Onshore NZ Minerals Sector Environmental Research – Mine Environment Life Cycle Guide

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Abstract

Between 2014 and 2018, the Ministry of Business, Innovation and Employment (MBIE) has contracted CRL Energy, Landcare Research, Otago University, Canterbury University and O'Kane Consulting to complete a project called 'The NZ Mine Environment Life Cycle Guide'. This project encompasses the bulk of central government funding for onshore minerals sector environmental research and has been developed in consultation with mining companies, regional councils, Department of Conservation, iwi and minerals sector advocacy groups.

There are several foci for this project related to reducing environmental risk and uncertainty for mining activity;

(1) To reduce uncertainty related to predictions that are made by mining or exploration companies with respect to mine drainage chemistry especially at and after closure.
(2) To improve our knowledge of mining related impacts on aquatic ecology and understand ecological recovery processes after mine closure.
(3) To improve application and certainty for implementation of passive treatment systems.
(4) To identify optimal strategies for effective rehabilitation of mining impacted landscapes and define key criteria that predict a successful trajectory toward closure.
(5) To integrate mātauranga māori and provide insight into successful Iwi engagement
(6) To integrate environmental economics into early decision making in mine design and operations.
(7) To establish and maintain the Centre for Minerals Environmental Research (CMER), a virtual centre for housing minerals environmental research.

This is a broad and ambitious project. In this paper and presentation we present early outputs from the project; the structure of the Mine Environment Life Cycle Guide and preliminary results from selected sub-projects that are under way.

Keywords: aquatic toxicology, geochemistry, mine rehabilitation, economics, life-cycle.

Introduction

Coal and gold mining are important economic activities in New Zealand, and the West Coast of the South Island, Southland and the Coromandel Peninsula, for example, have long histories of mining. The process of mineral extraction inevitably results in environmental impacts, but few tools exist to help mining companies and regulators assess, predict and minimise environmental impacts of mining operations. This collaborative research programme is working with key mining partners including mining companies, regional councils, Department of Conservation and iwi to assist with planning and operations of mine developments, in particular to ensure that post-mining outcomes are appropriately identified and can be achieved in the most cost-effective manner. To do this requires on-going engagement with stakeholders and appropriate environmental management throughout the life cycle of a mine. This programme draws on and extends previous research on rock geochemistry, aquatic chemistry, freshwater ecology, aquatic toxicity, and management, treatment and rehabilitation techniques for mining, and undertakes new research to integrate economics and cultural values into the decision-making process.

Developing the Mine Environment Lifecycle Guide (MELG)

The Mine Environment Lifecycle Guide considers environment information in the framework of a conventional mine lifecycle, taking account of the current mine permitting regime, including land access arrangements, now operating in New Zealand and resource consents required under the Resource Management Act. The key stages are outlined in Table 1.

Table 1. Summary of a conventional mine life cycle, and the mine permitting/consenting regime operating in New Zealand.

Mine Life Cycle[1]	Permitting/Consenting regime
Exploration	Prospecting (land access)
	Exploration (land access)
Mine planning	Mine Permit – requires pre-feasibility study Resource Consent
Operations (including commissioning and construction)	Annual reporting
Decommissioning (Closure)	Permit relinquishment
Post Closure	Agreement with regulators

(1) Adapted from GARD Guide

A recent change in the mine permitting regime places greater emphasis on cost analyses at the mine permit stage, requiring a more in-depth consideration and quantification of the costs associated with environmental management throughout the project and the (general) final closure objectives. However, it is recognised that uncertainty will remain for quantification during the prefeasibility stage (mine permit application) and that only general post-mining outcomes, e.g. type of native ecosystem, and non-negotiable outcomes (e.g. changes in ridgeline or topography) should be identified and agreed at this point. For mine permitting, it is expected that best estimates will be used to ensure the closure objectives can reasonably be achieved and the related uncertainty is managed with the bond. The Mine Environmental Lifecycle Guide (MELG) utilises much of the existing Minerals Sector Environmental Framework (Cavanagh et al., 2015) within the permitting and consenting stage but extends this to incorporate economic considerations such as Net Present Value (NPV), and stakeholder consultation, in particular iwi engagement, to ensure all relevant closure options are adequately considered. Research undertaken within the current programme will also fill in gaps (e.g. in-depth understanding of geochemistry of waste rock stockpiles and high walls).

During the operational phase of a project further information will be obtained, the uncertainty related to closure and post closure will be reduced and the bond can be adjusted to reflect more certain outcomes. Similarly, more specific post-mining outcomes can be determined, and agreed with stakeholders. The MELG greatly expands on the information required during operations to ensure that the post-mining outcomes can be delivered in a cost-effective manner. This is achieved by moving from laboratory based studies on small samples to field trials and mass balanced experiments under local environmental conditions. Specifically, the MELG aims to identify the critical elements that will influence the likelihood of success and/or cost of achieving the agreed outcomes at closure, and the information that can be used to reduce the uncertainty for these outcomes. The increased certainty benefits all stakeholders because bond quantum is related to real data rather than estimates while for stakeholders most interested in the post-closure outcomes, the increased certainty provides greater assurance that post-mining outcomes will be achieved.

The MELG will also identify the ongoing stakeholder engagement processes that are required during operations, particularly with the ebb and flow of operational projects associated with changing global commodity prices, to provide assurance that specific agreed post-mining outcomes will be achieved.

An overview of the proposed process and outcomes is presented diagrammatically in Fig. 1, with a brief summary of the content of the Mine Environment Lifecycle Guide provided in Table 2.

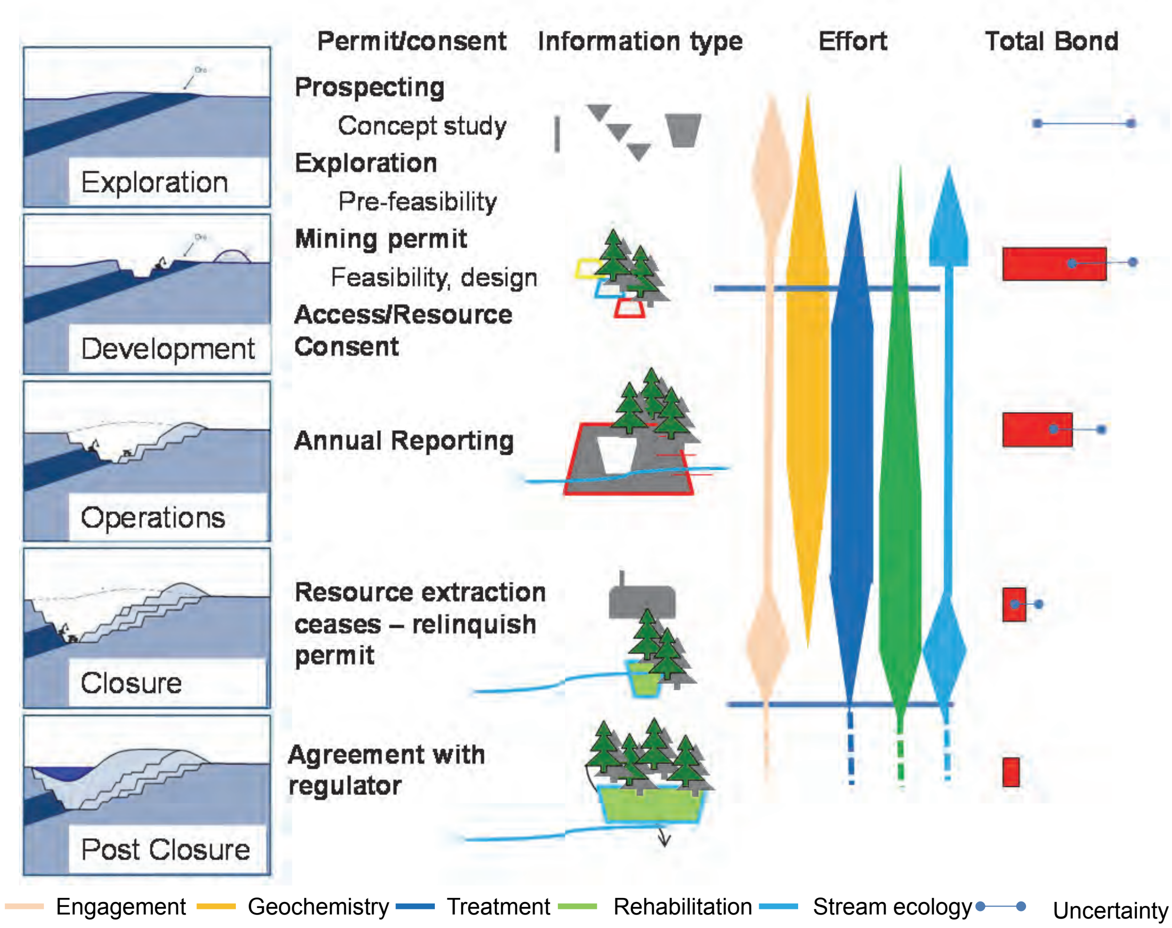

Figure 1. Summary of the relationship between the mine life cycle, the type of information able to be obtained at each stage of the mine life cycle (e.g. laboratory studies, field trials), and the focus of effort required in different science streams to reduce the uncertainty associated with the bond.

Table 2. Stages of mine life cycle, and associated content of the Mine Environment Life Cycle Guide.

Mine Life Cycle Stage	Mine Environment Life Cycle Guide Content
Exploration	Brief discussion of information required at this stage (concept study), outline of engagement processes
Mine planning	Much of existing framework, MELG extended to include economics & iwi engagement, focus on post-mining outcomes
Operations (including commissioning and construction)	Greatly expanded focus for all science disciplines and including economics and engagement processes
Decommissioning (Closure)	Greatly expanded focus for all science disciplines including economics and engagement processes, bond relinquishment
Post-closure	Expanded focus including economics and engagement processes, bond relinquishment

A critical component of the MELG, and of the whole research programme, is the involvement of key mining partners in the planning and implementation of the research undertaken, and guidance on the key areas that should be included in decision-making to achieve successful closure. To this end, we have established a North Island and a South Island governance panel with whom we meet bi-annually. The governance panels include representatives from Ngati Hako, Ngatiwai, Ngai Tahu, West Coast Regional Council, Waikato Regional Council, Northland Regional Council, Department of Conservation, Straterra, Minerals West Coast, Oceana Gold, Newmont, Solid Energy of New Zealand, Francis Mining Group and Bathurst Resources.

Case studies

Case studies provide a key mechanism by which fundamental research is undertaken to fill knowledge gaps. These are phased throughout the programme, and deliver information relevant to the different stages of the mine lifecycle:

- Planning for minimal impact
- Optimising operations for rehabilitation success
- Achieving closure

Some selected case studies are mentioned below.

Optimising operations for rehabilitation success: high-walls and waste rock

The effective management of acid-generating materials is a critical factor influencing the potential environmental impact of mines that are located in regions where acid-forming materials are present. In particular, we are focussing on two aspects for which limited data is currently available; the management of acid materials in high walls, and the effect of waste rock disposal methods to create engineered landforms. Effective management of these aspects throughout mining operations will reduce the scale of treatment and management required when mine operations cease and to achieve the desired post-mining outcomes. For highwalls, we are undertaking detailed monitoring and geochemical analyses to better understand the factors influencing the formation of acidic leachate, and management options. For waste rock disposal, we are undertaking detailed monitoring of waste rock landforms to assess the influence of methods of waste rock disposal and particle size on oxygen ingress, and formation of acidic leachate. This information can be used to provide guidance on best-practice methods for managing potentially acid-forming waste rock.

Achieving closure: Bellvue mine

The Bellvue Mine is an abandoned coal mine located northeast of Greymouth, on the West Coast of the South Island. Previous studies have shown that the Bellvue Mine adit is the primary contributor of AMD to Cannel Creek, thus treatment of the water from this adit will lead to significant improvement in the water quality of Cannel Creek (Trumm and Cavanagh, 2006). Subsequent research has undertaken pilot trials to assess the efficacy of different systems to treat the water. The current programme is partnering with Minerals West Coast to help to achieve a goal within the Minerals West Coast Strategic Plan to *"Locate a disused, abandoned mine/operations site and establish a programme to rehab this from its present state to greenfields status as a project in conjunction with industry, training organizations and regulators"*. Currently, funding is being sought to enable full-scale treatment systems to be put in place, and trials to assess the efficacy of low-cost methods to rehabilitate have been implemented. When full-scale treatment systems have been implemented, this site will provide a case study site to assess the recovery of both terrestrial and aquatic ecosystems.

Achieving closure: Tui mine

The Tui Mine, located at Te Aroha in the Waikato region commenced operations in 1967 and extracted base metals including copper, lead and zinc from the mined ore. The mine was abandoned in 1975, leaving behind waste rock and ore dumps, tailings and the ruins of the mine workings that leach heavy metals from acid rock drainage into the Tui and Tunakohoia Streams. In June 2007 the Ministry for the Environment (MfE) announced funding for the remediation of the Tui Mine site. The $21.7 million project that involved the Ministry for the Environment, Waikato Regional Council, Matamata-Piako District Council, the Department of Conservation and local iwi, was completed in March 2014. Ongoing work, led by local iwi, aims to accelerate the healing of the maunga and ensure the long term health and sustainability of the streams for future generations. We are working with local iwi to help achieve these goals, including by assessing the factors influencing recovery of the Tui and Tunakohoia Stream ecosystems and options for achieving the desired outcomes for terrestrial ecosystems. Current research includes a detailed assessment of food webs in the Tui and Tunakohoia streams.

Centre for Minerals Environmental Research (CMER)

Building on the information and data gathered and collaborations developed through previous research, the current research team has established CMER to:

- Provide current state-of-the-art research information to minerals sector stakeholders and the New Zealand public
- Identify and encourage collaborations between minerals sector stakeholders and research scientists
- Provide a bibliographic service for New Zealand minerals environmental research publications
- Link minerals sector stakeholders throughout New Zealand
- Provide a hub for international linkages

More information on CMER, including research currently being undertaken is available at: http://www.crl.co.nz/cmer/. This site will be regularly updated and provides a focal point for Minerals Environmental Research currently being undertaken in New Zealand.

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