Pit lakes and mine closure – liability or opportunity?

by Dr Clint McCullough, Principal Environmental Scientist at Golder Associates

Many open cut mining operations worldwide leave pit voids at closure that fill with surface and groundwater inflows. Such lakes may contain vast volume (often many millions of cubic metres) and can occur in large numbers across a post-mining landscape, transforming a terrestrial-dominated ecosystem into that of a new lake district. Across Australia, actively eroding, open and contaminated pit lakes remain long after their surrounding waste rock dumps and tailings ponds have been restabilised and revegetated. Although previously often poorly rehabilitated, these 'pit lakes' are increasingly under scrutiny by regulators as legacy concerns of stakeholders, particularly local communities.

Pit lakes are often seen as problematic to company sustainability aims. Stakeholders, particularly community members, are increasingly aware that pit lakes can contribute significant health and safety risks, these include: people coming into direct contact with contaminated waters; harbouring of disease vectors such as mosquitoes; and through contamination or increased evaporative loss of regional surface and groundwater resources. Even when contained, pit lakes may also impact upon a region's ecology through fresh and even saline pit lakes watering feral animals, and through poorer quality water allowing direct contact of native wildlife with pit contaminants.

Mine Closure Plan Guidelines typically require protection of regional water resources and their expressions, such as wetlands and rivers, to meet environmental regulations and stakeholder expectations (McCullough and Lund 2006). Closure guidelines also increasingly require consideration of pre-mining land uses and proposed post-mining land use of equivalent capacity during initial project planning and design, often involving documented stakeholder engagement and agreement to rehabilitation goals. Such expectations of above ground mining landforms are nothing new to the mining industry, which has provided many good examples of closure outcomes for these features. However, meeting these closure expectations for pit lakes, when the landscape has already been heavily modified by pit lakes, into a new aquatic-dominated environment represents new challenges to the mining industry outside of previous regulatory and typical sustainability mine closure considerations.

A way forward

Regulation against these liabilities has largely driven regulators and stakeholder views in the past, which is not surprising given the large number of pit lakes in the Australian landscape; there are many hundreds in Western Australia alone (Johnson and Wright 2003). Explicit consideration of pit lake opportunities for regional benefits is also now becoming increasingly common in international regulator closure guidance documents. In Australia, stakeholder expectations for pit lake closure opportunities are also growing, with increasing numbers of sustainable pit lake closure outcomes demonstrating the benefits to regional communities and environments. Pit lake utility as a water resource for forestry, horticulture, aquaculture and as a recreational location for fishing, boating and swimming, are all existing pit lake end uses in Australia (McCullough and Lund 2006).

Company pit lake closure designs may meet current State Guideline requirements or even lead industry best practice for closure management. Incorporating pit lake design into early mine rehabilitation and closure planning is likely to reduce environmental liabilities and may avoid many closure costs and risks. For example, by considering designs that reduce environmental liabilities such as salinisation and Acid and Metalliferous Drainage (AMD) by taking proactive steps to reduce or even prevent these problems developing (Kumar *et al*, in press). Stakeholder engagement at an early stage, particularly from regulators, can provide direction to mine planning toward the end use identified for the site, minimising post-closure liability and maximising the opportunities and benefits created by a large body of water in the region.

Developments of pit lakes as aquatic ecosystems (such as wetlands) is another option that may even offset terrestrial habitat losses and contribute further to corporate biodiversity and sustainability objectives at closure (McCullough and van Etten, submitted). As a typical rehabilitation goal for mining, closure and relinquishment of pit lakes as wildlife habitat both create a genuine use for these vast water bodies and keep available compatible end use opportunities, such as recreation and water storage.

Other end uses oriented toward achieving specific closure outcomes may still be compatible with other closure needs, such as tailings or waste material storage. These 'in-pit' disposal strategies may be pragmatic uses of pit lakes where encapsulation and adequate modelling detail show no long-term effects on water quality. In some cases, pit lakes may help stabilise the geochemistry of these waste materials, by reducing oxygen ingress into reactive wall rock and in-pit waste materials. In this manner, weathering may be reduced and rates of acidity production of sulphide-bearing ores may be significantly decreased. Alternatively, pit lakes may act as storage reservoirs for erosive and leaching materials from surrounding mining landforms. As water evaporates from pit lake surfaces, some pits may act as a groundwater 'sink', leading to mean flow direction of water into the pit and retention of pit lake contaminants within the immediate pit vicinity.

Figure 1. Acid and metalliferous drainage contamination of pit lakes is an all-too-common problem that continues to plague the mining industry.

Figure 2. As this aquaculture farm at the Premier Coal operation south of Perth demonstrates, pit lakes can represent opportunities to communities and even the regional environment at a time when water resources are under increasing pressure.

In many cases reducing the pit lake size to a practicable minimum or avoiding a pit lake altogether may be of best interest to the surrounding environment. However, backfill costs and risk of ore sterilisation is of concern to all pit backfill strategies. In these cases, managing development of a pit lake, even in a short term of decades, may provide wildlife habitat, and trial opportunities and guidance for final pit lake restoration and closure. For example, with deep pit lakes there will be little ecological value obtained from the deep central water column. Selectively reducing pit wall angles and forming shallow beaches at predicted final water levels, however, will still provide opportunities to plant the lake's edge with regionally-relevant wetland species. This lake edge rehabilitation will achieve a novel, but still valuable, addition to the regional environment. Reducing below-water gradients will also make the lake safer for any recreational users; permitted or otherwise!

Such landscape-level planning requires a transdisciplinary approach where expert input ranging from geotechnical engineers working with final landform stability to geochemists and geohydrologists predicting final water quality, through to scientists determining restoration goals; and community consultation facilitators determining what communities such as Traditional Owners want from the final closure designs. These designs should sit within current or developing mine closure plans, at both conceptual and detailed stages, to provide direction for mine managers at all stages of mine development and closure planning (McCullough *et al* 2008).

Conclusions

Australia's mining operations and resulting pit lakes do not tend to occur close to large community centres, as they often do in Europe and Africa. However, with a changing climate forecast for much of Australia, and a concurrent increase in frequency and scale of mining activity, pit lakes will become a more common feature of our post-mining landscapes.

Restored pit lakes that contribute to a landscape in a meaningful manner do not happen by accident; instead they are end use targeted, and carefully planned and managed as they develop. Developing restored landscapes that explicitly incorporate pit lakes into existing mine closure and rehabilitation plans is internationally becoming a more common requirement in closure planning documentation. This approach benefits regional environments, regional communities and those companies seeking corporate sustainability and good mine closure outcomes for all.

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