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Use of remote sensing and GIS in a risk assessment of gold and uranium mine residue deposits and identification of vulnerable land use

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South African Legislation Pertinent to Gold Mine Closure and Residual Risk

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Abstract

Mining is an important contributor to the South African economy but has the potential for significant negative impacts on the environment. Under section 24 of the Constitution of South Africa Act 108 of 1996 (the Constitution), the right to environmental health has been elevated to a basic human right, and since 1998 a series of Acts have been promulgated to prioritize environmental protection. In addition, the Mineral and Petroleum Resources Development Act 28 of 2002 (the MPRDA) and its Regulations (GN R527 in Government Gazette 26275 of 23 April 2004) have been promulgated to regulate the minerals and petroleum industry in terms of constitutional requirements. The MPRDA attempts to ensure sustainable development of mineral resources, equitable access to the benefits, better environmental protection, and includes provisions for mine closure. We reviewed the legislation associated with mine closure to assess whether it adequately addresses constitutional and environmental requirements, including known risks to gold mine closure. Although the MPRDA does aim to provide for the protection of the environment at mine closure, it currently contains some flaws and gaps which need to be addressed. Some of the gaps are however potentially addressed by the provisions of other legislation, such as the National Environmental Management Act 107 of 1998 (the NEMA) and the National Water Act 36 of 1998 (the NWA). A key requirement of the MPRDA is for mining companies to undertake the necessary studies to determine the quantum required for the rehabilitation or management of impacts, and to make sufficient financial provision for these. In this regard a guideline document has been published to assist the Department of Minerals and Energy (DME) when reviewing the quantum of provisioning. The MPRDA also attempts to establish an exit route whereby mining companies, which demonstrate an agreed degree of environmental compliance, can then transfer their remaining liabilities to the State or a third party together with sufficient funds to address them. However, if funds are insufficient, the mining company and the directors in their personal capacity remain liable. Thus it is vital that mining companies and directors keep abreast of international trends in order to pro-actively minimize their exposure. Un-answered questions relate largely to end land-uses and restrictions thereon. Based on current information, we consider residential townships, edible crop production and livestock grazing to be high risk land-uses for tailings storage facilities (TSFs), TSF footprints and areas within the aqueous or aerial zone of influence of TSFs and metallurgical plants in South Africa. Failure by the regulators and industry to agree on suitable `soft' end land-uses and buffer zones could exacerbate liabilities for closing mines by resulting in subsequent land-uses that are sub-economic or risky.

1 Introduction

In contrast to earlier views that environmental legislation impacts negatively on company financial performance (Leonard, 1988), international experience is beginning to demonstrate that there is little evidence for negative effects, and in some cases regulation has actually encouraged improved financial performance (Porter and van der Linde, 1995). Mining has the potential for significant negative environmental impacts, and the role of emerging legislation in guiding the performance of mining companies in South Africa is of the utmost importance. Although mining contributed 8.1% to the GDP in 2002, is a major foreign exchange earner and a significant employer (CoM, 2003); abandoned and derelict mines could cost the state SAR100 billion to rehabilitate (M&G, 2007).

Minerals and environmental legislation prior to the Constitution failed to prevent significant environmental damage through mining, and created legacies for citizens to bear and the State to address. The recent MPRDA and its regulations promulgated by the DME therefore focus on sustainable development and end-

land use post mining, together with internalisation of social and environmental costs. Further, in terms of section 43(1), the holder of a mining right or similar remains responsible for any environmental liability, pollution or ecological degradation, and management thereof, until the Minister has issued a closure certificate to the holder concerned.

We selected gold mining to assess whether the new minerals legislation meets constitutional requirements and is aligned with sound environmental principles. We also identified areas in the minerals legislation that need clarification or further development. In South Africa the risks and impacts of gold mining on the Witwatersrand Basin may include, *inter alia*, contamination and alteration of surface watercourses through tailings spillages, surface instability through seismicity and sinkholes, TSF failure, contaminated decant from underground workings, and dust (illustrated in Figure 1), as well as noise, vibration, radioactivity from naturally occurring radioactive materials (NORMs), soil and ground water contamination, air pollution, land degradation and loss of productivity, bioaccumulation of metals and NORMs, loss of biodiversity, impairment of ecosystem services, contributions to ozone depletion, contributions to global warming, and human health impacts (Rudd, 1973; Funke, 1990; Pulles, 1992; Cogho et al., 1992; Coetzee, 1995; Weiersbye et al., 1999; 2006; Rosner and Van Schalkwyk, 2000; Hodgson et al., 2001; Rosner et al., 2001; Winde, 2001; Naiker et al., 2003; Tutu et al., 2003; 2004; 2005; Weiersbye and Witkowski, 2003; 2007; Coetzee et al., 2004; Cukrowska and Tutu, 2004; Harrington et al., 2004; Mphefu et al., 2004; Winde et al., 2004a;b;c; Steenkamp et al., 2005a;b; Sutton et al., 2006; O'Connor and Kuyler, 2007).



Figure 1. Examples of environmental impacts associated with gold mining in South Africa, (a) a river channel diverted by 3 m high tailings spillages; (b) property damage during earth tremor above an abandoned mine (source: Anon.); (c) sink-hole (source: Anon.), these are exacerbated through de-watering / re-watering of dolomites; (d) slimes dam failure (source: SADF, 1938); (e) cattle grazing in decanting mine water; (f) dust from a TSF.

2 Review

2.1 Protection of communities and the State from having to bear costs of impacts

Section 24 of the Constitution affords all South Africans the right to an environment that is not harmful to their health or well-being; and to have the environment protected, for the benefit of present and future generations, through reasonable legislative and other measures that prevent pollution and ecological degradation; promote conservation; and secure ecologically sustainable development and use of natural resources while promoting justifiable economic and social development. To give effect to this right, the NEMA was promulgated by the Department of Environmental Affairs and Tourism (DEAT). NEMA

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contains a set of 18 environmental principles that must guide administrative and court decisions in the field of environmental management. These principles are themselves guided by the ideal of sustainable development, as defined by the Brundtland Commission (WCED, 1987). Section 2(4)(a) of NEMA requires that sustainable development considers all relevant factors related to the disturbance of ecosystems, the loss of biological diversity, pollution and degradation of the environment, the disturbance of landscapes and sites that constitute the nation's cultural heritage, the generation of waste, and the use and exploitation of non-renewable natural resources. Overall, section 2(4)(a) recognises that, for development to occur, there will possibly be some negative impacts, however, it calls for a risk-averse approach and for any of these impacts to be anticipated, prevented whenever possible, or otherwise minimised and remedied. Another of the principles in NEMA (section 2(4)(p)), commonly known as the 'polluter pays' principle, refers specifically to who must bear these costs;

> *"The costs of remedying pollution, environmental degradation and consequent health effects and of preventing, controlling or minimising further pollution, environmental damage or adverse health effects must be paid for by those responsible for harming the environment."*

The DME has also used the term sustainable with an object of the MPRDA, given under section 2(h), being to give effect to section 24 of the Constitution by ensuring that the nation's mineral and petroleum resources are developed in an orderly and ecologically sustainable manner while promoting justifiable social and economic development. Nonetheless, despite the good intentions of the MPRDA to give effect to constitutional and national environmental policy and principles with regard to mining, it is a complete rewrite of minerals legislation. Consequently there are some errors and gaps, which could be taken advantage of by mining operators or expose mining companies to risk. At the time of coming into effect the MPRDA required existing mining and prospecting rights (`old order rights') to be converted to `new order rights' under specified conditions otherwise the rights were lost. However, not only did the holder of unused old order mining rights lose rights after a period of one year under Section 8 of Schedule II but obligations were also incidentally lost, which could be interpreted as any obligations for rehabilitation and mine closure. It is possible that this type of gap could also exist when the continuation period of 5 years for used `old order rights', which are not converted, expires.

Another area that requires clarification relates to the definition and scope of mining. According to Scholes in Tyrer (2005), there is an anomalous position in the MPRDA whereby this Act does not apply to gold slimes dams produced under title granted through legislation prior to the MPRDA (known as `old order mine dumps') simply because the MPRDA refers to mine residue stockpiles and deposits, and defines these as resulting from the depositional activities of the holder of a "new order" mining right. Furthermore, the transitional arrangements do not specifically mention ownership of residual minerals in tailings deposits as qualifying for an "old order" mining right; so, strictly speaking, there is no transitional process to convert from an "old order" mining right to a new one. Consequently, Scholes is of the opinion that once the "old order" right lapses the owner can continue processing residual minerals in tailings deposits without needing to approach the DME and without a mining authorisation.

Lastly, in accordance with MPRDA Regulations, a guideline on financial provisioning for mine closure has been produced for use by the DME when reviewing the quantum determined by mining companies. Within this guideline gold and uranium processing waste has erroneously been defined as basic, salt producing (DME, 2005), which could result in financial provisioning requirements for gold mine residue deposits being significantly underestimated. Since the requirement is for the mining company to carry out the necessary studies to determine the quantum the DME accepts no liability for any shortfall and in such an event the mining company and its directors, in their personal capacity, remain liable. Gold is largely mined from sulphidic ores in South Africa, and there are approximately 6 billion tonnes of gold mine tailings in unlined facilities on the Witwatersrand Basin of South Africa (Chevrel et al., 2003), containing an estimated 30 million t of sulphur (Witkowski and Weiersbye, 1998) and 430 000 t of low grade uranium (Council for Geoscience). The generation of acid mine drainage and contaminated seepage by these tailings is well established (Rösner et al, 2001; Naiker et al., 2003; Tutu et al., 2003; Winde et al., 2004a; b; c), as are the substantial environmental and financial liabilities incurred worldwide through pollution of water and soil resources (Sasowsky et al., 2000; Jarvis and Younger 2000). Although the Constitution prescribes an environment not harmful to human health, practical means of limiting human exposure to harm are not adequately dealt with in current legislation. For example, buffer zones to human settlement, cropping and

grazing need to be defined and legally enforced around TSFs and residual contamination, and limits need to be set upon the uses of contaminated water (discharge, polluted streams and groundwater) for crop irrigation.

2.2 Identification and management of all actual and potential environmental impacts

Although seeking to reduce the exposure of mines to environmental liabilities, the Environmental Impact Assessment (EIA) guidelines of the MPRDA could have the opposite effect. The Constitution and the NEMA clearly established the DEAT as lead agent for environmental protection and the EIA process in South Africa. Division of the responsibility for environmental protection between departments on a favoured industry basis will result in a lowering of standards as the MPRDA in section 39(1) advocates `accelerated' EIAs for the mining industry by requiring an EIA, as well as environmental management programme (EMP), to be submitted within 180 days. This EIA process is not based on scientifically sound principles, and mines therefore face the risk of having operations endorsed under the provisions of the MPRDA, only to find later that they have incurred liabilities which could easily have been avoided by adhering to sound EIA practices.

Just as all areas are not equal in terms of mineral resources; neither are all areas equal in terms of natural capital and biodiversity. The majority of gold and coal mines in South Africa occur in a region known as the Grassland Biome. The South African Grassland Biome is classified by the WWF (2002) as highly diverse in flora and fauna, with high levels of endemism, but critically endangered due to habitat loss, fragmentation and development threats, principally due to deep-level gold mining, surface coal mining, and cropping. The impact of deep level gold mining on carbon storage and water quality is considered the highest of all land-uses in the Grassland Biome, with soil erosion one of the highest (O'Connor and Kuyler, 2007).

Unfortunately, the MPRDA EIAs can be conducted at any time of year, although the influence of seasonality on detection of flora and fauna, and evaluation of biodiversity, is well recognized worldwide. For example, within the Grassland Biome, most plant species (83% of which are actually non-grasses, Reyers and Tosh, 2003), and smaller fauna experience seasonal dormancy, whereas some avian species are migratory. At worst, if not conducted in appropriate seasons and for biologically relevant time periods, the EIA could under-represent biodiversity by almost 95%. Assessment of hydrology requires a full hydrological cycle to encompassed, and assessment of ecosystem goods and services could be similarly compromised by an `accelerated' EIA. A preliminary, conservative estimate of the value of ecosystem services in South African grasslands is SAR9.7 billion per annum, or SAR29 000/km^2 of grassland per annum (De Witt and Blignaut, 2006). With respect to social aspects, rural and urban livelihoods of the poor in South Africa are highly dependent on ecosystem goods, and potential impacts on community resource bases can rarely be assessed within such short time periods (Dovie et al., 2005; Shackleton et al., 2007).

Planning mining operations for closure, and thus avoiding high risks and minimizing impacts, is globally considered the most cost-effective approach in any setting. The EIA is the foundation of this approach, and should be undertaken in accordance with ecologically-sound principles.

2.3 Maintenance of mine amelioration or mitigation measures after mine closure

Regulations 56, 60 and 62 of the MPRDA Regulations require that residual and possible latent impacts are identified and quantified, but do not provide any practical manner for dealing with them, which renders financial estimation difficult. Although the Minister of the DME may, under Section 41(5) of the MPRDA, retain such portion of the financial provision as may be required to rehabilitate the closed mining or prospecting operation in respect of latent or residual environmental impacts, latent impacts by their definition are unknown or at best merely suspected, and therefore provision is seldom made for them. For example, gold deposits on the Witwatersrand Basin naturally co-occur with uranium, other NORMs and metals such as Mg, Cu, Zn, Mn, As, Ni, Cr, Co and Pb. In addition, long-lived cyanide-metal complexes persist in TSFs, and Hg is still used for gold amalgamation by artisinal miners.

The latent impacts on biota, including humans, of bioaccumulation and exposure to elevated levels of metals and NORMs are established in the international scientific literature. Furthermore, the mining industry should have gained enough experience from the asbestosis and silicosis catastrophes in South Africa to justify application of precautionary principles in respect of other suspected latent impacts. Where feasible, a mining company should take steps to minimize future exposure before a closure certificate is granted by the DME. Alternatively, risk insurance products could be used to cover future exposure and currently unsuspected

latent impacts. In order to address residual and latent liabilities, we recommend that gold-mining operations in South Africa adopt the precautionary approach, and consider the following risks when determining financial provision:

- The near certainty of contaminated water, which will require some form of decontamination treatment, decanting from closed underground mines, or from lower-lying interconnected neighbouring mines (Pilson et al., 2000; Hodgson et al., 2001);
- The near certainty of sulphate, chloride, metal and NORM contamination of soils and sediments by seepage from unlined tailings storage facilities (TSFs), tailings spillages and plant discharges, and the potential for contamination of downstream / downwind soils and sediments (Witkowski and Weiersbye, 1998; Rösner and Van Schalkwyk, 2000; Rösner et al., 2001; Mphefu et al., 2004; Tutu et al., 2003; 2004; 2005);
- The near certainty of sulphate, chloride, metal and NORM contamination of surface water bodies and their sediments, and ground water, by seepage from unlined tailings storage facilities (TSFs), tailings spillages, plant discharges and underground workings (Cogho et al., 1992; Coetzee, 1995; Pulles et al., 1996; Hodgson et al., 2001; Winde, 2001; Coetzee et al., 2004; Winde et al., 2004a; b; c). In addition, the potential contamination of surface soils overlying shallow polluted groundwater via evaporative pathways during dry seasons (Naiker et al., 2003; Tutu et al., 2004);
- The potential for `salt', sulphate, chloride, metal and NORM contamination of crop soils irrigated with contaminated surface water or contaminated groundwater (Sutton et al., 2006; Philips, 2007).
- The near certainty of selection for an acid mine drainage and salt-tolerant flora on polluted soils and water, use of which would be expected to reduce TSF and soil rehabilitation costs (Angus, 2005; Weiersbye and Witkowski, 2003; 2007; Weiersbye et al., 2006; Straker et al., 2007);
- The concomitant loss of genetic / biodiversity, and potentially ecosystem goods and services on disturbed, fragmented or polluted properties (Angus, 2005; O'Connor and Kuyler, 2007; Weiersbye and Witkowski, 2007);
- The potential for bioaccumulation of some metals and NORMs by flora and fauna (Weiersbye et al., 1999; Weiersbye and Witkowski, 2003; Cukrowska and Tutu, 2004; Steenkamp et al., 2005b; McIntyre et al., 2007);
- The potential for exposure of fauna and humans to bioaccumulated pollutants (Steenkamp et al., 2005b; Weiersbye and Cukrowska, 2007);
- The potential for acute and latent toxicity impacts of bioaccumulated pollutants on humans (Steenkamp et al., 2005a); and the potential for radioactivity impacts from NORMs on humans (Philips, 2007);
- The potential for human disease as a result of exposure to wind-blown dust from TSFs (CoM, 2001);
- The potential for structural damage to buildings and other structures, and human injury, by mining-exacerbated seismicity (Le Roux, 2005);
- In dolomitic regions, the potential for structural damage to buildings and other structures, and human injury, by mining-exacerbated sink-hole formation (Funke, 1990; Buttrick et al., 2001);
- The potential for uncontrolled future land-uses on, or within the zone of influence of TSFs, footprints and mineral processing facilities, such as human settlement and recreation, food crops and home vegetable gardens, livestock grazing, and informal re-mining or scavenging, all of which are incompatible with safety and the fragile status of lands under rehabilitation, and could exacerbate liabilities for mining and the State post-closure (Sutton, 2007; Reichardt and Reichardt, 2007).

2.4 Establishment and achievement of closure objectives

Regulation 61 of the MPRD Regulations requires closure objectives to be established at the outset of the project in order to guide project design, development and management of environmental impacts, to provide

broad future land use objectives and to enable closure costs to be estimated. At a later stage, when preparing the detailed closure plan for a mine, regulation 62 of the MPRD Regulations requires a description of the closure objectives and how these relate to the mine's environmental and social setting. To achieve this in practice requires consultation with local planning authorities and consideration of the integrated development plan. Some level of public participation is also required. Clear, specific and measurable targets then need to be set in accordance with these objectives so that future performance can be assessed and the State can determine the acceptability of risk and liability prior to issuing a closure certificate (DWAF, 2004). The DME and the MPRDA recognizes the requirement for regional mine closure plans, and for the probability of residual and latent impacts by mining operations, together with the need to make financial provision. However, the Act does not adequately address the possibility that some damage may be irreversible, and hence require long-term site containment and financial provision, and/or compensation, and/or the replacement of land to affected parties.

2.5 Alternatives to mine closure

2.5.1 Polluting mineral residues

Secondary pathway exposure to metals and NORMs are recognized as potential hazards to humans worldwide. This risk has been inadequately addressed in South African legislation due to the lack of locally-orientated scientific knowledge prior to the 1990's, thus exposing the local gold and uranium mining industry. The NEMA, the NWA, the Environment Conservation Act and the MPRDA do not adequately address bioaccumulation and exposure through secondary pathways as a consequence of inadequate mine waste disposal. All the legislation and guidelines have an end-of-pipeline approach that focuses on the control of the primary emission pathways (i.e. dissemination of pollutant loads above a specified standard to air and water) and do not take adequate cognisance of the affinity of different classes of pollutants for specific media and biota. International experience has established that, (a) sediments are significant and reversible sinks for metals and NORMs, (b) aquatic and terrestrial bioaccumulation and secondary pathway exposure are significant risks, and (c) that these risks cannot be established from simple determination of pollutant levels in the primary emissions to air and water.

Precautions related to the safe handling, transport and containment of long-lived NORMs are addressed by the Nuclear Energy Act 46 of 1999 (the NEA) and the National Nuclear Regulator Act 47 of 1999 (the NNRA). TSFs and other gold and uranium processing facilities in South Africa have to be registered with the National Nuclear Regulator (NNR) if the radioactivity exceeds 0.5 Bq/g. However, as the NNR is solely mandated to ensure protection from radioactivity, the risk of toxicity from NORMs is not addressed in their regulations or guidelines. There are internationally-accepted models for secondary pathway exposure to radioactivity via what are considered common routes, but these do not always have direct relevance to the South African social and environmental setting. Models of secondary exposure to radioactivity also lack relevance to the potential toxicity of bioaccumulated uranium and other NORMs – even where radioactivity from NORMs is well within NNR requirements, NORMs may still be highly bioavailable and present a toxicity risk through bioaccumulation pathways (Tutu et al., 2003; 2004; 2005; Winde et al., 2004a; b; c; Weiersbye and Cukrowska, 2007). Similarly, despite the widespread co-occurrence of low-grade uranium with gold in South Africa, the DWAF, DEAT and National Department of Agriculture (NDA) have not produced guidelines for monitoring of NORMs in water, soils or foodstuffs. Some gold mining companies therefore lack awareness of the risks posed by bioaccumulation, and how to minimize these through emissions control, safer rehabilitation measures, and `soft' or restricted land-uses.

2.5.2 Alternatives to restoring land to unrestricted end land-uses

Contaminated land policy world-wide is shifting towards restricted `soft' end-land uses, instead of the multifunctional approach - which by insisting that clean-up to allow for all land-use eventualities effectively denies practical implementation of any. The same approach should govern outcomes for closure. Remediation of some sites to multifunctional end land-uses is not always feasible, meaning that unrealistic goals are pursued for closure. Restoration and rehabilitation are dynamic processes that span long periods of time. The MPRDA provisions for land rehabilitation and/or restoration assume that all damage can be

rehabilitated. However, some degradation associated with mining is irreversible from an ecological perspective, at least within the span of a few to many generations.

The omission of alternative solutions will render it difficult for responsible holders of mining rights to effect legitimate closure. For example, the end land-uses stipulated for TSF footprints and other contaminated sites in many South African mine EMPs is `agriculture' or `grazing', which may imply edible crop production, or pasture and rangelands populated by livestock. Apart from the high risk to mining companies of enabling edible crops and grazing systems on contaminated or degraded (fragile) sites, grazing as an end land-use is considered sub-economic on rehabilitated mine pastures in South Africa (O'Connor and Kuyler, 2007). Furthermore, an estimated 80% of gold mine properties on the Witwatersrand Basin are considered to be irreversibly transformed, meaning that restoration is not technically-achievable; although in some cases ecosystem services comparative to the original services could be achieved. Rehabilitation of mine sites must be undertaken, but on contaminated sites and degraded sites, safer and `soft' alternative land-uses need to be implemented. Description of the range of soft land-uses suitable for interim and end-land uses should be included in regulatory guidelines in order to support mining companies in their decisions and financial provisioning. Provision should also be made for environmental compensations for irreparable damage and/or irreversible loss of ecosystem services to be paid to affected parties (i.e. downstream users) and for trade-offs of devastated land for land in better condition. These actions should complement, and not replace, technically-achievable methods of land and water rehabilitation.

2.5.3 Restricted and `soft' end land-uses

Not all risks can be addressed by the gold mining industry. Future land-uses must be addressed by the regulator to ensure that current rehabilitation practices are not short-sighted or incompatible with end land-uses, and that municipal development plans are risk-averse. Simple examples of the former are the grassing of TSF footprints in the Johannesburg region, at great cost to the industry, only to have the land converted shortly thereafter to industrial sites or landfills. Examples of the latter include residential and agricultural developments well within the zone of influence of TSFs, and the use of contaminated water for crop irrigation (Sutton et al., 2006). The presence of contaminated mine water and soils in South Africa has long been recognized (Rudd, 1973; Funke, 1990; Pulles, 1992), and the World Health Organization has identified hand-to-mouth activity in young children worldwide as a significant risk factor in the consumption of contaminated soil. The close proximity of poorer and high density residential areas, together with household food gardens, to TSFs and acid mine drainage in South Africa could expose to risk the sector of the population that is least equipped to deal with it (Sutton, 2007).

There is also a lack of regulatory guidance regarding what land-uses TSFs and footprints can potentially be converted to during and post-closure, and this has resulted in gold mining companies allocating resources to short-term measures for dust control and aesthetics. Guidelines for sustainable closure options which minimize future risks to the industry and the State should encompass the conversion of gold mine tailings and mine water to resources, and mainstream the objectives of the Kyoto Protocol, to which South Africa is a signatory, and the Marrakesh Accord of 2001 which supports the use of new land forms as carbon sinks. Examples include the treatment of mine water to standards suitable for industrial purposes, with concomitant recovery of useful chemical compounds (W. Pulles and J. Maree, pers comm.), and the conversion of TSFs and footprints to restricted `soft' land-uses that combine rehabilitation with economic returns – at least on a break-even basis (Ilgner, 2006; Limpitlaw, 2006). Restricted end land-uses that are potentially suitable for mine closure outcomes in the semi-arid South African climate include industrial sites, lined landfills, graveyards, sewage sludge disposal and land-farming, and carbon sinks facilitated by the growth of low-water demand and high root-biomass crops, such as certain fibre, pharmaceutical and biofuel species.

2.6 Modifications in design and operating practice towards achieving closure objectives

The current legislation and guidelines in South Africa all support an end-of-pipeline approach to pollution control. Many of the pollution control and monitoring measures appear to have been designed with the more commonly-known inorganic pollutants, such as sulphates and chlorides or `salts' in mind. Although the impacts of acidity and salinity on ecosystems are indeed severe, these pollutants do not bioaccumulate, and the latter require stringent measures to be in place for emissions reduction. Legislation and guidelines to assist the mining industry in reducing risk and achieving closure objectives should adopt a strict Cleaner

Production (CP) approach for the extractive and waste disposal phases of new mining operations and incorporate the precautionary principle for medium-term to older operations. New mining operations requiring a CP approach also include the reclamation of older sand and slimes dams for residual gold, as there is evidence for remobilization of contaminants (such as uranium and cyanides) during disturbance of old tailings deposits (Mphefu, 2004; Tutu et al., 2004).

2.7 Provision of sufficient finance for mine closure, including unexpected occurrences

In terms of section 41(1) of the MPRDA, an applicant for a prospecting right, mining right or mining permit must, before the Minister approves the EMP in terms of section 39(4), make the prescribed financial provision for the rehabilitation or management of negative environmental impacts. The quantum of financial provision must cover planned closure, premature closure and post-closure monitoring and maintenance. Furthermore; the requirement to maintain and retain the financial provision remains in force until the Minister issues a certificate in terms of section 43 to such holder, but according to section 41(5) the Minister may retain such portion of the financial provision as may be required to rehabilitate the closed mining or prospecting operation in respect of latent or residual environmental impacts.

Thus it appears that legislation requires sufficient funds to be provided to achieve closure and to provide for any latent impacts. The main challenges are therefore to determine the extent of liability, predict the latent impacts and calculate the amount required, and also for the mining company to reach agreement on these issues with numerous different Government departments via the DME as lead agent for mine closure (i.e. the DWAF and its' regional authorities, the DEAT and its' regional authorities, the NDA, the Department of Health and the Department of Labour). This task "will challenge researchers in both non-market valuation and natural resources accounting," (Poulin and Jaques, 2004).

2.7.1 Unexpected occurrence of disease and adverse health impacts

There are numerous examples of the difficulty herein, one of which relates to the unforeseen occurrence of occupational disease due to asbestos exposure. Asbestos is a fibrous mineral. When mining was taking place, only the long fibres had any commercial value so short fibres were discarded onto dumps. For many years these dumps were not recognised as being of any particular concern; they simply caused the occasional dust nuisance (Fuggle and Rabie, 1996). Although the carcinogenic nature of the fibres had long been suggested by international studies, acceptance in South Africa came too late for thousands of workers and residents in asbestos mining areas who developed lung diseases such as mesothelioma and asbestosis. The consequent legal determination of liabilities delayed Gencor from unbundling its SAR18 billion stake in Impala Platinum until sufficient provision had been made for asbestos-related diseases injury claims (IOL, 2003). The DME in South Africa has had to undertake the responsibility of covering abandoned asbestos mine tailings, at significant cost to the State (Mail and Guardian, 2007) and ultimately the taxpayer.

Silicosis is another incurable and ultimately fatal respiratory disease, associated with exposure to alpha quartz particles from the quarrying or blasting of silicaceous rock. Exposure to alpha quartz is recognized as a major risk by the South African gold mining industry, which implements various measures to reduce the probability of worker exposure. The industry routinely screens workers for symptoms of silicosis, but considers the occupational risk to be largely associated with underground worker exposure to particles from the blasting of rock, and to be negligible from public or worker exposure to TSF dust. However, alpha particle concentrations in gold mine tailings dust can potentially also exceed regulatory limits, and this is of concern due to the large volumes of dust generated over long time periods by unprotected tailings (total erosive losses can reach 500 tonnes / ha / annum, of which a significant portion may be airborne, Blight, 1991; H. Annegarn, pers comm.). Financial provisioning for protection of tailings during operations, in addition to final rehabilitation, is expected to mitigate the requirements for latent impact provisioning.

2.7.2. Accurate assessment of financial provision

In terms of section 41(3) of the MPRDA, the holder of a prospecting right, mining right or mining permit must annually re-assess their environmental liability, and increase their financial provision to the satisfaction of the DME, thereby providing for new developments and discoveries to be included. Subsection (4) provides for the possibility that the Minister is not satisfied with the assessment and financial provision contemplated. In this event, the Minister is empowered under section 41(4) to appoint an independent

assessor to conduct the assessment and determine the financial provision. In order to recognize the adequacy of provision, it is therefore essential for the State to stay abreast of scientific developments, to provide adequate standards and guidelines, and to implement them in a timely manner.

In similar manner to provisions in the NEMA and the NWA, in the event of ecological degradation, pollution or environmental damage, section 45(1) provides for the Minister of DME to direct the holder of the relevant right to undertake various measures. If, however, the Minister establishes that the holder, or the successor in title, is deceased or cannot be traced or (in the case of a juristic person), has ceased to exist, been liquidated or cannot be traced, the Minister may, in terms of section 46(1) instruct the Regional Manager concerned to take the necessary measures. According to section 46(2) the measures taken must be funded from the financial provision made by the holder, or if there is no such provision or if it is inadequate, from money appropriated by Parliament for that purpose.

In other words, in the event of the aforementioned, and the Minister failing to adequately assess the amount of financial provision necessary, the State may be required to meet the costs of rectifying environmental impacts. It also appears that it is the intention of the legislation that the State will take responsibility for rectifying environmental impacts once a closure certificate has been issued because section 43(1) provides that the holder of the right or permit remains responsible … until the Minister has issued a closure certificate, implying that once the closure certificate has been issued this is no longer the case. It seems that the intention is for the Minister to retain sufficient funds from the financial provision to cover any latent or residual impacts, this being provided for in section 41(5).

But what happens if the amount was underestimated? It does not appear to be the intention of the DME to then turn to the previous holder of the right or permit, otherwise why issue a closure certificate? However, for the state to then take responsibility is contrary to the 'polluter pays' principle in South Africa's over-riding environmental legislation, i.e. the NEMA.

2.8 Transfer of environmental liabilities when mining operations are sold

According to section 43(1) of the MPRDA, the holder of a right remains responsible for any environmental liability, pollution or ecological degradation, and the management thereof, until the Minister has issued a closure certificate to the holder concerned. From this it seems as though, in terms of the MPRDA, the environmental management and liability for environmental pollution or ecological degradation can be transferred when the right is ceded or transferred because only the holder of the right is responsible for any environmental liability relating to the relevant operation. An exception to this rule is to be found in 43(2) of the MPRDA, which provides that when applying for a closure certificate, the holder of a right may apply to the Minister for permission to transfer the environmental liabilities and responsibilities that are identified in the EMP and any closure plan to a person with prescribed qualifications.

Thus section 43(2), at first glance, appears to make it possible for a mining company to 'walk away' from its environmental liability before the closure certificate is issued, by transferring the environmental liabilities to the suitably qualified person. However, this does not mean that the mining company has no further responsibility; the provisions of the NEMA and the NWA will still apply. In terms of section 28(1) of NEMA, every person "*who causes, has caused or may cause significant pollution or degradation of the environment must take reasonable measures to prevent such pollution or degradation from occurring, continuing or recurring, or, in so far as such harm to the environment is authorized by law or cannot be avoided or stopped, to minimize and rectify such pollution or degradation of the environment*."

The words 'has caused' here indicate that the duty of care is retrospective, and that the previous owner of a prospecting or mining operation remains liable for pollution or degradation caused by the operation whilst they were still the owner or in control. This responsibility for damage caused remains even though they are no longer the owner of the operation, and regardless of whether they have been granted a closure certificate. In addition, the person to whom the operation was transferred must also take reasonable measures to prevent, minimize or rectify the pollution or degradation, regardless of when the pollution or degradation occurred.

Similarly section 19(1) of the NWA provides that – "*An owner of land, a person in control of land or a person who occupies or uses the land on which any activity or process is or was performed or undertaken;*

or any other situation exists, which causes, has caused or is likely to cause pollution of a water resource, must take all reasonable measures to prevent any such pollution from occurring, continuing or recurring."

The words "*was performed or undertaken*" and "*has caused*" clearly indicate that the previous prospecting or mining operation owner would have been responsible to fulfil the requirements of section 19(1) when they were in control of the prospecting or mining operation and will remain liable for any pollution or degradation caused whilst they were still in control. The NWA therefore also requires that the person to whom the operation was transferred would also be responsible for taking reasonable measures to prevent any pollution from occurring, continuing or recurring regardless of when the cause of the pollution or degradation arose.

2.9 Enforcement of environmental law

Compliance by the prospecting or mining rights holder with the environmental management requirements of the MPRDA is achieved via the EMP, which is approved in terms of section 39 of the MPRDA. A person who prepares an EMP must, in terms of section 39(3)(d), describe the manner in which they intend to (a) modify, remedy, control or stop any action, activity or process which causes pollution or environmental degradation; (b) contain or remedy the cause of pollution or degradation and migration of pollutants; and (c) comply with any prescribed waste standard or management standard practices.

The EMP-approach attempts to move away from the traditional directive-based regulations towards a co-regulatory instrument. The mining company sets itself environmental objectives in consultation with government departments and other stakeholders and then describes methods of achieving these objectives in the EMP, which must then be approved by the government departments. Nevertheless, the MPRDA reverts back to command and control regulation when the holder does not comply with its requirements. For example, according to Section 47(1)(c), the Minister may cancel or suspend any right if the holder is contravening the approved EMP. In terms of Section 98(a)(iii) it is an offence to fail to comply with the requirements of an approved EMP. In terms of Section 99(1)(c) a person convicted of this offence is liable to a fine not exceeding SAR500,000.00 or to imprisonment for a period not exceeding 10 years or to both such fine and imprisonment.

Once a closure certificate is issued in terms of section 43(1) the holder of a right is no longer liable for environmental damage in terms of the MPRDA. However, as discussed previously, the holder still remains liable in terms of the NEMA and the NWA. According to section 28(4) of the NEMA, the DEAT may direct any person who fails to take the measures required in terms of section 28(1) to (a) investigate, evaluate and assess the impact of the specific activities and report thereon; (b) commence taking specific reasonable measures before a given date; (c) diligently continue with those measures; and (d) complete them before a specified reasonable date. Similar provisions are contained within the NWA.

Should a person fail to comply, or inadequately comply, with such a directive given by the DEAT, the DEAT may, in terms of section 28(8), themselves undertake the reasonable measures to remedy the situation and recover the costs from any or all of the following persons:

- Any person who is or was responsible for, or who directly or indirectly contributed to, the pollution or degradation or the potential pollution or degradation (this would include the previous owner of a prospecting or mining operation or the owner of a 'closed' mining operation);
- The owner of the land at the time when the pollution or degradation or the potential for the pollution or degradation occurred, or that owner's successor-in-title (this will include the current and previous owner of the prospecting or mining operation, if the land is owned by the operation);
- The person in control of the land or any person who has or had a right to use the land at the time when the activity or the process is or was performed or undertaken or the situation came about (this would include the holder of the mining or prospecting right because this is a right to use the land); or
- Any person who negligently failed to prevent the activity or the process being performed or undertaken or the situation from coming about.

The NEMA also empowers private individuals and communities affected by mining. According to Section 32(1) any person or group of persons may seek appropriate relief in respect of any breach or threatened breach of any provision of NEMA, or any other statutory provision concerned with the protection of the

environment or the use of natural resources either in that person's or group of person's own interest; in the interest of, or on behalf of, a person who is, for practical reasons, unable to institute such proceedings; in the interest of or on behalf of a group or class of persons whose interests are affected; in the public interest; or in the interest of protecting the environment.

There have been a number of recent examples of residents and communities in South Africa approaching the court, and recently the court found in favour of residents in Kagiso and Davidsonville near Johannesburg. In the first case the court gave the National and Gauteng DME two weeks to implement measures to control dust on an old TSF and to rehabilitate the mine within 2 years. In the second case the judge declared that the pollution and environmental damage caused by an unused TSF required urgent remedial measures. In the latter case the application was against a mining company and its board of directors, the DME and DEAT and other provincial authorities (Citizen, 2006).

The NEMA also provides for private prosecutions and criminal proceedings in sections 33 and 34 respectively and sections 34 (5) to (9) of the NEMA make provision for personal liability on the part of directors, managers, agents and employees should they be found guilty of an offence in terms of the Act. The common law remedies of interdict, delict and nuisance are also available as civil remedies to prevent or obtain recourse for environmental harm even after the mine has been granted closure.

2.10 Competency of persons involved in environmental management

Within the MPRDA and its regulations there are limited references to competency regarding environmental management. Regulation 54(2) requires that the quantum of financial provision is annually reviewed and updated in consultation with a competent person; regulation 73 requires that mine residue stockpiles and deposits are classified and designed by a competent person; regulation 58 allows environmental liabilities and responsibilities to be transferred to a competent person; and regulation 55(4) permits, but does not require, an independent competent person to be appointed by the holder of a mining right to conduct the performance assessment report of the EMP. A competent person is defined as meaning a person who is qualified by virtue of knowledge, expertise, qualifications, skills and experience; is familiar with the provisions of the MPRDA and other related legislation; and has been trained to recognise any potential or actual problem in the performance of the work.

The lack of a strict requirement in conducting the MPRDA EIA or performance assessment report is problematic. The NEMA makes provision for personal liability on the part of directors, managers, agents and employees should they be found guilty of offence. Such offences include inaccurate reporting of liabilities, irrespective of whether this is due to ignorance, uncertainty or concealment. This personal liability renders an absolute requirement for competency essential in the MPRDA. Requirements for environmental management implementation in the mining industry should include minimum educational standards, certificates of competency and legal appointments.

Other disciplines that have important reporting requirements and/or responsibilities have either recognised professional registration, government certificates of competency, or are appointed in terms of legislation. In addition to ensuring a minimum level of knowledge and competency, professional registration or legal appointments can bring about accountability. An annual financial statement would not be accepted without it being signed off by a chartered accountant; the safety of a dam must, in terms of section 117(a) of the NWA, be signed off by an “approved professional person” registered in terms of the Engineering Profession of South Africa Act No. 114 of 1990. However the MPRDA EIA, the quantum of financial provision and the environmental risk report, can all currently be signed off by anybody. This is a significant risk for the mining industry, and steps must be taken to require some form of professional registration and proof of competency.

3 Conclusion

We found that minerals legislation in South Africa sets out to provide for the protection of the environment at mine closure but contains some flaws and gaps. While some gaps may enable mines to externalise impacts and costs, others could result in increased long-term liabilities and costs because appropriate measures were not taken. The DME is the lead agent for granting mine closure but can only grant such after approval by the DWAF. Since the DEAT and its provincial authorities are the constitutionally-appointed custodians of the environment, their approvals should also be incorporated. Most importantly, even after a closure certificate is granted by the DME, the provisions of other legislation, such as the NEMA and the NWA, could still prevail

in the event of undisclosed or future environmental damage. Un-answered questions largely relate to closure mechanisms and guidelines, and especially to the need for regulation of future (i.e. post-closure) land-uses in order to minimize potential liabilities. When assessing economic and environmental viability of future land-uses in mining regions, the regulators, planners and developers must consider the potential for latent impacts such as impaired ecosystem functioning and bioaccumulation of contaminants, long after mine closure. As a result, we do not consider residential townships, edible crop production or livestock grazing to be safe end land-uses for TSF footprints or areas within the aqueous or aerial zone of influence of TSFs and metallurgical plants. Failure by the regulator and industry to agree on suitable land-uses and buffer zones could exacerbate liabilities by leading to subsequent land-uses that are sub-economic or risky.

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