Managing uncertainty in planning opencast coal final void closure and relinquishment

David A Salmon[1]

[1]*Amanzi Consulting, 44 Lakeside Drive, Peregian Springs, Queensland 4573, Australia*

Abstract

Coal mining companies face uncertainty when selecting appropriate management measures during planning for closure and relinquishment of opencast coal mine final pit voids.

Existing guidelines generalise mine water management and mine rehabilitation practices. Coal mine specific needs may not be met. Guidance can be misinterpreted, and inappropriate, unacceptable measures applied, such that mine water, closure and relinquishment goals are not achieved, making business decisions uneconomic and ineffective. This is a causal factor in the lack relinquishment of opencast coal mine final voids.

ACARP project C25030 researched this dilemma in the eastern coalfields of Australia. The guidance material produced is described.

Keywords: AMD, mine water, guideline, coal mine, opencast, pit void, pit lake, mine closure, mine relinquishment

Introduction

Emphasis on closure planning by Australian coal mines has increased as these mines mature and as some mines face early closure. A common strategy that mines adopt when planning closure is relinquishment of the mining lease to the State. In opencast coal mines this strategy could include leaving open pit final voids that are commonly recharged to form a pit lake. Public concerns apropos water filled coal mine voids in Eastern Australian coalfields have been increased by recent media articles and published documents by stakeholder groups (Walters 2016). These articles have driven stakeholder expectations regarding post mining use, which are not always practical or economically feasible. Backfilling of final voids with mining waste, changing final void pit lakes storing mine water to a backfilled pit containing mine water as groundwater within the backfill, is now the regulator's preferred option.

When assessing and planning water management, rehabilitation and closure options, and implementing designs, the overarching goal is to ensure post closure water and land uses are safe, stable, sustainable, and non-polluting. Existing guidance on the subject of mine water management and closure and relinquishment practices to achieve these goals is generic (DRET 2006, 2007, GARD 2012, ICMM 2008, DISS 2016). Guidelines for pit lakes and mine voids are frequently based on experience in hard rock mines and quarries; coal mine specific needs are not covered. Therefore, available guidance can be misinterpreted resulting in inappropriate and unacceptable measures being applied to coal mines that have their own unique characteristics. In these situations, mine water, mine closure and relinquishment goals may not be achieved, and the business decisions made can prove uneconomic and ineffective. Furthermore, such guidance has lead to misunderstanding by regulators and other stakeholders as to the practices and management measures that can be appropriately applied to coal mine sites.

Application of inappropriate management options financially impacts mining companies wanting to expend effort and resources on workable and acceptable actions leading to relinquishment. This has resulted in uncertainty occurring during planning and implementing coal mine closure activities. Unsurprisingly, uptake of existing guidance, by coal mines, has been limited.

These challenges in the closure of the

opencast coal mine void domain are such that relinquishment of mine sites, in the Queensland (QLD) coalfields of Australia, has not been achieved.

An Australian Coal Association Research Program (ACARP) project C25030 report (Salmon, 2017) provides guidance material to address the uncertainty during water management planning, closure and relinquishment of opencast coal mine final pit voids. The project was supported for ACARP funding by six mining houses; Anglo American, BHPBilliton, New Coal, Peabody Energy, Premier Coal and Qcoal. This paper presents a very brief overview of this work.

Project objectives

At the outset, the project had eight key objectives; to document examples of practices applied to coal pit voids; to provide a reference list of examples of practice; to identify and confirm challenges to pit closure; to provide a list of findings; to identify gaps in knowledge that could increase residual water environmental risk post-closure; to identify stakeholder perceptions of risks associated with void closure; to record regulator understanding and requirements for void closure including scientific and engineering studies and methodologies needed for relinquishment application; and to develop a guideline and a process for opencast coal pit void closure.

The overarching goal of the project was the provision of guidance to support decisions made by coal mine staff planning and implementing closure activities, and which enables residual risk reduction, lists the aspects needing assessment by mines preparing relinquishment applications, and provides assurance to regulators and other stakeholders that residual risk is minimised or removed.

Guidance given in the report is applicable to hard bituminous thermal and coking coal pits, brown coal and lignite mines, and coal pit voids that are dry or contain mine water. Some approaches may be applicable to other types of opencast mining and commodities, but this was not the focus of the project.

Methods

Information was collected through global literature searches, meetings with mining company representatives and site visits to thirteen coal mine sites. The coal mine sites visited were located in the north, central and southern parts of the Bowen Basin coalfield and in the West Moreton coalfield of QLD, and in the Hunter Valley and the Newcastle coalfields of New South Wales (NSW).

Thirteen criteria were used to assess the suitability of sites visited including; mine site geographic location, geological location, coal type, climatic, mining methods employed, surface water regimes, groundwater regimes, rehabilitation methods used or planned, backfilling, final void type, landform design, planned final land use, stakeholder and community engagement and the closure criteria in place.

Guideline development was based on mine site practices and those found in the literature.

Findings

Twelve findings, common to all coal mines were determined and included;

- Uncertainty in acceptable water management and rehabilitation practice occurs throughout the industry
- Void terminology has not been adequately defined leading to confusion amongst practitioners and stakeholders
- Variability in geology and mining methods creates differing pit void geometries
- A variety of water and rehabilitation management measures are employed
- A variety of different planned final land and water uses occur
- Planning and implementing water management and rehabilitation measures for the final pit cannot be considered in isolation from the rest of the void because they are hydraulically interlinked
- Stakeholder engagement gives a better outcome
- Mines have been overly optimistic in stating final water and land use
- External stakeholders may have inappropriate expectations of open pit void post-closure water and land uses
- Safety and health are important aspects of closure and relinquishment of voids
- Final void management plans are being requested more frequently by regulators.

Gaps in information needed for void closure management planning were found and included the lack of or inadequate, water monitoring data, geochemical characterisation of mine materials, characterisation and classification of voids, and development of void water balances and mine waste material balances. A further twenty-six additional constraints and issues that could affect void closure and relinquishment are listed in the report (Salmon 2017).

Aspects to consider in planning void closure measures

General guiding principles in planning coal mine void closure measures were developed. These provide confidence that correct process is being followed. For coal mine voids these general principles include:

- Definition and quantification of the total void area, including the backfilled areas as well as any final pit void
- Determination of the final land use of the total void area (catchment) and the final void taking into consideration the type, amount and extent of the backfill used and the surface landform created, as these factors impact both surface water and groundwater regimes
- Definition of the geology including geochemical assessment and geotechnical testing of all materials mined and placed in the void to allow understanding of the hydrogeological regime
- Development of a void water balance
- Development of a mine waste material balance
- Investigation and trials of any planned measures
- Development of the geometries of the coal mine pits such as the basic cross section for a coal mine pit void given in Figure 1. Water flows into and out of coal pits are described in Salmon (2000).

The guideline report (Salmon 2017) contains examples of existing practice. Some of these include:

- Investigation of the impacts of mining methods and development of void geometry
- The development of void water balances and modelling
- The development of mine waste material balances and impact on final void geometry including surface water drainage and the water holding capacity of the void
- Pit void backfilling methods and backfill material types both solid and liquid waste such as overburden, coal processing coarse discards and wet and dewatered tailings, reactive waste materials, water storage and water treatment waste
- Descriptions of high wall and low wall treatments for stability and development of final landforms slopes, including the methodology and practice of leaving highwalls and side walls in place, reprofiling highwalls and sidewalls to shallower slopes and blending these into the adja-

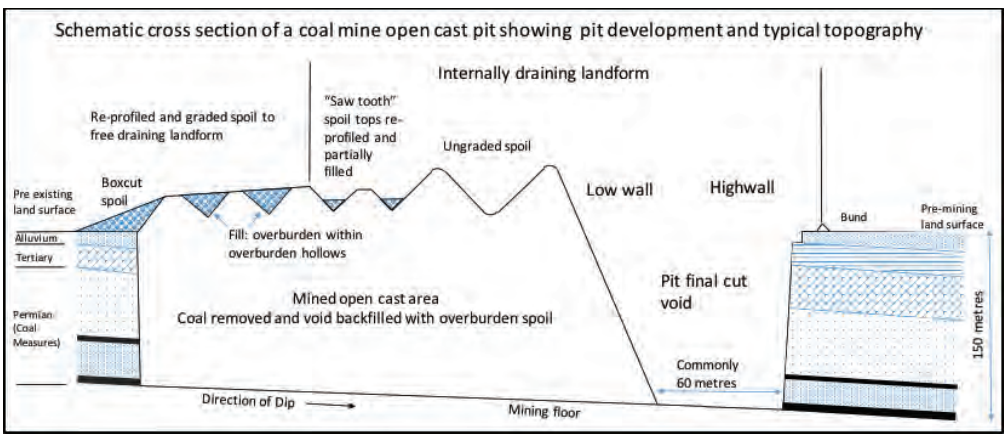

Figure 1 A cross section showing the geometry of a coal mine pit void (modified from Salmon, 2017)

cent void backfilled landforms and the effects on surface water and groundwater water
- Final land uses and impact on water resources
- Final void water uses
- Description of options analysis methods
- Description of risk assessment methodology based on source, pathway and receptor analysis and the impacts to water resources
- Environmental risks to water resources associated with the landforms implemented
- Land rehabilitation and closure strategies, specifically actions to achieve safe, stable and sustainable and non-polluting landforms
- Development of final void management plans.

A process for closure and relinquishment

A number of decision making processes were produced for the guideline. The process considers discussion of benefits and challenges of relinquishment, an analysis of alternative water management and closure options and a risk assessment for pit voids.

An overarching fourteen-step process from closure of coal mining operations to the relinquishment application is described (Salmon 2017). These steps include:
- Site assessment
- Regulatory assessment
- Stakeholder participation
- Assessment and strategy for void land and water use
- Backfilling solid or liquid backfill and effects on water regimes and land form (slope) design and water runoff and usage
- Geotechnical stability and impact of groundwater on this aspect
- Classification of the void based on water balance
- Final void environmental impact statement
- Rehabilitation of the watershed land surface
- Care and maintenance of the watershed and pit lake
- Closure criteria and water monitoring
- Residual water risks specifically AMD and mine water hydrochemistry
- The financial assurance estimation
- Relinquishment application.

Within these overarching process steps there are other processes such as the actions to characterise void type. This process is shown in Figure 2. Voids are divided into three distinct types; dry voids, seasonal pit lakes and permanent pit lakes. Pit lakes are further classified, according to their water balance, into terminal sinks, through flow, recharge or overflow systems.

Conclusions

Existing guidance on open pit coal mine voids has not met the business needs of the coal mining sector in the Eastern coalfields of Australia. Guidance is too generalised and based on hard rock mine pit needs and experience. This has resulted in poor business decisions by applying inappropriate water management and void closure strategies or being requested of coal mines by regulators and stakeholders. In eastern Australian coal mines this is illustrated by demands for internally drainage void systems and the later reversal to demands for free draining landforms.

Unsurprisingly, uncertainty continues to exist on what is required to be done to achieve relinquishment due to the generic nature of existing guidelines and lack of regulatory process.

Open pit coal strip mining will, for most pits, end in a permanent void which, if mined below the water table, will fill as groundwater rebounds and surface runoff inflows to form a pit lake. In eastern Australian coal strips mines the void will commonly be a terminal sink unless it is backfilled with solid material to above the water table rebound elevation.

The unique characteristics of each coal mine requires site specific approaches to mine water in void landform surface and groundwater drainage. There is no one size fits all guideline or a single strategy, package of practices or set of methodologies and techniques that can be applied across all mine sites since each mine has unique issues reflecting site-specific characteristics.

Any application of generic water manage-

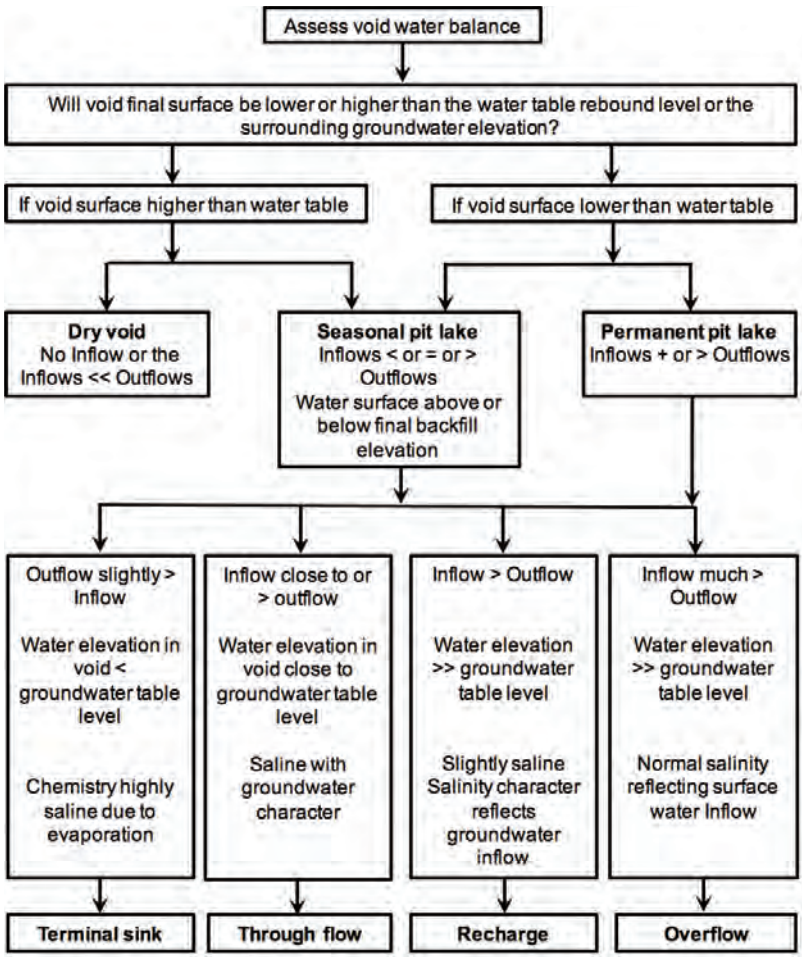

Figure 2 *Characterising pit voids and lakes (modified from Salmon 2017)*

ment and rehabilitation and closure measures or those used by different mines and mines in different geographies must be trialled to ensure practical relevance to a mine site.

A lack of appropriate guidance limits regulator and community understanding of opencast coal mine closure. It can result in demands for coal mines to apply inappropriate rehabilitation measures that can raise community expectations on what can reasonably be achieved. Mine staff should engage with stakeholders and demonstrate to them appropriate water management measures to prevent such demands.

Mining company statements have historically overstated potential post mining water uses. Such statements raised stakeholder expectations and created distrust of mines by regulators and communities when expectations are not achieved. Scientifically based assessment of water management practice applicable to mine site conditions is needed.

Final void post- closure uses are highly dependent on the geographic location of the mine; its proximity to urban areas, transport routes or its location in remote areas. Successfully implemented mine water uses post mine closure are those that match the surrounding landscape and have received endorsement by local communities and regulators.

Planning and implementing rehabilitation measures for the final pit cannot be considered in isolation from the rest of the void because they are intimately interlinked, hydrologically and hydrogeologically. Knowledge on aspects of backfill spoil hydrogeology

and pit void wall geotechnical stability are inadequate to provide confidence about post - closure residual risks to the environment and safety. These aspects require further investigation.

Information on existing practices combined with knowledge sharing between mines can provide confidence to operators that they are planning or implementing the right mine water management practice to achieve the best possible outcomes and gain acceptance by regulators and stakeholders.

Acknowledgements

ACARP staff Keith Smith and Nicole Youngman and the ACARP industry mentors Jason Fittler, Hayden Leary and Pieter Swart provided direction for this project. The staff at the mines visited provided valuable information on the respective sites and willingly gave up time from their work schedules to do this. To all these people I would like to express my gratitude and thanks.

References

DRET (2006) Mine Completion and Closure. Leading Practice Sustainable Development Program for The Mining Industry.

DRET (2007) Managing acid and metalliferous drainage. Leading Practice Sustainable Development Program for The Mining Industry

Department of Industry, Innovation and Science (DIIS). (2016a) Mine closure. DIIS, Canberra

ICMM (2008) Planning for integrated Mine Closure Toolkit. International Council on Mining and Metals 2008.

INAP (2012)) Guideline on Acid Rock Drainage (GARD).

Salmon DA (2000) Management of coal mining impacts on water resources in South Africa. In Sililo, O. (Ed). Past Achievements and Future Challenges. Proceedings of the XXX IAH Congress on Groundwater. Cape Town, South Africa. Published by A.A. Balkema, Rotterdam.

Salmon DA (2017) Guidelines for coal mine open pit final void closure and relinquishment. ACARP Project C25030 Report 169pp June 2017. ACARP Brisbane Australia

Walters A (2016) The Hole Truth: The mess coal companies plan to leave in NSW. Energy and Resources Insights Report for the Hunter Communities Network. http://www.erinsights.com/research/hole-truth.