REHABILITATION OF MINE CONTAMINATED ECO-SYSTEMS

A contribution to a just transition to a low carbon economy to combat unemployment and climate change

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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
DRD Gold – Durban Roodepoort Deep Gold Mine
DWAF – Department of Water and Forestry
DWS – Department of Water and Sanitation
EAP – Economically Active Participants
EC – Electrical Conductivity
EIA – Environmental Impact Assessment
EMPr – Environmental Management Programme Report
EPWP - Expanded Public Works Programme
ESRC – Environmental and Social Remediation Curve
Fe - Iron
GN – Government Notice
IDP – Integrated Development Plan
KOSH – Klerksdorp, Orkney, Stilfontein, Hartbeesfontein
LHWP – Lesotho Highlands Water Project
Mg –Magnesium
mg/l – milligram per litre
ML – Mega Litre
Mn - Manganese
MPRD Reg - Mineral and Petroleum Resources Development Regulations
MPRDA – Mineral and Petroleum Resources Development Act (28 of 2000)
MRA – Mine Residue Area
MRD – Mine Residue Deposits
NEA – Not Economically Active
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
SO4 - Sulphate
RTSF – Regional Tailings Storage Facility
SWOT – Strengths, Weaknesses, Opportunities, Threats
TDS – Total Dissolved Solids
TSF – Tailings Storage Facility
U- Uranium
WRC – Water Research Commission

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1. INTRODUCTION

This booklet makes the case for a project to address the waste and pollution legacy of mining in the Witwatersrand basin, with a clear linkage between the potential for revenue generation through materials reclamation and comprehensively addressing the entire rehabilitation challenge, with the participation of all stakeholders. It sketches the background and the extent of the challenge, the legislative and regulatory context and the imperatives for urgent action, then focuses in on the Tweelopiespruit wetlands area for a potential pilot project.

Work on pollution remediation and eco-system rehabilitation fits within the rubric of climate jobs, as it is necessary to address the growing vulnerability of communities to climate change impacts, as well as to address on-going natural resource degradation that is deepening poverty and inequality. While such work is in theory the responsibility of the mining companies involved, there has been a failure in duties of care and the urgently needed interventions require concerted action by the state, which is also necessary to realise the potential benefits for impacted communities.

Gold and uranium mining in the Witwatersrand gold fields has resulted in the contamination and destruction of **wetlands**, as well as negative impacts on **biodiversity** and on soil, groundwater and air quality, thus also exacerbating the adverse impacts of **climate change**. The impacts of **global warming** include changes in rainfall and in ambient temperature that will have an over-all negative impact on subsistence activities and commercial agriculture, as well as on biodiversity and the health of river systems.

If no measures are taken in the short term to help communities to adapt, poverty and vulnerability to climate change will be increased and the prospects for future generations will be further compromised. The extractives sector can – if responsibly managed – mitigate these impacts it had on natural systems and resources, and contribute to economic growth and development by developing and implementing programs for the **remediation** of contaminated wetlands, eco-systems, receptor dams and rivers. The potential to recover metals during rehabilitation and use the revenues generated to contribute to the costs of clean-up are recognized by the mining industry[1]. After **reclamation** of metals, the residue can be disposed of in an operational residue dam to minimise any further impacts.

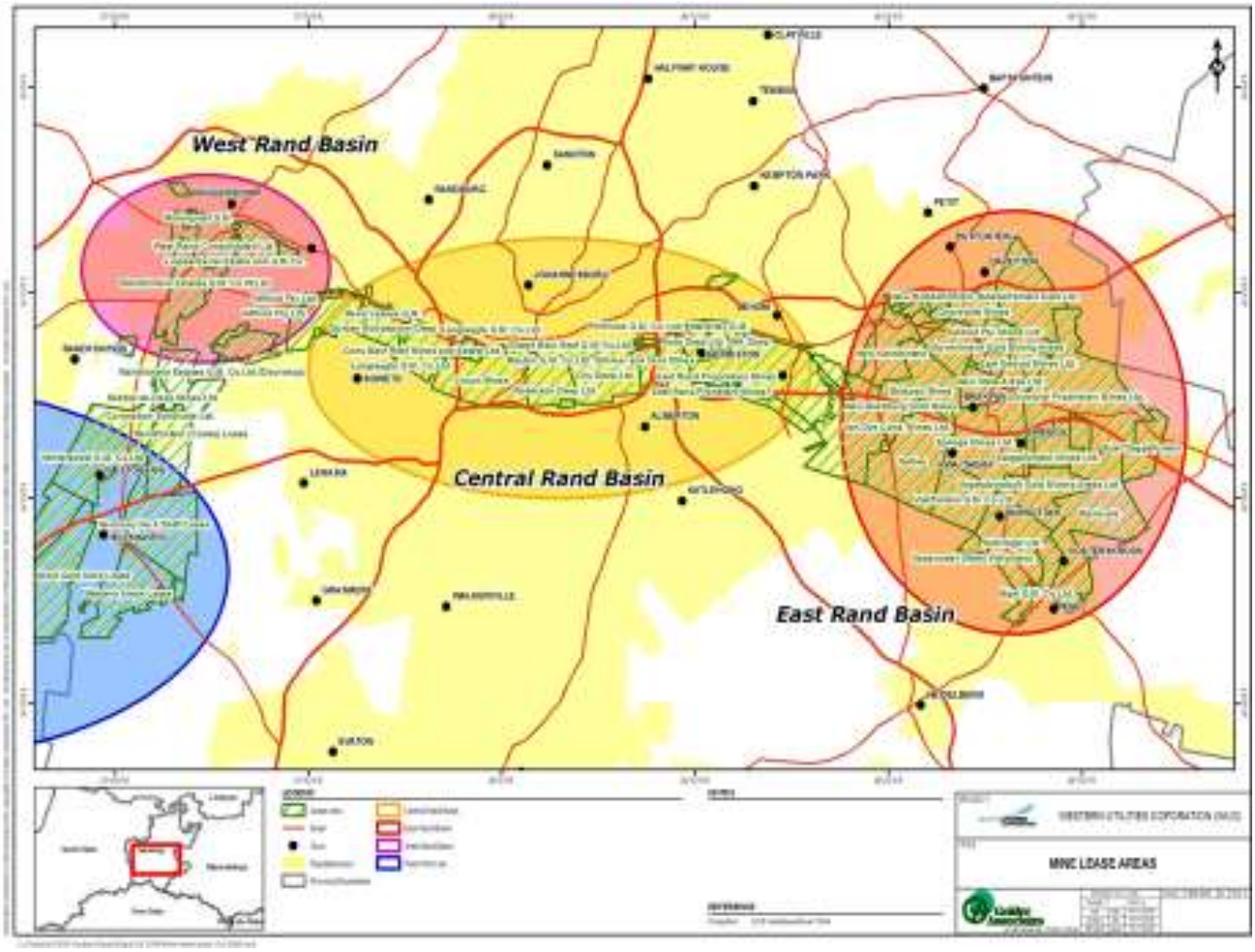
Establishment of the link between extractive industries, their impacts, and climate change, should serve as motivation for eco-system **rehabilitation** with tangible socio-economic benefits for local communities, during and after mine closure. Government exercising its responsibilities for addressing mining legacy wastes and continuing acid mine drainage, while holding the private sector accountable, offers an important opportunity for participatory development that would alleviate poverty and reduce vulnerability not only in the short term, but into the future.

[1] CF Human, JC Botha. Revenue Generation during Rehabilitation of Contaminated Land on Gold Mines in South Africa. Mine Closure 2008.

2. BACKGROUND

MINING AND POLLUTION IN THE WITWATERSRAND BASIN

The Witwatersrand[2] has been mined for more than a century. It is the world's largest gold and uranium mining **basin**.



Western, Central and Eastern Mining **Basin**s, 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^2 in surface area[3] and 6 billion tons of pyrite **tailings** containing 600 000 tons of uranium[4].

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[5].

[2] 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.
[3] AngloGold Ashanti, 2004.
[4] S. Chevrel et al. A Remote-Sensing and GIS-Based Integrated Approach for Risk Based Prioritization of Gold Tailings Facilities – Witwatersrand, South Africa. 2008.
[5] 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,
- 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[6].

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[7].

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 of mines. Residential townships, edible crop production and livestock grazing are high risk land-uses for Tailings Storage Facility **(**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

[6] 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.

[7] H. Coetzee. Radiometric Surveying in the Vicinity of Witwatersrand Gold Mines. Mine Closure 2008.

"attractive nuisances". These encourage use by potentially vulnerable receptors such as grazing livestock and children[8].

It is estimated that 1.6 million persons live in Informal Settlements next to MRDs[9]. The majority of Mine Residue Areas (MRAs) are radioactive because the Witwatersrand gold-bearing ores contain almost ten times the amount of uranium than gold[10].

Three main issues relating to MRAs located in Gauteng are:

1) air-quality, with particular reference to dust pollution (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.

IDENTIFIED LONG TERM RISKS

The following long term risks have been identified[11]:

- 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[12];
- 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. In addition, the potential contamination of surface soils overlying shallow polluted **groundwater** via evaporative pathways during dry seasons[13].
- The potential for 'salt', sulphate, chloride, metal and NORM contamination of crop soils irrigated with contaminated surface water or contaminated **groundwater**[14];
- The concomitant loss of genetic /**biodiversity** and potentially **ecosystem** goods and services on disturbed, fragmented or polluted properties[15];
- The potential for **bioaccumulation** of some metals and NORMs by flora and fauna[16];
- The potential for exposure of fauna and humans to **bioaccumulated** pollutants[17];
- The potential for acute and latent **toxicity** impacts of **bioaccumulated** pollutants on humans; and the potential for **radioactivity** impacts from NORMs on humans[18];

[8] 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
[9] Dorothy Tang and Andrew Watkins. Ecologies of Gold: The Past and Future Mining Landscapes of Johannesburg. 2011
[10] 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
[11] 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.
[12] Pilson et al., 2000; Hodgson et al., 2001.
[13] 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; Naiker et al., 2003., Tutu et al., 2004.
[14] Sutton et al., 2006; Philips, 2007.
[15] Angus, 2005; O'Connor and Kuyler, 2007; Weiersbye and Witkowski, 2007.
[16] Weiersbye et al., 1999; Weiersbye and Witkowski, 2003; Cukrowska and Tutu, 2004; Steenkamp et al., 2005b; McIntyre et al., 2007.
[17] Steenkamp et al., 1999; Weiersbye and Cukrowska, 2007.
[18] Steenkamp et al., 2005a; Philips, 2007.

- The potential for human disease as a result of exposure to windblown dust from the **reclamation** operations and the RTSF[19];
- The potential for structural damage to buildings and other structures and human injury by mining exacerbated seismicity[20];
- In dolomitic regions, the potential for structural damage to buildings and other structures, and human injury, by mining exacerbated sinkhole formations[21];
- The potential for uncontrolled future land uses on or within the zone of influence of the **Tailings Storage Facilities (**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[22].
- 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[23].
- Long term migration of contaminant plumes in shallow aquifer and surface water from TSFs and footprints[24].

WASTE

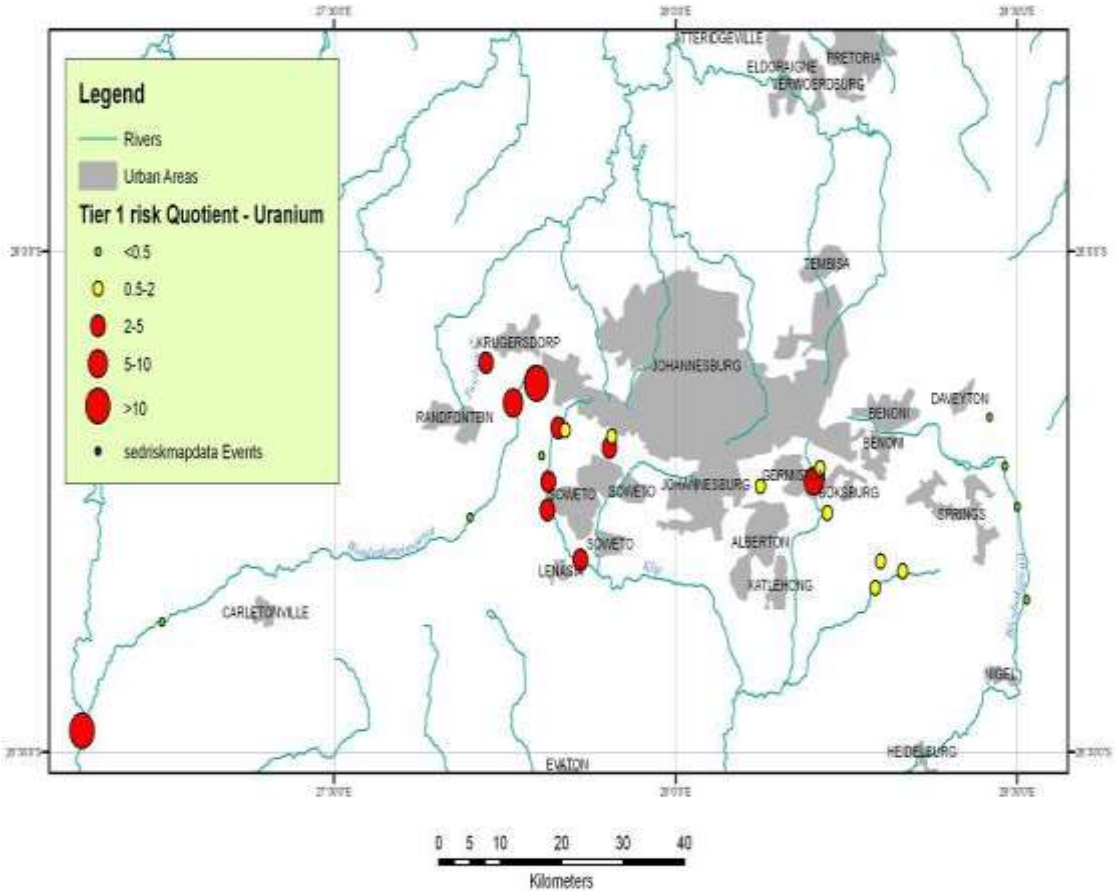
As early as 1987, the US Environmental Protection Agency recognised that *"...problems related to mining waste may be rated as second only to **global warming** and stratospheric ozone depletion in terms of ecological risk. The release to the **environment** of mining waste can result in profound, generally irreversible destruction of **ecosystem**s.*[25]"

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[26]. Gold mining waste was estimated to account for 221 million tons or 47 % of all mineral waste produced in South Africa[27].

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[28].

[19] CoM, 2001.
[20] Le Roux, 2005.
[21] Funke, 1990; Buttrick et al., 2001.
[22] Sutton, 2007; Reichardt and Reichardt, 2007.
[23] W. Pulles. Water Research Commission Report. 2015.
[24] Guidance for the Mining Industry for the Management of Post-Closure Water. Pulles W; 2015/04/01; Research Report No.TT 628/14.
[25] 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.
[26] Department of Water and Forestry, 2001.
[27] Ibid
[28] 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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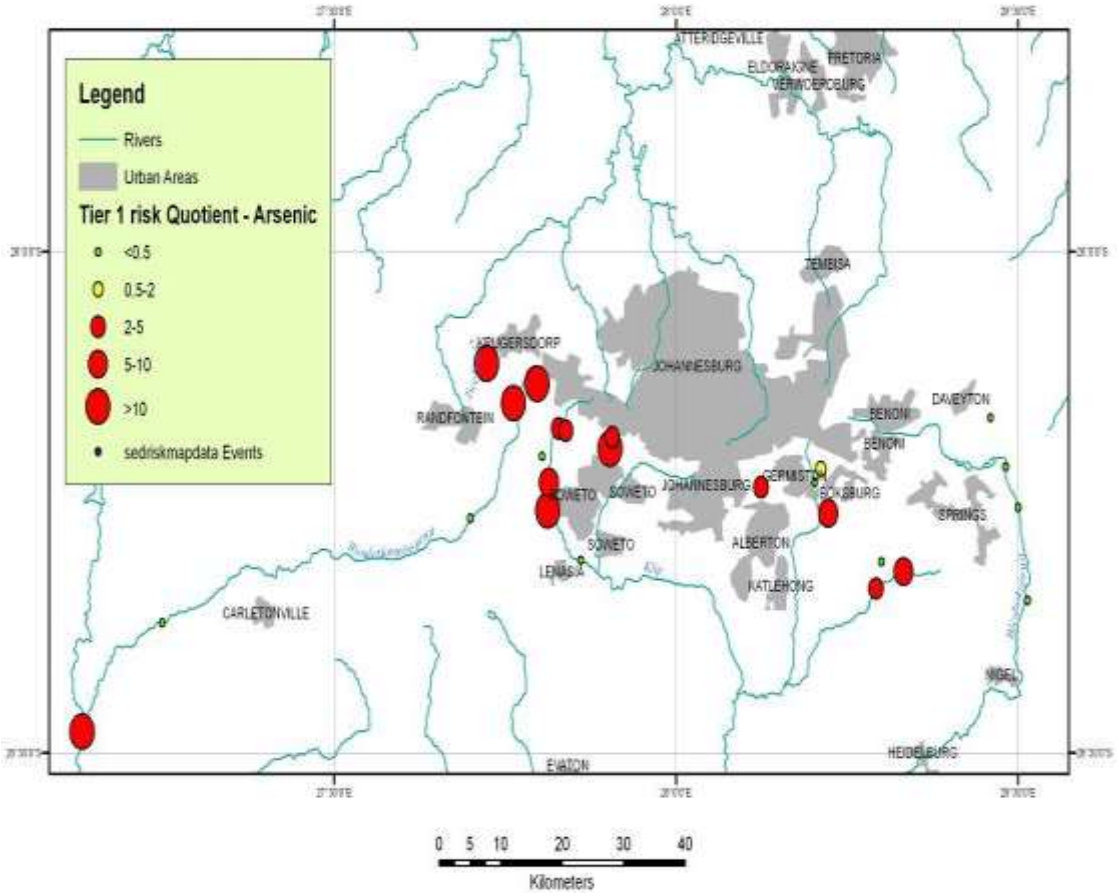
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SPRINGS
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CARLETONVILLE
VIGEL
EVATON
HEIDELBURG
0 5 10 20 30 40
Kilometers

Risk quotients for the maximum uranium, arsenic, nickel and copper concentrations for each wetland sampling site[29].

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

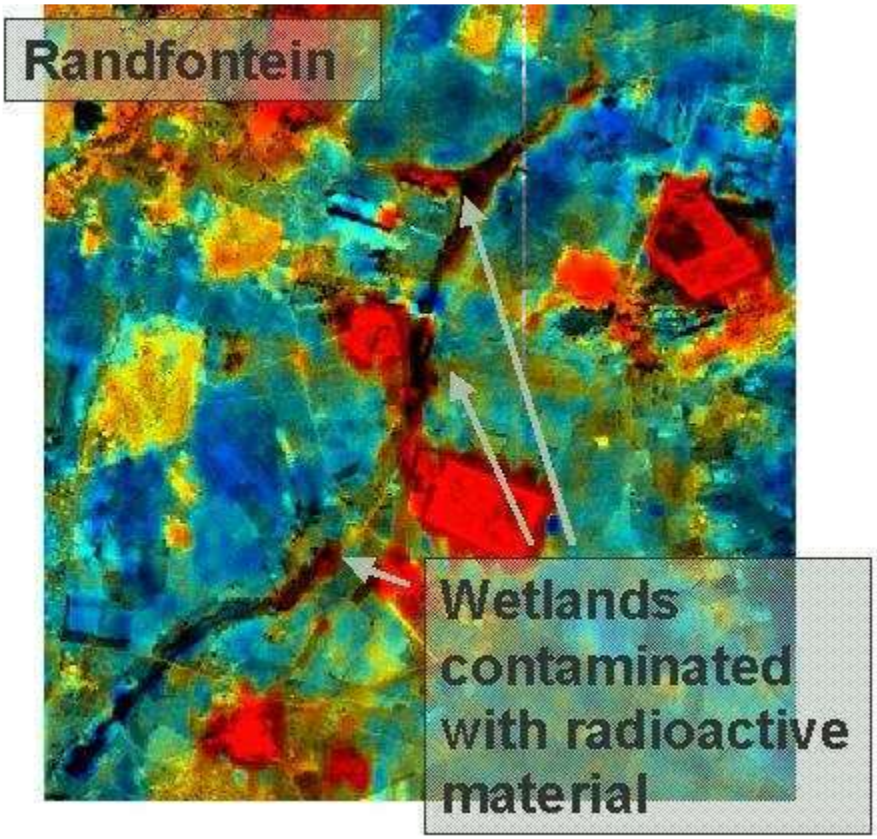
The mean values for the Wonderfonteinspruit[30] samples were found to exceed not only natural background concentrations, but also levels of regulatory concern for cobalt, zinc, arsenic, cadmium and uranium, with uranium and cadmium exhibiting the highest **risk** coefficients. These metals may be remobilised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

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.

[29] 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

[30] The Wonderfonteinspruit, also known as the eastern catchment of the Mooi River, is located in West Rand District Municipality, Gauteng, South Africa. The Wonderfonteinspruit, 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.

[31] 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.



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[32].

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[33].

[32] 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.

[33] (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** drop 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 foetus which can result in mental retardation[34].

Metals from AMD coating grass and seeping into the soil

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 which decanted from the flooded mine void in the West Rand from 2002 to 2012. 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[35] after underground mine water decanting into the Tweelopiespruit was pumped into the lake and resulted in the National Nuclear Regulator (NNR)

34 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.

35 Since 2011 the SABS adopted a value of 15 µg/l uranium for class I water (suitable for lifetime consumption) in line with the new value of the WHO making the analysis of uranium mandatory for water monitoring programmes in SA (SABS 2011).

declaring the lake a **radiation** area. This extreme concentration is believed to be the result of remobilisation of uranium from contaminated sediment by acidic water.[36]

Robinson Lake, a declared **radiation** area (photograph taken in 2016)
The area is unfenced with no warning signs, adjacent to residential dwellings.

The potential volume of AMD for the Witwatersrand Goldfield amounts to an estimated 350ML/day (1ML = 1000m^3). This represents 10% of the potable water supplied daily by Rand Water to municipal authorities for urban distribution in Gauteng province and surrounding areas, at a cost of R3000/ML. 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[37].

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 adjust 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 change 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[38].

[36] 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.
[37] 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.
[38] 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).

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[39].

The sulphate concentrations in the neutralised AMD remain high (2 000 – 3 000mg/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. Usually individuals exposed to elevated sulphate concentrations in their drinking water for long periods become adapted and cease to experience acute health effects (diarrhoea). 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[40].

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

Pipes transporting **Acid Mine Drainage**. The photograph on the left shows a pipe with **precipitated** metals and the photograph on the rights shows 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[41].

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**

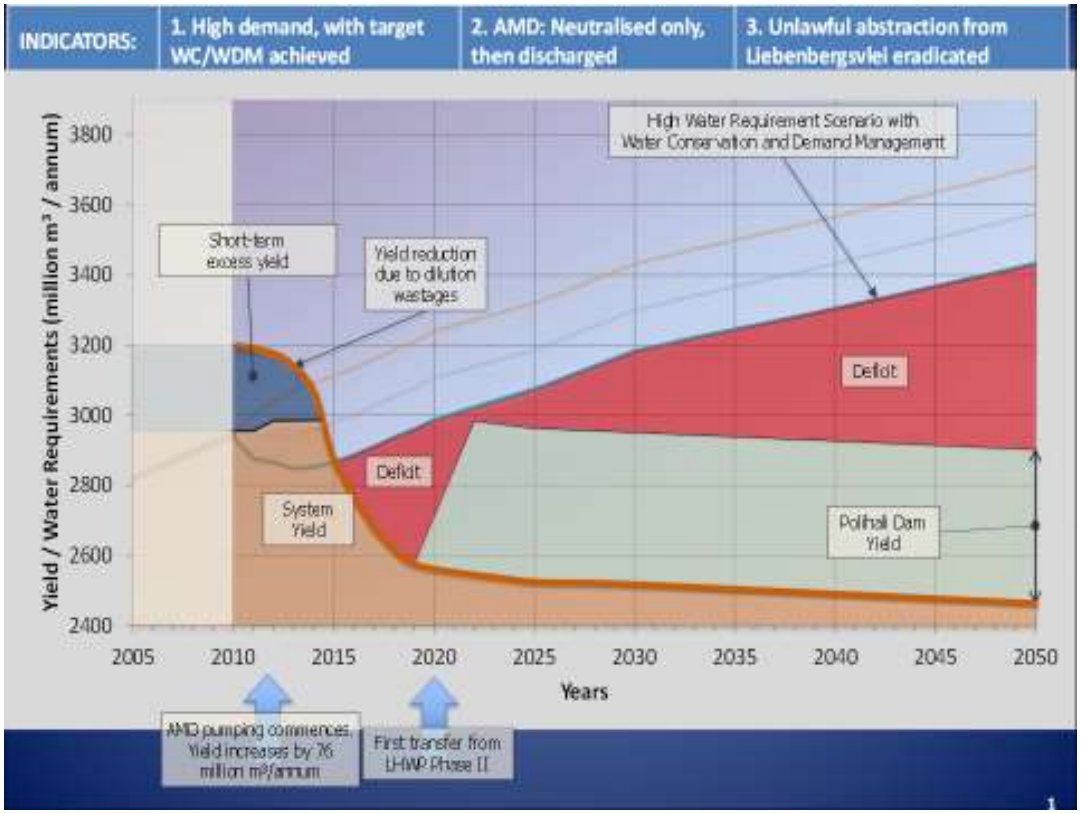
[39] Department of Minerals and Energy. Regional Mine Closure Strategies for the West Rand Goldfield. 2008.

[40] Resource Quality Objectives:

- Only legislated resource qualities to which specific sites in sub-quaternary reaches (SQRs) must comply to.
- Do not often directly apply to the smaller SQRs most mines impact on directly, but are assigned for larger catchments into which these SQRs feed into.

[41] 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?"

as a result of AMD will create water security risks. In order to comply with the regulatory Instream Quality Objective (IQ)) limit of 600 mg/l sulphates[42], 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, to the extent that it cancels out the addition of the total capacity of Phase 2 of the Lesotho Highlands scheme.

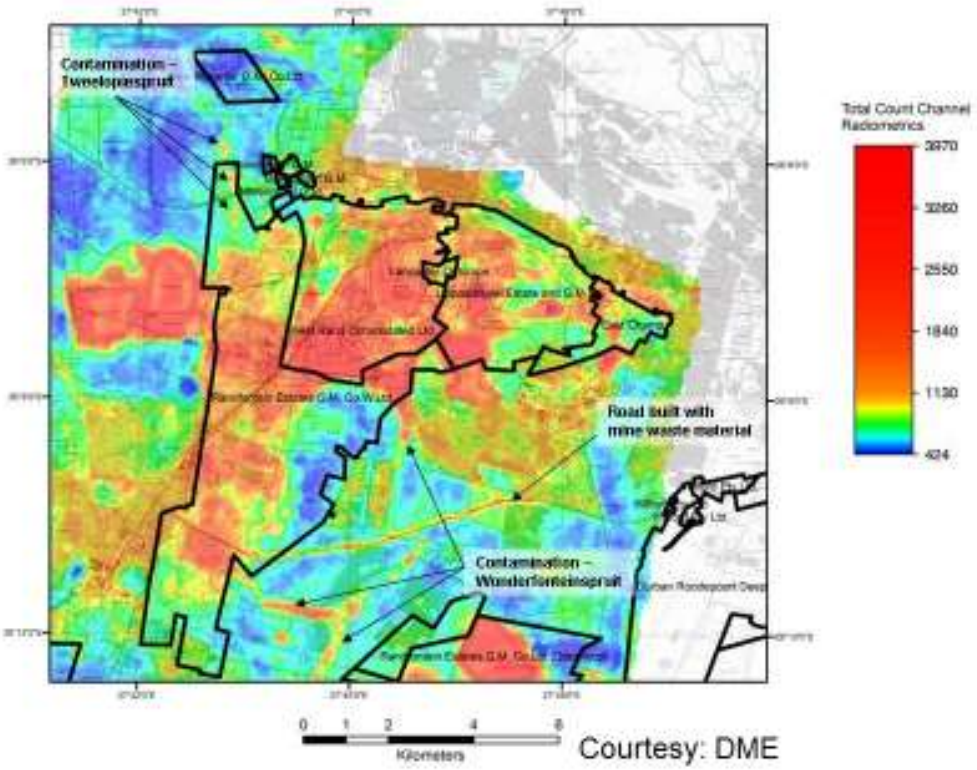


Vaal River System: Reconciliation Strategy[43].

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[44].

[42] These Objectives are not legislated but can be made a condition of a Water Use Licence (WUL). They are set per sub-quaternary reaches (SQR), usually for each WUL but can also be set for the greater SQR to aid DWS in monitoring.
[43] Department of Water Affairs. 2014.
[44] 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.



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[45].

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 crops (pasture, vegetables) by the deposition of radioactive dust particles, which can cause considerable dose contributions via ingestion.[46]

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 the 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.[47]

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[48].

The measured uranium content of many of the fluvial (living in a stream or river) sediments e.g. in the Wonderfonteinspruit, including those off mine properties and therefore outside the boundaries of licensed sites, exceeds the exclusion limit for regulation by the National Nuclear Regulator[49].

[45] Department of Minerals and Energy. Regional Mine Closure Strategy for the West Rand gold fields. 2008.
[46] NNR Report – TR-RRD-07-0006 – Radiological Impacts of the Mining Activities to the Public in the Wonderfonteinspruit Catchment Area. 12 July 2007
[47] Ibid
[48] Department of Minerals and Energy. Regional Mine Closure Strategy for the Central Rand Goldfield. 2008.
[49] 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."

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 Wonderfonteinspruit is that no short-cuts exist which would allow certain pathways to be ignored in a study of radioactive contamination within these mining areas.[50]

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 shows 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[51].

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 deposit**s are often left un-rehabilitated. Radiometric surveys have in some cases shown elevated levels of residual **radioactivity** in the soils. Failure by the relevant

[50] Department of Minerals and Energy. Regional Mine Closure Strategy for the East Rand goldfield. 2008
[51] 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.

organs of state to enforce the non-compliances by the mining industry in this regard has resulted in unrestricted development and inappropriate land-uses.

Photograph on the left: Unrehabilitated footprint adjacent to the acutely toxic Lancaster Dam, one of the 36 radioactive hotspots within the Wonderfonteinspruit Catchment Area. Photograph on the right: Unrehabilitated footprint of a reclaimed TSF in the Central Rand (Photograph: McCarthy, T.)

The associated contribution to ingress of AMD into the mine voids or **basin**s 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.[52]

3. Mining Industry and Organs of State: Neglect of Duty of Care

The gold mining industry within the Witwatersrand is a 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[53] and environmental impacts for the region, the costs of which are currently borne by communities and a mute **environment**, and in time 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.

[52] The following impacts have not been assessed hence not controlled:

- The associated contribution to ingress is likely to be considerable as old tailings are hydraulically mined using high-pressure cannons containing partially treated acid mine drainage water (Winde et al. 2011).
- 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. (Sutton & Weiersbye 2007; Winde et al. 2011).

[53] 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.

Prof. Tracy-Lynn Humby[54] 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.

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.

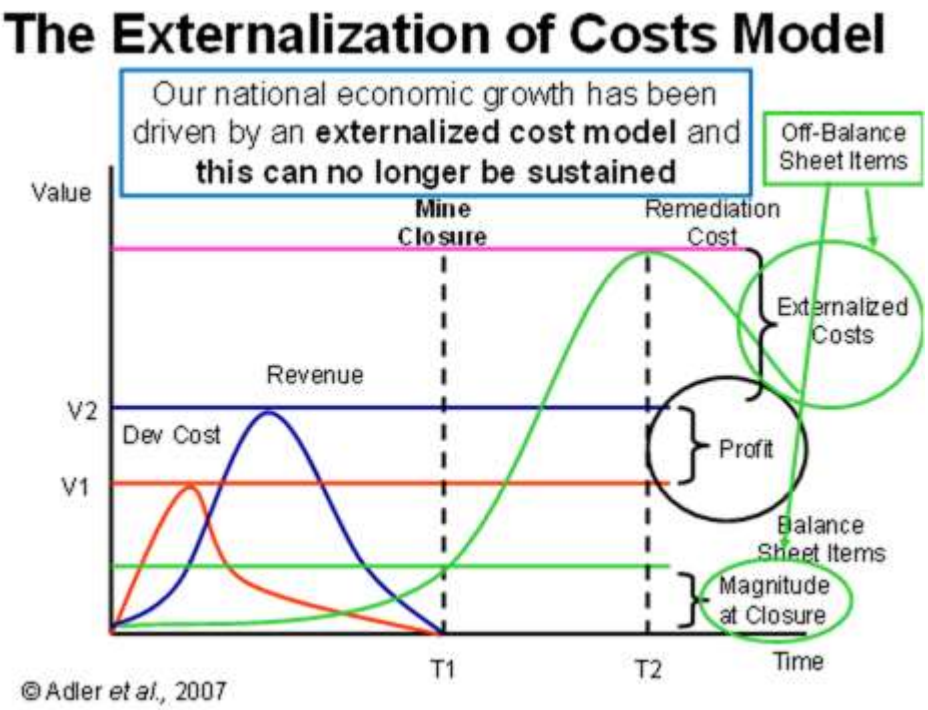
While BGMC's legally binding **Environmental Management Programme** Report (EMPR) of 2007 stated that *"The site would be left ecologically and geophysically stable and would not pose an economic, social or environmental liability to the local* ***community*** *and the state now or in the future"*, BGMC 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 are 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.[55]

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.

[54] 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.
[55] Rebecca A. Adler et al. Water, mining and waste: an historical and economic perspective on conflict management in South Africa. 2007.



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 the 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 compelled 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[56]:

[56] The Mine Water Management Policy was issued in 2016. At the time of writing no positive impacts have been observed

- 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 National Water Act (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 National Environmental Management Act (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 Department of Water & Sanitation (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 to apportion 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 into 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 the 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 an 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 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 still to be implemented "*Water Quality Management Policies and Strategies for South Africa Report*"[57], 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[58]. 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 field**s.

The National Nuclear Regulator, the competent authority responsible for the protection of the public, property and the environmental against nuclear damage, because of its narrow interpretation of its mandate[59], 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.

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*"[60], 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[61].

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[57] Water Resource Planning Systems Series Water Quality Management Policies and Strategies for South Africa DWS Report No.: P RSA 000/00/21715/12

[58] 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)

[59] Tracy-Lynn Humby. Environmental Justice and Human Rights on the Mining Wastelands of the Witwatersrand Gold Fields. 2013.

[60] 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

[61] Ibid

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[62].

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[63].

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[64].

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[65].

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[66].

EXTRACTS FROM RELEVANT ENVIRONMENTAL LEGISLATION

There are a number of legal and regulatory frameworks with which a mining company must comply in terms of **rehabilitation** and **closure**, namely:

- Constitution of the Republic of South Africa (Act 108 of 1996) (Constitution);
- National Environmental Management Act (Act 107 of 1998);
- National Environmental Management Amendment Act (Act 62 of 2008) (NEMA); National Environmental Management Act: Regulations pertaining to the **Financial Provision** for Prospecting, Exploration, Mining or Production Operations (GN 1147) which replaces the Mineral and Petroleum Resources Development Act (Act 68 of 2002) (MPRDA) – **closure** and **financial provision** elements repealed;
- Mineral and Petroleum Resources Development Act (Act 68 of 2002) (MPRDA) as it pertains to the **social and labour plan**;
- National Environmental Management: Waste Act (59 of 2008) and supporting regulations;
- National Environmental Management: Air Quality Act (Act 39of 2004);
- National Environmental Management: **Biodiversity** Act (Act 10 of 2004);

[62] Ibid
[63] Ibid
[64] Ibid
[65] Ibid
[66] Ibid

- National Environmental Management: Protected Areas Act (Act 57 of 2003);
- National Water Act (Act 36 of 1998) (NWA);
- The Nuclear Energy Act (Act 131 of 1999) and National Nuclear Regulatory Act (Act 47 of 1999);
- The National Radioactive Waste Disposal Institute Act (Act 53 of 2008);
- Mine Health and Safety Act (Act 29 of 1996).

The subjoined Table provides a brief description of the legislation as it pertains to **closure**.

Table 1: Summary of SA legislation and implications for closure Legislation	**Implications for Closure**
The Constitution In terms of Section 24 of the Constitution "Everyone has the right To an **environment** that is not harmful to their health or well-being; and To have the **environment** protected, for the benefit of present and future generations."	Constitutional requirement to ensure that the Plan includes measures that protect the rights of people to an **environment** that is not harmful to health or well-being post **closure**.
National Environment Management Act Sections 28 (1) and (3) of NEMA set out the duty of care principle, which is applicable to all types of **pollution** and must be taken into account in considering any aspects of potential **environmental degradation**. Every person who causes, has caused or may cause significant **pollution** or degradation of the **environment** must take reasonable measures to prevent such **pollution** or degradation from occurring, continuing or recurring, or, in so far as such harm to the **environment** is authorised by law or cannot reasonably be avoided or stopped, to minimise and rectify such **pollution** or degradation of the **environment**.	The measures required in terms of subsection (1) may include measures to - Investigate, assess and evaluate the impact on the **environment**; Inform and educate employees about the environmental risks of their work and the manner in which their tasks must be performed to avoid causing significant **pollution** or degradation of the **environment**; Cease, modify or control any act, activity or process causing the **pollution** or degradation; Contain or prevent the movement of pollutants or the causes of degradation; Eliminate any source of the **pollution** or degradation; or Remedy the effects of the **pollution** or degradation.
Environmental Impacts Assessment Regulations, 2014 These regulations were developed for the preparation, evaluation, submission, processing and consideration of, and decision on, applications for environmental authorisations.	Any new EIAs or BAs for the mine will be required to consider **closure** during planning and to include a **closure** plan and **closure** estimate to support an authorisation application.
National Environment Management: Waste Act Part 8 of Chapter 4 of the Act indicates the requirement to identify the status and **risk** of contaminated sites and provides a legal mechanism for **remediation** activities to be instigated and controlled.	Contamination resulting from operational activities will require **remediation**, with the final soil quality meeting requirements as specified in the Acts Regulations.
Waste Classification and Management Regulations The Waste Classification and Management Regulations require that (Chapter 2, 4(2)) all waste generators must ensure that the waste they generate is classified in accordance with SANS 10234 within 180 days of generation and if the waste is to be disposed of to landfill	The Waste Classification and Management Regulations and the supporting Norms and Standards as well as Regulations regarding the Planning and Management of Residue Deposits and Residue Stockpile do not contain specifications around **closure**, other than the requirements in Regulations regarding the Planning and Management of Residue Deposits and Residue Stockpile.

that (Chapter 2 (8)1) (a) the waste is assessed in.	

The requirements for **remediation**, including mine **closure**, in the applicable sections of the NEMA and NWA 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[67].

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[68]?

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."

Section 28 of the NEMA, South Africa's framework legislation regarding all environmental matters, deals with duty of care towards **pollution** prevention and **remediation**, and provides for a very broad duty to take reasonable measures to rectify **pollution** or degradation in section 28(1). It includes persons who, *inter alia*, cause and have caused **pollution** or degradation.

WHO IS LIABLE[69]?

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

[67] Carin Bosman and Louis J. Kotze. Responsibilities, liabilities and duties for remediation and mine closure under the MPRDA and NWA. 2005.
[68] Ibid
[69] Ibid

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.

The sting in the tail is that NEMA section 28(14) is now 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**.[70]

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 mining activity.

WHAT ARE THE DUTIES AND OBLIGATIONS OF THE RESPONSIBLE PERSON[71]?

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[72], training, ceasing or modification of activities or processes, containment and **remediation**.

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.

[70] Duard Barnard et al (Compiler). Road Map to Environmental Legislation. Edition 4. 2011

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

[72] 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."

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 programme**s 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 programme**s 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 provision**s of the mines. The audit reports and updated financials 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 **Environmental Management Programme** Report (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 sub regulation (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."*

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, which still await official approval, 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.

With such an impressive legal armoury, one is bound to ask (a) when it has been used; (b) against whom and (c) with what outcome? Without this info, the detail of the previous sections is just left hanging. These issues need to be addressed, even if it's just to repeat that little if any of the law is enforced

4. PROPOSED PILOT PROJECT

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 goldfields of the West Rand are 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**, Electrical Conductivity (EC), Total Dissolved Solids (TDS), Sulphate (SO4), Iron (Fe), Magnesium (Mg), Calcium (Ca), Manganese (Mn), Aluminium (Al), Lead (Pb), Cobalt (Co) and Nickel (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. [73]

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

[73] 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** (2010)
(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.

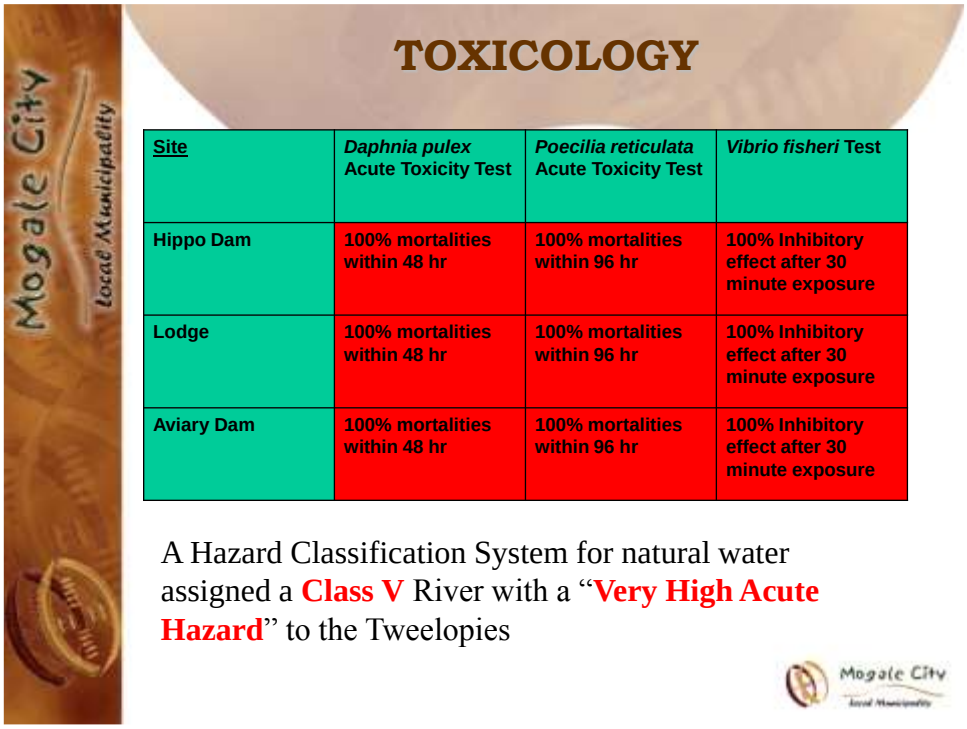
The Tweelopiespruit represents the most direct route for the mine void water to reach the Zwartkrans Compartment, which hosts the sensitive Cradle of Humankind World Heritage Site. The Tweelopiespruit is part of the Crocodile West Water Management Area and the Magaliesburg Water Catchment Forum.

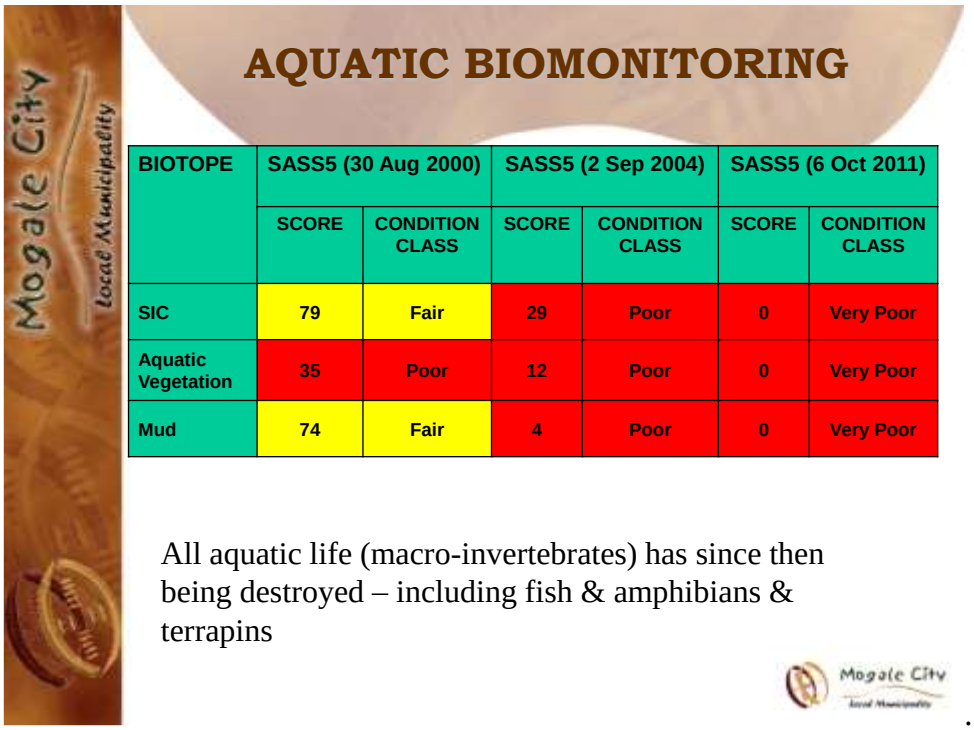
In terms of the Harmony Environmental Impact Document titled *"Impact of the discharge of Treated Mine Water, via the Tweelopies Spruit, on the receiving Water body Crocodile River System, Mogale City, Gauteng Provinc*e" (DWAF 16/2/7/C221/C/24) (3 December 2006), 2654 Ha are under irrigation using borehole 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 **ecosystem**s.

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**.*"[74]

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.

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

While land uses can seldom be restored to their original state, it may be sometimes possible for river **ecosystem**s. 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

[74] Winde F. 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. May 2011.

- 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 have 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 the 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 efforts 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.

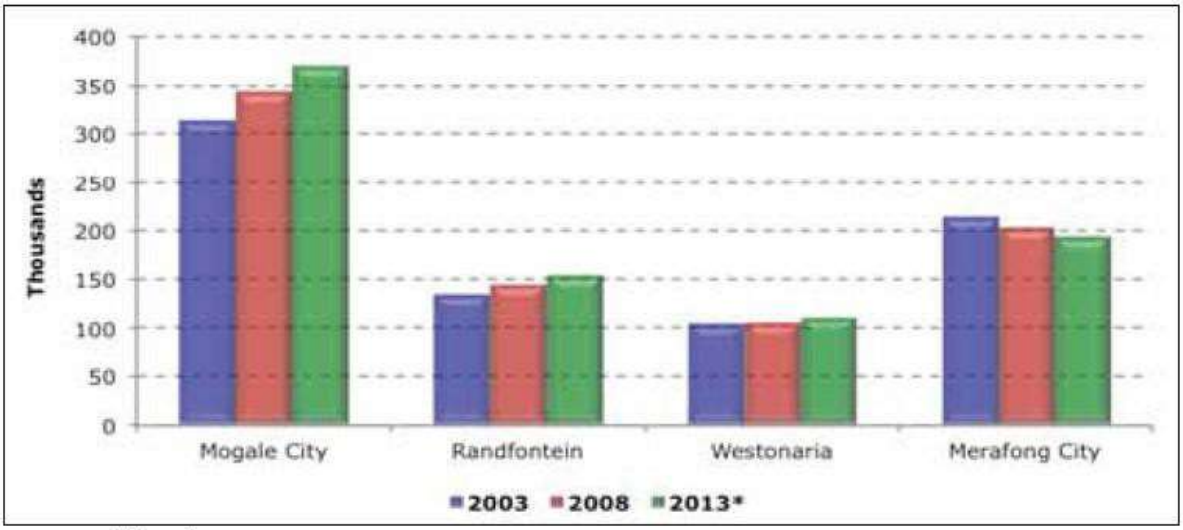
JOB CREATION OPPORTUNITIES

In order to assess the job creation opportunities for the **remediation** of the Tweelopiespruit and its adjacent contaminated wetlands and receptor dams, it is helpful to know the demographics[75] of the West Rand **gold field**s.

[75] West Rand District Municipality: Integrated Development Plan Review 2015/16

POPULATION

Figure 1 shows the population per municipality.



Source: IHS Global Insight, 2013
Note: * indicates an estimate

Figure 1: Population West Rand District, 2003, 2008 & 2013

The gap between employment growth and the labour force growth has resulted in rapidly rising numbers of unemployed individuals. The section below gives the labour market profiles of the West Rand district municipalities, followed by an analysis of employment and unemployment in these municipalities.

LABOUR MARKET PROFILES

	Mogale City	Randfontein	Westonaria
Economically Active Population	179 968	61 670	61 534
Employed	100 311	30 463	25 472
Unemployed	52 663	22 306	15 175
Unemployment rate	29.3%	36.2%	24.7%

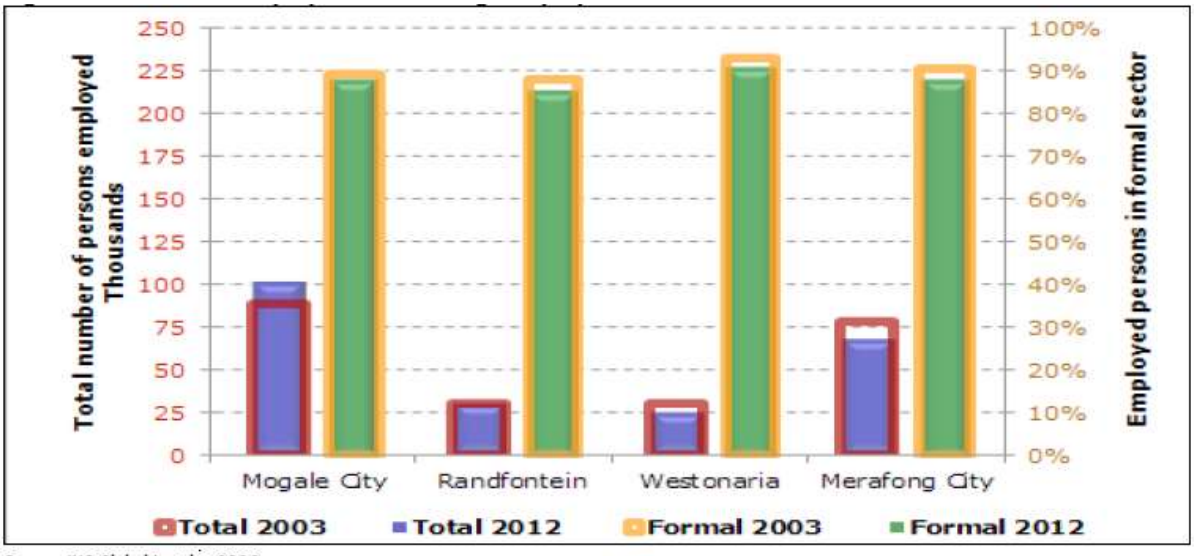
Figure 2: Labour profiles of West Rand District 2012 (Source: HIS Global Insight, 2014)

Figure 2 shows the labour profiles of the West Rand district municipalities in 2012. Mogale City local municipality had the largest EAP (Economically Active Participants), at 179 968, as well as the second-highest unemployment rate, at 29.3%. It also had a comparatively large NEA (Not Economically Active) population, with 8 197 discouraged work-seekers and 73 240

other NEA. Randfontein local municipality had the highest unemployment rate in the West Rand, at 36.2%. Employment in this municipality has primarily been growing in the government, social and personal services, with some growth in finance and business services.[76] Westonaria had the smallest EAP in the West Rand District, at 61 534. It also had the second-lowest unemployment rate, at 24.7%, after Merafong City. The unemployment rate was contributed to by the weakening mining and quarrying sub-sector in the municipality. The Westonaria economy is highly focussed on mining and the loss of output in the sub-sector has a negative impact on its labour market. The Merafong City municipality had an EAP of 78 136. With 67 654 of those persons employed, its 10 253 unemployed persons translated into an unemployment rate of 13.1%. This was the lowest unemployment rate in the West Rand in 2012.

EMPLOYMENT

When formal employment fell due to the global financial crisis, some of those who left the formal sector were absorbed in the informal sector. The figure below indicates the employment trends within the district.



Source: IHS Global Insight, 2013

Figure 3: Employed persons in the formal sector

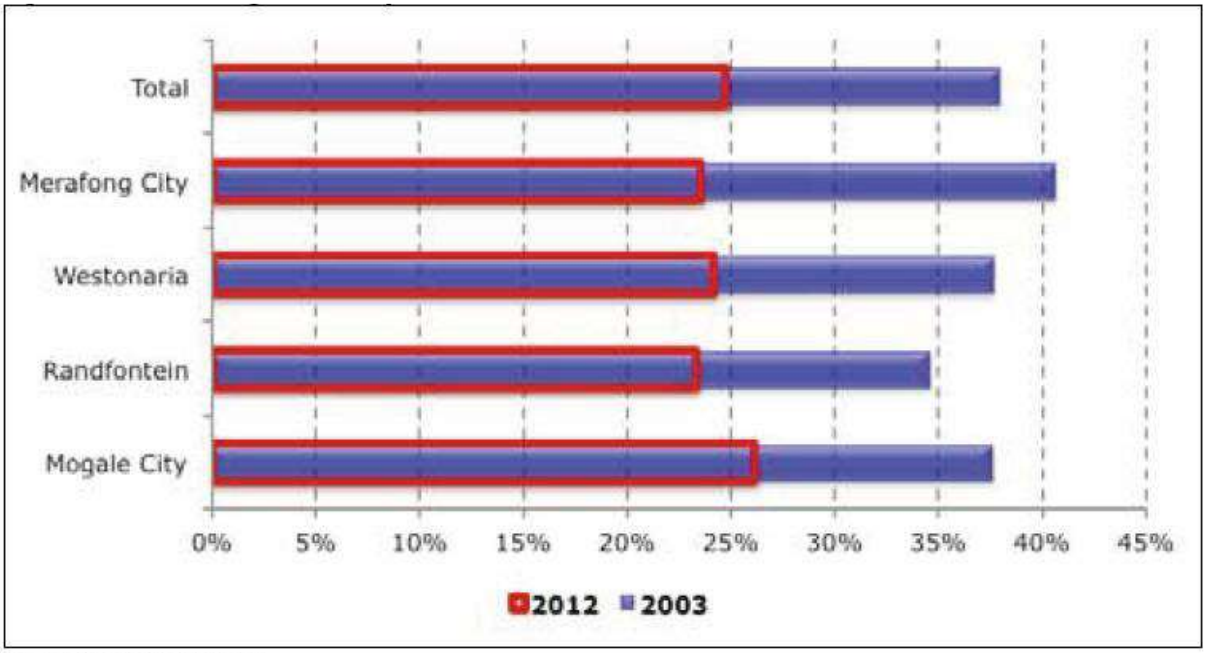
Figure 3 shows the number of employed persons as well as the percentage of those employed in the formal sector for the local municipalities of the West Rand in 2003 and 2012. Mogale City had the largest number of employed persons and was the only local municipality in the West Rand with significant employment gains between 2003 and 2012. In 2003, 87 391 workers were employed in Mogale City; by 2012, this had risen to 100 311. The increase in employment was driven by the expansion of the government, social and personal services and the finance and business services sub-sectors. The percentage of workers in the formal sector remained largely static, at about 89%.

[76] 2016 IHS Global Insight Southern Africa.

There was negligible growth in employment in Randfontein, from 29 391 in 2003 to 30 463 in 2012. Higher employment in the finance & business services, government, social and personal services and wholesale and retail trade sub-sectors was largely offset by decreases in the mining and quarrying sub-sector. The percentage of Randfontein's workers employed by the formal sector decreased from 88.2 to 85.7% over the same period. In Westonaria and Merafong City, the mining and quarrying sub-sector dominated the economy and provided the largest share of employment. The decline of the sub-sector therefore resulted in a reduction in employment levels in both local municipalities from 2003 to 2012. This has probably influenced the small declines in the percentage of the workers employed in the formal sector in both regions.

UNEMPLOYMENT

The high unemployment rate remains a key challenge for South Africa. At the local municipality level, the Expanded Public Works Programme (EPWP) continues to form part of the initiative to provide short-term employment opportunities and thus to lessen unemployment. In the years leading up to the global recession, progress was being made in lowering the unemployment rate. However, the recession eroded most of the jobs gains from the preceding years of economic growth. Although there has been some recent recovery in employment levels, many local municipalities have yet to return to pre-recession levels.

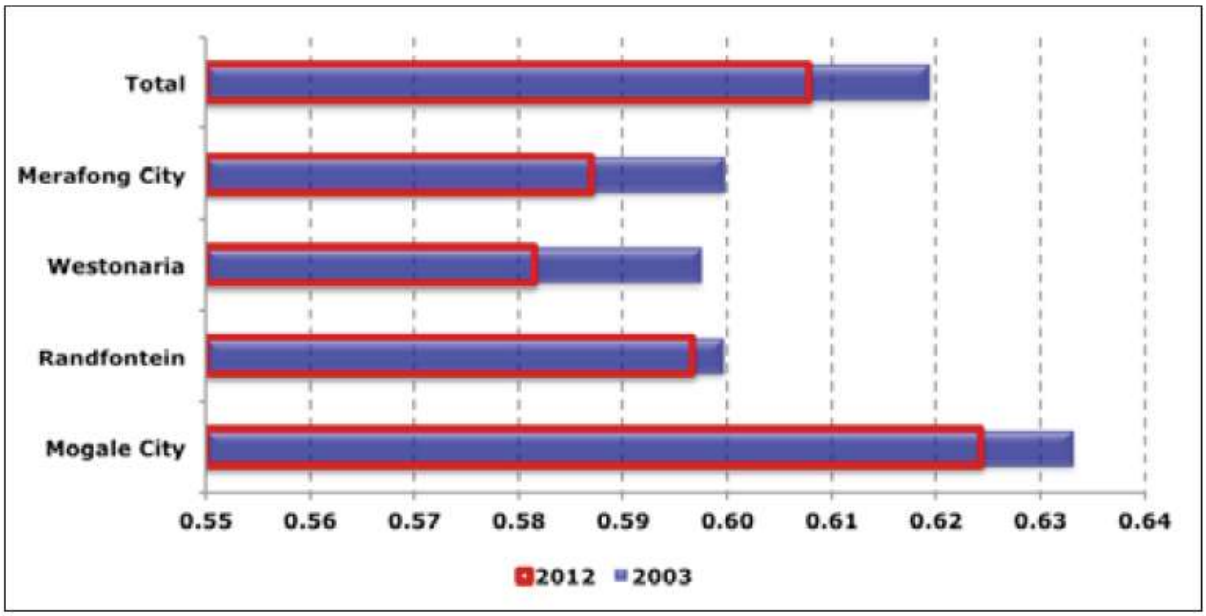


Source: IHS Global Insight, 2013

Figure 4: Percentage of people living in poverty in the West Rand 2003 & 2012

Figure 4 above shows the percentage of people living in **poverty** in the West Rand and its local municipalities in 2003 and 2012. The percentage of those living in **poverty** has declined over the review period for the West Rand and all of its local municipalities. At 40.7%,

Merafong City was the local municipality with the largest percentage of people living in **poverty** in 2003. By 2012, this had declined to 23.5%. In Mogale City, the share of people living in **poverty** was 37.1% in 2003. Despite falling by 11 percentage points, it remained the municipality with the largest share of its people living in **poverty** in 2012, at 26.1%. The smallest proportion was in Randfontein, at 34.6% in 2003 and 23.3% in 2012.



Source: IHS Global Insight, 2013

Figure 5: Gini coefficient in the West Rand 2003 & 2012

Figure 5 shows the Gini coefficient for the West Rand and its component local municipalities in 2003 and 2012. The West Rand had a relatively low Gini, at 0.62 in 2003 and 0.61 in 2012. The highest level of inequality was in Mogale City, with a Gini of 0.63 in 2003; this had declined to 0.62 by 2012. Westonaria had a Gini coefficient of approximately 0.60 in 2003, the lowest amongst the West Rand local municipalities. Its Gini coefficient had decreased to 0.58 by 2012.

The findings of Elize van Eeden, Professor in History at the North West University and Busi Khaba, Political Analyst and Lecturer, of the Monash University in South Africa in terms of their recent treatise, titled *"Politicising Service Delivery in South Africa: A Reflection on the History, Reality and Fiction of Bekkersdal, 1949-2015*" have relevancy to the project since it provide an insight into the political and social conditions of settlements within the West Rand.

NUMBER OF JOBS TO BE CREATED

The communities to benefit most from the **rehabilitation** project will be the residents of informal settlements in close proximity to the Tweelopiespruit. These settlements will include informal settlements in the districts of Randfontein, Mogale City Local Municipality and Westonaria. These settlements are densely populated.

The project will be in the position to supply jobs for 100 persons to rehabilitate the Tweelopiespruit, the receptor dams and **wetlands** over a period of a year.

The possibility exists to expand this project to other mine contaminated **wetlands** and rivers within the West Rand **gold field**s such as:

RIVER	STATE OF THE RIVER	COMMUNITY
The Leeuspruit and its associated **wetlands** and receptor dams	The Leeuspruit flows downstream from Gold Fields' South Deep Mine and Sibanye Gold's Ezulweni Mine. The two mines (South Deep and Ezulweni Mines) had been historically responsible for discharging sub-standard water into the Leeuspruit; "*sub-standard*" meaning not in compliance with the SA Water Quality Guidelines for Domestic use (DWAF 1996). Studies were commissioned by South Deep Mine in 2009 and 2015. These studies have clearly shown the contamination of this stream, the **wetlands** and the receptor dams, resulting in the build-up of large amounts of potentially harmful sediment in the Leeuspruit. [77].	• Emerging Farmers within Jachtfontein/Kalbas-fontein • Thusanang • Poortjie • Simunye • Bekkersdal • Westonaria
The Wonderfonteinspruit Catchment Area	The eastern catchment of the Mooi River, also known as the Wonderfonteinspruit, has been identified in a	• Kagiso and Informal Settlements such as Tudor Shaft Informal Settlement, Bull Brand, Soul City, Baghdad

[77] Krige W.G. The Impact of the South Deep Gold Mine on the Water Quality in the Borehole of Portion 48 of Kalbasfontein 365 IQ. 2009.

	number of studies as the site of significant radioactive and other **pollution**, generally attributed to the mining and processing of uraniferous gold **ore**s in the area.[78]	• Khutsong

The above-mentioned projects can create jobs for an additional 300 persons over a period of a year.

[78] Wade, P., Winde, F., Coetzee, H. (2004): Risk assessment. In: Coetzee, H (compiler): 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, pp 119-165

5. GLOSSARY OF TERMS

Acid Mine Drainage (AMD)
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 **basin**s of the Witwatersrand goldfields (hereafter referred to as the Eastern, Central and Western **Basin**s) 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 AMD, also known internationally as Acid Rock Drainage (ARD). AMD-water is characterised by a low **pH** – i.e. too acidic – 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 Field**s with Special Emphasis on Acid Mine Drainage*" described the background as follows: "A*MD has been reported from a number of areas within South Africa, including the Witwatersrand **Gold Field**s, 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.

Basic Assessment
A basic assessment needs less information and is done as one single project, but still contains all the steps of a full assessment. The main difference is that only one report is submitted to the authorities for approval.
It is used for less complicated EIAs. A full environmental assessment is required for the more complex projects and involves more interactions with the stakeholders and the authorities. It often involves one or more specialist studies.

Basin
The geological term "basin" refers to an area where sediments, soil and rocks are added to a land mass. The Witwatersrand Basin is a good example of this in the case of gold.

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.

Bioaccumulation
Bioaccumulation refers to the accumulation of metals and chemicals in plants and animals. Bioaccumulation occurs when an organism absorbs a - possibly toxic - substance at a rate faster than that at which the substance is lost by catabolism and excretion.

Biodiversity
Variety of different species (species diversity), genetic variability among individuals within each species (genetic diversity), variety of **ecosystem**s (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 – the lowest portion of Earth's atmosphere –based on an analysis of its weather records over a long period (at least 30 years). The two main factors determining an area's climate are its average temperature, with its seasonal variations and the average amount and distribution of precipitation – the water released from clouds in the form of rain, freezing rain, sleet, snow, or hail.
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 Mineral and Petroleum Resources Development Act (MPRDA). It includes decommissioning and **rehabilitation**.

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'
A concept for the characterisation and/or valuation of ecosystems according to the utility derived from them by people, in terms of services such as the water-cleansing functions of wetlands, the pollination provided by insects or the maintenance of biodiversity and tourism potential of protected natural areas.

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 the 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 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
Costs associated with the production of goods or services that are not accounted for in commercial production chains, generally referring to negative social, environmental and/or economic impacts, such as the costs of health care required as a result of air pollution; the term is used generically to refer to consequences or costs that are not included in the market price of goods, but also more specifically as a way of quantifying social and environmental impacts in monetary terms such that addressing the impacts may be taken up through market mechanisms.

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 **ecosystem**s (destruction of **wetlands**, especially peatlands), industrialisation, energy production and agriculture etc. Global warming is the principle cause of climate change.

Gold field
A geologically distinct area / unit where gold occurs.

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 the 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.

Metasediment
In geology, metasediment is sediment or sedimentary rock that appears to have been altered by metamorphism. The overall composition of a metasediment can be used to identify the original sedimentary rock, even where they have been subject to high-grade metamorphism and intense deformation.

Mine Residue Deposit
Mine Residue Deposits are defined as residual material from mining and associated beneficiation operations. The residual material is commonly managed by deposition on surface or by disposal in mine workings excavated below the natural surface of the land. In both cases, the residual material constitutes a potential source of pollution by either wind-borne or water-borne migration of contaminants.

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.

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.

Precipitate
“Precipitate” is defined as to cause (a substance e.g. metals) to be deposited in solid form from a solution.

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

Regional Tailings Storage Facility (RTSF)

RTSF is the centralization of waste (management by integration) from a number of mines within a region and the consolidation of contaminated sites. The residues are then deposited on a single large dump, commonly referred to as a super dump.

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 **ecosystem**s to a situation where a 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 Resource Quality Objectives 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.

Sludge
Gooey or jelly like mixture of toxic chemicals, and settled solids (metals) removed from acid mine water at a treatment plant.

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