GEOTECHNICAL STAFF TRAINING FOR CLOSED MINES, A NEW MINING BEST PRACTICE?

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ABSTRACT

At operational mines, on-going inspection and surveillance of significant earth structures such as dams and waste rock dumps is undertaken by professional staff that is experienced with soil, rock and mining projects. At a closed mine, site surveillance and monitoring staff may have limited geotechnical, geological and mining experience. In order to address this potential issue, the Faro Mine site has undertaken an on-going program of geotechnical training for selected site staff involved with environmental monitoring, dam inspection and site management. These training seminars have covered the basic issues of geotechnical engineering, general dam design, failure modes for dams and dumps, surveillance and monitoring of earth structures, geotechnical instrumentation and waste dump safety. In addition, as the Emergency Preparedness Plan and the Operations, Surveillance and Maintenance Manual for major earth structures have been developed, site staff have also been involved in related training seminars for these topics as well. The benefits include a diligent monitoring staff able to respond quickly and effectively to potential site emergencies, along with meaningful interaction and understanding between the consulting geotechnical engineer and site staff. Recognizing that surveillance and monitoring are important aspects for dam safety, it is proposed that geotechnical staff training as developed at Faro Mine become a new Best Practice to be followed at other closed mine sites.

1.0 INTRODUCTION

1.1 Background

The Faro Mine, located in the central Yukon Territory as shown in Figure 1, has operated and closed several times in its history. The latest owner, Anvil Range Mining Corporation (Anvil Range) came under creditor protection in 1998, and as a result, the mine went into temporary closure.

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Deloitte and Touche Inc. (Deloitte) was appointed the Interim Receiver for Anvil Range to manage their business affairs and to manage the day-to-day operations of the closed mine, including environmental and geotechnical aspects

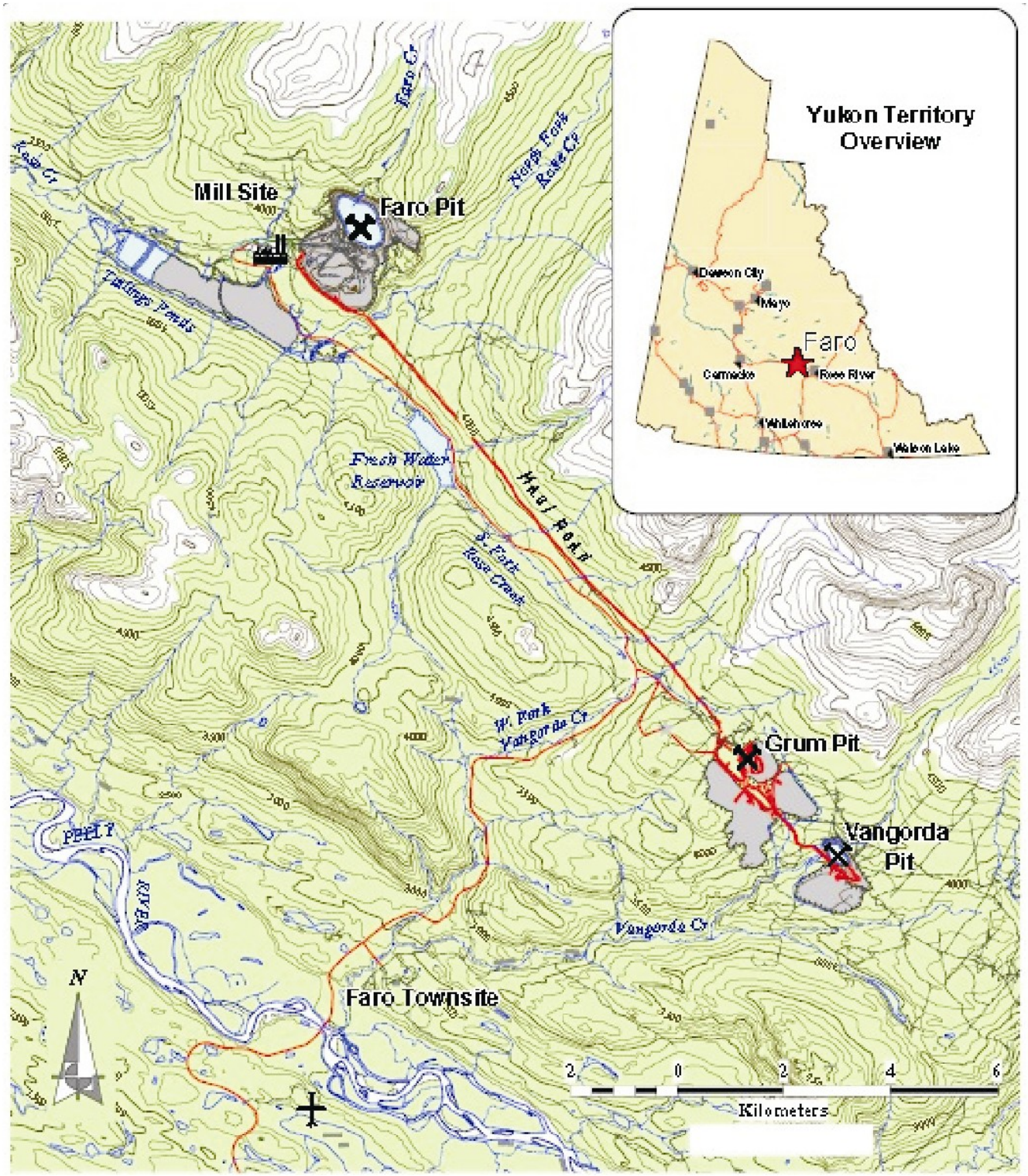

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Figure 1 Faro Mine Location Plan

The Faro Mine operation consists of several distinct elements including the Grum and Vangorda pits and dumps located on the Vangorda Plateau, the Faro open pit, dumps and mining complex and the tailings disposal area, located within a valley previously host to Rose Creek. Within this mine site therefore, numerous tailings and water retention dams, waste dumps and water diversion structures and ditches currently exist. Figure 2 shows an aerial view of some of the structures located within the Rose Creek Valley, which provide retention for approximately 55 million tonnes of tailings.

Figure 2 Aerial View of Tailings in Rose Creek Valley, Looking East (M. Bryson photo)

Within this valley, two significant dams (and associated spillways) and a 3 km long bypass channel need to continue to operate properly and safely. Even before any final reclamation and closure work is undertaken at Faro Mine, these geotechnical structures (and several others as well) need to continue to perform in accordance with their design intent, to prevent any impacts on the surrounding environment. At the current time, the ongoing geotechnical assessment program consists of instrumentation monitoring, surveillance and consultant inspections. Daily and weekly inspection of geotechnical structures is undertaken by a combination of site management and environmental staff.

The staff responsible for the geotechnical inspections comes from a variety of technical backgrounds, including mining operations, mill processing, assay laboratory and environmental monitoring. As such, the majority of the site staff responsible for geotechnical monitoring and surveillance have almost no academic training in and likely, very little practical experience with geotechnical and earthworks issues. This state of affairs should be contrasted to active mining operations staffed by mining and geological engineers, pit and grade control geologists, pit blasting and stripping superintendents and ground control engineers at selected underground operations. Each of these positions requires geological and geotechnical education, likely supplemented by years of site earthworks experience, including blasting, excavation, hauling

and dumping. As such, active mining operations have experienced site personnel available to initially deal with geotechnical and earthworks issues while closed operations may not have access to such personnel.

To rectify this situation, and to increase the skill set of site staff, Anvil Range and Deloitte retained BGC Engineering Inc. (BGC) to develop a geotechnical issues training course for their site staff. The current paper reviews the objectives of that program, some relevant mining best practices, the technical content covered within the sessions to-date and summarizes the benefits of the program, from various staff perspectives.

1.2 Program Objectives

The objectives of the geotechnical training program for site staff at Faro Mine were as follows:

- For non-engineering staff to gain an appreciation of the basic issues of soil mechanics, geotechnical engineering (including jargon such as Factor of Safety) and dam safety issues.
- Site staff responsible for performing dam surveillance should have suitable training relevant to dam safety. Site staff are the “eyes and ears” for consistent monitors of the performance of site structures and facilities. As such, provide a basic level of geotechnical training to assist site staff with monitoring and surveillance of important earth structures
- Review the potential failure modes for dams and dumps and the relative probability of these failures. This provides context for potential incidents and failures and also helps site staff in understanding the potential incident and how to respond.
- The training seminars were not planned to make site staff into geotechnical engineers. This role is still the venue for the external engineering consultant.

2.0 EXISTING BEST PRACTICES

Environment Australia (www.deh.au.gov) provide the following definitions and principles related to best practices for mining:

> “Best practice can simply be explained as "the best way of doing things". Best practice environmental management in mining demands a continuing, integrated process through all phases of a resource project from the initial exploration to construction, operation and closure. It is based on a comprehensive and integrated approach to recognising, and avoiding or minimising, environmental impacts. In order to be fully effective, this approach must be based on a sound set of generic and mining specific principles.
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> Some of the key principles include the following:
>
> - Ecologically sustainable development;
> - Accountability and compliance with environmental standards and principles;

- Application of the Precautionary Principle;
- Use of well informed and trained staff;
- Effective communication;
- Flexibility; and
- Continual improvement.

The last two principles recognise that best practice is not fixed in space or time. A best practice technique at one mine may not be suitable at a similar mine elsewhere. Continual improvement may be driven by changes in legislative requirements, public expectations, corporate thinking, or by the development of new and improved technology."

This definition and principles provide a standard to which existing operational protocols and practices should be compared.

Some of the relevant best practice documents with respect to mining projects in general, tailings facilities, dams and the closure of such structures are reviewed in the following paragraphs:

Berlin Round Table on Mining and the Environment ("Berlin Guidelines") – Fundamental Principles for the Mining Sector (1991 and 1999)

The potential scope of environmental management best practices for mines are reflected in the following partial list of fundamental principles:

1. Recognise environmental management as a high priority, notably through the development and implementation of environmental management systems.
2. Encourage employees at all levels to recognise their responsibility for environmental management and ensure that adequate resources, staff and requisite training are available to implement environmental plans.
3. Adopt best practices to minimise environmental degradation, notably in the absence of specific environmental regulations.
4. Adopt environmentally sound technologies in all phases of mining activities and increase the emphasis on the transfer of appropriate technologies that mitigate environmental impacts including those from small-scale mining operations.
5. Adopt risk analysis and risk management in the development of regulation and in the design, operation, and decommissioning of mining activities, including the handling and disposal of hazardous mining and other wastes.
6. Reinforce the infrastructure, information systems service, training and skills in environmental management in relation to mining activities.

From this partial list, it is apparent that best practices for environmental management include a mix of high quality regulatory standards, administrative controls, mine management and training and application of new and appropriate technologies.

The Mining Association of Canada (MAC) – A Guide to the Management of Tailings Facilities (1998)

MAC developed the Guide to "encourage mining companies to practice safe and environmentally responsible management of tailings facilities through the development of customized site-specific management systems". As such, the document suggests the establishment of a comprehensive tailings management system and provides the following main areas of guidance:

- Framework of management principles, policies and objectives;
- Checklists for implementing the framework through the life cycle of a tailings facility; and
- Lists of technical considerations.

No explicit direction on the training of site staff specifically for monitoring purposes is provided.

Canadian Dam Association (CDA) – Canadian Dam Safety Guidelines (1999)

This document provides design and safety criteria guidance for most of the important elements of a dam such as the slope stability, earthquake loading and flood events. Besides some of these technical aspects, the document also provides guidance on the important following points:

- Each dam needs to be classified in terms of the potential consequences of failure. This classification of the dam then controls the dam safety criteria used for assessment of that dam and the suggested timing of Dam Safety Reviews.
- Requirement for the preparation and use of an Operations, Maintenance and Surveillance (OMS) Plan and Emergency Preparedness Plan (EPP) for each dam.
- Qualified personnel shall be used for the operation, maintenance and surveillance of a dam. Suitable training programs may be required for staff.
- Training is required for all dam personnel involved with EPP for dams.

Hence, the guide explicitly notes the requirement for staff training related to operations and emergencies for dams.

MAC – Developing an Operation, Maintenance and Surveillance Manual for Tailings and Water Management Facilities (2002)

The guide was developed to facilitate operational assistance with tailings facilities and dams by preparing guidance on the development of OMS Manuals for mines. No information is specifically provided with regards to training of site staff during closure operations.

International Commission on Large Dams (ICOLD)

The President of ICOLD in 1980 made eight major recommendations relative to dam design and safety assessments including the following two:

- Instrumentation in a dam is vital.
- Thorough and careful surveillance on a continuing basis is a must.

South African Bureau of Standards- Code of Practice, Mine Residue (1998)

This code of practice focuses primarily on "ensuring that appropriate safety and environment objectives are set and achieved." The standard sets out the use of an integrated management system to achieve its objectives and attempts to make the mine waste disposal operation part of the main activities of mining. Some specific items within the standard are noted below:

- Environmental responsibility (within the broadest sense of the term) should be inherent in all mine residue disposal systems.
- A precautionary approach should be taken so that management anticipates risk and implements mitigative measures, before undesired events occur.
- A site manager should appoint qualified and experienced subordinate managers to be responsible for mine residue disposal. The site manager is responsible for the actions of these sub-managers.
- A management framework, including senior company management, mine site managers and responsible consultants, is reviewed and each component has various responsibilities.
- Training is noted for all personnel working of the management of mine waste.

Based on a review of these documents, there does not appear to be any explicitly documented practice or recommendation that site monitoring staff (for closed mine operations) should be trained in geotechnical awareness. Several documents due refer to need for suitably trained staff in order to operate tailings dams. The following sections will document the program undertaken at Faro Mine.

3.0 GEOTECHNICAL TRAINING PROGRAM

3.1 Topics and Sequence

The first geotechnical training seminar occurred in August 2001 and the following topic items were reviewed in the initial presentation:

- Objectives of the seminar and relevance
- Introduction to geotechnical issues
- Dam issues
- Waste dump issues
- Hydrotechnical issues
- Geotechnical instrumentation

The second training seminar was held in September 2002 and the topics covered in that presentation were as follows:

- Objectives of the seminar

    - Site staff has a very important role in overall dam safety. They are:
        - responsible for performing dam surveillance.
        - likely the “first responders” if an incident occurs.
- Introduction to tailings dams and some failures
- Failure modes and causes
- Introduction to Down Valley (Rose Creek Valley) Dams
- Emergency Action Plan
- Emergency identification and response

In September 2003, the third seminar focused on waste dumps and covered the following agenda:

- Objectives of the seminar
    - Add to geotechnical knowledge base of site staff.
    - Site staff should be able to:
      –visually recognize indications of failure in waste dump
      –be able to visually monitor for change in dump stability
      –be able to relay important information concerning stability to geotechnical engineer in relation to waste dumps
- Faro waste dumps
- Waste dump stability
- Stability assessment of Faro waste dump
- Waste dump monitoring
- Long term issues and reclamation

The fourth seminar held in September 2004 focused on monitoring instrumentation and included the following topics:

- Objectives of the seminar
    - To provide an understanding of the existing instrumentation at site
    - How it works
    - Why they were installed and where
    - How to interpret the data acquired
- Review of monitored structures
- Review of instrumentation and monitoring practices
- Trouble shooting

For 2005, site staff has requested training in the topic of seepage/flow monitoring and gauging.

3.2 Format

For each of the seminars, a PowerPoint presentation is made, along with summary handout notes. The presentation content consists of basic factual technical information, supplemented by diagrams, photos, animated cartoons, video and soundtracks (e.g. CNN soundtrack reporting from tailings dam failure at Los Frailes in Spain). This content is both specific to Faro Mine and more general to other mining projects or dam failure incidents, where appropriate. The combination of different media and case histories is important to keep the presentation interesting and relevant. Questions are entertained throughout the presentation to ensure that critical concepts and ideas are understood. Depending upon the extent of the topics discussed, each seminar is approximately 2 to 3 hours in length.

After the seminars, laminated certificates are made for each of the attendees to formally acknowledge their participation.

3.2 Links to EPP and OMS

During dam performance reviews and other dam safety reviews, a need was identified to develop both an Emergency Preparedness Plan (EPP) and an Operations, Surveillance and Maintenance (OMS) Manual for significant dams and water diversion structures on site. As such, these two documents have been developed for the Faro Mine site. When draft versions of both documents were developed, training seminars were held with site staff in order to make them familiar with the content. Since site staff had already taken several training seminars, some of the background information (e.g. dam failure modes) was already known to them. Hence, it was possible to focus on other important details of the plans.

4.0 FEEDBACK, BENEFITS AND RESULTS

Specific feedback from site staff on the geotechnical training seminars includes the following:

- “the seminars are certainly beneficial and presented in a manner that keeps your attention”;
- “knowledge gained from the seminars over the years has allowed us to better our understanding of our site inspection duties”;
- “instrumentation seminars have given us a better understanding of what is taking place when we use the slope indicator and pneumatic piezometer etc”; and
- “overall, we would like to see them continue.”

As such, the training seminars appear to be of benefit to the site staff.

Benefits from the training program can accrue from several different perspectives with regards to site staff, management and external consultants. Table 1 lists some of the noted benefits from each of these perspectives:

Table 1 Summary of Training Benefits

Perspective	Benefits
Site Manager	• Increased confidence with respect to monitoring and surveillance program by site staff. • Reduced incidence of false alarms and time wasting due to "minor" issues noted by site staff. • Delegation of appropriate inspection and monitoring duties to site staff as their experience increases and judgment becomes better. • Confidence that site staff can respond timely and effectively in event of emergency or alert.
Site Staff	• Enhanced ability to do the monitoring and surveillance program with relevant and germane information, more confidence and better judgment with respect to geotechnical and dam safety issues. • Better ability to communicate effectively and efficiently with both site manager and external consultants with respect to geotechnical issues. • Enhanced ability to respond to geotechnical emergencies and alerts. • More work enjoyment since site staff understand their role within the overall geotechnical monitoring programs and are able to identify and solve minor issues.
Geotechnical Consultant	• Enhanced ability to communicate with site staff with the use of technical jargon. • Increased confidence with respect to monitoring and surveillance by site staff. • Validation that site staff understands the importance and relevance of their monitoring and surveillance tasks. • Reduced incidence of false alarms and time wasting due to "minor" issues noted by site staff.
Corporate Management	• Increased confidence that site is being monitored effectively (both physically and fiscally) by combination of site manager, site staff and external consultants. Hence, increased confidence in the overall site environmental management plan. • Delegation of monitoring and selected decision making to active and far reaching site staff rather than busy site manager.

In the end, the training program makes the three core members (site manager, site staff and geotechnical consultant) work better as a cohesive "monitoring team", rather than as remote, disparate elements as they physically are.

In 2004, a significant precipitation event (estimated at greater than the 1:100 year return period flood event) occurred within the watershed of Vangorda Creek. As a result, the flow within the Vangorda Diversion Flume rose very quickly, causing partial destruction of the flume due to the extreme turbulence. A subsequent review of the site staff actions found that they followed all required emergency response protocols, hence minimizing the potential impacts from the flood event. The site training seminars, in combination with the preparation of the EPP, appears to have paid off with tangible results last year.

5.0 CONCLUSIONS

For the site staff and managers at the closed Faro Mine, an incremental geotechnical training program has been implemented. Numerous benefits for site management, corporate management, site staff and the geotechnical consultant have been noted and summarized. In addition, site staff continues to request additional training seminars, in order to do their job better. The emergency response of site staff to a 2004 flood event validates the usefulness of the training.

As such, it is proposed that geotechnical issues training for site staff at closed mines become another mining industry “best practice” to ensure efficient and effective geotechnical monitoring of critical structures and to protect the environment from undue impacts.

6.0 ACKNOWLEDGEMENTS

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