

# **One Million Climate Jobs – A just transition to a low carbon economy to combat unemployment and climate change**

**Pilot Project: Rehabilitation of mine contaminated wetlands, eco-systems and receptor dams within the Tweelopiespruit, West Rand, Gauteng**

**By Mariette Liefferink - November 2016**



**FRIEDRICH  
EBERT**   
**STIFTUNG**



**AIDC**  
**Alternative  
Information &  
Development  
Centre**



## Glossary of Terms

### Acid Mine Drainage

AMD is caused when water flows over or through sulfur-bearing materials forming solutions of net acidity. AMD comes mainly from abandoned gold and coal mines and currently active gold and coal mining.

Gold mining in the East, Central and West Rand underground mining basins of the Witwatersrand goldfields (hereafter referred to as the Eastern, Central and Western Basins) started in the late 1880s. Underground mining on the Witwatersrand essentially ceased in 2010. While the mines were operating, they pumped water to the surface to dewater their mine workings, but since mining stopped the underground voids that were left after the mining have been steadily filling with water. The water in the mine voids interacts with the exposed sulphide bearing minerals in the rock formations to form Acid Mine Drainage (AMD), also known internationally as Acid Rock Drainage (ARD). AMD is characterised by a low pH and an excessive concentration of dissolved metals and sulphate salts.

The Report to the Inter-Ministerial Committee on Acid Mine Drainage (December 2010) titled *“Mine Water Management in the Witwatersrand Gold Fields with Special Emphasis on Acid Mine Drainage”* described the background as follows: *“AMD has been reported from a number of areas with South Africa, including the Witwatersrand Gold Fields, Mpumalanga and KwaZulu-Natal Coal Fields and the O’Kiep Copper District. The Western, Central and Eastern Basis are identified as priority areas required immediate action because of the lack of adequate measures to manage and control the problems related to AMD, the urgency of implementing intervention measures before problems become more critical and their proximity to densely populated areas.*

*“The cessation of underground mine water extraction leads to the mine voids becoming flooded. This phenomenon was highlighted in September 2002, when acidic mine water started flowing from an abandoned shaft in the Mogale City/Randfontein area of the Western Basin as a result of the flooding of the mines in this basin to a level where water could flow out onto the surface. This surface flow or decant of mine water is of concern to the*

*environment as the water, in accordance with well-known and researched chemical and geochemical reactions between the mine rock strata, wastes and oxygen, readily becomes acidic, characterised by elevated concentrations of salts, heavy metals and radionuclides.”*

### **Assessment**

The start of collecting, organising, analysing, interpreting and communicating information that is relevant to decision-making.

### **Basin**

The geological term “basin” refers to an area where deposition took place. The Witwatersrand Basin is a good example of this.

### **Best Practicable Environmental Option**

The option that provides the most benefit or causes the least damage to the environment as a whole, at a cost acceptable to society, in the long term as well as in the short term.

### **Biodiversity**

Variety of different species (species diversity), genetic variability among individuals within each species (genetic diversity), variety of ecosystems (ecological diversity), and functions such as energy flow and matter cycling needed for the survival of species and biological communities (functional diversity).

### **Climate Change**

Climate refers to the physical properties of the troposphere of an area based on analysis of its weather records over a long period (at least 30years). The two main factor determining an area’s climate are its average temperature, with its seasonal variations and the average amount and distribution of precipitation.

Climate Change occurs largely as a result of the combustion of fossil fuels, emissions from agriculture and pastoralism, and land-use changes that accompany the destruction, clearance and burning of forests. Climate change already has observable ecological and social effects, and its projected impacts could potentially result in profound changes in global mean surface temperature (periods of unusually warmer weather), a rise in sea level, ocean circulation, precipitation patterns (heavy precipitation events), climatic zones, species distributions (changes in plant and animal distribution and population) and ecosystem function, melting glaciers polar warming, coral-reef bleaching, longer droughts and dry periods, and increased environmental degradation and natural disasters.

## **Closure**

A whole of mine life process that typically culminates in the issue of a closure certificate in terms of Section 43 of the MPRDA. It includes decommissioning and rehabilitation.

## **Community**

(a) Means any group of persons or a part of such a group who share common interests, and who regard themselves as a community; and

(b) In relation to environmental matters pertaining to prospecting, mining, exploration, production or related activity on a prospecting, mining, exploration or production area, means a group of historically disadvantaged persons with interest or rights in a particular area of land on which the members have or exercise communal rights in terms of an agreement, custom or law: Provided that where as a consequence of the provisions of the National Environmental Management Act, negotiations or consultations with the community is required, the community shall include the members or part of the community directly affected by prospecting, mining, exploration or production on land occupied by such member or part of the community.

## **Desalination**

Purification of salt water or acid mine water by the removal of dissolved salts.

## **Ecosystem**

One or more communities of different species interacting with one another and with the chemical and physical factors making up their non-living environment.

## **Ecosystem services**

Natural services or natural capital that support life on the earth and are essential to the quality of human life and the functioning of the world's economies. Examples are the chemical cycles, natural pest control and natural purification of air and water.

## **Environment**

Defined in Section 1 of the MPRDA as meaning the environment as defined in the National Environmental Management Act, 1998 (Act 107 of 1998), which characterises environment as follows:

'Environment' means the surroundings within which humans exist and that are made up of:-

- (i) The land, water and atmosphere of the earth;
- (ii) Micro-organisms, plant and animal life;

(iii) Any part or combination of (i) and (ii) and the interrelationships among and between them;

and

(iv) The physical, chemical, aesthetic and cultural properties and conditions of the foregoing that influence human health and well-being.

### **Environmental degradation**

Depletion or destruction of a potentially renewable resources such as soil, grassland, forest or wildlife that is used faster than it is naturally replenished. If such use continues, the resource becomes non-renewable (on a human time scale) or nonexistent (extinct).

### **Environmental law**

Body of statements defining what is acceptable environmental behaviour for individuals and groups, according to the large community, and attempting to balance competing social and private interests.

### **Environmental Management Programme**

A legal document capturing the current state of the mine, mine progress as to the agreed state and the interim arrangements made during the course of each year of the mine's operation, as contemplated in Section 39 of the MPRDA.

### **External cost**

Harmful environmental, economic/social effects of producing and using an economic good that is not included in the market price of the good.

### **Financial Provision**

Section 1 of the MPRDA defines financial provision as meaning the insurance, bank guarantee, trust fund or cash that applicants for or holders of a right or permit must provide in terms of sections 41 and 89 guaranteeing the availability of sufficient funds to undertake the agreed work programmes and to rehabilitate the prospecting, mining, reconnaissance, exploration or production areas, as the case may be.

### **Global Warming**

A gradual increase in the overall temperature of the earth's atmosphere generally attributed to the greenhouse effect caused by increased levels of carbon dioxide, CFCs (chlorofluorocarbons) and other pollutants. Anthropogenic changes in the earth system contribute to global warming such as the modification of landscapes, the modification of ecosystems (destruction of wetlands, especially peatlands), industrialisation, energy production and agriculture etc.

Gold field - The economic geology term gold field describes a geologically distinct area/ unit where gold occurs.

### **Groundwater**

Water that sinks into the soil and is stored in slowly flowing and slowly renewed underground reservoirs called aquifers; underground water in the zone of saturation, below the water table.

### **Habitat**

Place or type of place where an organism or population of organisms lives.

### **Integrated waste management**

Variety of strategies for both waste reduction and waste management designed to deal with the solid wastes produced by the mining industry.

### **(Ionizing) radiation**

Fast-moving alpha or beta particles of high-energy radiation (gamma rays) emitted by radioisotopes. They have enough energy to dislodge one or more electrons from atoms they hit, thereby forming charged ions in tissue that can react with and damage living tissue.

### **Interested and affected party**

In relation to the assessment of environmental impacts of listed or related activities, it includes:

- a) Any person, group of persons or organisation interested in or affected by such operation or activity; and
- b) Any organ of state that may have jurisdiction over any aspect of the operation or activity.

### **Ore**

Part of a metal-yielding material that can be economically extracted from a mineral; typically containing two parts: the ore mineral, which contains the desired metal, and waste mineral material.

### **pH**

pH (potential of hydrogen) is a scale of acidity from 0 to 14. It tells how acidic or alkaline a substance is. More acidic solutions, have lower pH. More alkaline solutions, have higher pH. Substances that aren't acidic or alkaline (that is, neutral solutions) usually have a pH of 7.

### **Pollution**

Means any change in the environment caused by-

- (i) Substances;

- (ii) Radioactive or other waves; or
- (iii) Noise, odours, dust or heat, emitted from any activity, including the storage or treatment of waste or substances, construction and the provision of services, whether engaged in by any person or an organ of state, where that change has an adverse effect on human health or well-being or on the composition, resilience and productivity of natural or managed ecosystems, or on materials useful to people, or will have such an effect in the future

### **Post-Closure**

Post-closure defines the point at which decommissioning activities have ceased and post-closure management activities have commenced. This usually signifies that there is no intention to mine or process minerals at the site in the foreseeable future.

### **Poverty**

Inability to meet basic needs for food, clothing and shelter.

### **Radioactivity**

Nuclear change in which unstable nuclei of atoms spontaneously shoot out “chunks” of mass, energy, or both at a fixed rate. The three principal types of radioactivity are gamma rays and fast-moving alpha particles and beta particles.

### **Reclamation**

Means in the context of this booklet, the re-mining or recovery of metals from mine residue or gold tailings storage facilities.

### **Rehabilitation**

The term used for the intervening actions (including engineering interventions) which aim to improve the land area or river with the intention of either reinstating the original ecosystem processes or structures (restore), or facilitating the use of the contaminated land area or river ecosystem to an agreed upon new system (remediate).

### **Remediation**

The term used to describe the improvement of contaminated land areas or degraded river, or ecosystems to a situation where new sequential land use or river ecosystem has been established.

### **Resource Water Quality Objectives**

They are defined as numeric or descriptive in-stream (or in-aquifer) water quality objectives typically set at a finer resolution (spatial or temporal) than RQOs to provide greater detail upon which to base the management of water quality of the resource



**Restoration**

The term used to describe the improvement of a contaminated land area or degraded river ecosystem to its original or natural state or use, where all aspects have been returned to the pre-disturbance level of structure and functioning.

**Risk**

Probability that something undesirable will result from deliberate or accidental exposure to a hazard.

**Risk Assessment**

Process of gathering data and making assumptions to estimate short- and long-term harmful effects on human health or the environment from exposure to hazards associated with the use of a particular product or technology.

**Salinity**

Amount of various salts dissolved in a given volume of water.

**Sludge**

Goey mixture of toxic chemicals, and settled solids (metals) removed from acid mine water at a treatment plan.

**Social and Labour Plan**

As contemplated in Regulation 40 and 46 of the MPRDA, a plan to ensure that mine right holders contribute to the socio-economic development of the areas in which they mine.

**Tailings**

Rock and other waste materials removed as impurities when waste mineral material is separated from the metal in an ore.

**Tailings Storage Facility**

Dams or dumps created from tailings or slimes. The embankments and impoundments are referred to as tailings storage facilities (TSF).

**Toxicity**

Measure of the harmfulness of a substance.

**True (Full) cost**

Cost of a good when its internal costs and its estimated short- and long-term external costs are included in its market price.

**Waste management**

Managing wastes to reduce their environmental harm without seriously trying to reduce the amount of waste produced.

**Water pollution**

Any physical or chemical change in surface water or groundwater that can harm living organisms or make water unfit for certain uses.

**Wetland**

Land that is covered all or part of the time with salt water or fresh water, excluding streams, lakes and the open ocean.

## Acronyms

Al – Aluminium

AMD – Acid Mine Drainage

BGMC – Blyvooruitzicht Gold Mining Company

BPEO – Best Practicable Environmental Option

Ca - Calcium

CBD – Central Business District

Co - Cobalt

CoM – Chamber of Mines

CPS – Central Power Station

CSIR – Council for Scientific and Industrial Research

DEA – Department of Environmental Affairs

DMR – Department of Mineral Resources

DOCC- Development and Operational Cost Curve

DOE – Department of Energy

DWAF – Department of Water and Forestry

DWS – Department of Water and Sanitation

DRD Gold – Durban Roodepoort Deep Gold Mine

EC – Electrical Conductivity

EIA – Environmental Impact Assessment

EMPr – Environmental Management Programme Report

ESRC – Environmental and Social Remediation Curve

Fe - Iron

GN – Government Notice

KOSH – Klerksdorp, Orkney, Stilfontein, Hartbeesfontein

LHWP – Lesotho Highlands Water Project

ML – Mega Litre

Mg –Magnesium

mg/l – milligram per litre

Mn - Manganese

MRA – Mine Residue Area

MRD – Mine Residue Deposits

MPRDA – Mineral and Petroleum Resources Development Act (28 of 2000)

MPRD Reg - (Mineral and Petroleum Resources Development Regulations

NEMA – National Environmental Management Act (47 of 1998)

NEM-Air Quality Act – National Environmental Management Air Quality Act (39 of 2004)

NEM-Waste Act – National Environmental Management Waste Act (59 of 2008)

Ni – Nickel

NNR – National Nuclear Regulator

NNRA – National Nuclear Regulator Act (47 of 1999)

NORM – Naturally Occurring Radioactive Material

NWA – National Water Act (36 of 1998)

Pb – Lead

pH – Potential of Hydrogen

RC – Revenue Curve

Reg - Regulation

Rn – Radon

RQOs – Resource Quality Objectives

SO<sub>4</sub> - Sulphate

SWOT – Strengths, Weaknesses, Opportunities, Threats

TDS – Total Dissolved Solids

TSF – Tailings Storage Facility

U- Uranium

WRC – Water Research Commission

## Introduction

The possible impacts of global warming range from changes in rainfall, which affects agriculture, river courses and wetlands, as well as changes in the distribution of biodiversity. In the short term if no measures are taken to help communities adapt, people's vulnerability to poverty will be increased partly because of ecosystem degradation. The rural poor, subsistence farmers and communities who are dependent on eco-system goods in developing countries such as South Africa are particularly vulnerable.

Gold mining in the Witwatersrand gold fields has resulted not only in the contamination of wetlands but also in the destruction of wetlands and eco-systems, and adverse impacts on biodiversity, water, soil and air. This contributes to the adverse impacts of climate change.

The extractives sector can – if responsibly managed – mitigate these impacts it had upon wetlands, biodiversity and eco-systems, and contribute to economic growth and development by developing and implementing programs for the remediation of contaminated wetlands, eco-systems, receptor dams and rivers.

Establishment of the link between extractives and climate change should provide motivation for eco-system rehabilitation and tangible socio-economic benefits for local communities not only in the short term but in the long term after mine closure.<sup>1</sup>

The potential to recover metals from rehabilitated material and use of the revenues generated are recognized by the mining industry. Future financial clean-up costs can thus be reduced. The residue, after the reclamation of metals, can then be disposed of in a homogenous and safe manner onto an operational residue dam, which will minimise potential environmental impacts<sup>2</sup> and impacts of climate change.

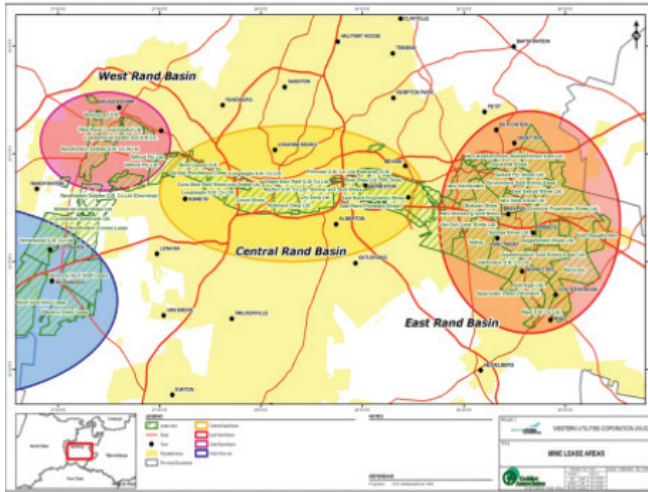
---

<sup>1</sup> Rüttinger, L., and Sharma, V. (2016). Climate Change and Mining - A Foreign Policy Perspective. Report: Climate Diplomacy.

<sup>2</sup> CF Human, JC Botha. Revenue Generation during Rehabilitation of Contaminated Land on Gold Mines in South Africa. Mine Closure 2008.

## Background

The Witwatersrand<sup>3</sup> has been mined for more than a century. It is the world's largest gold and uranium mining basin.



**Western, Central and Eastern Mining Basins, which are flooded or flooding with acid mine water (Source: Golder Associates)**

More than 120 mines extracted 43 500 tons of gold in one century and 73 000 tons of uranium between 1953 and 1995, which resulted in a legacy of more than 270 tailings storage facilities (TSFs) in the Witwatersrand, covering approximately 400 km<sup>2</sup> in surface area<sup>4</sup> and 6 billion tons of pyrite tailings containing 600 000 tons of uranium.<sup>5</sup>

These TSFs are mostly unlined and many are not vegetated, providing a source of extensive dust, as well as soil and water (surface and groundwater) pollution.<sup>6</sup>

---

<sup>3</sup> The Witwatersrand Mining Basin includes the Eastern Basin, the Central Rand Basin, the Western Basin, the Far Western Basin, KOSH and the Free State gold mines.

<sup>4</sup> AngloGold Ashanti, 2004

<sup>5</sup> S. Chevrel et al. A Remote-Sensing and GIS-Based Integrated Approach for Risk Based Prioritization of Gold Tailings Facilities – Witwatersrand, South Africa. 2008

<sup>6</sup> AngloGold Ashanti, 2014



**Tailings Storage Facility (West Rand)**

Pollution related to Witwatersrand mines poses a number of hazards to surrounding communities. The major primary pathways by which contamination can enter the environment from a mine site are:

- the airborne pathway, where radon gas and windblown dust disperse outwards from mine sites,
- the waterborne pathway, either via ground or surface water or due to direct access, where people are contaminated,
- or external irradiation after unauthorized entry to a mine site,
- living in settlements directly adjacent to mines or in some cases, living in settlements on the contaminated footprints of abandoned mines<sup>7</sup>.

Concisely stated, direct access to mine sites may expose the public to risks due to direct external gamma radiation, inhalation and ingestion of radionuclides and chemotoxic metals, as well as the physical dangers inherent to mining sites.

To limit the risk due to external gamma radiation, the Chamber of Mines uses a guideline that each tailings deposit should have a 500 m buffer zone surrounding it, where no human settlement is allowed. In many cases, however, this guideline has not been adhered to in the development of new settlements<sup>8</sup>.

---

7 M. W. Sutton. Land-Use after Mine Closure – Risk Assessment of Gold and Uranium Mine Residue Deposits on the Eastern Witwatersrand, South Africa. Mine Closure. 2008

8 H. Coetzee. Radiometric Surveying in the Vicinity of Witwatersrand Gold Mines. Mine Closure 2008.

With the curtailing of gold mining on the Witwatersrand mining land is being redeveloped. However, inappropriate developments, such as houses or farms, on Mine Residue Deposit (MRD) footprints and other contaminated sites could result in liabilities for the public and the closing mines. Residential townships, edible crop production and livestock grazing are high risk land-uses for TSF footprints and areas within the aqueous or aerial zone of influence of (MRD) footprints and other contaminated sites could result in liabilities for the public and the closing mines. Residential townships, edible crop production and livestock grazing are high risk land-uses for TSF footprints and areas within the aqueous or aerial zone of influence of TSF footprints and TSFs. Failure by the industry and regulators to agree on suitable 'soft' end land-uses and buffer zones could exacerbate liabilities for the mine by resulting in subsequent land-uses that are sub-economic or risky.

Avoiding built developments altogether and vegetating MRDs and footprints with unsuitable plants species, such as those for pastures and playing fields, can also increase risk through the creation of 'attractive nuisances.' These encourage use by potentially vulnerable receptors such as grazing livestock and children. <sup>9</sup>

It is estimated that 1.6 million persons live in Informal Settlements next to MRDs.<sup>10</sup> The majority of MRAs are radioactive because the Witwatersrand gold-bearing ores contain almost ten times the amount of uranium than gold.<sup>11</sup>

Three main issues relating to MRAs located in Gauteng are:

- 1) air-quality, with particular reference to dust pollution from MRAs (including radioactive dust);
- 2) water-flux and water-quality, with particular reference to Acid Mine Drainage (AMD) and the transport of radioactive materials associated with the exposed uranium ore; and
- 3) geotechnical safety concerns related to the dangers of ground instability and collapse above abandoned mine workings and also around open, unsealed mine shafts that present a danger to nearby settlements.

---

<sup>9</sup> M. W. Sutton. Land-Use after Mine Closure – Risk Assessment of Gold and Uranium Mine Residue Deposits on the Eastern Witwatersrand, South Africa. Mine Closure. 2008

<sup>10</sup> Dorothy Tang and Andrew Watkins. Ecologies of Gold: The Past and Future Mining Landscapes of Johannesburg. 2011

<sup>11</sup> Gauteng Department of Agriculture and Rural Development: Feasibility Study on Reclamation of mine Residue Areas for Development Purposes: Phase II Strategy and Implementation Plan . 2011



- soils overlying shallow polluted groundwater via evaporative pathways during dry seasons (Naiker et al., 2003., Tutu et al., 2004).<sup>12</sup>
- 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);<sup>13</sup>
- 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; WeiersbyeThe following long term risks have been identified:<sup>14</sup>
- 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);<sup>15</sup>
- The near certainty of sulphate, chloride, metal and Naturally Occurring Radioactive Material (NORM) contamination of soils and sediments by seepage from an unlined regional tailings storage facility, tailings spillages and plant discharges and the potential for contamination of downstream / downwind soils and sediments (Witkowski and Weiersbye, 1998; Rosner and Van Schalkwyk, 2000. Rosner et al, 2001; Mphefu et al., 2004, Tutu et al., 2003; 2004; 2005; (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 and Witkowski, 2007);<sup>16</sup>
- 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);<sup>17</sup>
- The potential for exposure of fauna and humans to bioaccumulated pollutants (Steenkamp et al., 1999; Weiersbye and Cukrowska, 2007); <sup>18</sup>

---

12 Ibid

13 Ibid

14 A. Fourie, M. Tibbett and J. Wiertz (eds). M.W. Sutton and I.M. Wiersbye. South African Legislation Pertinent to Gold Mine Closure and Residual Risk. Mine Closure 2007.

15 Ibid

16 Ibid

17 Ibid

18 Ibid

<sup>9</sup>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)<sup>19</sup>;

- The potential for human disease as a result of exposure to windblown dust from the reclamation operations and the RTSF (CoM, 2001)<sup>20</sup>;
- The potential for structural damage to buildings and other structures and human injury by mining exacerbated seismicity (Le Roux, 2005)<sup>21</sup>;
- In dolomitic regions, the potential for structural damage to buildings and other structures, and human injury, by mining exacerbated sinkhole formations (Funke, 1990; Buttrick et al., 2001)<sup>22</sup>;
- The potential for uncontrolled future land uses on or within the zone of influence of the TSFs, footprints and mineral processing facilities, such as human settlements and recreation, food crops and home vegetable gardens, livestock grazing and informal re-mining and scavenging, all of which are incompatible with safety and the fragile status of lands under rehabilitation, and could exacerbate liabilities for mines and the State in the post closure phase (Sutton, 2007; Reichardt and Reichardt, 2007)<sup>23</sup>.
- Waste rock dumps have very large inventories of fine material and they are much more permeable to oxygen than tailings dams. Contaminants remain in the soil after a dump has been removed<sup>24</sup>.
- Long term migration of contaminant plumes in shallow aquifer and surface water from TSFs and footprints<sup>25</sup>.

---

19 Ibid

20 Ibid

21 Ibid

22 Ibid

23 Ibid

24 W. Pulles. Water Research Commission Report. 2015.

25 Guidance for the Mining Industry for the Management of Post-Closure Water. Pulles W; 2015/04/01; Research Report No.TT 628/14

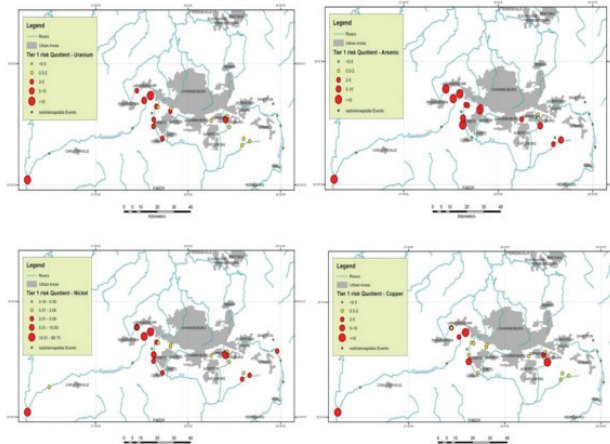
## Waste

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.”<sup>26</sup>

Waste from gold mines constitutes the largest single source of waste and pollution in South Africa. As at 1997, South Africa produced an estimated 468 million tons of mineral waste per annum.<sup>27</sup> Gold mining waste was estimated to account for 221 million tons or 47 % of all mineral waste produced in South Africa, making it the largest, single source of waste and pollution.<sup>28</sup>

## Wetlands

Wetlands, which have developed downstream of the Witwatersrand’s mining areas, have trapped metals and contain elevated levels of arsenic, uranium, cobalt, copper and nickel.<sup>29</sup>



**Tier 1 risk quotients for the maximum uranium, arsenic, nickel and copper concentrations for each wetland sampling site**

(Source: Henk Coetzee, Jaco Venter & Gabriel Ntsume. Contamination of wetlands by Witwatersrand gold mines – processes and the economic potential of gold in wetlands. Council for Geoscience Report No. 2005-0106)

<sup>26</sup> CSIR. Briefing Note August 2009. Acid Mine Drainage in South Africa. Dr. Pat Manders. Director, Natural Resources and the Environment. European Environmental Bureau (EEB). 2000. The environmental performance of the mining industry and the action necessary to strengthen European legislation in the wake of the Tisza-Danube pollution. EEB Document no 2000/016. 32

<sup>27</sup> Department of Water and Forestry, 2001

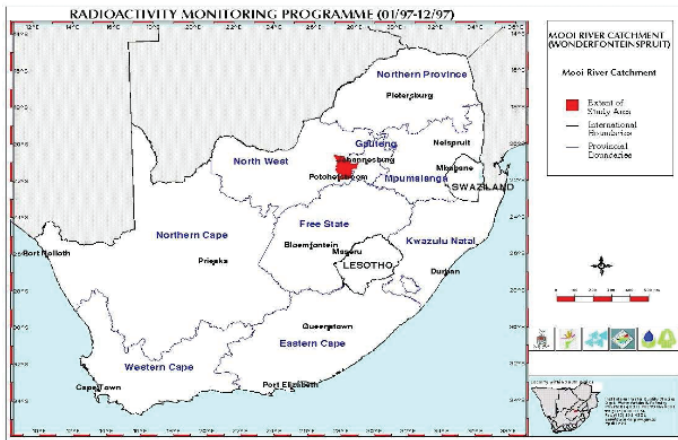
<sup>28</sup> Department of Water and Forestry, 2001

<sup>29</sup> Henk Coetzee, Jaco Venter & Gabriel Ntsume, Contamination of wetlands by Witwatersrand gold mines – processes and the economic potential of gold in wetlands.. Council for Geoscience Report No. 2005-0106



Wetlands, contaminated by pipeline spillages of uraniferous slurry and AMD within the Upper Wonderfonteinsspruit Catchment Area

The mean values for the Wonderfonteinsspruit<sup>30</sup> samples were found to exceed not only natural background concentrations, but also levels of regulatory concern for cobalt, zinc, arsenic, cadmium and uranium, with uranium and cadmium exhibiting the highest risk coefficients. These metals may be remobilised by environmentally plausible chemical processes<sup>31</sup>.

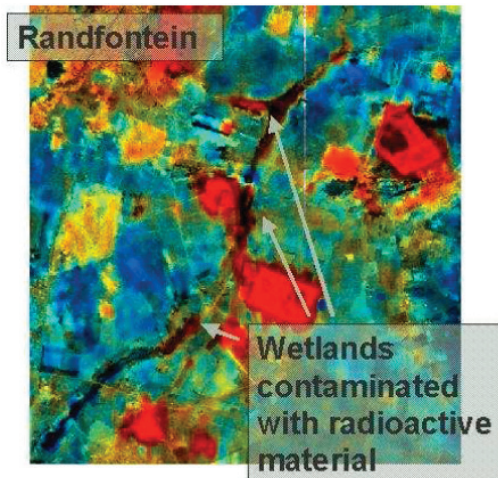


Wonderfonteinsspruit Catchment Area

<sup>30</sup> The Wonderfonteinsspruit, also known as the eastern catchment of the Mooi River, is located in West Rand District Municipality, Gauteng, South Africa. The Wonderfonteinsspruit, has been identified in a significant number of studies as the site of significant radioactive and other pollution, generally attributed to the mining and processing of uraniferous gold ores in the area.

<sup>31</sup> Coetzee, H. (compiler) 2004: An assessment of sources, pathways, mechanisms and risks of current and potential future pollution of water and sediments in gold-mining areas of the Wonderfonteinsspruit catchment.  
WRC Report No 1214/1/06, Pretoria, 266 pp.

Airborne radiometric surveys over the catchment have identified the contamination of wetland areas within the Wonderfonteinspruit and other catchments in the Witwatersrand with radionuclides. The following image from the Wonderfonteinspruit catchment is typical of those recorded from wetlands in the vicinity of gold-mining activities.



**Total count radiometric image of a portion of the Wonderfonteinspruit catchment, over a Landsat image background. Red areas indicate elevated radioactivity levels. Note the elevated radioactivity in the wetlands downstream of mining areas. The presence of uranium series radionuclides implies that other metals associated with the mining waste stream are probably also present.**

(Source: Coetzee, H. (compiler) 2004: An assessment of sources, pathways, mechanisms and risks of current and potential future pollution of water and sediments in gold-mining areas of the Wonderfonteinspruit catchment  
WRC Report No 1214/1/06, Pretoria, 266 pp.)

## **Acid Mine Drainage**

There is wide acceptance that Acid Mine Drainage (AMD) is responsible for the most costly environmental and socio-economic impacts. AMD is a long recognised problem within the gold mining industry. In 1903 AMD was referred to as an established phenomenon concerning pumped water on the Witwatersrand.<sup>32</sup>

---

<sup>32</sup> (O'Flaherty 1903). R.Scott. WRC Report No 486/1/95. "Flooding of Central and East Rand Gold Mines: An Investigation into Controls over the Inflow Rate, Water Quality and the Predicted Impacts of Flooded Mines".



**Metals in Acid Mine Drainage drops out as a precipitate after neutralisation or a pH adjustment  
(Photographs: Stephan du Toit)**

AMD has a low pH and is high in acidity. In addition to the acidity in AMD, a number of other elements/determinants are also present in the water, mostly metals. Many of these metals are present in toxic concentrations in the water. Radioactive metals also occur in the water.

AMD is associated with surface and groundwater pollution, degradation of soil quality, for harming aquatic sediments and fauna, and for allowing metals to seep into the environment. Long-term exposure to AMD polluted drinking water may lead to increased rates of cancer, decreased cognitive function and appearance of skin lesions. Metals in drinking water could compromise the neural development of the fetus which can result in mental retardation.<sup>33</sup>



**Metals from AMD coating grass and seeping into the soil**

---

33 S.H.H. Oelofse, P.J. Hobbs, J. Rascher and J.E. Cobbing. The pollution and destruction threat of gold mining waste on the Witwatersrand - A West Rand case study. CSIR, Natural Resources and the Environment, PO Box 395, Pretoria, South Africa.

Results indicate that U-levels in water resources of the whole Wonderfonteinspruit catchment increased markedly since 1997 even though U-loads emitted by some large gold mines in the Far West Rand were reduced. This apparent contradiction is explained by the contribution of highly polluted water decanting from the flooded mine void in the West Rand. Coetzee et al., 2003 reported a uranium concentration in a surface-water body next to the northern watershed of the headwater region of the Wonderfonteinspruit (Robinson Lake) of 16 mg/l after underground mine water decanting into the Tweelopiespruit was pumped into the lake and resulted in the National Nuclear Regulator (NNR) declaring the lake a radiation area. This extreme concentration is believed to be the result of remobilisation of uranium from a contaminated sediment by acidic water.<sup>34</sup>



**Robinson Lake, a declared radiation area**

The potential volume of AMD for the Witwatersrand Goldfield amounts to an estimated 350ML/day (1ML = 1000m<sup>3</sup>). 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. The gold mining industry in South Africa (principally the Witwatersrand Goldfield) is in decline. The post-closure decant of AMD is an enormous threat, and this could become worse if remedial activities are delayed or not implemented.<sup>35</sup>

The current (immediate and short term) treatment of AMD is by means of neutralisation or a pH adjustment. In most cases, metals will precipitate out of solution if the pH is adjusted upwards i.e. the water is made more alkaline. It should be noted that the metals do not simply disappear but change to a different oxidation state, which changes them from a soluble form to a solid form. The metals are still there, in the area where the precipitation has occurred in the first place. The process can be reversed and the contaminants mobilised, should the water become acidic.<sup>36</sup>

---

<sup>35</sup> Dr. Pat Manders. Director, Natural Resources and the Environment. Council for Scientific and Industrial Research. "Briefing Note. Acid Mine Drainage in South Africa." August 2009.

<sup>36</sup> Harmony Environmental Impact Document titled "Impact of the discharge of Treated Mine Water, via the Tweelopies Spruit, on the receiving Water body Crocodile River System, Mogale City, Gauteng Province"





The CPS and West Wits Pits into which the high density sludge is discharged after the neutralisation of AMD within the West Rand. The numerous open pits in the West Rand Goldfield have been identified as a source of ingress of AMD into the West Rand Basin, by a study commissioned by the mining industry estimating that they contribute approximately 30% of the total ingress. (Source: Department of Minerals and Energy. Regional Mine Closure Strategies for the West Rand Goldfield. 2008)

The sulphate concentrations in the neutralised AMD remain high (2 000 – 3000mg/l). High concentrations of sulphate exert predominantly acute health effects (diarrhoea). Sulphate concentrations of 600mg/l and more cause diarrhoea in most individuals and adaptation may not occur. The numerical limit for sulphate in terms of the Resource Quality Objectives (RQOs) for the Upper Vaal is between 200 and 500mg/l depending on the water use.

Elevated sulphate concentrations increase the corrosion rate of metal fittings in water distribution systems.



Pipes transporting Acid Mine Drainage. The first photograph shows a pipe with precipitated metals and the second photograph corrosion caused by acid mine drainage

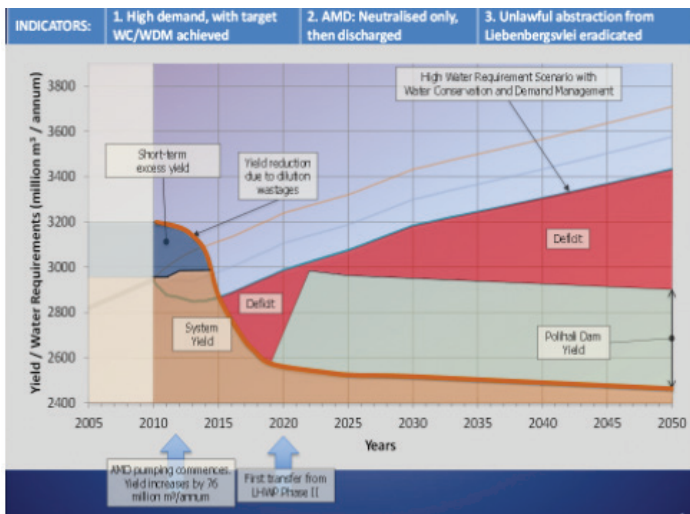
In livestock watering, it was found that sulphate levels above 250 mg/l suppress copper and selenium which result in poor fertility and condition<sup>37</sup>.

---

37 Jan Myburgh, Faculty of Veterinary Science University of Pretoria, Onderstepoort. Conservation Medicine: Toxicology. “Is there a connection between acid mine drainage, acid rain, trace element nutrition of livestock and HIV / AIDS in humans on the eastern Transvaal Highveld?”



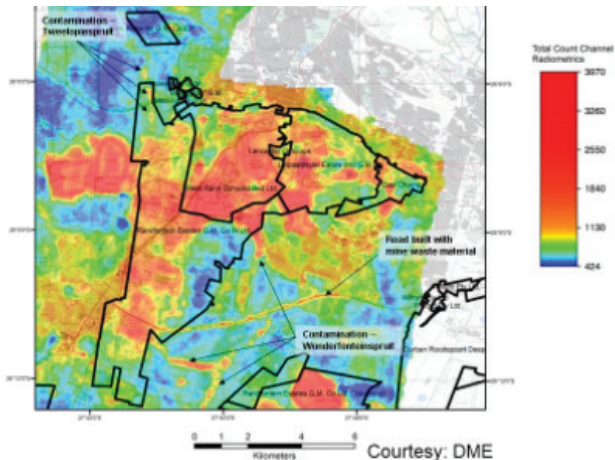
The Department of Water and Sanitation's Feasibility Study for the Long Term Treatment of AMD (2013) and the Reconciliation Strategies for the Integrated Vaal River System warned that the additional salinity as a result of AMD will create water security risks. In order to comply with the regulatory limit of 600 mg/l sulphates, good quality water has to be released from the Vaal Dam in order to ensure that the water below the Vaal Barrage is fit for use, that is, by means of dilution. The projected demand for increased releases from the Vaal Dam of expensive Lesotho water will increase the stress upon the water supply. The additional volume of water that has to be released as a result of the salinity associated with AMD has resulted in a considerable reduction of water supply to the Upper Vaal so much so that the total capacity of Phase 2 of the Lesotho Highlands scheme will be cancelled.



Vaal River System: Reconciliation Strategy. (Source: Department of Water Affairs)

## Uranium and Radioactivity

As a consequence of the uraniferous nature of the gold ore, Witwatersrand tailings and other mining residues often contain significantly elevated concentrations of uranium and its daughter radionuclides, with the decay series of U238 being dominant.<sup>38</sup>



**An airborne radiometric survey of the West Rand and Far West Rand was done for the Department of Water and Forestry. Interpretation of the data shows many of the residential areas fall within areas of high risk of radioactivity contamination. (Source: Department of Minerals and Energy. Regional Mine Closure Strategy for the West Rand gold fields. 2008)**

Significant radiation exposure can occur in the surroundings of mining legacies, due to:

1. Inhalation of Rn-222 daughter nuclides from radon emissions of desiccated water storage dams (e.g. Tudor dam) and slimes dams.
2. The inhalation of contaminated dust generated by wind erosion from these objects, and
3. The contamination of agricultural crop (pasture, vegetables) by the deposition of radioactive dust particles, which can cause considerable dose contributions via ingestion.<sup>39</sup>

---

<sup>38</sup> Institute for Water Quality Studies, 1995; Institute for Water Quality Studies, 1999, Department of Water Affairs and Forestry, 2003. Radiometric Surveying in the Vicinity of Witwatersrand Gold Mines. H. Coetzee. Mine Closure. 2008.

<sup>39</sup> NNR Report – TR-RRD- 07-0006 – “Radiological Impacts of the Mining Activities to the Public in the Wonderfontein Catchment Area.” 12 July 2007

Significant radiation exposure can occur in the surroundings of mining legacies, due to:

1. Inhalation of Rn-222 daughter nuclides from radon emissions of desiccated water storage dams (e.g. Tudor dam) and slimes dams.
2. The inhalation of contaminated dust generated by wind erosion from these objects, and
3. The contamination of agricultural crop (pasture, vegetables) by the deposition of radioactive dust particles, which can cause considerable dose contributions via ingestion.<sup>39</sup>

Strong dust emissions from tailings storage facilities occur during wind events. Due to the small particle size of the slimes, particulate matter can be transported over relatively long distances to agriculturally used land in his surroundings. The deposition of radioactively contaminated dust on leaves of vegetable and forage plants can cause radiation exposures exceeding those from the inhalation of contaminated dust substantially.<sup>40</sup>

There has also been a historical migration of generally elevated radioactive levels to the urban areas of Johannesburg central business district (CBD) indicating the use of dump and waste material for building purposes as well as downstream plumes in wetlands areas.<sup>41</sup>

The measured uranium content of many of the fluvial sediments e.g. in the Wonderfontein spruit, including those off mine properties and therefore outside the boundaries of licensed sites, exceeds the exclusion limit for regulation by the National Nuclear Regulator.<sup>42</sup>

The sediment pathway can cause radioactive contamination of livestock products (milk, meat) resulting in effective doses of the public in some orders of magnitude above those resulting via the water pathway.

The most important lesson learnt from the studies in the Wonderfontein spruit is that no short-cuts exist which would allow certain pathways to be ignored in a study of radioactive contamination within these mining areas.<sup>44</sup>

---

**39** NNR Report – TR-RRD-07-0006 – “Radiological Impacts of the Mining Activities to the Public in the Wonderfontein spruit Catchment Area.” 12 July 2007

**40** Ibid

**41** Department of Minerals and Energy. Regional Mine Closure Strategy for the Central Rand Goldfield. 2008.

**42** The National Nuclear Regulator Act of 1999 set up the National Nuclear Regulator (NNR) The NNR came into force in February 2000 and its role is to protect the public, property and the environment against nuclear damage. Tailings Storage Facilities are defined in the National Nuclear Regulator Act as “nuclear installations.”

**43** Department of Minerals and Energy. Regional Mine Closure Strategy for the East Rand goldfield. 2008

An airborne radiometric survey of the West Rand was done for the Department of Water and Forestry by the Council of Geoscience. Interpretation of the data show many of the residential areas fall within areas of high risk of radioactivity contamination.

### **Dump Reclamation**

In dump reclamation activities, a number of cases have been identified where the re-mining of the dumps was not completed due to the lack of funding on the part of the mining company or due to the heterogeneity in the dumps which were mined. The granting and authorization for the reprocessing of individual residue deposits by the Department of Mineral Resources has allowed the selective extraction of value from portions of a site without ploughing some of that value back into the rehabilitation of the entire area.<sup>44</sup>

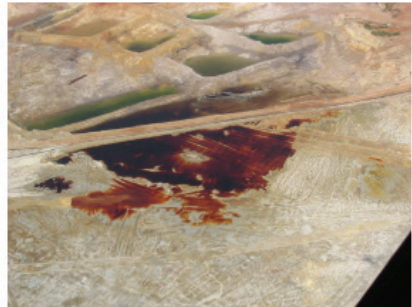


**North Sands Dump within the West Rand where the reclamation was not completed due to the low grade of gold in the remainder of the Dump. Note the tailings spillage within a wetland.**

The footprints of re-mined mine residue deposits are often left un-rehabilitated. Radiometric surveys have in some cases shown elevated levels of residual radioactivity in the soils. Failure by the relevant organs of state to enforce the non-compliances by the mining industry in this regard has resulted in unrestricted development and inappropriate land-uses.

---

<sup>44</sup> Mine Closure 2008. D.M. van Tonder et al. South Africa's Challenges Pertaining to Mine Closure – The Concept of Regional Mining and Closure Strategies.



Unrehabilitated footprints adjacent to the acutely toxic Lancaster Dam, one of the 36 radioactive hotspots within the Wonderfonteinspruit Catchment Area and the Central Rand (Photograph: McCarthy, T.)

The associated contribution to ingress of AMD into the mine voids or basins is likely to be considerable as old tailings are hydraulically mined using high-pressure cannons containing partially treated acid mine drainage water. This practice introduces air and water into anaerobic tailings, which not only contributes to acid mine drainage formation but there is also evidence for the remobilization of contaminants such as uranium and cyanides during disturbance of old tailings deposits.

## Mining Industry and Organs of State: Neglect of Duty of Care

The gold mining industry within the Witwatersrand is the primary provider of income, employment and services to the local economy. However, any commodity is finite which results in ore depletion. The decline of the gold mining industry has resulted in adverse socio-economic<sup>45</sup> and environmental impacts for the region, the costs of which are currently borne by communities and a mute environment, and in future by future generations.

Although many environmental and social justice issues are addressed in Environmental Legislation post 1994, deficiencies in current legislation remain, as do challenges pertaining to the enforcement of non-compliance with environmental legislation.

Prof. Tracy-Lynn Humby<sup>46</sup> summarises it as follows:

*“The attempt to establish and enforce standards to order and ameliorate the enduring effects of a mine presence in a particular locality has for long been a concern of the South African state. A trajectory of gradual elaboration and strengthening of the regulatory frame is evident, from the sparse provision for closure issues in the Mines and Works Act No. 12 of 1911, to the far more rigorous obligations imposed by the Mineral and Petroleum Resources Development Act No. 28 of 2002 (MPRDA) as amended.*

*“Despite these regulatory advances, there are still a number of legal design flaws that enable mining companies to evade costly closure obligations. These are flaws in the powers, duties, liabilities and rights of key agents in the regulated closure model and the manner in which these intersect with (i) the transfer of mining rights, and (ii) the winding up of mining companies.”*

To exemplify: The Blyvooruitzicht Mine was floated in 1937 as a subsidiary of West Witwatersrand Areas Ltd., Blyvooruitzicht was an “outstanding mine” yielding 1 102 238 kg of gold, silver, uranium and other mineral commodities. Durban Roodepoort Deep Gold Ltd (DRD Gold) was the majority shareholder in the Blyvooruitzicht Gold Mine Company (BGMC.) In June 2011, the BGMC placed itself under supervision and business rescue in terms of the Companies Act 71 of 2008.

---

<sup>45</sup> This includes the social legacy of people employed, supported, and attracted to the mine and its surrounding areas, and the impacts on affected populations when a mine closes or becomes insolvent.

<sup>46</sup> T. Humby, School of Law, University of the Witwatersrand, South Africa “Facilitating dereliction? How the South African legal regulatory framework enables mining companies to circumvent closure duties” 2014.

On 6 August 2013 a provisional winding-up order was granted. The winding up provisions do not accommodate the financial provision for rehabilitation as a special call on the company's assets that should be set aside before any other creditors are satisfied.

While BGMC's legally binding Environmental Management Programme Report (EMPR) of 2007 stated that "The site would be left ecologically and geophysically stable and would not pose an economic, social or environmental liability to the local community and the state now or in the future", BGMC left in its wake a number of un-rehabilitated footprints of reclaimed tailings storage facilities, toxic and radioactive water and soil, radioactive infrastructure, tailings storage facilities without vegetation, retainer walls and functional toe paddocks and penstocks, and total liabilities of R891 098 234. Only R36 947 540 was held in trust for rehabilitation, however these rehabilitation funds were not released by the Minister of Mineral Resources to mitigate or remedy the significant environmental and social impacts. There also significant flaws in mine closure arising from problems in enforcement such as lack of state responsiveness, political interference and weak state institutional capacity.

Costs and impacts continue to be externalized, with impunity, by the mining industry. Called negative externalities, these deflected costs are imposed on stakeholders other than the mining companies.<sup>47</sup>

The externalisation of costs is described by Rebecca A. Adler et al in the *Economics of Peace and Security Journal* (2007). The article is titled "*Water, mining, and waste: an historical and economic perspective on conflict management in South Africa.*"

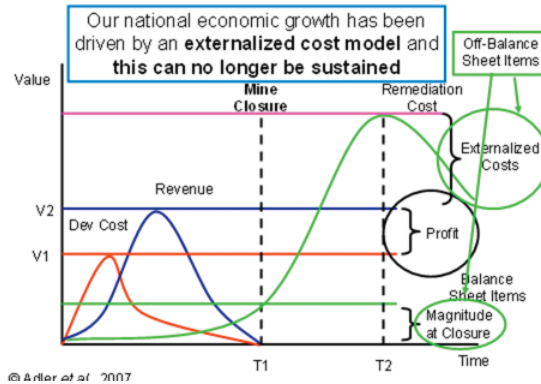
The subjoined theoretical representation is used by Adler to describe the externalization of costs by the gold mining industry in South Africa.

---

<sup>47</sup> Rebecca A. Adler et al. *Water, mining and waste: an historical and economic perspective on conflict management in South Africa*. 2007.

The subjoined theoretical representation is used by Adler to describe the externalization of costs by the gold mining industry in South Africa.

## The Externalization of Costs Model



Adler explains the above-mentioned figure as follows: “The figure represents costs and benefits associated with gold mining. The vertical axis expresses value in monetary terms and the horizontal axis represents time. The Development and Operational Cost Curve (DOCC) refers to the cost of developing and operating a specific mine. This includes costs of prospecting, sinking of mine shafts, pumping of ground water, cooling of shafts, along with developing and employing water treatment facilities and complying with other environmental regulations. The Revenue Curve (RC) represents the revenue generated by the mine. The area under the curves thus equals cumulative development and operational costs and cumulative operational revenues. The difference between the two lines at any one point in time equals profit earned by the mine at that instance. The difference between the total areas under DOCC and RC reflects lifetime profitability of the mining operation.

“The financial success of a mine has historically been represented by the cost of development and operation (DOCC) and the revenues generated (RC). These are balance sheet items reported to shareholders. Mine closure occurred when revenue streams dropped below the cost of operating the mine (to the right of T1).

“The third curve in the Figure, the Environmental and Social Remediation Curve (ESRC), represents the costs associated with rehabilitation of mining operations after decommissioning, including the cost to human and environmental health and the social legacy of people employed, supported, and attracted to the mine and its surrounding areas. Importantly this factors in impacts on affected populations that live off mine, something that is never brought onto any balance sheet. This curve is slow to gain amplitude because the environmental impacts of mining are cumulative



*and typically require several decades to take effect. By the time environmental and socio-economic consequences become noticeable, the mines have typically closed or become insolvent and thus cannot be completed anymore to contribute to remediation, either financially or through other actions.”*

With reference to the management of Mine Water, the Department of Water and Sanitation identified the following problems in its Mine Water Management Policy of 2016:

° The delegation of powers between different 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, even our own NWA to remove ambiguity and address mine water directly.

° The MPRDA may play a leading role in the mining sector, but persons/companies/institutions still have to comply with other statutory duties under the NEMA and the NWA. Liability thus is based on a consistent and comprehensive application of the abovementioned (not limited to) legislations. This suggests that any person/company/institution that can be proven to fall within the ambit of Section 19 NWA, and/ or Section 28 NEMA, and/ or Section 38 MPRDA, can be held legally liable for damages and/ or negative impacts caused by mine water. The existing frameworks place Government and DWS specifically in the position of having limited powers in terms of imposing sanctions. The legislation needs to be strengthened, to give the DWS a strong legislative basis to impose sanctions and apportion of liabilities. The best funding models to deal with historic pollution should be identified. Abandoned mines need to be rehabilitated by DWS in cases where water security is at risk.

- The selected technology for the long term treatment of Acid Mine Drainage should be situational based. It should be sustainable, clean (with minimal residuals and/or easily manageable residues) and economical.
- The current legal and policy context does not draw a clear distinction between the handling and regulation of (1) new, (2) active and (3) historic mines (including abandoned mines). The current legal and policy context does not impose special and/

or stricter measures in the case of mines with a significant adverse impact potential. Specific conditions should be imposed on mines that have an acid generation potential.

- There is a perception that mining is often authorised, irrespective of whether the long-term “benefit” outweighs the long-term “cost”, including the costs for managing mine water. More investigation is required on the possibility to use the green approach in mining. This will involve investigations on green technologies, sustainable mining methods, etc. and the evaluation of socio-economic sustainability.
- Apportioning liability remains problematic. The NWA has gaps with regards to “retrospective liability”. The impacts caused by mine water drainages e.g. AMD is often externalised by the mining sector, whether during active mining or subsequent to mine closure. Financial Provision predominantly applies to surface rehabilitation.
- From a mine water management perspective, there often appears to be a mismatch between environmental planning and the actual interventions earmarked for implementation. The DMR mandate, i.e. to promote minerals development, appears to be incompatible with DWS’s mandate, i.e. to protect and use water resources sustainably. Mining authorisations often appear to be granted for mines that are to mine in water sensitive areas. From a mining sector perspective – significant impacts due to AMD are often attended to on a case-by-case basis. From a regulatory perspective – an “Integrated Master Plan” is currently required for the regulation of future mining developments. Mining authorisations appear to be granted on an ad hoc basis without the necessary consultations amongst the relevant Government Departments (DMR, DWS and DEA). It is hoped that the recently-adopted one environmental permitting system will address this gap.
- The Mining Charter provides that mines are expected to design and plan all operations so that adequate resources are available to meet the closure requirements of all operations. Section 28(2) (c) of the MPRDA contemplates that mines should report on their compliance to the Mining Charter on annual basis. However in instances where a mine is declared insolvent and subsequently closes, the responsibility is inherited by the State who then has to ensure the continuous rehabilitation of derelict and ownerless mines. Technically, the mine escapes liability and the rehabilitation fund provided prior by the mine is often not sufficient for continuous infrastructure management and rehabilitation. As a result, mine water is left unmanaged if transfer has not taken place which then typically becomes a State liability.

The Department of Water and Sanitation's "Water Quality Management Policies and Strategies for South Africa Report"<sup>48</sup>, 2016 identified the following weaknesses with particular reference to the management of Mine Water:

- ° Poor cooperative governance and inadequate cross-regulatory interfaces with DWS
- ° Historical and recent lack of precautionary planning, regulation and enforcement
- ° Inappropriate licence conditions;
- ° Lack of monitoring and reporting of own pollution loads;
- ° Lack of enforcement
- ° Lack of compliance with licence conditions; inappropriate licence conditions; inadequate enforcement capacity

Uranium, an important by-product of gold mining in the Witwatersrand and an identified hazardous component of the wastes and effluents from Witwatersrand mining activities, occurs due to both radiotoxicity and chemical toxicity, with in some cases, the chemical toxicity dominating over the radiotoxicity. It is therefore logical that an integrated approach be adopted for the management of radioactive and chemical contamination and that this be facilitated by the different government agencies and regulators involved.<sup>49</sup> There is little or no horizontal and vertical co-operation between the relevant organs of state in this regard. The Department of Health is notably absent from involvement in the assessment and mitigation of health risks and hazards of mining within the Witwatersrand gold fields.

The National Nuclear Regulator, the competent authority responsible for the protection of the public, property and the environment against nuclear damage, because of its narrow interpretation of its mandate<sup>50</sup>, has failed to implement the remediation of areas with residual radioactive material outside licensed sites and to protect persons living on radioactive mine residue areas.

---

<sup>48</sup> Water Resource Planning Systems Series Water Quality Management Policies and Strategies for South Africa

DWS Report No.: P RSA 000/00/21715/12

<sup>49</sup> DM van Tonder et al. South Africa's Challenges Pertaining to Mine Closure – The Concept of Regional Mining and Closure Strategies. Mine Closure 2008. AB Fourie, M. Tibbett, IM Weiersbye, PJ Dye (eds)

<sup>50</sup> Tracy-Lynn Humby. Environmental Justice and Human Rights on the Mining Wastelands of the Witwatersrand Gold Fields. 2013.

A recent Report titled “The Cost of Gold: Environmental, Health, and Human Rights Consequences of Gold Mining in South Africa’s West and Central Rand by the International Human Rights Clinic Harvard Law School”<sup>51</sup>, dated October 2016 found that while the South African government has during the last five years taken some noteworthy steps to address the adverse impacts of gold mining, it has failed to live up to many relevant human rights obligations. Its response to the crisis in the West Rand has generally been slow and insufficient. As a result, mining has not only created environmental and health risks, but it has also prevented community members from realizing numerous human rights. Widespread contamination has raised concerns under the rights to health, a healthy environment, water, and housing, while inadequate community engagement has interfered with the rights to receive information and participate in decision making.<sup>52</sup>

The Report furthermore found that the South African Government’s efforts to minimize the impacts of gold mining have been largely incomplete. The government has permitted new residential developments in close proximity to tailings storage facilities. It has neither pursued adequate dust control measures, such as irrigation and vegetation of tailings dams, nor ensured that the mining industry has done so. While the massive amount of waste has been daunting, the government has taken inadequate steps to develop a more complete solution to the root causes of polluted dust and soil i.e., the tailings storage facilities themselves. Mining companies have extracted and removed some metals through re-mining, but government oversight seems to have been insufficient to minimize the side effects of the process, which exacerbates dust fallout and increases AMD.<sup>53</sup>

The government’s poor track record of communicating and engaging with residents about mining matters has been almost as problematic as the adverse effects of mining operations. It has prevented local people from fully exercising two key civil and political rights—the right to receive information and the right to participate in decision making.<sup>54</sup>

---

51 International Human Rights Clinic Harvard Law School. “The Cost of Gold: Environmental, Health, and Human Rights Consequences of Gold Mining in South Africa’s West and Central Rand”. October 2016

52 Ibid

53 Ibid

54 Ibid

In addition, while contamination levels have been well documented, there has been a shortage of epidemiological studies regarding the effects of mining contamination on human health in the region. The lack of such information has undermined residents' abilities to protect themselves or advocate on their own behalf.<sup>55</sup>

Communities are often left out of discussions related to mining operations. Frustration at the lack of engagement has led to violence, litigation, and feelings of mistrust.<sup>56</sup>

The Government failed in establishing a coordinated and comprehensive program that both mitigates the effects of mining and helps the country meet its responsibilities under domestic, international, and regional human rights law.<sup>57</sup>

---

55 Ibid

56 Ibid

57 Ibid

## Extracts from relevant Environmental Legislation

The following Acts are mainly applicable to remediation and mine closure:

<sup>o</sup> The National Environmental Management Act 107 of 1998 (NEMA) specifically sections 28 and 30 including the 2014 EIA Regulations

<sup>o</sup> The National Water Act 36 of 1998 (NWA) specifically sections 19 and 20; and Regulations on Use of Water for Mining and Related Activities aimed at the Protection of Water Resources. GN. R. 704 of 4 June 1999

<sup>o</sup> The Mineral and Petroleum Resources Development Act (28 of 2002) (MPRDA) and the Mineral and Petroleum Resources Development Regulations (MPRD Regulations) (GNR 527 in GG 26275 of 23 April 2004)

The requirements for remediation, including mine closure, in the applicable sections of the above-mentioned three Laws are similar, namely that a “responsible person” must take all “reasonable measures” to prevent, control and remediate the effects of pollution. This raises four specific legal-technical questions, namely, who is responsible, which ‘responsible person’ will be liable under these statutory provisions, what are the liabilities facing this “responsible person” and what are the duties and obligations of the “responsible person” towards “reasonable measures” that can be taken to avoid these liabilities.<sup>58</sup>

Three of these questions are now discussed, namely who is responsible, who is liable and what are the duties and obligations of the ‘responsible person’ in terms of the National Environmental Management Act (107 of 1998) (NEMA) and the National Water Act (19 of 1998) (NWA).

### Who is responsible?<sup>59</sup>

Section 19 of the NWA deals with prevention and remedying effects of pollution and states in subsection 19(1) that “an owner of land, a person in control of land or a person who occupies or uses the land on which- (a) any activity or process is or was performed or undertaken; or (b) any other situation exists, which causes, has caused or is likely to cause pollution of a water resource, must take all reasonable measure to prevent any such pollution from occurring, continuing or recurring.”

---

<sup>58</sup> Carin Bosman and Louis J. Kotze. Responsibilities, liabilities and duties for remediation and mine closure under the MPRDA and NWA. 2005.

<sup>59</sup> Ibid

## Who is Liable?<sup>60</sup>

Under the NEMA and by implication the NWA, liability is specifically extended to the director of the business concern in his or her personal capacity i.e. personal liability.

In terms of NEMA section 34(7) a person who is or was a director (member of the board, executive committee, or other managing body of a corporate body and, in the case of a close corporation, a member of that close corporation or in the case of a partnership, a member of the partnership of a company at the time of the commission by that firm of an offence under a provision listed in Schedule 3 (this includes the NWA) will be guilty in their personal capacities of the offence and liable on conviction to the penalties imposed in the offence by the company. Proof of the said offence by the company under the Schedule 3 provision shall constitute prima facie evidence that the director is guilty under this subsection of NEMA.

Under these provisions, which include the NWA, it is only necessary to show that the responsible person at the time failed to take reasonable measures, which implies a strict liability, since such failure to take reasonable measures, or even if pollution impacts were caused inadvertently automatically invokes the liability.

### Retrospectivity of the polluter pays principle

“NEMA has been amended to clarify that the duty to take reasonable measures to prevent significant pollution or degradation of the environment from occurring, continuing or recurring (“the duty of care”) also applies to pollution that occurred before NEMA commenced; to pollution that might arise at a different time from the actual activity that caused the contamination and to pollution that may arise following an action that changes pre-existing contamination (NEMA section 28(1A)). It is therefore no defence to say that the pollution is historic, indirect or underlying – the responsibility to take reasonable steps remains.

The significance of these changes becomes more apparent when one remembers that section 34 of NEMA makes provision for both ‘firms’ (including companies and partnerships) and their ‘directors’ (including board members, executive committees or other managing bodies or companies or members of close corporations or of partnerships) to be held liable, in their personal capacities, for environmental crimes. This personal liability also applies to managers, agents or employees who have done or omitted to do an allocated task, while acting on behalf of their employer. In all instances, the offence in question has to be one that is listed in Schedule 3 of NEMA and the person concerned must have failed to have taken all reasonable steps necessary under the circumstances to prevent the commission of the crime.

---

<sup>60</sup> Ibid

The sting in the tail is that NEMA section 28(14) is not listed as a Schedule 3 offence. This means that unless it can be shown that all reasonable steps necessary to prevent the crime were taken, even an unintentional (but negligent) unlawful act or omission which causes significant pollution or degradation of the environment, can make a ‘director’ personally liable”.

(Reference: Environmental Law and Liability. Enviropoedia. 2012. Glendyr Nel – Associate: Cullinan and Associates.

Section 19 of the NWA deals with pollution prevention, and in particular the situation where pollution of a water resource occurs or might occur as a result of activities on land. The person who owns, controls, occupies or uses the land in question is responsible for taking measures to prevent pollution of water resources. If these measures are not taken, the catchment management agency concerned may itself do whatever is necessary to prevent the pollution or to remedy its effects, and to recover all reasonable costs from the persons responsible for the pollution.<sup>61</sup>

*The “Regulations on use of water for mining and related activities aimed at the protection of water resources”* (GN. R. 704 of 4 June 1999) impose restrictions on locality and restrictions on use of material, capacity requirements of clean and dirty water systems, protection of water resources, security measures and temporary or permanent cessation of mine or activity.

### **What are the duties and obligations of the Responsible Person?<sup>62</sup>**

In terms of both the NEMA and NWA, the “responsible person” must take all “reasonable measures” to prevent such pollution or degradation from occurring, continuing or recurring. These Acts then describe a variety of actions that must be undertaken, ranging from investigations<sup>63</sup>, training, ceasing or modification of activities or processes, containment and remediation.

---

**61** Duard Barnard et al (Compiler). Road Map to Environmental Legislation. Edition 4. 2011

**62** Carin Bosman and Louis J. Kotze. Responsibilities, liabilities and duties for remediation and mine closure under the MPRDA and NWA. 2005.

**63** Section 28(4) of the NEMA:

“(4) The Director-General or a provincial head of department may, after consultation with any other organ of state concerned and having given adequate opportunity to affected persons to inform him or her of their relevant interests, direct any person who fails to take the measures required under subsection(1) to-

- (a) Investigate, evaluate and assess the impact of 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.”



In addition to taking these 'reasonable measures', an applicant for a mining right or permit, prior to approval of his environmental Management Programme Report, must make financial provision for remediation of environmental damage or management of negative environmental impacts.

In terms of Regulation 26(h), all environmental authorisations issued under the EIA Regulations of 2014 post December 2014 must be made available by the authorisation holder on the company's website, at the site of operation, and on request:

- the environmental authorisation itself;
- the environmental management programme;
- any independent assessments of financial provision for rehabilitation and environmental liability;
- closure plans (where applicable);
- audit reports; and
- all compliance monitoring reports.

This requirement, or condition of operation, is legally binding. Failure to adhere is a criminal offence in terms of section 49A(1)(c) of NEMA and can attract a fine of up to R10 million or imprisonment for a period of up to 10 years.

Mining companies which did not hold NEMA environmental authorisations pre-December 2014 will also be subjected to these disclosure requirements when they amend their environmental management programmes previously issued under the Mineral and Petroleum Resources Development Act 28, 2002 (MPRDA). This is because the 2014 EIA Regulations specifically provide (Regulation 54) that the amendment of environmental management programmes issued under the MPRDA must be dealt with in terms of the 2014 EIA Regulations under the provisions for amending environmental authorisations. The only logical outcome to such an amendment process would be for the competent authority to issue a new environmental authorisation, which would then be subject to the requirements of Regulation 26(h). Regulation 34(5) of the EIA Regulations of 2014 makes provision for public participation on the annual audit report and financial provisions of the mines. The audit reports and updated financial must also be available to the public in accordance with regulation 11(3) of the 2105 financial provision regulations.

The audit report has to be completed by an independent qualified auditor and should contain:

- The ability of the EMPr and closure plan to sufficiently provide for the avoidance, management, mitigation of the ongoing and closure impacts. (reg 34(3) 2014)
- The level of compliance with the EA, EMPr and closure plans. (reg 34(3) 2014)

Any insufficiency must be brought to the attention of the holder of the right. When submitting the report the holder must also submit recommendations to rectify and come into compliance. These must also be made available for public participation. (Reg 34(4)).

The results of the assessment of the adequacy of the financial provision must be compiled by an independent auditor and must be included in the annual audit report. (Reg 11(3) 2015).

The annual rehabilitation plan audit must include the sum of the financial provision and an indication of how the sum was determined. (Reg 12(4) 2015)

The environmental audit report in terms of GN 982 of 4 December 2014 NEMA EIA Assessment Regulations must provide for recommendations regarding the need to amend the EMPr, and where applicable, the closure plan.

In terms Reg 34 (3), the environmental audit report contemplated in sub regulation (1) must determine-

- (a) the ability of the EMPr, and where applicable the closure plan, to sufficiently provide for the avoidance, management and mitigation of environmental impacts associated with the undertaking of the activity on an ongoing basis and to sufficiently provide for the , avoidance, management and mitigation of environmental impacts associated with the closure of the facility; and
- (b) the level of compliance with the provisions of environmental authorisation, EMPr and where applicable the closure plan.

34 (4) Where the findings of the environmental audit report contemplated in sub regulation (1) indicate-

- (a) insufficient mitigation of environmental impacts associated with the undertaking of the activity; or
- (b) insufficient levels of compliance with the environmental authorisation or EMPr and, where applicable the closure plan; the holder must, when submitting the environmental audit report to the competent authority in terms of subregulation (1), submit recommendations to amend the EMPr or closure plan in order to rectify the shortcomings identified in the environmental audit report.

34(5) When submitting recommendation in terms of sub regulation (4), such recommendations must have been subjected to a public participation process, which process has been agreed to by the competent authority and was appropriate to bring the proposed amendment of the EMPr and, where applicable the closure plan, to the attention of potential and registered interested and affected parties, including organs of state which have jurisdiction in respect of any aspect of the relevant activity and the competent authority, for approval by the competent authority.

34(7) An environmental audit report must contain all information set out in Appendix 7 to these Regulations.

The Scope of the Financial Provision in terms of the above-mentioned GN 1174 of 20 November 2015 is as follows:

“An applicant or holder of right or permit must make financial provision for—

- (a) rehabilitation and remediation;
- (b) decommissioning and closure activities at the end of prospecting, exploration, mining or production operations; and
- (c) remediation and management of latent or residual environmental impacts which may become known in future, including the pumping and treatment of polluted or extraneous water.”

#### **Mine closure<sup>64</sup> in terms of the MPRD Regulations and the NWA**

The principles for mine closure are as follows:

“In accordance with applicable legislative requirement (i.e. NEMA, NWA, etc.) for mine closure, the holder of a prospecting right, mining right, retention permit or mining permit must ensure that-

- (a) The closure of a prospecting or mining operation incorporates a process which must start at the commencement of the operation and continues throughout the life of the operation;
- (b) Risks pertaining to environmental impacts must be quantified and managed proactively, which includes the gathering of relevant information throughout the life of a prospecting or mining operation;
- (c) The safety and health requirements in terms of the Mine Health and Safety Act, 29 of 1996, are complied with;
- (d) Residual and possible latent environmental impacts are identified and quantified;
- (e) The land is rehabilitated, as far as is practicable, to its natural state, or to a predetermined and agreed standard or land use which conforms with the concept of sustainable development; and
- (f) Prospecting or mining operations are closed efficiently and cost effectively”.

---

<sup>64</sup> Ibid

This implies that, before a decision is taken on which measures to implement for remediation and closure, the objectives that need to be achieved with the implementation of such measures must be established and agreed upon. This ties in with the MPRD Regulations objectives for mine closure stated above “the land is rehabilitated, as far as is practicable, to its natural state, or to a predetermined and agreed standard or land use which conforms with the concept of sustainable development”. Such objectives would include, from a generic perspective, the following:

- Immediate harm to human health and safety must be eliminated
- Groundwater must be fit for current and future domestic and other uses consistent with agreed current and future land use
- Surface water must be fit for current and future basic human needs and aquatic ecosystems requirements
- Risks of harm to non-aquatic organisms must be eliminated; and
- Soil must be fit for use consistent with current and future land use.

Specific Objectives must be established for each of these aspects. In this context, it is therefore impossible to determine if measures taken to remediate environmental impacts with the aim of achieving mine closure are in fact “reasonable measures” unless the future land use has been determined, and objectives for remediation have been agreed upon.

Since they are the ultimate recipients of potential, ongoing and historical pollution and the potential future land-users, the requirement of MPRD Regulation 62 entails that interested and affected parties must be involved in the agreements regarding future land use of affected areas and thus in the decisions regarding the establishment of objectives for such future land use, as well as in discussing the alternatives for engineering interventions, where decisions regarding such options will affect the future land use.

### **Legal Principles and Practical Guidance to determine “Reasonable measures”<sup>65</sup>**

NEMA Section 2:

- Precautionary approach
- Polluter Pays Principle
- Duty of Care
- Pollution prevention
- Principles of Participation
- Transparency and democracy
- Best Practicable Environmental Option (BPEO)

---

<sup>65</sup> Ibid

BPEO is defined in NEMA as “the option that provides the most benefit or causes the least damage to the environment as a whole, at a cost acceptable to society, in the long term as well as in the short term.”

BPEO is the outcome of a systematic consultative and decision making process.

### **The Regulatory Framework in terms of National Nuclear Regulator Act (47 of 1999) (NNRA)**

In terms of Section 2 of the NNRA, the Act is applicable to:

- “(a) the siting, design, construction, operation, decontamination, decommissioning and closure of any nuclear installation;*
- (b) Vessels propelled by nuclear power or having radioactive material on board which is capable of causing nuclear damage; and*
- (c) Any action which is capable of causing nuclear damage.”*

A nuclear installation is defined in the Act as:

*a) “a facility, installation, plant or structure designed or adapted for or which may involve the carrying out of any process, other than the mining and processing of ore, within the nuclear fuel cycle involving radioactive material, including, but not limited to-*

*(i)A uranium or thorium refinement or conversion facility;*

*(ii)A uranium enrichment facility*

*(iii)A nuclear fuel fabrication facility*

*(iv) A nuclear reactor...*

*(v) A spent nuclear fuel reprocessing facility*

*(vi) A spent nuclear storage facility*

*(vii)An enriched processing and storage facility; and*

***(viii) A facility specifically designed to handle, treat, condition, temporarily store or permanently dispose any radioactive material which is intended to dispose of as waste material, or***

*(ix) Any facility, installation, plant or structure declared to be a nuclear installation in terms of section 2(3)”*

(Emphasis added.)

Tailings storage facilities or tailings dams fall squarely within the definition of a “*nuclear installation*.”

### **NNR Regulations**

The draft NNR Regulations are aligned with international best practice for remediation and establish an authorisation process, criteria for release of land remediated, other than exclusion and exemption criteria and the development of a skills plan for training and development of newly appointed staff in the area of remediation as well as the establishment of contracts and cooperative agreements with other Governmental Departments.

## Proposed pilot study

Four major mines in the West Rand have over a period of more than 130 years, extracted gold and at times uranium from metasedimentary rocks of the Witwatersrand Supergroup. The goldfield occupies a triangular area bounded by the Rietfontein Fault in the north, the west Rand Fault in the west and the Witpoortjie Fault in the south and east.

The West Rand Goldfields is currently constituted by the mining companies, Sibanye Gold, Harmony Gold and Mintails SA (Pty) Ltd.

Mining in the West Rand Goldfield began after the discovery of gold in 1886. As gold was mined from greater depths in the 1890s it became necessary to dewater the mines by pumping water from the underground workings. This continued until the 1990s when underground mining was abandoned and the underground workings were allowed to flood. During the mining period all the underground workings within the goldfield were interconnected. During flooding, this allowed the establishment of a hydraulic equilibrium, with all of the mine workings flooding to an approximate constant level. Recent mining activities by Mintails and Sibanye Gold have been limited to shallow operations via a number of open pit operations and the reclamation of the large volume of tailings present on the surface.

In 2002 the water level in the underground workings rose to the point where it was able to decant to the surface via a seepage through an outlier of dolomite and a low-lying shaft. The water quality was extremely poor, with low pH and high levels of sulphate, iron, metals and radionuclides, primarily from the uranium series. Many of these metals are present in toxic concentrations in the mine water. In addition, radioactive metals also occur in the mine void water. The following determinants in the mine void water exceed the Maximum Allowable Limits (Class II) of the SABS 241 Drinking Water Standard, in many cases by several orders of magnitude: pH, EC, TDS, SO<sub>4</sub>, Fe, Mg, Ca, Mn, Al, Pb, Co and Ni. It can be assumed with a reasonable amount of certainty that most of the other metals would also be present in elevated concentrations. The mine void water is toxic and could lead to severe health effects or death in humans, should it be used for drinking purposes in its undiluted form.<sup>66</sup>

This water flowed into the neighbouring Krugersdorp Game reserve where it has been shown to have had a devastating effect on the local ecology.

---

<sup>66</sup> Harmony Environmental Impact Document titled "Impact of the discharge of Treated Mine Water, via the Tweelopies Spruit, on the receiving Water body Crocodile River System, Mogale City, Gauteng Province" (DWAF 16/2/7/C221/C/24) (3 December 2006)



Hippo Dam, prior to the decant of AMD, known as the Dry Dam. Note the precipitated metals in the Dam.



Hippopotami bulls in the Hippo Dam, coated with metal sludge

(Photographs: Stephan du Toit)



Tweelopiespruit with precipitated metals, a yellow-orange solid colloquially known as yellow boy.

(Photographs: Stephan du Toit)

In 2012 the immediate and short term treatment of the void water has improved the conditions, although the quality of water discharged into the Tweelopiespruit is non-compliant with the Department of Water and Sanitation's requirements.

The Tweelopiespruit represents the most direct route for the mine void water to reach the Zwartkrans Compartment, which hosts the sensitive Cradle of Humankind World Heritage Site. The Tweelopiespruit is part of the Crocodile West Water Management Area and the Magaliesburg Water Catchment Forum.



In terms of the Harmony Environmental Impact Document titled “*Impact of the discharge of Treated Mine Water, via the Tweelopies Spruit, on the receiving Water body Crocodile River System, Mogale City, Gauteng Province*” (DWAF 16/2/7/C221/C/24) (3 December 2006), 2654 Ha are under irrigation using borehole water within the Zwartkrans Compartment and 458 Ha are under irrigation using river water. More than 11 491 people use the water for domestic purposes.

Its path through the Krugersdorp Game Reserve assigns to it even greater ecological importance and sensitivity.

The decant of untreated mine water from 2002 to 2012 and the current discharge of neutralised mine water via the Tweelopiespruit has resulted in the contamination of receptor dams such as the Hippo Dam and Aviary Dam within the Tweelopiespruit and its associated wetlands. The Dams, associated wetlands and streambed contain a yellow-orange solid colloquially known as yellow boy and other types of iron precipitates, including iron oxides and oxyhydroxides. All these precipitates discolour the water and smother plant and animal life on the streambed, disrupting stream ecosystems.

The ecological status of the Tweelopiespruit is:

Winde found that the main pollution sources of void water are perhaps not located underground but on surface. It was found that “small streams crossing the mining belt are highly contaminated by mining related pollution sources resulting in stream water frequently displaying characteristics of acid mine drainage.”<sup>67</sup>

A number of workers have identified elevated gold contents in wetlands around Witwatersrand mines, with gold concentrations reaching as much as 10g/t in some places (Coetzee et al, 2002). There is therefore the potential to recover metals in the Hippo Dam and Aviary Dam and the Tweelopiespruit, and the impacted wetlands, which can be used to fund the ecological rehabilitation. The rehabilitation of these Dams, wetlands and Spruit can be used as an engine for job creation for residents of poorer parts of Mogale City (Krugersdorp) and Randfontein.

The rehabilitation project has the possibility to be integrated with Sibanye Gold’s Social and Labour Plan and will assist with its regional planning for closure and a more satisfactory environmental conclusion, and the resultant minimisation of human and environmental impacts in the post closure phase.

---

<sup>67</sup> Desktop Assessment of the risk to basement structures of buildings of Standard Bank and ABSA in Central Johannesburg to be affected by rising water levels in the Central Basin. Winde F. May 2011

The rehabilitation project can furthermore form part of the Department of Water and Sanitation's "Adopt-a-River" programme. The Adopt-a-River programme has been expanded to areas where interested parties can participate in the Adopt-a-River programme and learn about the protection and management of their water resources. The aim is to mobilise volunteers to assist in safeguarding the health of the rivers and wetlands in a sustainable way.

## **The remedial action required**

Restoration is the term used to describe the improvement of a contaminated land area or degraded river ecosystem to its original or natural state or use, where all aspects have been returned to the pre-disturbance level of structure and functioning.

Remediation is used to describe the improvement of contaminated land areas or degraded river ecosystems to a situation where new sequential land use or river ecosystem has been established.

Rehabilitation describes the intervening actions (including engineering interventions) which aim to improve the land area or river with the intention of either reinstating the original ecosystem processes or structures (restore), or facilitating the use of the contaminated land area or river ecosystem to an agreed upon new system (remediate).

Stabilisation means the halt, or at least reduction in the rate of degradation, through a specific rehabilitation activity.

While land uses can seldom be restored to their original state, it may be sometimes possible for river ecosystems. If this is not possible local communities should be involved in the decisions regarding the establishment of objectives for such future use, as well as in discussing the alternatives for engineering interventions, where decisions regarding such options will affect the future land and river ecosystem use since they are the ultimate recipients of potential, ongoing and historical pollution and the potential future land and ecosystem users.

Remediation is seen, in the context of the Pilot Project, as action by the responsible and relevant parties to remove radioactive contaminated material from the Hippo Dam, the Aviary Dam and the wetlands downstream of the Tweelopiespruit, and rehabilitation of these sites and restoration of the eco-system. The action of removing material and rehabilitation will have to be done within the confines and to the standards as set by legislation and the mandated authorities.

The rehabilitation pilot project will have to comply with all the relevant Acts and Regulation, in particular:

- The NWA and Regulations
- The MPRDA and the MPRD Regulations for Mine Closure
- The NNRA
- The NEMA
- The NEM:Waste Act
- The NEM: Air Quality Act

Remediation activities in wetland areas should be based on a survey to determine the nature of the wetland and its ability to recover to a fully functioning wetland after the clean-up. Wetlands are protected by law, and authorisation for the clean-up action will have to be obtained from the environmental authorities.

It is recommended that a consultative and collaborative remediation framework be established to address the complex challenge of the remediation of the receptor dams, eco-system, and wetlands of the Tweelopiespruit. J.F. Ellis in his treatise titled *“Establishing a Framework for Intervention and Remediation of Radioactive Contamination from Gold Mining – Learning from the Past”* recommends that the proposed frame should include:

- Industry grouping
- Regulatory grouping
- Community grouping
- Project steering committee
- Project management team and associated technical teams

Ellis recommends that the proposed management framework should aim to enhance the effectiveness and efficiency of the process by:

- Consolidated and focused technical teams following a common methodology
- The establishment of a consultative and collaborative steering committee to ensure the necessary buy-in from all stakeholders
- The establishment of the necessary third party type structures to ensure that the project is concluded with the control of the regulatory framework.

Furthermore, a significant number of peer reviewed academic reports and governmental reports has been published, which identified and characterized the contaminated sites. Through an integrated approach all this information should be pooled and made available. Once that is done, a strengths, weaknesses, opportunities and threats (SWOT) analysis can be performed, from which an action plan for the remediation of the Tweelopiespruit, wetlands, eco-system and receptor dams should flow for the remediation of the contaminated sites.

The “*Guidelines for the Rehabilitation of Mined Land*” (Chamber of Mines of South Africa/ Coaltech, November 2007) should guide the rehabilitation of the wetlands, eco-systems and receptor dams within the Tweelopiespruit.

The Guidelines address the following:

- Soil replacement
- Soil amelioration
- Dealing with metal toxicities and soil acidity
- Revegetation and biodiversity re-establishment
- Rehabilitation monitoring and maintenance.

The Guidelines are applicable to “*all forms of mining, both surface and underground and all mineral extraction*”.

The findings and recommendations of the Department of Water Affairs and Forestry’s and the National Nuclear Regulator’s “*Wonderfonteinspruit Catchment Area Remediation Plan, Radioactive Contamination Specialist Task Team, Report on Site Visits and Recommended Actions*” (2009) have particular relevance to the proposed pilot project and should also advise the actions of the proposed pilot project.

The rehabilitation pilot project will have to be integrated with the local Municipalities’ Integrated Development Plans and the Mining Company’s:

- EMPr
- Social and Labour Plan
- Closure Plan
- Water Use License
- Waste Licence
- Certificate of Registration in terms of the NNRA

The above-mentioned integration will call for close co-operation or collaboration with local and district Municipalities, e.g. Mogale City Local Municipality and the West Rand District Municipality as well as the Mining Companies operating within the area, namely Sibanye Gold and Mintails.

The action plan for remediation Pilot Project must be underpinned by ensuring the provision of adequate funding. Without funding the Pilot Project cannot succeed.

The NNR's "*Plan for Remediation of Contaminated Sites*" (PLN-SARA-15-012) ("the Plan") and "Remediation Criteria and Requirements" (PP-0018) ("Remediation Criteria), dated September, 2015 have particular reference to the Pilot Project. Relevant extracts from the Plan and Remediation Criteria are subjoined hereunder and ought to advise the proposed Pilot Project for the remediation of the Tweelopiespruit, wetlands, receptor dams and eco-system.

- *"Land not under NNR authorisation must therefore be brought under NNR authorisation before it may be remediated.*
- *"The site that shall be remediated shall be appropriately demarcated sufficiently to be called up in a formal authorization.*
- *"The site coordinates shall be specified on a map of the area in order that the NNR may authorize this site. The site coordinates shall be provided to the NNR by the responsible authorisation holder operating in the area.*
- *"The site map shall be called up in a Certificate of Registration and shall be the site on which all clean-up operations take place.*
- *A detailed safety assessment will be required."*

The various governmental organizations concerned with remediation of historically contaminated land will have to oversee the remediation pilot project e.g. the NNR, the Department of Water and Sanitation, the Department of Mineral Resources, the Department of Energy, the Department of Agriculture, Forestry and Fishing, etc. hence an authorization request will have to be submitted to the above-mentioned organs of state in order to clean-up the contaminated sites.

Grounded upon the NNR's Criteria and Requirements:

- A site or sites will be selected for remediation
  - After the site has been selected, a remediation action plan will be developed
  - The action plan will include a detailed operational plan
    - The operational plan will identify the remediation technologies to be used as well as the waste management options.
    - The operational plan will feed into a worker safety assessment to establish worker and workplace safety and protective requirements.
  - Worker safety assessments and public safety assessments will be conducted
    - This safety assessment will determine the dose to the representative person, who is a member of the public.
    - All age categories will be considered.
    - Exposure from all pathways, external and internal will be considered and summed. Internal exposure will include ingestion and inhalation.
    - The results of this safety assessment will be used together with other factors to prioritize the identified sites earmarked for remediation.
  - Derived from the operational plan and the safety assessments, will follow a radiation protection plan, which includes workplace and worker safety plans.
  - An environmental surveillance programme, waste management programme, security plan, emergency plan will be developed.
  - All of this will be linked through a total integrated quality plan.
- Site release criteria will be developed. This criteria will be based on exposure from all pathways. Therefore the release criteria will contain reference levels for external exposure, surface contamination and volume contamination levels.
- A monitoring programme for demonstration of compliance with release criteria will also be established and implemented.

The remediation strategy should, in terms of the NNR's Plan and Criteria and Requirements, include:

- Optimization of remediation measures
- Remediation planning
- Radiological surveys during clean-up operations
- Dose Assessment for all pathways

- Training of workforce
- Site security during the clean-up
- Radiation protection during remediation
- On-site and Off-site monitoring
- Emergency planning
- Administrative control

The NNR developed a process map for remediation. The Pilot Study for the remediation of the Tweelopiespruit eco-system, receptor dams and wetlands will have to comply with the process map for remediation.

The process map is subjoined hereunder:

a) NNR's Regulatory Guidance on Remediation

- Regulatory requirements specified
- Remediation criteria specified
- Use of safety standards
- Site Specific activity levels
- Dose limits for public safety
- Reference levels applied

b) Co-operation with the other Regulators (e.g. DMR, DOE, DWS, DEA) on Regulatory Guidance on Remediation

- Ensure that legislative requirements are integrated
- Invoke provisions of remediation
- Exercise cooperative governance
- Joint actions carried out

c) Secure funding for Plan implementation

- Enquire regarding the DMR's funding of ownerless sites
- Comply with legal basis for ownerless sites
- Obtain assistance for a cost estimation for remediation of selected sites
- Agree on central administration for disbursement of funds

d) Plan joint effects to implement Plan and Work

- Consolidate plan with key role players
- Ensure that the project is carried out in terms of an approved project plan
- Have an implementation plan with achievable deliverables

e) Facilitate consultation with Technical Organisations, Chamber of Mines, Mine Water Research Group, Council for Geoscience, Mining Interest Group, Civil Society

- Situational Analysis of contaminated sites
- Technical inputs from institutions to be collated with the Plan
- Use of historical data for decision making
- Be informed by radiological data, site data, environmental parameters and geological issues
- Unified approach to be utilised for remediation options
- Involve interested and affected parties

f) Apply the agreed authorisation process for remediation including identification of applicant for remedial actions

- Applicant for the authorisation must be identified
- Site must be demarcated
- Suitable authorisation conditions applied for remediation
- Likelihood that contractor becomes the applicant
- Requirements from other regulators need to be complied with

g) Facilitate the performance of the safety assessment process

- All radiological pathways to be assessed
- Dose criteria in terms of prescribed limits and reference levels
- Compliance with Safety Standards
- Use of Regulatory Guide on Assessment of Mining Residues

h) Review of Safety Assessment for Remediation

- Compliance to regulatory requirements
- Compliance to remediation criteria
- Approved remediation process
- Approval of remediation technology
- Safety in terms of waste management and disposal

i) Authorise Actions associated with Remediation

- Approve control measures



- Ensure project control is in place

j) Approve Remediation Operations

- Appropriate remediation technology deployed
- Roles and responsibilities of parties approved
- Duration of projects to be monitored
- Workforce safety to be demonstrated
- Protection of public to be controlled

k) Inspect and monitor Remediation Operations

- Have inspection plan for project
- Monitor progress made with operations
- Conduct inspections

l) Holder to provide close out report

- Submission to the NNR on effectiveness of remediation
- Demonstration whether remediation is achieved
- Safety assessment of remedial actions

m) Verification of remediation

- Carrying out of confirmatory surveys by inspectors
- Confirmation of reduction of contamination
- Depth profiles accepted
- Preparation of regulatory decisions in regard to the operations and removal of contamination

n) Removal from regulatory control

- Motivation for the end-state of the site
- Consideration of the future use of the site
- Regulatory criteria to be applied in terms of release
- Revocation of the authorisation

In conclusion, in view of the potential costs of remediation it is critical that source control mechanisms are agreed in addition to appropriate remediation measures to ensure that the current situation does not repeat itself in future.



