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**Briefing Note 2009/02**
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# Acid Mine Drainage in South Africa

**The effect of mining on the environment includes the release of many chemical contaminants into water resources, which can cause environmental damage and threaten the health and safety of nearby communities long after mine closure. This pollution is so persistent that, in the absence of available remedies, in many instances the contaminated sites may never be completely restored.**

**The threat of AMD to the environment will not be solved in the short to medium term, and is likely to persist for centuries to come. It is also not solved by a single intervention, but will require the integrated implementation of a range of measures.**

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**CSIR Natural Resources and the Environment**

As early as 1987, the US Environmental Protection Agency recognised that "*.....problems related to mining waste may be rated as second only to global warming and stratospheric ozone depletion in terms of ecological risk. The release to the environment of mining waste can result in profound, generally irreversible destruction of ecosystems*."

## South African context

South Africa is a water-stressed country. Security of water supply has become a key strategic issue as well as driver for continued and sustained economic growth and service delivery to the people of South Africa. The South African mining sector is one of the critical pillars and drivers of the South African economy.

However, mining activities are also associated with environmental contamination such as acid mine drainage (AMD). AMD is highly acidic water, usually containing high concentrations of metals, sulphides, and salts as a consequence of mining activity. The major sources of AMD include drainage from underground mine shafts, runoff and discharge from open pits and mine waste dumps, tailings and ore stockpiles, which make up nearly 88% of all waste produced in South Africa. Drainage from abandoned underground mine shafts into surface water systems (decant) may occur as the mine shafts fill with water. Although the chemistry of AMD generation is straightforward, the final product is a function of the geology of the mining region, presence of micro-organisms, temperature and also of the availability of water and oxygen. These factors are highly variable from one region to another, and, for this reason, the prediction, prevention, containment and treatment of AMD must be considered carefully and with great specificity.

The gold mining industry in South Africa (principally the Witwatersrand Goldfield) is in decline, but the post-closure decant of AMD is an enormous threat, and this could become worse if remedial activities are delayed or not implemented. For example, acid mine water started to decant from defunct flooded underground mine workings near Krugersdorp on the West Rand in August 2002, leading to polluted surface water. Randfontein and the Wonderfontein Spruit are also problematic. These cases have received substantial media attention, which has been critical of the efforts so far to address the problems. In the absence of remediation, there is likely to be substantially more decant in future, with potentially severe implications for aquatic systems.

AMD from coal mining is problematic in the Highveld Coalfield in Mpumalanga, and has been reflected by media attention on the consequences of severe pollution seen in the Loskop Dam and the Olifants River Catchment. It is likely that new coal mining in the Waterberg Coalfield (Limpopo Province) will lead to similar problems in that area in the future.

## Treatment of AMD

The potential volume of AMD for the Witwatersrand Goldfield alone amounts to an estimated 350ML/day (1ML = 1000m$^3$). This represents 10% of the potable water supplied daily by Rand Water to municipal authorities for urban distribution in Gauteng province and surrounding areas, at a cost of R3000/ML. These figures place not only the volume, but also the potential economic value of the mine water in perspective. While many mines have established *ad hoc* chemical, biological or physical processes to treat localised water pollution, South Africa urgently needs a regional, consolidated approach to AMD.

It is against this background that the Western Utilities Corporation (WUC) is planning to establish a mine water treatment plant that will produce some 60ML/day of industrial grade 'process' water for reuse and 15ML/day of potable water for Gauteng in the first phase. Ultimately, the plan is to treat up to 300ML/day for various potential users, and to recover a range of by-products such as sulphur and metals so that there is little or no residual waste.

This follows the example set by the Emalahleni Water Reclamation Plant in Mpumalanga, which treats 25ML/day of acid mine water generated by coal mining to a drinking water standard. These initiatives provide benefits, not only to the potential users of the treated water, but also the receiving aquatic environment. There is an estimated 62ML/day post-closure decant from coal mines in the Highveld Coalfield and around 50ML/day of AMD discharging into the Olifants River Catchment, reducing the quality of water for irrigation and municipalities, as well as damaging freshwater ecosystems. Further remediation is urgently required.

The threat of AMD to the environment will not be solved in the short to medium term, and is likely to persist for centuries to come. It is also not solved by a single intervention, but will require the integrated implementation of a range of measures. Such measures include active water treatment (as demonstrated by the Emalahleni and WUC plants), passive water treatment systems (e.g. constructed wetlands), controlled placement of acid-generating mine waste, and prevention of water ingress into mine voids and of AMD loss from mine voids.

**AMD issues requiring further attention**

A major concern has to be the absence of a national view on the development of optimal, integrated solutions to the management of AMD and how to approach the utilisation of 'new' water generated through treatment technologies.

**Policy frameworks**

Two broad classes of problems have been identified in the existing policy frameworks used to address AMD. Firstly, the delegation of powers between various government departments at the national, provincial and municipal levels is unclear. Institutional roles and responsibilities are fragmented, overlapping or vaguely defined. There is a need to rationalise and align national legislation to remove ambiguity. Secondly, the existing frameworks place the government in the position of having to be reactive rather than proactive. This is evident in the pricing structures and enforcement mechanisms used to discourage pollution using the 'polluter pays' principle, as well as the legal framework that outlines requirements for environmental impact assessments.

**Research**

There is still a tremendous need for further technical research and innovation in the treatment of AMD, to enable cost-effective treatment of the range of AMD waters present in South Africa. Many treatment processes give rise to new large waste streams (such as brines or gypsum), and there needs to be ongoing effort to develop near zero waste processes. Near zero waste processes have a further benefit in that they allow for the recycling of a large portion of treatment chemicals. This recycling not only has the benefit to generate income through the recovery of saleable by-products, thereby reducing operational costs of treatment, but also allows for the reuse of chemicals such as lime and limestone. These chemicals are likely to be in short supply soon, as they are used increasingly in AMD and other forms of remediation. When the value of treated water and by-products exceeds the cost of treatment, it is feasible to create enterprises that will provide economic benefits while dealing with the environmental problems.

**Strategic research and implementation**

A national view on approaches to AMD would be supported by evidence-based policy and regulation, founded on improved links between research institutions, government agencies and key line departments of government. A strategic approach would be supported by the development of a centralised database of historical, current and potential future mine pollution from which to determine the nature and extent of impacts, and to identify priority areas and actions for the implementation of remedial measures. Prioritisation would be supported by a research programme to investigate the impacts of AMD on human health, wellbeing and ecosystems. Sensitive physical environments such as dolomitic aquifers may require specific management interventions. Integrated solutions would be supported through improved links between universities, research organisations and the international research community.

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## Useful resources

Godfrey, L., Oelofse, S., Phiri, A., Nahman, A. and Hall, J. (2007). Mineral Waste. The required governance environment to enable reuse. CSIR Report CSIR/NRE/PW/IR/2007/0080/C.

Adler, R.A., Claassen, M., Godfrey, L. and Turton, A.R. (2007). Water, mining, and waste: An historical and economic perspective on conflict management in South Africa. The Economics of Peace and Security Journal, 2(2): 33-41.