**CCE Award Submission** 

Faro Mine Closure: Environmental Assessment



# Introduction / Project Summary

The Faro Mine is located approximately 380 km by road northeast of Whitehorse, Yukon (Figure 1). The Faro Mine was once the largest open pit lead-zinc mine in the world, which resulted in a tailings storage facility, several large waste rock piles, a mill complex, a camp, a network of roads and supporting civil infrastructure. It is situated within the watersheds of Rose Creek and Vangorda Creek, which drain into the Pelly River. Today, it is the site of one of the most complex abandoned mine remediation projects in Canada, with a 25 km<sup>2</sup> footprint in which 70 million tonnes of tailings and 320 million tonnes of waste rock have the potential to leach metals and acid into the surrounding land and water.

The Faro Mine Remediation Project (the Project) was developed to remediate the Faro Mine Site. The Project is led by the Crown-Indigenous Relations and Northern Affairs Canada with input from the Government of Yukon. and First Nation groups.





Remediation of the Faro Mine Site involves significant earth works, water management activities, and measures that are focused on addressing potential risks to human health and the environment. Key components of the Remediation Plan (developed by the engineering design firm with input from the Golder-AECOM team) include creek diversions to avoid contamination of clean surface water, application of covers to isolate and/or restrict infiltration to waste rock and tailings, collection and treatment of contaminated surface water and groundwater, development of borrow sources to support the Project, and land forming and revegetation of the site in an effort to re-establish a viable ecosystem.











Photo 1 Aerial photo of the Faro Pit, Waste Rock Dumps, Mill Area, and Rose Creek Tailings Area

Planning for remediation of the Faro Mine and Rose Creek Tailings Areas was initiated over 20 years ago and has evolved as the Faro Mine Site has continued to deteriorate. The overall philosophy for the Project team is to plan and execute a Remediation Plan that mitigates against the future conditions at the Faro Mine Site (i.e., acid rock drainage) and provides long-term protection for people and the environment by minimizing adverse environmental and socio-economic effects and maximizing socio-economic benefits locally and in Yukon.

The scope of the Remediation Plan is to mitigate for the both current and future conditions on the Faro Mine Site. Some of the waste rock dumps and parts of the Rose Creek Tailings Area are currently producing acid rock drainage. Over time, acid rock drainage is expected to intensify and ultimately affect most of the waste rock dumps and all of the Rose Creek Tailings Area (referred to as "complete onset of acid rock drainage"). The Remediation Plan is designed to mitigate the future conditions with complete onset of acid rock drainage.

Golder Associates Ltd. (Golder) and AECOM Canada Ltd. (AECOM) were contracted by Crown-Indigenous Relations and Northern Affairs Canada to assess the environmental and socio-economic impacts from remediation of the site. The scope of the assessment, called a "Project Proposal" by the Yukon Environmental and Socio-Economic Assessment Board (YESAB), is directly tied to the scope of the Project described above. The scope of the assessment was to identify and evaluate the potential benefits and adverse effects associated with the activities and works associated with the Project during and after remediation activities were completed. This included assessing the impacts of the construction period (approximately 15 years) as well as into the long-term. The assessment also evaluated whether implementation of the Remediation Plan is likely to achieve outcomes that will help realize the five objectives established for the overall remediation of the Faro Mine Complex. Golder and AECOM were also contracted to participate in the on-going environmental monitoring at the site.

# Innovation / Advancement of Technology

### **Environmental Assessment Methodology for Remediation Projects**

The Faro Mine Site is complex system with rapidly deteriorating conditions and the Project is designed to improve those conditions. Comprehensive modelling was completed to evaluate a broad range of potential outcomes to support the environmental assessment of the Remediation Plan, and plans were developed to manage and mitigate the anticipated evolution of site conditions over time.









#### FARO MINE CLOSURE: ENVIRONMENTAL ASSESSMENT

Unlike most projects submitted for an environmental and socio-economic assessment, remediation works are, by definition, works that aim to mitigate ongoing environmental degradation, improve the environmental conditions relative to existing conditions, and provide socio-economic benefits. Current environmental and socio-economic effects assessment regulatory systems in Canada are not designed to evaluate the positive effects of remediation projects in a meaningful way. Golder developed environmental assessment methods to determine both the adverse effects of the construction period and the benefits of the remediation project on key environmental components.

The methods for a remediation project are different from those used to determine whether the adverse effects of a greenfield development project are sufficiently low that the project can proceed. Along with adverse and neutral effects, the positive outcomes were identified and assessed.

Golder-AECOM developed a qualitative method to determine whether the remediation of the site would meet the five overarching objectives. Draft methods were presented to stakeholders several times during their development and were accepted by a multi-stakeholder group as the methods that would be utilized for the assessment.

#### **Collaboration and Engagement**

In the spirit of collaboration, living draft documents of the environmental and socio-economic assessment were shared as they were being developed with the territorial government, federal stakeholders, and First Nations to get input into the development of the assessment. The rationale for this was three-fold:

- 1. To allow for early engagement and feedback from stakeholders in order to incorporate meaningful feedback.
- 2. To address major concerns before the assessment was submitted, to potentially expedite the assessment process, which can take years, particularly in northern jurisdictions.
- 3. To ensure key mitigations that allowed for socio-economic benefits to local communities and First Nations and protect resources of most value to Indigenous people were considered.

### **Technical Excellence**

The Faro Mine Site is complex system with changing conditions and the Project is designed to improve those conditions. Comprehensive modelling was completed to evaluate a broad range of potential outcomes to support the environmental assessment of the Remediation Plan, and plans were developed to manage and mitigate the anticipated evolution of site conditions over time.

### Water Modelling

Golder-AECOM created several linked water models to evaluate the implications of the Remediation Plan on future water quantity and quality at a downstream of the Faro Mine Site. A regional-scale water balance and water quality model was constructed to integrate outputs from a site-scale water balance and water quality model, a regional groundwater flow model, a regional hydrology model, climate inputs and geochemical inputs, and simulate water quality constituent concentrations within and downstream of the Faro Mine Site to the Pelly River, which is a river of importance to First Nations. The results were used to evaluate the effects of the Project on the downstream aquatic receiving environment as part of the 2019 Project Proposal. This modelling also included water quality and quantity from other creeks that could cumulatively impact the Pelly River.











Photo 2. Rose Creek downstream of the Rose Creek Tailings Area.

Numerous predictive scenarios were developed as part of the downstream modelling to evaluate the influence of the Project on water quality in advance of remediation. Modelled scenarios reflect a variety of conditions such as existing mine stressors, natural variation, active mitigation, and future conditions in consideration of variability in flow conditions. Modelled scenarios also included looking at future conditions should the Project not be implemented. The schedule proposed by the Remediation Plan was explicitly incorporated into all water models to understand the combined effect of simultaneous remedial activities over time. Several scenarios were modelled to facilitate an understanding of the range of potential outcomes of the Project, including a no Project scenario. Although implementation of the Project would prevent many of the outcomes, this modelling approach was established to determine if and how much water quality might improve from the remediation of the Faro Mine Site as well as to determine how much future downstream water quality degradation the Project would prevent.

### Human Health and Ecological Risk Assessment

Because the Faro Mine Site is a contaminated site, a comprehensive human health, aquatic and terrestrial risk assessment was completed to quantify the current risks at site and the risk during and following the remediation of the Faro Mine Site.

The human health risk assessment was comprised of two components:

- An air quality risk assessment, which evaluated the risks of acute and chronic effects associated with certain airborne or gaseous constituents that are only present in air. An evaluation of the risk of estimated exposure to airborne particulate matter was included.
- A multimedia assessment to evaluate risk associated with exposure to constituents that might be present in air, soil, sediment, water, and food.

The ecological risk assessment included the following:

- An evaluation of potential risks to soil invertebrates and terrestrial plants by comparing soil chemistry to applicable soil guidelines for the protection of soil invertebrates and plants.
- A multimedia food web assessment to evaluate risk to terrestrial and aquatic-feeding wildlife associated with exposure to constituents that might be present in soil, sediment, water, and food.









#### FARO MINE CLOSURE: ENVIRONMENTAL ASSESSMENT

The aquatic risk assessment considered these current risks, the risks associated with the Project, and the risks should the Project not be implemented, to provide a basis for the assessment. The aquatic risk assessment considered a number of receptors, and benchmarks were developed for each aquatic receptor (i.e., fish, amphibians, invertebrates, and plants) to evaluate potential effects of constituents of potential concern that will continue to be present at concentrations greater than the site-specific water quality objectives developed for the Project.

### Water Monitoring Program

Approximately 185 groundwater wells, 100 seeps, and 70 surface water monitoring stations are monitored several times over the course of each year to evaluate the geochemical evolution of waste rock, tailings, groundwater quality and surface water quality at and downstream of the Faro Mine Site. The monitoring program is designed to capture variability in flow conditions and water quality in consideration of climatic conditions at the Site. This is an extensive program, requiring collaboration between different water technical disciplines and integration with the on-site care and maintenance operator, as well as the proponent and the engineering design firm.

An annual report is created to summarize and evaluate groundwater quality, seepage water quality, surface water quality, and surface water quality results relative to water quality criteria and past results. A key objective of the report is to identify any changed conditions, evaluate the need for urgent response to anomalous results, and make recommendations for adjustments to future monitoring programs in a timely and efficient manner.

An adaptive management plan was developed and implemented to guide responses to the anticipated evolution of groundwater and surface water quality, which are primarily related to the evolving geochemical conditions in the tailings and waste rock, and mitigation measures associated with the management of surface water and groundwater at the Site. Key water quality monitoring events have been highlighted where the potential for water quality degradation is the highest and these are reported on separately to determine if remedial actions are required urgently through quarterly reports and adaptive management plan annual report.

Quarterly adaptive management reports are produced that compare recent water quality data to pre-defined action levels. The overall purpose of the report is to confirm that interim mitigation measures are functioning as intended and evaluate the need for additional mitigation measures. This monitoring has resulted in the implementation of early remedial works.



Photo 3: Jonathan Ward of AECOM angling in the Rose Creek Diversion. Here the field crew were targeting large adult grayling to support understanding of the population's age distribution.



Photo 4. Faith Ladue, a First Nations Environmental Monitoring Field Assistant of Golder, conducting groundwater sampling at the Faro Mine Complex.









The water monitoring program has produced a substantial data set over a long period of time that requires significant management and evaluation to maintain the integrity of the data, and the full value of the data is realized. This required development of a strong data management system to host and evaluate the data and to inform the proponent on a monthly, quarterly and annual basis of the current state at the Faro Mine Site. The data management system has been also been developed for ease of transfer to the proponent so that it can be done in-house on a monthly basis.

## Management of Risk

The key risks to executing the scope of work were related to working with multiple parties. Golder and AECOM worked as a unified team to deliver the environmental and socio-economic assessment, with AECOM as a subcontractor to Golder. The largest risks for the Project were related to timely delivery of the assessment to allow the Project to advance through the regulatory process. The Project Description was developed by the engineering design firm in parallel with the assessment, and the schedule and delivery was dependent on the timely delivery of the Remediation Plan. The risks to the schedule were managed through regular communication between Golder and AECOM's management teams, the engineering design firm management team, and Crown-Indigenous Relations and Northern Affairs Canada. Golder and AECOM's technical leads for the various disciplines that contributed to the environmental and socio-economic assessment were directly linked with the engineering design team leads for the various remediation components. Face to face meetings were scheduled between the proponent, the design engineering firm and Golder-AECOM to advance the schedule, highlight technical risks and come to decisions on key items in a timely manner to advance the assessment.

Risk around managing the team to create a consistent document was high. An assembly line approach was used to maintain consistency through the documents and to maintain the delivery schedule. A table of contents was developed with significant input from the proponent, and the team was established by assigning a technical lead, senior reviewer and support staff for each technical discipline. The communication approach focused on messaging the technical lead as the responsible authority who acted as a liaison with the rest of the team to ensure consistency in messaging and allow for technical vetting of key decisions in advance of providing direction to the rest of the team. Due to the complexity of the Project, assessment methods were developed well in advance of conducting the assessment. Multiple internal meetings were held to provide ongoing direction to the lead writers, and a group of experienced editors were assigned to the Project. A staggered schedule was developed to allow documents to proceed through the editorial process with minimal downtime. Implementation of a secure document sharing platform allowed for simultaneous work on a single document by multiple individuals. A detailed tracking document was developed and maintained to track the progress of each document from production of draft documents, through the editing and review process, to submission of the Project Proposal to YESAB.

# Degree of Difficulty

The primary goal of the proponent was to deliver a high quality Project Proposal in a timely manner. The schedule was aggressive, but it was also dependent on the progress of the remedial design being completed by the design engineering firm. Although the schedule slipped due to the availability of the remediation design (beyond the control of the Golder-AECOM team), the environmental and socio-economic assessment team compressed timelines and completed work in parallel with the design engineering team to continue to allow for submission of the Project Proposal by an acceptable deadline. Engineering design information and assessment results were passed between teams as soon as they were available to facilitate collaboration between the proponent, the design engineer, and the environmental and socio-economic assessment team, to allow for agreement on key mitigations and subsequent incorporation into the Remediation Plan.









#### FARO MINE CLOSURE: ENVIRONMENTAL ASSESSMENT

The Project was funded through a contribution funding agreement, making changes to budgets based on changes in scope difficult. Contribution funding agreements are pre-set agreements between the Government of Canada and their contractors that lay out the budget for the year, sometimes for numerous years at a time - this was the case for Golder. In cases where additional budget was required due to changes in scope, the project management team often had to trend budgets between tasks to find money. In cases where the agreement amount for the year was insufficient to complete required work, an amendment to the agreement was created by the Government of Canada's legal team, often requiring more effort for the Project teams. From initiation of the environmental assessment to the submission was a multi-million dollar effort. Changes in scope were managed by implementing several project management best practices including a monthly scope deviation tracker and regular communication discussion of changes in scope, schedule, and budget with the client. In addition, the budget was managed using tools that allowed for the prediction of future and anticipated final costs to allow for redistribution of funds prior to the end of each fiscal year.

To meet the schedule, the team was integrated on multiple levels, from technical leads to project managers to corporate sponsors, to avoid communication bottlenecks, and ensure technical collaboration and information sharing occurred at every level. The Golder-AECOM team consisted of more than 140 people, who spent more than forty-five thousand labor hours developing and completing the Project Proposal across 15 different disciplines. Additional contributions came from IMG Golder, SRK Consulting Inc., Integral Ecology Group Ltd., CH2M Hill Canada Ltd., Minnow Environmental Inc., Robertson Geoconsultants Inc., Stratos Inc., and Northwest Hydraulic Consultants.

### **Environmental Value**

The Faro Mine Site is one of the largest and most contaminated sites in Canada and is continuing to degrade due to acid rock drainage and metal leaching into the groundwater. To avoid future contamination into the downstream environment, and to allow for potential future land use in the area, the Faro Mine Site requires permits to proceed with remediation activities. Draft environment and socio-economic impact assessments were completed in the past, but the environmental and socio-economic assessment completed by Golder and AECOM is the first assessment to be submitted to the YESAB. Approval of the environmental and socio-economic assessment will be the first very important step toward implementing the Remediation Plan and protection of the downstream environment.

Monitoring plans developed by Golder-AECOM were developed in an integrated manner to monitor conditions at the Site and determine if there any impacts during and following remediation. Implementation of these robust monitoring plans provides a mechanism for confirming that positive impacts are realized. The adaptive management plan was developed to track existing conditions and guide regular evaluation of trends in monitoring results until the Remediation Plan is approved. Rigorous protocols, including Project Management and Monitoring Plans, were developed to guide decision-making at the Faro Mine Site and inform responses to anomalous results.

# Added Value

- Collaborations across geographies and companies. Golder and AECOM allocated the work based on the company and people best suited for each role on the combined team. The resultant team benefitted from individuals located in Vancouver, Victoria, Whitehorse, Edmonton, Calgary, St. John's, Saskatoon and Mississauga that worked seamlessly across geographic locations, companies and technical disciplines. The Project significantly benefitted from long-term trusted relationships between managers and technical staff in Golder and AECOM.
- Golder-AECOM and the engineering design firm invested significant time in collaboration. The collective team remained focused on what was best for the Project and functioned as an aligned and cohesive team.









# Benefit to Society

- The novel approach developed and implemented for the environmental and socio-economic assessment of the Project can be applied to the assessment of other contaminated sites, where the core purpose of the project is to improve environmental conditions.
- The environmental and socio-economic assessment serves as a positive example of a balanced and collaborative approach to evaluating remediation of very large abandoned mines in sensitive remote environments in consideration of input from numerous environmental assessment practitioners, regulatory agencies, First Nations and other affected communities. The Project Proposal optimizes environmental and socio-economic outcomes in consideration of fiscal responsibilities.
- Remediation of the Faro Mine Site, one of the most contaminated sites in Canada, is anticipated to significantly reduce environmental impacts to downstream water quality. The protection of downstream water quality and the aquatic and terrestrial ecosystem is important to limit impacts to asserted Kaska Traditional Territory, and Selkirk First Nation territory located downstream of the Faro Mine Site.
- First Nations had the opportunity to engage in the Project through several means: local workshops, monthly newsletters, tele-conferences, email, site tours, opportunity to review draft documents and through local governing bodies.
- Golder-AECOM was also contracted to complete monthly environmental monitoring programs at the Faro Mine Complex including surface water, groundwater, and seepage monitoring. Golder hired two First Nation Environmental Monitoring Field Assistants to help with these programs and have provided a variety of on the job training both internally and externally.



Photo 5: Faro Creek Diversion downstream of the Faro Mine Area.









### Conclusion

The Faro Mine was once the largest open pit lead-zinc mine in the world. Today, it is the site of one of the most complex abandoned mine remediation projects in Canada. Completion of the environmental and socio-economic assessment is the first step to implementation of the Remediation Plan.

The environmental and socio-economic assessment was developed to meet the requirement for a screening pursuant to the Yukon Environmental and Socio-economic Assessment Act by the YESAB Executive Committee. The Project was led by the Crown-Indigenous Relations and Northern Affairs Canada with input from the Government of Yukon, the Ross River Dena Council, the Liard First Nation and the Selkirk First Nation, through workshops and meetings held regarding the Project and through opportunities to review draft documents and participate in real time in the development of the final documents.

The Project team adopted a collaborative and integrated approach to completing the environmental and socioeconomic assessment of the Remediation Plan. Innovative methods were employed to assess the impacts associated with implementation of the Remediation Plan, which was designed to maintain or improve overall environmental conditions and provide socio-economic benefits to First Nations and affected communities. An experienced team of technical staff, information technology and best practices in project management were leveraged by a spatially distributed Project team to produce the Project Proposal for submission to YESAB. The design of mitigation measures was refined based on the results of a preliminary assessment and feedback obtained during community consultation. Robust monitoring and adaptive management plans have been developed and implemented to monitor the site and guide responses to anomalous results.

Once implemented, remediation of the Faro Mine Site is anticipated to significantly reduce environmental impacts to downstream water quality that is valued by First Nations, Yukoners and Canadians. Further, it is anticipated to provide lasting socio-economic benefits to First Nations and other affected communities.









