Mine Closure Water Management: Choosing the Right Alternative within a Changing Environment

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Abstract South Africa has experienced extensive changes with respect to environmental legislation governing mining in the last fifteen years. Thus operations have had to implement substantial changes to the management of environmental impacts. Whilst operational mines have the opportunity to ensure necessary changes are applied, many closed operations now face a major challenge in trying to adopt and conform to the legislation when budget is no longer available. Innovative thinking is often required, with extensive consultation with various stakeholders, to ensure that a sustainable solution for closure that is both economically and environmentally sound is identified. This paper examines a case study of a closed operation in South Africa and highlights the process that was followed in identifying an appropriate long term water management solution for the mine water decant to ensure legislative requirements post operation are met. What was once a "simple" water management project has now become a minefield of options in which both passive and active treatment technologies are potentially feasible.

Key Words IMWA 2010, water management, closure, alternatives, passive and active treatment, legislation

Introduction

The extensive changes in mining legislation in South Africa have necessitated the need for mining operations to institute substantial changes, in particular with respect to the management of their environmental impacts particularly those pertaining to water. Whilst operational mines have the opportunity to ensure necessary changes are applied, many closed operations now face a major challenge in trying to adopt and conform to the legislation, as legacy issues have to be rectified in compliance with stricter requirements when budget is no longer available. This is particularly true for the case study in question; a closed colliery, in South Africa which ceased operations in 1992. The mine's closure strategy had to be adapted by finding an appropriate long term water management solution for its mine water decant to ensure legislative requirements post operation are met. This has required innovative thinking by the project team. Extensive consultation with various stakeholders including; company management, the various mining rights holders, the regulators, neighbouring mines and industry, the local municipality, etc was undertaken to ensure that a sustainable solution for closure can be found that is both economically and environmentally sound.

Project Setting

The Colliery discussed in this paper is an old defunct mine, consisting of two legally separate sections, each with their own mining right; Section A and Section B. Neither section is connected to the other hence preventing intermine transfer between the two sections. Mining started at the Colliery in 1959 and ceased in September 1992, with rehabilitation of the colliery being initiated in 1993. Rehabilitation was focussed on surface rehabilitation as specified by the regulations at that time, the Minerals Act, Act No. 50 of 1991 and included coal contaminated areas as well as sealing and rehabilitation of the shafts and adits. These areas included the discard dump, closing and rehabilitating all opencast areas, the process plant and rail siding earthwork rehabilitation to mention but a few. In April 2004, Section B underground workings filled to maximum storage elevations and the mine started to decant. Department of Water Affairs (DWA) was notified about the matter. A contingency measure which involved the transfer of water across to Section A via a pipeline was implemented. This allowed for the water levels in Section B to be lowered thereby controlling decant. However by September 2005 both sections had filled and a water use licence for the release of water was applied for. DWA issued a directive to release affected mine water from Section A under controlled conditions for a five year period on the proviso that within the five years the mine must develop and begin implementing a long-term water management plan. This water use licience has since been extended for an additional five years whilst the project implements its long-term water management plan.

Mining Legislation Revolution

The South African mining, environmental and water legislation has been completely rewritten following the democratic transformation in South Africa in 1994, with focus being given to ensure that potential polluters internalise their externalities. This implies that where pollution does occur, the polluter rather then society will pick up the bill thereby applying the “polluter pays principle”. This has seen the need for the application of an integrated approach with a greater focus on the environmental impacts of mining and the management thereof from conception of the project through to operation and closure with environmental liabilities in fact remain the responsibility of the mine into perpetuity. In regards to water these legislative changes have resulted in a scenario where once water was seen as just something to be avoided from a safety perspective, to the 1970’s and early 1980’s were mines considered it as part of the mine plan, to present day where mine water management is crucial to the management of an operation impacting on regulatory approvals and licence to operate (fig. 1). (Mey and van Niekerk 2009).

At present the main statutory requirements that govern mining and mine water management in South Africa are the Mineral and Petroleum Resources Development Act, Act 28 of 2002, the National Water Act, Act 36 of 1998, and the National Environmental Management Act, Act 107 of 1998 amended in 2006, all of which are founded on the Constitution of South Africa, Act 108 of 1996 which states that:

> *“everyone has the right to an environment that is not harmful to their health and wellbeing and to have the environment protected for the benefit of both present and future generations through reasonable legislative and other measures that; prevent pollution and ecological degradation; promote conservation; secure ecologically sustainable development and the use of natural resources while promoting justifiable, economic and social development”.*

As a mining fraternity the South African constitution and its subsequent supporting mining and environmental legislation thus provides mines the right to economic activity, but not to externalise its impacts on people or the environment. Further to this both the National Water Act and the National Environmental Management Act places a duty of care on a company to prevent, minimise and rectify pollution and/or degradation. This duty of care is retrospective in nature and thus a company will still be responsible even if they no longer own the premises or are in operation. Mining houses are thus no longer able to walk away once mining has ceased and closure activities have been undertaken. These changes in the South African legislation have thus revolutionised the way in which water management at a mine site are approached during planning, operation and closure. However whilst mines in a planning and operational phase are still able to make fundamental changes to their water make and management through applying DWA‘s Hierarchy of Control (step 1: pollution prevention, step 2: minimises impacts, step 3: water use & reclamation, step 4: water treatment, step 5: discharge) and making adequate provision for water management / treatment at closure, closed mines are left to manage legacy issues with very few

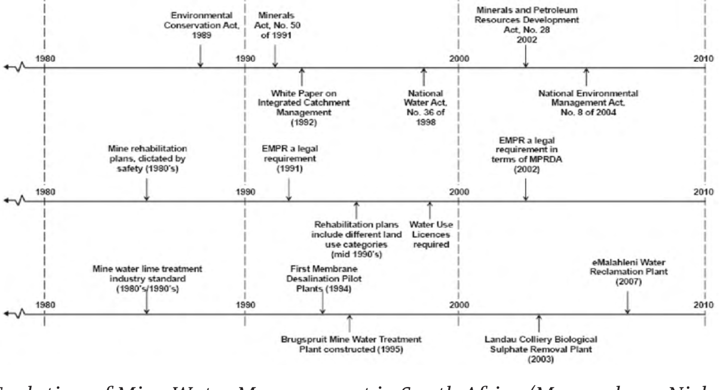

Figure 1 *Evolution of Mine Water Management in South Africa (Mey and van Niekerk 2009)*

alternatives at hand and even less funding. This poses a serious threat to the actual sustainability of the solution proposed by defunct operations and it is these challenges which the organisation now faces in dealing with the water problem at the Colliery in question.

Alternatives Selection

Driven by the DWA directive and the Company's Environmental policies, a project was initiated as a means of ensuring legal compliance and minimising the Company's long term liability at the mine. The scope of work was thus to; "develop a long-term sustainable strategy to manage the polluted mine water of Sections A and B, as well as Section A individually, that ensures legal compliance at lowest acceptable risk and cost". With this in mind, a Problem Framing workshop was undertaken where both passive and active treatment technologies were evaluated, based on the technologies performance evaluation results from desktop studies and laboratory scale tests, to mange less then 5ML/d of sodium sulphate enriched mine water decant (tab. 1).In evaluating the options the project also considered the implications of having to deal with four times more water when looking at Sections A & B combined in comparison to Section A only. In addition, the water at Section A is far less impacted than the water at Section B, with Section B having three times the sulphate concentration of Section A and exceeding the In stream Water Quality Objectives by more the fifteen times the permissible concentration allowed for discharge into the natural environment.

Based on the outcomes of this process, water treatment using reverse osmosis was deemed the preferred go-forward option for Sections A and B combined, whilst for Section A alone, evapotranspiration was deemed the most feasible solution. Whilst water treatment is a potential solution for Section A as it produces water compliant with the In stream Resource Water Quality Objectives (IWRQO) for the catchment, it was deemed not feasible for Section A alone due to cost implications associated with the active treatment of small volumes of less impacted water. Based on the outcomes of the problem framing workshop it was thus decided to precede with trialling the use of trees as a means of addressing the water liability at Section A. In the meantime the Company will continue to manage Section B decant via the pumping of water to Section A and controlled release as per the updated five year water use licence issued to the mine. This will allow the project time to adequately trial evapotranspiration at Section A and depending on the outcome of the trials, the project hopes to prove the viability of evapotranspiration as a water management option for the Section B for the reduction of water ingress into the underground mine workings as well.

Application of Evapotranspiration

Evapotranspiration, also known as phyto-abstraction or phytohydraulics, forms part of a suite of phytotechnologies which are essentially based on the engineered use of plants and their associated microorganism for environmental clean-up (ITRC 2009). In the case of mining, evapotranspiration is considered an appropriate water management tool to reduce the ingress of water into underground mine workings, thereby controlling potential decant of the mine. Trials conducted

Table 1 *The Evaluation of Treatment Technologies to Manage Sodium Sulphate Water*

Approach	Feasibility of Soulution
Do nothing	Eliminated - Does not comply with IWQO (All parameters)
Nanotech technology	Eliminated - Does not comply with IWQO (Sodium)
SAVMIN process (Ettringite)	Eliminated - Does not comply with IWQO (Sodium)
Reverse osmosis with Barium sulphate by-product	Eliminated - Does not comply with IWQO (Sodium)
Reverse osmosis with a SPARRO process	Eliminated - Does not comply with IWQO (Sodium)
Electro coagulation with reverese osmosis	Eliminated - Does not comply with IWQO (Sodium)
Biological sulphate reduction with reverse osmosis	Eliminated - Does not comply with IWQO (Sodium)
Nanofiltration	Eliminated - Does not comply with IWQO (Sodium)
Passive treatment	Eliminated - Does not comply with IWQO (Sodium)
GYPCIX process	Eliminated - Does not comply with IWQO (Sodium)
Biological sulphate reduction	Eliminated - Does not comply with IWQO (Sodium)
Electro dialysis	Eliminated - Not yet been proven in large-scale coal mine water treatment applications.
EcoDose process	Eliminated - Not yet been proven in large-scale coal mine water treatment applications.
DesEL process	Eliminated - Not yet been proven in large-scale coal mine water treatment applications.
Conventional Reverse Osmosis	Viable - Proven technology able to meet IWQO
Evapotranspiration - Trees	Viable - Proven (SA goldfields)

in South Africa on mine impacted land showed that in wet scenario simulations, trees evaporated 227mm/annum more than grass thereby reducing drainage of rainfall through increased evaporation rates, whilst in a dry scenario trees were able to increase evaporation by 5mm/annum over grass although no drainage occurred (Jarmain 2001). In the case of Section A, the implementation of evapotranspiration covers, strategically placed, will control water ingress as a result of their capacity to store rainfall for subsequent evapotranspiration thereby reducing or limiting the amount of surface water migrating to underlying groundwater. In addition other benefits such as the inhibition of vertical leaching through hydraulic control, carbon sequestration, soil stabilization, improvement of functional soil ecosystems will be realised. Further positive aspects which are particularly important in the South African context from a community aspect, involves the potential production of value-add products, such as biofuel, high value wood etc as this creates opportunities for setting up sustainable industries in association with communities and will additionally ensure that tree stands are managed appropriately thereby providing assurance that the water issue is managed effectively into the future (Weiersbye 2007). With this in mind and based on work done by the University of the Witwatersrand, South Africa for AngloGold Ashanti, work was initiated with Wits University. It is estimated that approximately 150 to 200 ha of suitable land would be required to manage ingress of water into the underground mine workings at Section A, under normal rainfall conditions. Since extreme rain events may result in excess water which cannot be captured by the root system for evapotranspiration, additional measures are however still required. These will take the form of diversion channels which will enable the rerouting of clean water from dirty areas on site to ensure contamination of water is minimised. In addition, storage capacity within the underground workings will be maintained at appropriate levels to allow for storage of excess water not captured by the root systems and ultimately authorised controlled releases.

Conclusions

With the changes in South Africa's legislation has come the need to better manage the environmental impact associated with mining, in particular those related to mine water management as a means of ensuring mining companies legal compliance and minimising its long term liability. Whilst water treatment has proved technologically feasible as a means of meeting these criteria, in the case of defunct mines this is often not financially viable as generally no financial provision for such a costly exercise has been made. Further to this, the volumes of water to be treated are often so small; that the capital spend cannot be justified. This has required some innovative thinking by the parties involved. By going back to DWA's Hierarchy of Control and taking a fresh approach to determining means of pollution prevention through minimising water ingress, the project has been able to come up with a possible long term water management strategy for Section A using phytoremediation. It is hoped that in trialling evapotranspiration covers at Section A, the project will be able to prove the viability of this technology for coal mines in South Africa and in doing so may actually have found a long term solution for both Sections.

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