed along shorelines and channel banks to create riparian zones to enhance fish habitat by providing shade cover and temperature control for the near-shore water, and by reducing surface runoff and erosion. Sedge plugs, willow cuttings and alder seeds harvested from the site with a commercially produced grass seed mix containing species native to the area, were used for the re-vegetation.

During the completion of the drainage restoration works and the installation of the Steeves Lake sediment cap, measures were put in place to protect the water quality and aquatic habitat in and near the work areas. Completion of the drainage channels and the cap involved both the excavation and placement of granular material which resulted in increased turbidity and sedimentation in the water. To mitigate the risk to aquatic life and habitat, erosion and sedimentation control measures were implemented such as silt fences, sediment traps and impermeable silt curtains.

Following the installation of the silt curtains in several water bodies, an AECOM Fisheries Biologist was brought to site to develop and implement fish salvage procedures to remove fish from areas of in-water works. Due to the unique size and location of each isolated area, various salvage techniques were used. Techniques included angling, electrofishing, use of seine, drag and fyke (hoop) nets and use of a minnow trap. In addition, the biologist developed a plan for on-going water quality monitoring of the work areas. The biologist trained Tlicho employees to complete the water quality monitoring and to provide assistance during salvage activities.

Through the improvement of drainage pathways and existing shorelines, approximately 16,000 m^2 of new aquatic habitat, fish passage ways, flood plains and riparian habitat was created.

Truck Lake to Steeves Lake channel

The channel, completed to restore drainage and fish passage between Truck Lake and Steeves Lake, consisted of a seasonally flooded wetland on the shore of Truck Lake that fed into a constructed shallow meandering stream cut into a wide channel. The stream section was designed to allow for fish passage during times of high water.

Truck Lake to Steeves Lake Channel

Whitefish relocated from active work area

"Through the improvement of drainage pathways and existing shorelines, approximately 16,000 m^2 of new aquatic habitat, fish passage ways, flood plains and riparian habitat was created."

Newly planted willow stakes along Steeves Lake new shore

Successful growth of willow stakes

Effective containment of turbidity caused by construction activities

Daily monitoring of Steeves Lake

Use of hoop nets in Steeves Lake

Planting of live willow stakes

One of twelve leach tanks requiring decontamination

3. INNOVATIVE **APPROACH**

Due to the ever-changing conditions present on the Colomac site, several of the planned work items had to be modified or re-designed during the remediation. Redesigns required flexibility, ingenuity and creativity on the part of AECOM and the Contractor.

Leach Tank Decontamination

Twelve leach tanks were located outside the mill as part of the cyanide leaching process and each tank contained solid tailings and ice to be removed as part of the decontamination process prior to demolition. The contents of each tank were to be removed in a solid state and disposed of in a disposal cell for tailings contaminated waste. At the start of the remediation it was identified that the liquid within the leach tanks was not frozen and would have to be removed. The liquids were sampled and based on the analytical results, detailed contaminant loading mass balance calculations were completed for Zone 2.0 Pit, a large water-filled pit created by the ore mining process. It was determined that the release of water into the pit would not be detrimental, and 7,750,000 litres of water was released into the pit via a bed of corrugated steel pipe, salvaged from a demolished building, to provide aeration, slow the water velocity and remove suspended sediments. The leach tank liquids were successfully pumped into the pit with very little disturbance to the receiving water and the solid contents of the tanks were able to be removed and hauled with trucks to the disposal cell.

Corrugated steel pipe used to aerate discharging water in zone 2.0 pit

"The leach tank liquids were successfully pumped into the pit with very little disturbance to the receiving water..."

Spot Pond to Truck Lake Drainage Restoration

Natural drainage conditions between Spot Pond and Truck Lake were severely altered during mine operations by placement of a mine access road over an existing creek that connected two water bodies. The existing creek was identified for completion of a drainage restoration consisting of an extension of the Spot Pond to enhance the connection to the channel, removal of the road base and reduction of the overall grade of the creek to facilitate fish passage. During excavation of the Spot Pond extension and road removal, a significant amount of subsurface flow was noted through the side walls of the excavation. The subsurface flow caused significant erosion and a substantial reduction in the water levels in Spot Pond. Following completion of the road removal, it was clear that the hydraulic grades that existed prior to the mine development could no longer be maintained with an open channel. An AECOM hydrotechnical engineer was brought to site to assess the drainage channel and develop a long term control for the channel discharge. A plug-like dam, to be placed in the location of the former road bed, was designed and constructed from granular material salvaged from the interior of the concrete footings in the mill and polypropylene geomembrane liner left over from other site activities. Following installation of the plug, the water levels in Spot Pond rose to pre-construction levels and erosion was no longer observed along the walls of the Spot Pond extension.

Seepage Collection Systems

Hydrocarbon contaminated soil and subsurface free product was present throughout the mill complex area due to historical fuel spills. Two of the areas identified for contaminated soil excavation were located downgradient of the mill complex area, along the shoreline of Steeves Lake in areas historically observed to input hydrocarbons into the lake. As the areas were excavated to bedrock, free product was observed seeping through fractures in the bedrock. The impacts discharging at these two locations would not be attenuated by the peat trench located on the sediment cap downgradient due to the volume and concentration of hydrocarbons. To mitigate this, a seepage collection system was designed for each area to intercept and collect the discharge and allow for both monitoring and extraction of the free product. The system consisted of a slotted PVC pipe laid horizontally in a trench to collect discharge and several riser pipes to allow for the monitoring and removal of product. The collection systems were designed to be constructed from materials and equipment available on the site.

Salvage of Demolition Materials

The primary crusher consisted of an above ground building structure, several smaller shafts, and a conveyor access portal consisting of a large diameter open shaft. Remediation of the facility required the removal of the above ground structure, and capping of all open shafts. The initial design for the capping of the large open shaft consisted of a reinforced concrete plug. The cap structure was redesigned to make use of steel plates and beam sections salvaged from demolition. The final design consisted of backfilling the large openings with granular material for temporary support, placement and welding of the plates and beams and final cover with granular material. The salvage of demolition materials represented not only cost savings, but also appreciation for the recycling of onsite material.

Extension of Spot Pond

Installation of the dam in the Spot Pond to Truck Lake Drainage Channel

4. PROJECT **CHALLENGES**

Due to the location and scope of the Colomac Mine remediation, the project was faced with challenging logistics, changing site conditions and varied work activities that required the input of technical specialists. AECOM provided the expertise necessary to complete the remedial objectives.

The complexity of the remediation project required that AECOM provide multi-disciplinary experience and knowledge to complete the remediation objectives. Personnel involved in the project included senior design/project engineer, senior hydrotechnical engineer, geotechnical engineer, fisheries biologists, geochemical engineer, environmental engineers, technologists and scientists.

The Colomac Mine site is located in a remote area of the Northwest Territories and access to the site was available only by air in the summer and by ice road during mobilization and demobilization periods. Due to the logistical difficulties of transportation of equipment and resources, AECOM worked to design and implement solutions such that they could be accomplished using the available onsite equipment, resources and supplies.

The climate of the Northwest Territories provided additional challenges due to the harsh climate and short construction season. Some work activities, such as demolition, were restricted to the summer season due to equipment limitations in severe cold. Though work activities were completed nearly year-round at the site, scheduling, sequencing of work and flexibility were important to complete all work activities within the scheduled time period.

Fish salvage in winter conditions

Plane landing in winter conditions

Colomac Camp

5. COLOMAC AND THE **COMMUNITY**

Public Safety

The Colomac Mine site is within the traditional lands of the Tlicho people. Historically, the area has been used by Tlicho for hunting, trapping and fishing. Prior to the development of the mine, dozens of hunters and families from seven communities trapped annually within 30 kilometres of the mine site. Therefore, the removal of environmental and physical hazards associated with past mine operations was beneficial for the people who continue to actively use the land for food sources, recreation and cultural identity.

Variable ice conditions on the surface of Tailings Lake in winter was an ongoing hazard. Signs indicating weak ice had been placed at regular intervals surrounding the lake, but additional notification for people accessing the area post-remediation was considered prudent. AECOM, in consultation with AANDC and Tlicho Elders, identified locations where snowmobile traffic was most likely to access Tailings Lake. Therefore, barriers at access locations to Tailings Lake were constructed for public safety following the remediation. The granular barriers were designed to serve as visual advance warning to snowmobilers coming through the area, but were not intended to either limit caribou migration or to completely eliminate access to the area.

Tlicho Job Shadow and Wildlife Monitor

Community Contributions

The large warehouse located on the site was not demolished as part of the remediation but was left intact and ownership was turned over to the Tlicho Government to be used for future heavy equipment storage. Additionally, the airstrip at the site was decommissioned through Transport Canada but remains available for use as an emergency landing strip.

In addition, effort was made to provide economic opportunities and training programs for northern and Aboriginal communities in the management and remediation of the site. These efforts included hiring project staff from the surrounding communities, use of Aboriginal owned businesses and services and a job shadowing program for young Tlicho from the community.

Colomac Mine camp facilites

"...the removal of environmental and physical hazards associated with past mine operations was beneficial for the people who continue to actively use the land for food sources, recreation and cultural identity."

Tlicho employees

6. CLIENT **NEEDS**

The Colomac Mine remediation was a dynamic and challenging project that required dedication and commitment from AECOM, the client, the site owner and the community.

One of the goals of the Colomac Mine remediation was to contribute to a safer, healthier, sustainable environment for the Tlicho people and all northerners by preserving and enhancing the ecological integrity of the mine site. This goal was achieved through a strong partnership with the Tlicho, care was taken to adopt traditional knowledge while providing scientific and engineered solutions that were tailored to the northern environment and peoples wherever possible. This included the use of local knowledge and incorporating the unique needs of the local people and environment into the development and implementation of final remediation.

Colomac Mine was named one of the first major contaminated mine sites to be remediated by the Tlicho people, and also recognized as one of the most challenging. At the close of remediation activities, a site blessing ceremony was held at the site that included the unveiling of a commemorate plaque. The plaque is meant to act as a symbol of to the collaborative efforts of the Tlicho community and project personnel, working together on the mutual goal of bringing the site back to a state where wildlife and vegetation can once again thrive. The celebration was well attended by Tlicho Government representatives and Elders, many of whom provided valuable traditional knowledge during the remediation process.

Ultimately, by completing the remediation of the Colomac Mine site to the satisfaction of members of the community and those who rely on the area for food, recreation and cultural identity, AECOM was able to meet the goals of a challenging and complex project and the needs of the client.

Colomac Blessing Ceremony and Celebration

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