Case Studies of Adaptation to Climate Change in the Yukon Mining Sector: From Planning and Operation to Remediation and Restoration

BACKGROUND

This study examines climate change vulnerability and adaptation in three stages in the life of a mine, (i) inception and planning, (ii) operation, and (iii) post-closure (or remediation and restoration) through case studies located in the Yukon Territory, Canada. The report aims to provide insights on ways to enhance the competitiveness and adaptive capacity of the mining sector in a changing climate.

The Yukon mining industry has always dealt with stresses associated with extreme cold, snow accumulation, floods and the occasional summer drought. Historically such hazards were broadly predictable, but scientific evidence and local experience indicates that the region's climate is changing with implications for mining. The profitability of mining in the Yukon is highly sensitive to fluctuations in global mineral prices, and broadly predictable cost management is important for maintaining viability. Already experienced events, which may occur with greater frequency in the future, such as flooding and soil and permafrost instability have the potential to add to the costs of mining by disrupting operations and transportation. In response to emerging stresses, environmental review processes now require consideration of climate change in mine planning and site remediation, and the industry increasingly employs climate change modeling to identify potential future risks and adaptation measures.

ADAPTIVE STRATEGIES IN THE YUKON

(i) Incipient mines - increasingly incorporate knowledge of current and expected future climate change into the mine planning process.

Victoria Gold's Eagle Gold Project in the Mayo district in the northeast Yukon accesses climate model data to identify potential future landscape hazards as a result of a changing climate. Apart from extreme winter conditions, which have always been present, the company anticipates possible changes in local hydrology as shoulder season characteristics change and possible soil liquefaction associated with permafrost melt. Robust engineering is being employed in anticipation of extreme climate events with access roads, bridges and culverts upgraded to deal with increased spring-run-off and mine site layout modified to accommodate permafrost concerns. The mine's closure and remediation plan filed at inception incorporates knowledge of expected future climate trends. Climate modeling reduces uncertainty about the future, but is constrained by poor quality base-line data and the complexity of terrain in the Mayo region. As a result, the mine continually monitors site conditions and employs adaptive management to deal with events as they arise.

Main photo: Yukon vista - Bruce MacKay. Below from left to right: Victoria Gold, Yukon - Cathie Archbould; Capstone Resources Minto Mine in the central Yukon - Capstone Mining Corp.; Derelict Faro Mine closed in 1998 was once one of the world's largest zinc mines - Yukon News.

(ii) Operating mines - were designed before climate change became a significant issue and have been vulnerable to unanticipated climate induced events.

Capstone Resources' **Minto Mine** in the central Yukon was designed almost twenty years ago and has grappled with climate stresses including, flooding from increased precipitation and spring run-off, and permafrost degradation leading to holding pond and tailing instability. Major flooding was not anticipated in mine design and initial responses were "ad hoc," releasing untreated water into the Yukon River and digging ditches to manage on-site water. Subsequent responses were more robust, demonstrating flexibility to adapt to changing climatic conditions. Hydrological projections incorporating current data were completed, a new water treatment plant constructed, mine detritus placed in dry-stack storage, and mine operations moved underground. The dry-stack storage is now known to be shifting, however, and Capstone employs downscaled climate modelling to provide data for addressing the stack problem and in the longer term for closure and site remediation. Engineering and monitoring employed to adapt to emerging conditions represent unanticipated operating costs, which the company was able to bear because of the mine's economic viability but which other more marginal ventures might find prohibitive. Minto's experiences exemplify adaptive management and the difficulties inherent in responding to events in an environment which is in flux, and where base-line data are perhaps not overly reliable.

(iii) Mine Remediation

The derelict **Faro Mine** located some 200 km north east of Whitehorse was one of the world's largest zinc mines. Clean up of detritus at Faro is a formidable task in a stable environment and is especially challenging because remediation will be taking place in the context of current and long-term climate change. In the summer of 2008 the region experienced intense rainfall that caused erosion at the mine-site, in 2012 spring melt-water threatened to overwhelm the site and given the prognosis for increased precipitation and accelerated spring run-off in the central Yukon this problem could potentially worsen. Management of site hydrology and ensuring that mine-site water does not contaminate the larger watershed is a major concern. Additionally accelerated permafrost melt could increase slope instability and increase the potential for leeching. The broad components of the long term Faro closure and remediation plan involve stabilizing the site by upgrading dams containing tailings to ensure they can withstand natural events such as earthquakes and floods. All waste rock will be re-sloped to improve long-term stability and covered with soil, and a water treatment plant installed to clean water at the site. All these components require evaluation of potential future climate events, including precipitation and run-off forecasts and permafrost evaluation. Faro's experience underscores the importance of making adequate robust financial provisions for closure when a mine is developed, and incorporating contemporary climate change modeling into closure and remediation planning.

What has enhanced adaptation for Yukon mines?

- Acceptance by major players including industry and government, that climate is changing and the need for mainstreaming adaptation into operations
- Incorporation of climate change projections into full lifecycle planning from inception to closure and remediation.
- Adaptive management as a response to uncertainty and learning and adapting through experience as conditions change.
- Partnering with research institutions, such as Yukon College, to generate better quality data and conduct applied research

What would enhance adaptation for Yukon mines?

The major challenges facing the mining industry are informational, getting a better understanding of current and future climate trends, especially at the local scale, and translating trends into practical cost effective approaches to site design, operation and remediation. Adaptation would be enhanced through:

- Better quality data to identify potential future climate trends and reduce uncertainty.
- More applied research to identify ways in which climate change could affect surface water, ground water and permafrost, and identification of appropriate engineering standards to deal with future climate extremes.
- More extensive partnerships between the mining industry and educational institutions to promote applied research to identify innovative approaches for dealing with climate change.

arctic north consulting

Web: www.arctic-north.com
Email: tristanpearce@gmail.com
james.ford@mcgill.ca

FRANK DUERDEN CONSULTING

Email: fduerden@gmail.com

Northern Climate ExChange
YUKON RESEARCH CENTRE · Yukon College

Email: lkinnear@yukoncollege.yk.ca