Practices in Setting Sustainable Water Management Closure Performance Criteria

Henning Boshoff
ATC Williams, Australia

ABSTRACT

The processes and sources of acid rock drainage from mine wastes are well described, as is the definition of sustainability. However, the practices used to define closure performance criteria for mine water management do not always intersect with these definitions, nor does the water from operating mine sites or discharged from a closed mine site always meet sustainability criteria. The problem lays in that mine designers and planners develop initial mine water management objectives and criteria that are not always inherently linked with operational implementation. Furthermore, the same designers generally do not prepare these documents nor are they prepared at the same time creating further disparity. Setting suitable water management closure performance criteria are further complicated through not knowing definitively when closure related efforts will translate into a sustainable outcome.

It is recognised that appropriate and effective mine water management alone cannot ensure sustainable closure outcomes, which are made clear through environmental risk identification and the management thereof. However, experience shows that water management is key to achieving successful mine closure. Regulators require mining operations to closely manage mine effected water during and post mining, which are monitored through activities such as assessment of the receiving environment's water quality.

This paper provides perspective on the current guidelines and practices followed in setting mine water closure performance criteria and references current relevant Australian guidelines. Furthermore, it provides discussion on examples that are presented and recommendations to improve the current practices.

Keywords: Water Management, Closure, Performance Criteria

INTRODUCTION

Mine sites often face challenges to manage mine effected water, which vary from routine to the unexpected. Personnel responsible for mine water management will reference site procedures and guidelines when making some of these day to day decisions. However, in non-routine situations these decisions become difficult and more so, if the overall mine site water management objectives and performance criteria are unclear.

Those responsible for the planning and design of mine sites are not normally involved in the management of the mine site, and do not consider all management scenarios. Nor are they generally involved in closure planning or in implementing the closure and rehabilitation plans.

Various reports and planning documentation are developed during the feasibility and approval stage, during which high level mine management commitments are developed. These commitments include mine water management, which will provide the basis for setting mine water management objectives and criteria.

Significant work has been done in the field of assessing the potential and describing the formation of acid rock drainage with the aim prevent acid mine drainage. More strict legislation and setting better water management performance criteria aid in the drive to reduce the number of mine sites with acid mine drainage.

There is a lack of continuity in the design stage, and the operational and closure stages that results in developing mine water management criteria that are not sustainable. The paper highlights available the guidance, current practices and examples in setting sustainable water management criteria, and recommendations for further improvements.

METHODOLOGY

A desktop investigation was completed to identify relevant guidance documents and current practices followed in setting sustainable water management criteria. Information was compared to identify similarities and deficiencies to assist mine designers and planners to set sustainable water management criteria.

DISCUSSION

Mine water management is not the same for all mine sites, including the process followed to set sustainable mine water management closure performance criteria. The topic of mine water management is extensive and this paper will only focus on one aspect, which is believed to be pinnacle to the success of sustainable mine water management. Being, to identify and implement mine water management objectives and performance criteria.

Poorly defined performance criteria could lead to an anything-goes mentality. Unfortunately, this may result in long term closure liabilities such as acid rock drainage, saline drainage, erosion, flooding, etc. Furthermore, a lack of performance criteria will make assessment of closure performance nearly impossible.

What guidance is available for mine water management?

Regulators, scientific institutions and the mining industry develop many documents aimed at guiding the reader to undertake a specific activity. These documents are not developed by the same person or for the same purpose, and could duplicate information or contradict each other. Users of the information must therefore take care when using the information to ensure that it is applicable and of similar complexity to their situation.

The internet is a vast source of information and provides a multitude of relevant and irrelevant water management information. The following are some of the guidance information that are easily available:

- Water Management Leading Practice Sustainable Development Program- Australia (WMLPSDP, 2008);
- Managing Acid and Metalliferous Drainage Leading Practice Sustainable Development Program- Australia (MAMDLPSDP, 2007);
- Mine Rehabilitation Leading Practice Sustainable Development Program- Australia (MRLPSDP, 2006);
- Mine Closure and Completion Leading Practice Sustainable Development Program- Australia (MCCLPSDP, 2006);
- Guide to Leading Practice Sustainable Development in Mining- Australia (GLPSD, 2011);
- Managing mine water under extreme climate variability CSIRO project- Australia (CSIRO, 2013);
- Minesite Water Management Handbook- Australia (MWMH, 1997);
- Integrating the mining sector into water planning and entitlements regimes- Australia (Hamstead, 2012);
- Guidelines for Mining and Sustainable Development- International (UN, 2002);
- EU Water Framework Directive 2000/60- Europe (EU, 2000);
- Best Environmental Practices in Metal Ore Mining- Finland (Kauppila, 2013); and,
- Acid mine drainage prediction- United States (USEPA, 1994).

Other information that is not easily accessible on the internet, includes:

- Strategic Framework for Mine Closure 9 ANZMEC 2000. Strategic Framework for Mine Closure. Australian and New Zealand Minerals and Energy Council and Minerals Council of Australia (ANZMEC, 2000);
- Technical and Managerial Guidelines for Catchment Scale Management- United Kingdom (ERMITE, 2001);
- Checklists for sustainable mining- Australia (Barton, 2003); and
- Mining and the Environment from Ore to Metal- Australia (Spitz, 2008).

Guidance is also provided through legislation, licensing or policies. Mine sites identify site specific legislative requirements and manage these requirements. Not complying with relevant legislation or license conditions could result in legal action, under:

- The Environmental Protection and Biodiversity Act 1999 (EPBC Act), which protects and manages national and international important flora, fauna, ecological communities and heritage places. Notably, the EPBC Act on 22 June 2013 made water resources a matter of national environmental significance in relation to coal seam gas and large coal mining.

- The Queensland state government has released a number of environmental protection policies under the Environmental Protraction Act of 1994 (EP Act, 1994). The Environmental Protection Water Policy 2009 is one such policy relating to protection, monitoring and reporting of Queensland waters.

One common message was identified when reviewing the available guidance information. Being, that water management planning must be integrated at the beginning and throughout the project. Setting specific mine water management performance criteria gives focus to planning and design, and forms a common basis for setting related project objectives.

The guidance information is also clear on the importance of sustainability, which is well defined and discussed on many levels of society and industries. Water plays a vital role in the viability of economic activities (ATSE, 2012), such as mining and is one of the key resources assessed to ensure that a project is sustainable. This assessment includes both the reliance on water, as well as the potential risk to the water resource (NWI, 2011).

Guideline documents further identify the importance of setting water use regimes that support the mine water management performance criteria. A water use regime is set to ensure environmental and resource sustainability, while still allowing development. The 2011 National Water Initiative (NWI, 2011) identified the effect of mining on the sustainability of water resources, and raises concerns about the recognition and integration of the minerals industry in water reform. This is primarily due to historically treating the minerals and other extractive industries different to other water users, such as in the case of special water licenses giving mining operations the right to take and interfere with water (NWI, 2011).

Following the guidelines will assist in setting mine water performance criteria, however there are a number of issues to consider to ensure the sustainability of the mining project, these include:

- assuring an adequate water supply during the life of the project;
- ensuring that only water of an acceptable quality is discharged;
- providing infrastructure to prevent the flooding of mine workings and others;
- selecting a logical sustainability assessment process (Gasparatos, 2012); and
- considering project stakeholders and decision makers (RAC, 1992).

There are many sustainability assessment processes available (Gasparatos, 2012) however, selecting a suitable assessment process is not discussed in this paper.

Planning for effective mine water management in the initial design process

Mine water management has evolved over time and is a key focus area for many mining operations (Boshoff, 2014). Mine sites plan the mine water management layout based on the overall mine plan to ensure effective water management during all the stages of mining. Planning is generally based on modelling with limited verification of the assumptions and often no calibration of models, which could cause operational issues and redesign.

Mine designers also consider closure during this planning process and generally aim for a maintenance-free post mine closure water management system. Water management post closure will only be successful if supported through proper water and waste management during the life of the mine. This includes proper closure design for tailings and waste rock facilities. Integrating of closure requirements with the life of mine planning reduces the long term liabilities (Boshoff, 2014).

A water management plan is required for new mining projects seeking a license to operate. The Queensland government Department of Environment and Heritage Protection states that a water management plan must be developed by an appropriately qualified person and implemented by

the mine, as per the documented plan (EM944, 2013). Water management plans must further conform to guideline requirements (EM324, 2012), which include the following:

- study of the source of contaminants;
- a water balance model for the site;
- a water management system for the site;
- measures to manage and prevent saline drainage;
- measures to manage and prevent acid rock drainage;
- contingency procedures for emergencies; and
- develop a program for monitoring and review of the effectiveness of the water management plan.

Mine water management is not limited to the boundaries of the mine site, specifically in areas of high precipitation and for mine sites with an annual water excess that will most likely discharge frequently. Planning must include local and regional considerations to assess the impacts on water resources, including climate, topography, drainage and the receiving environment.

Mine planners and designers will assess the impacts, select objectives and develop cost effective mitigation strategies to ensure that the impacts post closure will be acceptable. Post mining water management performance criteria provides the basis for developing operational stage objectives. It will be difficult to meet more stringent closure performance criteria following an operational stage that had laxed performance criteria.

The mine designers involved during the feasibility stage of the mine are most likely not involved in operating of the mine (Bullock, 2011). Their objectives include cost effectiveness, which stems from pressures to make a mine feasible (McCarthy, 2013). The operating mine will also have an objective to keep overheads and production costs low, and the end result is a mine with inadequate water management considerations during the life of the mine and after closure.

Expertise and skill are required when planning, designing and implementing cost effective mine site water management that meet key cost effectiveness objectives. Even then, the water management plans should be considered living documents and altered as conditions change during mining or detecting unauthorised environmental impacts.

Setting effective mine site water management performance criteria

Will mine water management activities during mining and post closure result in sustainable outcomes? This is a question that cannot be answered qualitatively or quantitatively during the planning stage. Mine designers and planners consider project objectives and project design criteria during the design process (Elkington, 1997). The potential issues with project objectives and project design criteria includes:

- providing objectives that are not clear;
- selecting objectives that are general to the mining industry;
- selecting objectives prior to identifying environmental values;
- writing objectives as criteria or providing criteria as trigger limits;
- developing objectives that are not clear how and when it is relevant;
- quoting specific legislation or guidelines as objectives; and
- developing closure objectives not considering water management objectives and vice versa.

Below are some examples of water management objectives:

- General surface water management objectives (McArther River Mine, 2012):
  - **Separate** 'clean', 'dirty' and 'contaminated' water runoff as much as possible; and
  - **Minimise the area** of surface disturbance, thus minimising the volume of 'dirty' and/or 'contaminated' runoff.
- Site water management project operational and environmental objectives (RASP Mine, 2012):
  - **Prevent discharge** of potential contaminated surface waters from active mine areas off-site.
- Site water management principal objectives (Tarrawonga, 2006):
  - To ensure sufficient quantities of water can be obtained through the capture of "dirty" water, harvesting of "clean" water, and extraction/harvesting groundwater to meet the **requirements for dust suppression** on the mine site.
- Site water management objectives (Alpha Coal, 2011):
  - **Avoid** the need for **discharge** of contaminated water under normal operating conditions through preferential onsite reuse of contaminated water stores.

Similarities are observed, although planners and designers with different experiences and skills developed these objectives, of which the main similarities in the objectives consist of:

- meeting legislated mine site water management requirements;
- minimising the use of water from natural water resources on the surface and below;
- minimising the impact on surface water and groundwater flows and water quality;
- identify and control mine site erosion; and
- establishing a monitoring program to assess the actual impact on natural water resources.

Mine water management performance criteria, as with the objectives, are specific to the mine site. No one mine is the same or are located in exactly the same environmental setting resulting in different water management performance criteria. This is evident when comparing a number of environmental impact statements. The following are examples of water management performance criteria, of which the tabled water quality performance criteria were excluded:

- The characteristics of clean water are pH of 6.5 – 8.5 and suspended solids of **less than** 50 mg/l as well as hydrocarbons less than 10 mg/l (RASP Mine, 2012);
- Discharge **water quality will meet** the Australian and New Zealand Environment and Conservation Council Water Quality Guidelines for Fresh and Marine Waters (ANZECC, 2000);
- **Groundwater levels** in privately owned bore will **not exceed** more than 3 m sustained reduction over a 3 month period (RASP Mine, 2012);
- Long-term 'dirty' **runoff** drains that will be active for longer than 2 wet seasons **will be** constructed to **contain** the 1% Annual Exceedance Probability (100 year Average Recurrence Interval) design discharge (MacArthur River Mine, 2012);
- The performance of the water management plan in achieving the objectives and targets shall be **reviewed at least** quarterly (Ulan, 2014);
- Regularly **report environmental performance** to the environment and community manager (Ulan, 2014);
- **Runoff** from all disturbed areas across the mine site during the operational phase **is contained** by a mine water management system (Alpha Coal, 2011); and
- Mine closure runoff quality **meets** the water quality **objectives** for the identified surface water environmental values (Alpha Coal, 2011).

It was found that most of the water management performance criteria are focused on water quality and predominantly discharge water quality (as a lagging indicator), as required by the mine site license to operate. Regulators provide the discharge water quality requirements once the mine designed and approvals process are completed. The requirements are therefore based on the outcome of environmental studies, modelling and the mine's agreed/negotiated commitments. These commitments are therefore based on objectives, performance criteria and legislative requirements identified during the design and planning of the mine. More specifically, these commitments are specific to the environmental values relevant to the mine site and described in the key objectives to be enhanced or protected.

The main reason for selecting and describing water management performance criteria is to enable quantitative measurement of the effectiveness of the mine's water management activities.

Recommendations in setting mine water management performance criteria

Defining performance criteria for mine water management cannot be conducted by one person from a single engineering discipline (Gasparatos, 2012). This is due to the complexity of the issues associated with water management and closure objectives.

It is recommended to involve various disciplines; including civil engineering, mechanical engineering, structural engineering, environmental engineers, human resources, social and community studies in developing water management performance criteria.

Modelling of the water systems and assessing the potential effectiveness of various management options could provide early indications, however it is recommended that assumption must be verified once more tangible data becomes available.

A fully integrated planning and implementation process is recommended, which is broadly outlined as follows for all the stages in the life of the mine, including post closure:

- Identify surface water and groundwater environmental values relevant to the mining project;
- Set key closure objectives that will either enhance or protect the relevant surface water and ground water environmental values;
- Set water management performance criteria for the surface water and ground water relevant to the mining operations during;
- Undertake a risk assessment and identify the control measures, mitigation activities and responsibilities to ensure that closure objectives are met or exceeded;
- Set water management infrastructure design criteria relevant to the mining operations and key objectives;
- Plan, design and adequately cost the control measures and mitigation activities;
- Develop water management performance monitoring and reporting requirements;
- Develop a water management plan integrating closure;
- Obtain a social license to operate the mine committing to the water management plan;
- Verify all assumptions at the earliest possible stage of the design process; and
- Implement the water management infrastructure design and water management plan, as specified.

CONCLUSION

There are many freely available guidance documents that provide guidance in the development of water management performance and closure criteria. These objectives and performance criteria are best developed and agreed at the beginning of the planning and design process. Forward planning assist to ensure that selected water management objectives can be met during all stages of the mining project and after closure.

It can also be concluded that the development of objectives and the subsequent performance criteria needs input from individuals with experience and skill from a number disciplines. Site documentation must be linked back to the water management objectives and specific water management performance criteria. It is critical to develop effective objectives and criteria for water management performance and closure to ensure that site activities will drive to a common goal and that adequate budget is available during operations and after closure.

REFERENCES

Alpha Coal, (2011). *Alpha Coal Project Environmental Management Plan*, Alpha Coal Project, 2011.

ANZECC, (2000). *Australian and New Zealand guidelines for fresh and marine water quality*, Agriculture and Resource Management Council of Australia and New Zealand and the Australian and New Zealand Environment and Conservation Council, 2000.

ANZMEC, (2000). *Strategic Framework for Mine Closure 9 Strategic Framework for Mine Closure*, Australian and New Zealand Minerals and Energy Council and Minerals Council of Australia, 2000.

ATSE, (2012). *Sustainable Water Management: Securing Australia's future in a green economy*, Australian Academy of Technological Sciences and Engineering, 2012.

Barton, A (2003). *Checklists for sustainable mining: Best practice environmental management in mining series*, Environmental Australia, 2003.

Boshoff, H (2014). *Inadequate Water Management Planning Resulting in Long-term Closure Liabilities*, Life of Mine conference, Brisbane, 18 July 2014.

Bullock, R (2011). *Accuracy of Feasibility Study Evaluations Would Improve Accountability*, Mining Engineering, April 2011.

CSIRO, (2013). *Managing mine water under extreme climate variability*, CSIRO, April 2013

Elkington, J (1997). *Cannibals with Forks: The Triple Bottom Line of 21st Century Business*, 1997.

EM324, (2012). *Guideline for preparation of a water management plan for mining activities*, Department of Environment and Heritage Protection, 2 July 2012.

EM944, (2013). *Model mining conditions*, Department of Environment and Heritage Protection, 26 June 2014.

EP Act, (1994). *Environmental Protection Act 1994*, Queensland Government, Current as at 1 July 2014.

EPP Water, (2009). *Environmental Protection (Water) Policy 2009*, Queensland Government, Current as at 6 December 2013.

ERMITE, (2003). Environmental regulation of mine waters in the European Union, European Commission Framework Programme No. 5, July 2003.

EU, (2000). EU Water Framework Directive 2000/60, European Commission, December 2000.

Gasparatos, A (2012). *Choosing the most appropriate sustainability assessment tool*, Ecological Economics, Elservier, 20 May 2012.

GLPSD, (2011). G*uide to Leading Practice Sustainable Development in Mining: Leading Practice Sustainable Development Program for the Mining Industry*, Australian Government Department of Resources, Energy and Tourism, July 2011.

Hamstead, M, Fermio, S (2012). *Integrating the mining sector into water planning and entitlements regimes*, Waterlines Report Series No 77, March 2012

Kauppila, P, Räisänen, M, Myllyoja, S (2013). Best Environmental Practices in Metal Ore Mining, Finnish Environment Insitute, 2013.

MacArthur River Mine, (2012). *Draft Environmental Impact Statement, Phase 3 Development Project*, Glencore MacArthur River Mining, 2012.

MAMDLPSDP, (2007). *Managing Acid and Metalliferous Drainage: Leading Practice Sustainable Development Program for the Mining Industry*, Australian Government Department of Resources, Energy and Tourism, February 2007

McCarthy, P (2013). *Why Feasibility Studies Fail*, The Australasian Institute of Mining and Metallurgy Melbourne Branch, February 2013.

MCCLPSDP, (2006). *Mine Closure and Completion: Leading Practice Sustainable Development Program for the Mining Industry*, Australian Government Department of Resources, Energy and Tourism, October 2006

MRLPSDP, (2006). *Mine Rehabilitation: Leading Practice Sustainable Development Program for the Mining Industry*, Australian Government Department of Resources, Energy and Tourism, October 2006

MWMH, (1997). *Minesite Water Management Handbook*, Minerals Council of Australia, 1997

NWI, (2011). *The National Water Initiative—securing Australia's water future: 2011 assessment*, National Water Commission, September 2011.

RAC, (1992). *Multi-criteria assessment as a resource assessment tool, Resource Assessment Commission Research Paper No. 6*, Commonwealth of Australia, 1992.

RASP Mine, (2012). *Site Water Management Plan RASP Mine Broken Hill*, Broken Hill Operations, 30 April 2012.

Spitz, K, and Trudinger, J (2008). Mining and the Environment: From Ore to Metal, CRC Press, November 2008.

Tarrawonga, (2006). *Site Water Management Plan for the Tarrawonga Coal Mine*, Tarrawonga Coal Mine, February 2006.

Ulan, (2014). *Water Management Plan Ulan Coal Mine*, Umwelt Environmental Consultants, July 2014.

UN, (2002). *Guidelines for Mining and Sustainable Development*, United Nations, 2002.

USEPA, (1994). *Acid mine drainage prediction, Technical Document EPA 530-R-94-036*, U.S. Environmental Protection Agency, December 1994.

WMLPSDP, (2008). *Water Management: Leading Practice Sustainable Development Program for the Mining Industry*, Australian Government Department of Resources, Energy and Tourism, May 2008