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RESPONSE TO GOVERNMENT'S NATIONAL CLIMATE CHANGE RESPONSE WHITE PAPER

THE GROWING POTENTIAL RAVAGES OF CLIMATE CHANGE: CONTINUED POSSIBLE CATASTROPHE OR FUTURE HOPE?

ACID MINE DRAINAGE, RADIOACTIVE WASTE AND CLIMATE CHANGE

Contents

Heavy metals, including uranium, precipitating from Acid Mine Water within the West Rand Basin

Summary

This submission addresses the issue of Acid Mine Drainage (AMD) and its long term adverse impacts upon the surface and groundwater resources of South Africa.

Changes in water quantity and quality due to climate change are expected to affect water and food availability, stability, access and utilisation. AMD will increase water and food security risks and social unrest, and vulnerability for poor communities, especially mining communities[1].

The perpetuation of this crisis must be addressed by proactive management of South Africa's scarce surface and groundwater resources and by responsible mining practices and decision-making regarding the current and historical impacts of gold, uranium and coal mining upon surface and groundwater, as well as future impacts.

It is respectfully submitted that environmental authorizations for new coal, uranium and gold mining applications ought not to be issued if there is no financial provision made for the long term impacts of AMD, which is a deferred or delayed impact and which manifests and accrues in the post closure phases of mining.

The environmental crisis in the Witwatersrand goldfields was caused by the fact that externalities were not internalized. AMD is a typical negative externality. It imposes costs on others, often the most vulnerable and poor members of mining communities, but these costs are not paid for by the historic and current polluters.

The sustainability of a mining project ought to be assessed in terms of the lifetime of the impacts, and not merely in terms of the life time of the operations. Unless our decision-makers ensure that these externalities are internalised, mining companies and the public will continue to ignore the steady decline in the state of the environment and the quality and quantity of groundwater resources, which will be exacerbated by climate change.

[1] Bates, B.C., Z.W. Kundzewicz, S. Wu and J.P. Palutikof, Eds., 2008: Climate Change and Water. Technical Paper of the Intergovernmental Panel on Climate Change, IPCC Secretariat, Geneva, 210 pp 2008, Intergovernmental Panel on Climate Change. ISBN: 978-92-9169-123-4

Introduction

As early as 1987, the US Environmental Protection Agency recognised that "*.....problems related to mining waste may be rated as second only to global warming and stratospheric ozone depletion in terms of ecological risk. The release to the environment of mining waste can result in profound, generally irreversible destruction of ecosystems.*"[2]

The Witwatersrand gold mining area of South Africa is at serious risk.[3] The Witwatersrand straddles in Intercontinental Divide, with the Limpopo River System to the north and the Vaal River system to the south. The Vaal and Limpopo Rivers are national water resources.

Witwatersrand Goldfields

Witwatersrand[4] has been mined for more than a century. It is the world's largest gold and uranium mining basin with the extraction, from more than 120 mines, of 43 500 tons of gold in one century and 73 000 tons of uranium between 1953 and 1995. The basin covers an area of 1600 km^2, and led to a legacy of some 400 km^2 of mine tailings dams and 6 billion tons of pyrite tailings containing 430 000 tons of low-grade uranium.[5]

The key environmental issues within the Witwatersrand are:

- Interconnection of mining compartments within the basins
- Acid Rock Drainage and Mine Drainage
- Large Salt Loads

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[2] 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 p

[3] P Manders. Director, Natural Resources and the Environment. Council for Scientific and Briefing Note August 2009. Acid Mine Drainage in South Africa. P Manders. Director, Natural Resources and the Environment

[4] The Witwatersrand Mining Basin is composed of the Far East Basin, Central Rand Basin, Western Basin, Far Western Basin, KOSH and the Free State gold mines

[5] S Chevrel. A Remote-Sensing and GIS-Based Integrated Approach for Risk Based Prioritization of Gold Tailings Facilities – Witwatersrand, South Africa. Mine Closure 2008. AB Fourie, M Tibbett, IM Weiersbye, PJ Dye (eds). 2008 Australian Centre for Geomechanics, Perth. ISBN 978-0-9804185-6-9. 640 p

- Decanting of Flooded Mines
- Physical Instability
- Dust Pollution
- Land Use Conflicts with Growing Urban Centres
- Radioactivity (Contamination) and Uranium

Waste from gold mines constitutes the largest single source of waste and pollution in South Africa and there is wide acceptance that Acid Mine Drainage (AMD) is responsible for the most costly environmental and socio-economic impacts. As at 1997, South Africa produced an estimated 468 million tons of mineral waste per annum.[6]

Gold mining waste was estimated to account for 221 million tons or 47 % of all mineral waste produced in South Africa, making it the largest, single source of waste and pollution.[7]

There are more than 270 tailings dams in the Witwatersrand Basin, covering approximately 400 km^2 in surface area.[8] These dams are mostly unlined and many are not vegetated, providing a source of extensive dust, as well as soil and water (surface and groundwater) pollution.[9]

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

The gold mining industry in South Africa (principally the Witwatersrand Goldfield) is in decline, but the post-closure decant of AMD is an enormous threat, and this could become worse if remedial activities are delayed or not implemented.[10]

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[6] Department of Water Affairs and Forestry (DWAF). 2001. Waste generation in South Africa. Water Quality Management Series. Pretoria

[7] Ibid

[8] AngloGold Ashanti. 2004. Case studies. Woodlands Project – good progress being made with phytoremediation project. Environment – AngloGold Ashanti Report to Society

[9] Ibid

Acid Mine Drainage (AMD) from defunct and flooded underground gold mines in the West Rand Basin was first manifested during August and September 2002. The combination of the pH and redox driven reactions resulted in a measured uranium concentration of 16mg/l of the Robinson Lake, and resulted in the NNR declaring the lake a radiation area. The background U concentration in water is 0,0004mg/l. In terms of the DWAF regulations for drinking water, the U concentration should not exceed 0.07mg/l and for irrigation, 0.01mg/l.[11]

The Tweelopiespruit East, one of the receptor river systems of AMD, could be considered a Class V River (Very high acute hazard) in terms of DWAF: Resource Quality Service's Hazard Classifcation System for Natural Water.[12] All aquatic biota had been wiped out.

The decant of AMD, within the West Rand Basin, impacts upon two major river systems, namely the Limpopo River System to the North and the Vaal River System to the South.[13]

The Eastern and Central Basins are currently flooding and decant of AMD is anticipated within the next two to five years.[14] There are no management plans in place for the flooding and decant from the Far West Rand Basin (the largest gold mining basin within the Witwatersrand goldfields) and the KOSH Basin.[15]

Production of AMD may continue for many years after mines are closed and tailings dams decommissioned. AMD is not only associated with surface and groundwater pollution, degradation of soil quality, for harming aquatic sediments and fauna, and for allowing heavy metals to seep into the environment but long-term exposure to AMD polluted drinking water may lead to increased rates of cancer, decreased cognitive function and appearance of skin

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[10] P Manders. Director, Natural Resources and the Environment. Council for Scientific and Briefing Note August 2009. Acid Mine Drainage in South Africa. P Manders. Director, Natural Resources and the Environment

[11] H Coetzee. 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." Report, WRC, Council for Geosience. 2004. Report No 1214/1/06. 2006.

[12] Johan Fourie and Associates. Environmental Impact Document. 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. 53 p

[13] Ibid

[14] Report to the Interministerial Committee on AMD. 2010

[15] W Pulles. Water Research Commmission Report 1215/1/05. Executive Summary. ii p

lesions. Heavy metals in drinking water could compromise the neural development of the fetus which can result in mental retardation.[16]

Even though a large number of the world's rivers are contaminated by heavy metals released from present day and historic mining operations, relatively little is known about the effects on communities that live beside and rely on these rivers for food and livelihood. One of the complications is that the toxicity of many metals is a function of such conditions as redox, pH and water hardness.

Elevated salts and metals can also negatively affect the health of animals in many different ways, depending on the species, age, sensitivity, general health and diet of the consumer, among other factors.

Some metals, when consumed in excess, can affect organs and the central nervous system, cause reproductive failure or birth defects, and act as cofactors in many other diseases.

Certain receptors may be more sensitive than others, depending upon species, age, sex, season, body mass, metabolic rate, general health, diet, behaviour, etc, with younger animals and children being generally more at risk than adults under the same conditions of exposure (WHO).

The potential exists for trans-generational (genetic) impacts of bioaccumulated metals and NORMs (Naturally Occurring Radioactive Materials) on biota exposed above certain thresh-holds. There is the probability that such latent impacts will only be identified and assessed over the next 100 to 500 years.[17] The mean values e.g. for the Wonderfonteinspruit 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.[18]

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[16] SHH Oelofsse. The pollution and destruction threat of gold mining waste on the Witwatersrand - A West Rand case study. CSIR, Natural Resources and the Environment.

[17] AngloGold Ashanti. Draft Environmental Management Programme Report and Environmental Impact Assessment Report. West Wits Operations. 2008/2009.

[18] H Coetzee. 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." Report, WRC,Council for Geosience. 2004. Report No 1214/1/06. 2006

At present the U and other heavy metals, such as cadmium, copper, zinc, arsenic and cobalt are adsorbed in the sediment of the rivers and wetlands within the Witwatersrand goldfields.[19]

These heavy metals are not permanently immobilized and plausible environmental conditions such as acid mine drainage can cause the mobilization or transport of uranium and other heavy metals into the water column.

Results indicate that U-levels in water resources of the Wonderfonteinspruit catchment increased markedly since 1997 even though U-loads emitted by some large gold mines in the Far West Rand were reduced. This apparent contradiction is explained by the contribution of highly polluted water decanting from the flooded mine void in the West Rand.

Uranium concentrations in the river sediments of the Wonderfonteinspruit can exceed 1 000 ppm in places.[20]

800kg of U per year flows into Boskop Dam as Potchefstroom's main water reservoir. Of particular concern is the fact that U-levels in the Wonderfonteinspruit Catchment are comparable to those detected in the Northern Cape which had been geostatistically linked to abnormal haematological values related to increased incidences of leukaemia observed in residents of the area".[21]

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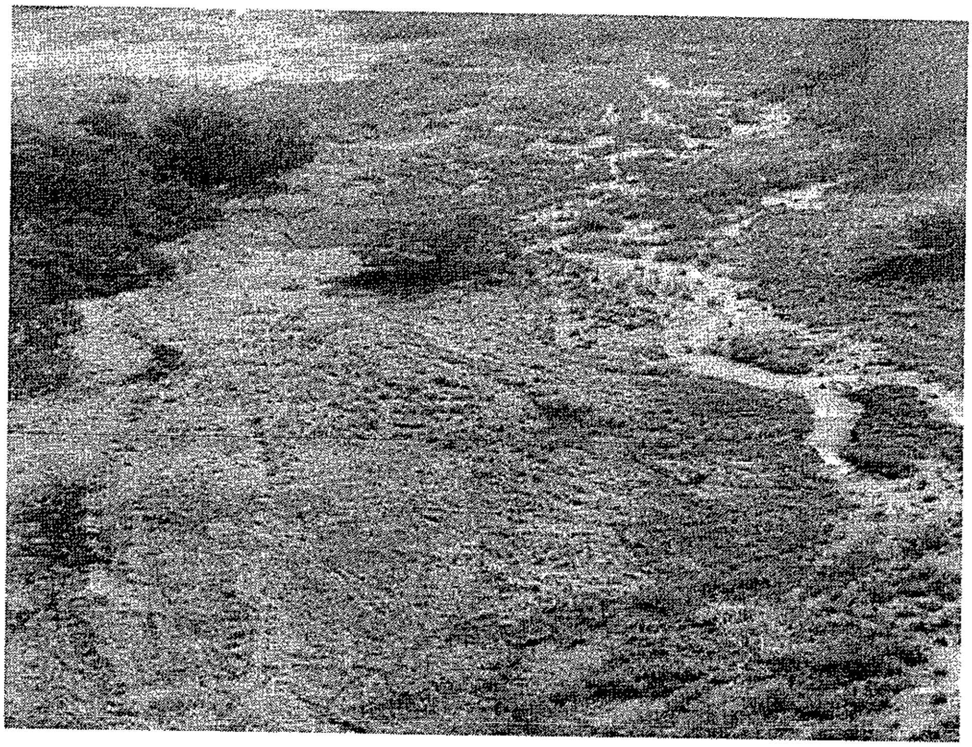
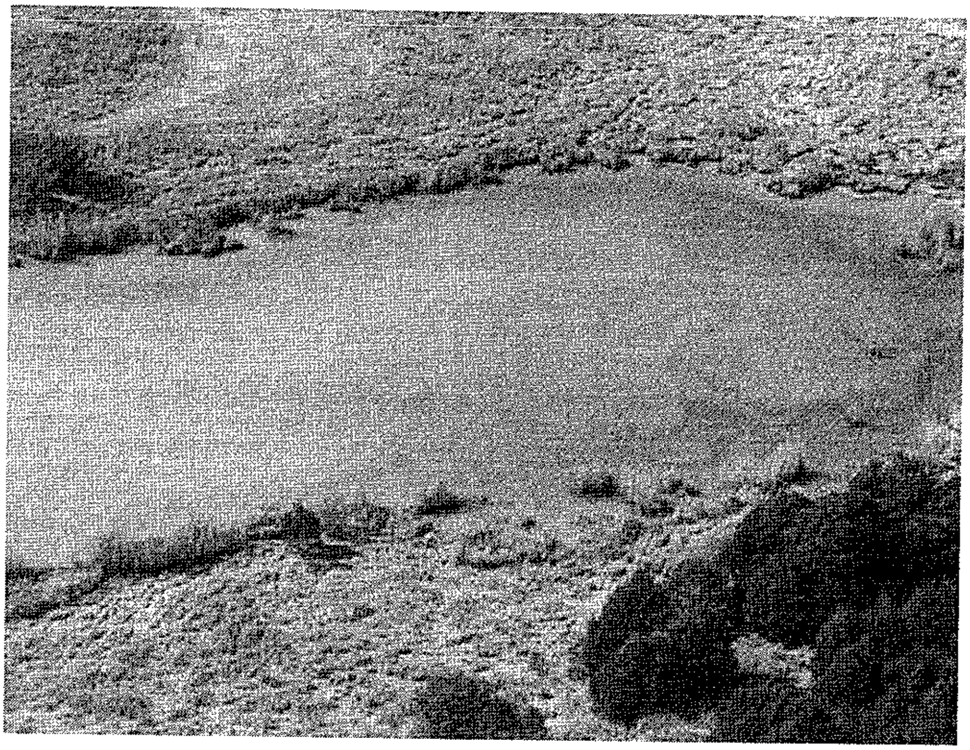
[19] H Coetzee. Contamination of wetlands by Witwatersrand gold mines – processes and the economic potential of gold in wetlands". Council for Geoscience Report No. 2005-0106

[20] H Coetzee. 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." Report, WRC,Council for Geosience. 2004. Report No 1214/1/06. 2006

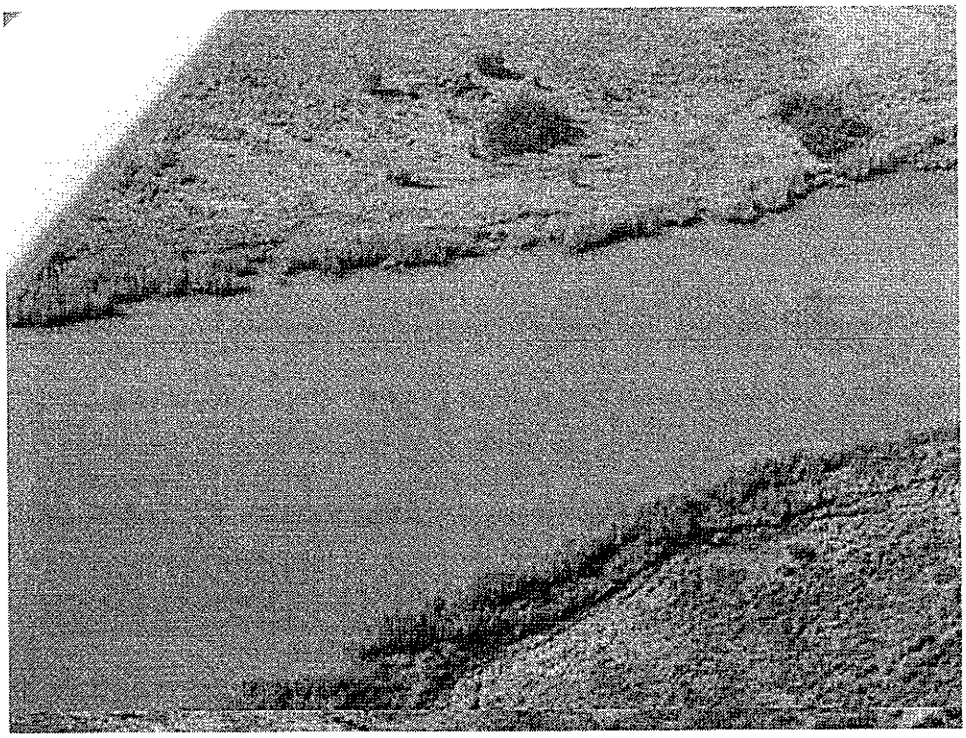
[21] Prof.Dr. Frank Winde. North West University. Uranium Pollution of Water resources in Mined-Out and Active Goldfields of South Africa – A Case Study in the Wonderfonteinspruit Catchment on Extent and Sources of U-Contamination and Associated Health Risks. 2009.



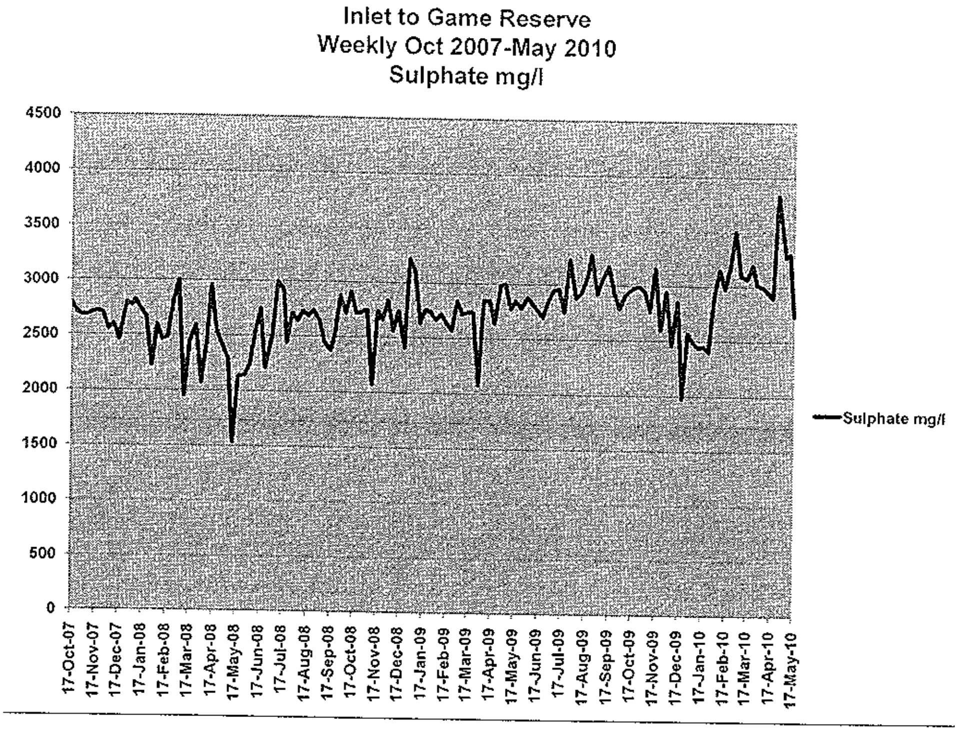
Tweelopiespruit – note the heavy metal precipitate. The Tweelopiespruit East is considered a Class V River (Very high acute hazard) in terms of DWAF: Resource Quality Service's Hazard Classification System for Natural Water (Reference: Environmental Impact Document. Impact of the discharge of Treated Mine Water,via the Tweelopies Spruit, on the receiving water body Crocodile River System, Mogale City, Gauteng Province. DWAF 16/2/7/C221/C/242006.)



Hippo Dam, the first receptor dam within the Krugersdorp Game Reserve. Note the paths of the hippopotami; their movements disturb the sediment. The heavy metals , which are adsorbed in the sediment are mobilized as a result.



Hippo Dam – See water quality results (sulphates) subjoined hereunder. The World Health Organisation's standard for drinking water is 200mg/l sulfates; the DWA guidelines for drinking water are 600mg/l; for irrigation 150mg/l; for the environment 100mg/l and for watering of cattle 1000mg/l


Inlet to Game Reserve
Weekly Oct 2007-May 2010
Sulphate mg/l
4500
4000
3500
3000
2500
2000
1500
1000
500
0
17-Oct-07
17-Nov-07
17-Dec-07
17-Jan-08
17-Feb-08
17-Mar-08
17-Apr-08
17-May-08
17-Jun-08
17-Jul-08
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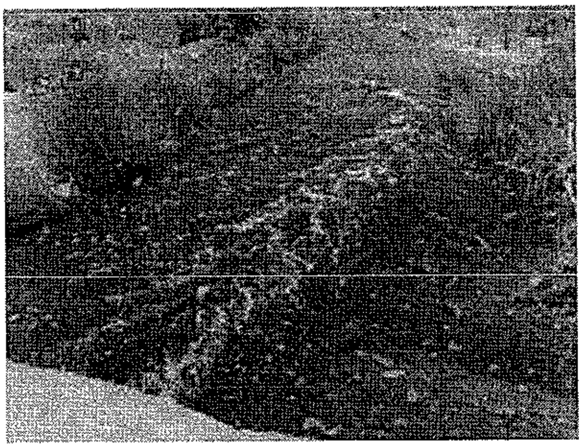
17-Oct-09
17-Nov-09
17-Dec-09
17-Jan-10
17-Feb-10
17-Mar-10
17-Apr-10
17-May-10
Sulphate mg/l

The ramifications of AMD for the subregion are enormous. The greatest focus in this regard is the Cradle of Humankind World Heritage Site. Of no lesser concern, however, are the downstream landowners and occupiers (11 491) and agricultural activities that are largely or whole dependent on groundwater for potable and economic use[22].

Of relevance are the findings of the Report by Hobbs, P.J. and Mills, P.J. (2011), entitled *The Koelenhof Farm fish mortality event of mid-January 2011* (Report prepared for the Management Authority, Department of Economic Development. Gauteng Province. South Africa. 19 pp). It was found that the red colouration of the water of the Riet Spruit at its intersection with Malmani Road is indicative of a "***strong acid mine water character.***"



Of relevance too are the findings of the report, intitled "*A Hydrologeological Assessment of Acid Mine Drainage Impacts in the West Rand Basin, Gauteng Province*" (Hobbs, P.J. and Cobbing, J.E., 2007) namely that "*...an unqualified volume still escapes downstream into the Zwartkrans compartment via the Tweelopiespruit, mostly subsurface.*"

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[22] "*A Hydrologeological Assessment of Acid Mine Drainage Impacts in the West Rand Basin, Gauteng Province*" (Hobbs, P.J. and Cobbing, J.E., 2007)

The Interministerial Committee on AMD has directed that the proposed (emergency) treatment of Acid Mine Drainage (AMD) within the Western and Central Basins is neutralization.

Neutralization involves the addition of base reagent (in the case under consideration, the addition of lime) to acidic mine wastewater. The product water will often require further treatment. Neutralised AMD will reduce sulphate levels from 4 700mg/l to 3 000mg/l. The neutralized AMD is toxic and unfit for any purpose.

Of relevance are the findings and recommendations of the following DWA reports:

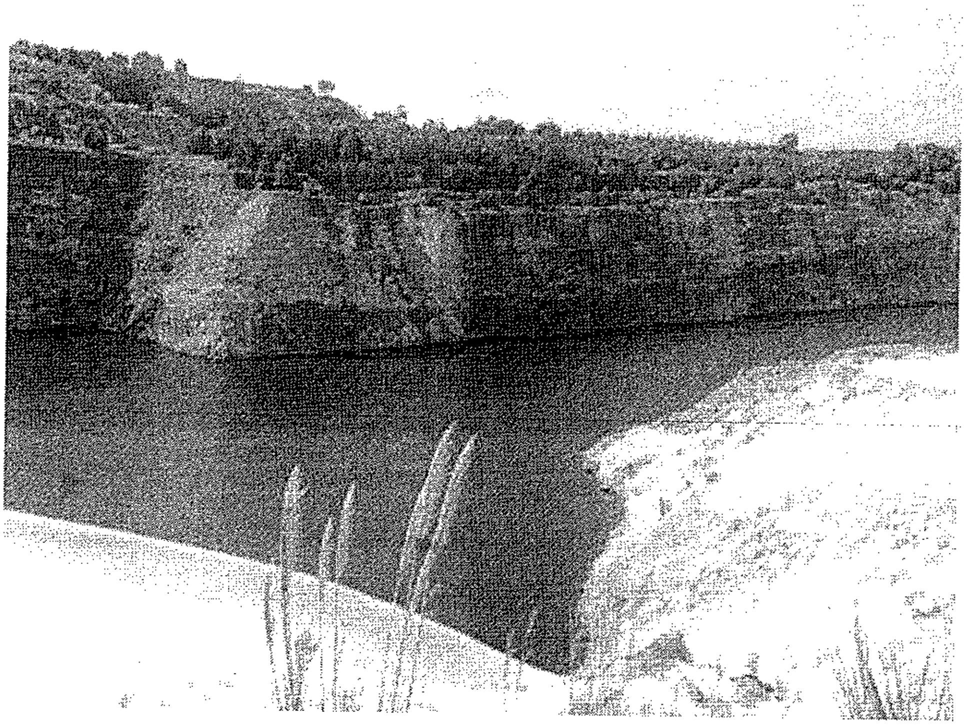
"Integrated Vaal River Water Resource Management Studies"(http://www.dwa.gov.za/Projects/VaalWRMS/); **"Vaal System Large Bulk Water Supply Reconciliation Strategy" – "Executive Summary** (http://www.dwa.gov.za/Projects/VaalWRMS/documents/LargeBulkWater/09_Vaal%20Recon%20Executive%20Summary_Final.pdf);**"Vaal River - Re-Use Options"** (http://www.dwa.gov.za/Projects/VaalWRMS/documents/LargeBulkWater/03_Re-use%20Options_Final.pdf); **"Second Stage Vaal System Large Bulk Water Supply Reconciliation Strategy"** (http://www.dwa.gov.za/Projects/VaalWRMS/documents/LargeBulkWater/08_Vaal%20Second%20Stage%20Reconciliation%20Strategy%20Report_Final.pdf); **"Water Quality Management Scenario** (http://www.dwa.gov.za/Projects/VaalWRMS/documents/VaalIWQMPWQMScenariosReportFinalSept2009.pdf **"Integrated Water Quality Management Strategy"** (http://www.dwa.gov.za/Projects/VaalWRMS/documents/VaalIWQMPTask8WQMStrategyReportFinalSept2009.pdf).

It was found and recommended in terms of the aforesaid Reports that:

- The addisional salinity as a result of Acid Mine Drainage (AMD) creates water security risks.
- In order to comply with the regulatory limit of 600 mg/l sulphates, good quality water has to be released from the Vaal Dam in order to ensure that the water below the Vaal Barrage is fit for use, that is, by means of dilution.

- The projected demand for increased releases from the Vaal Dam of expensive Lesotho water will increase the stress upon the water supply. Water supply shortages will be experienced by 2014.
- The additonal volume of water that has to be released as a result of the salinity associated with AMD will result in a considerable reduction of water supply to the Upper Vaal so much so that the total capacity of Phase 2 of the Lesotho Highlands scheme will be cancelled.
- It necessitates that the Tugela supplementary scheme will have to be advanced.
- It will have significant cost implications.
- It will result in the loss of water to the Oranje River system and poorer quality water discharges from the Vaal River to the Oranje River system, with associated costs for downstream water users.
- Desalination of AMD has been identified as the first option to limit the salination of the Vaal River System.

The neutralisation process is very pH specific and temperature sensitive. For metal recovery, very accurate process control is required. The resulting sludge residue is of variable stability and density complicating its handling. The radioactive and toxic sludge will be discharged in the West Wits Pit, an unlined pit with holings because of historical mine workings. The Pit intersects the old underground operations, providing direct continuity between the surface and the mine void. (Department of Mineral Resources. Draft Regional Mine Closure Strategy for the West Rand Goldfield. 2008.)

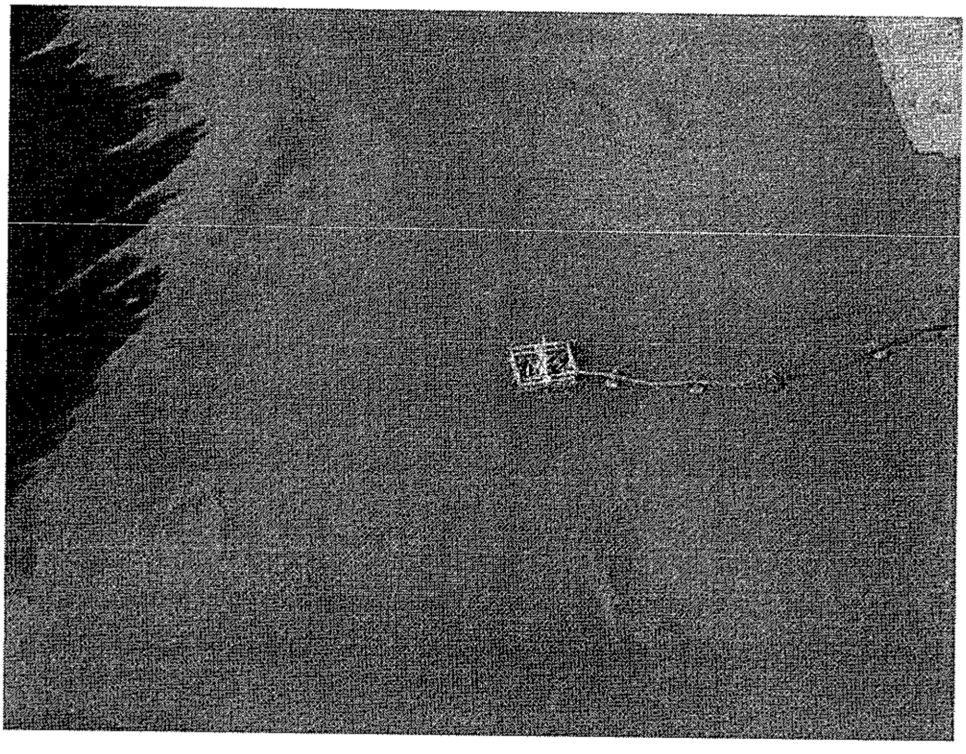


West Wits Pit

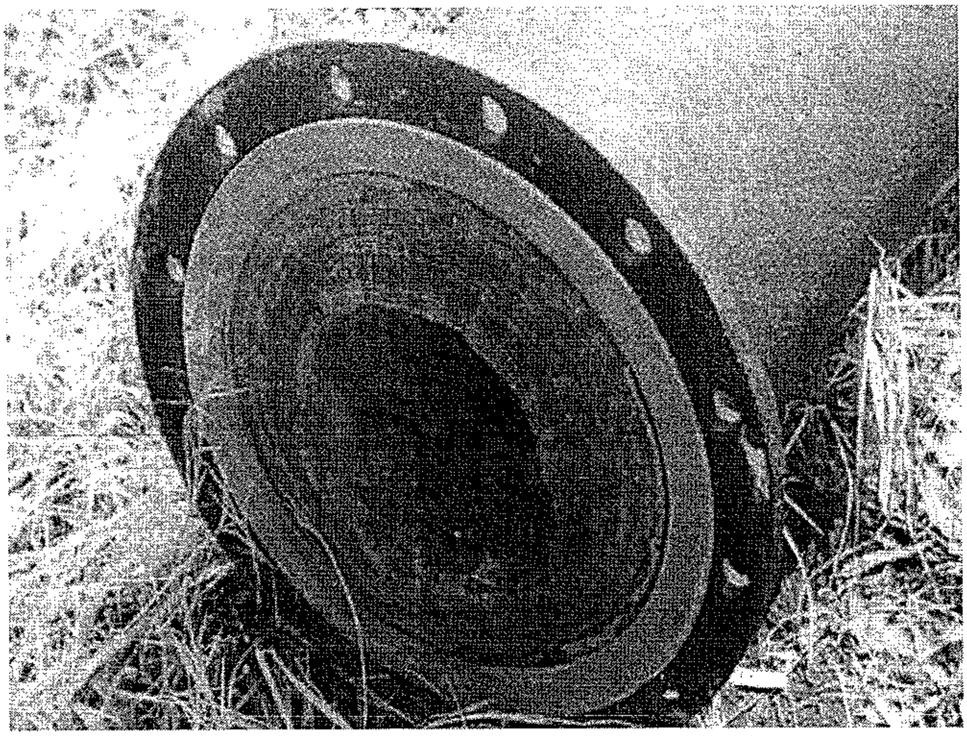
Neutralisation of AMD (lime dosing): Rand Uranium Water Treatment Plant

Heavy metal precipitation after neutralisation

Neutralised Acid Mine Drainage being discharged into the CPS



CPS Pit



Precipitated heavy metals coating on the inside of a water discharge pipe after neutralization of AMD

Precipitated heavy metals on vegetation.

Mpumalanga Coalfields

The most serious environmental problem arising from coal mining is the generation of sulphuric acid as a result of a chemical reaction between an iron sulphide mineral (pyrite) present in the coal and its host rocks and oxygen-bearing water (infiltrated rain water). Under natural conditions, the Karoo rocks have a very low permeability and although acid is generated, the process is extremely slow and other equally slow reactions completely neutralize the acid. However, mining breaks up the rock mass allowing free access of water and the acid-producing chemical reactions proceed faster than the acid can be neutralized. Consequently, the water becomes acidic and toxic to animal and most plant life. The acid water dissolves aluminium and heavy metals (iron, manganese and others), increasing its toxicity. Some rock types contain minerals (especially calcium carbonate) that can neutralize such acidity even when produced rapidly, but this is not the case with most of the rocks that host the South African coal[23].

Acid water produced in the mines may seep out at surface, where further reactions with oxygen occur, precipitating iron and generating yet more acid. This water sterilizes soil that it comes into contact with. The water enters rivers, which become acidified, reducing biodiversity to a few particularly hardy species. Neutralization reactions occur as a result of mixing with other neutral water sources, and may result in the precipitation of aluminium, which is toxic to fish and possibly other aquatic animals. Ultimately the acidity is neutralized, but the water remains sulphate-rich, typically containing 2000 to 3000 ppm (parts per million) sulphate (the recommended limit for water for human consumption is 200 ppm).

It furthermore results in the destruction of groundwater aquifers. Mining disturbs the aquifer structure. Opencast mining completely destroys the groundwater aquifers and creates a single, massive aquifer in the mine void. After mine closure,.water fills this aquifer to the lowest elevation of the bedrock rim, and additional water entering the void decants over the rim.
This water is of extremely low quality. Once an area has been mined, borehole water from that site will generally no longer be usable for agricultural or domestic use due to its low quality.

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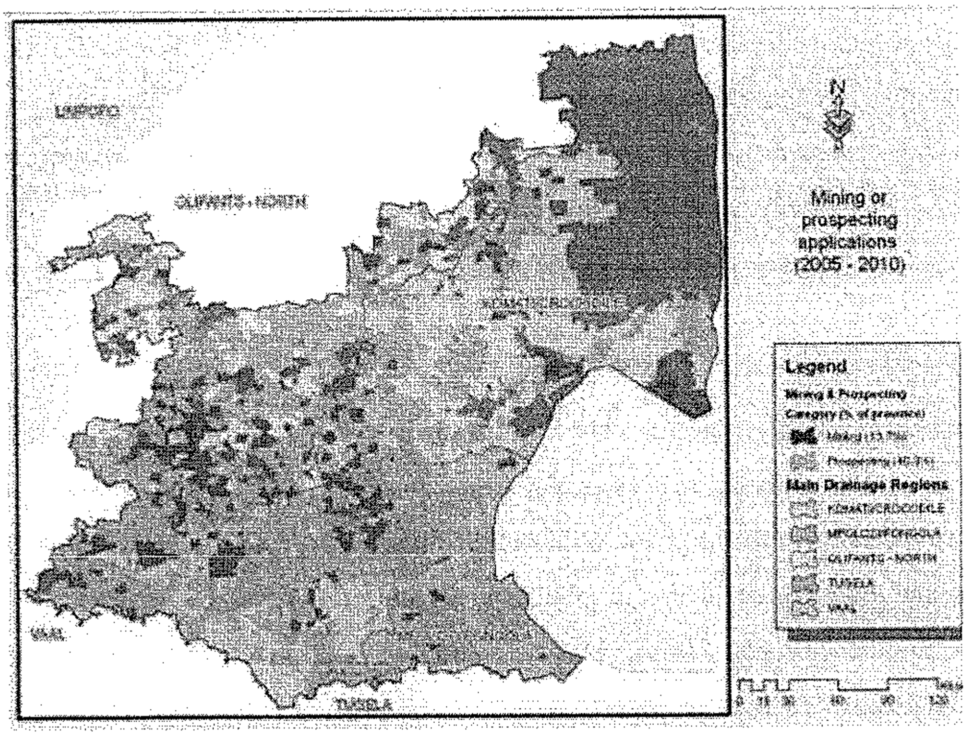
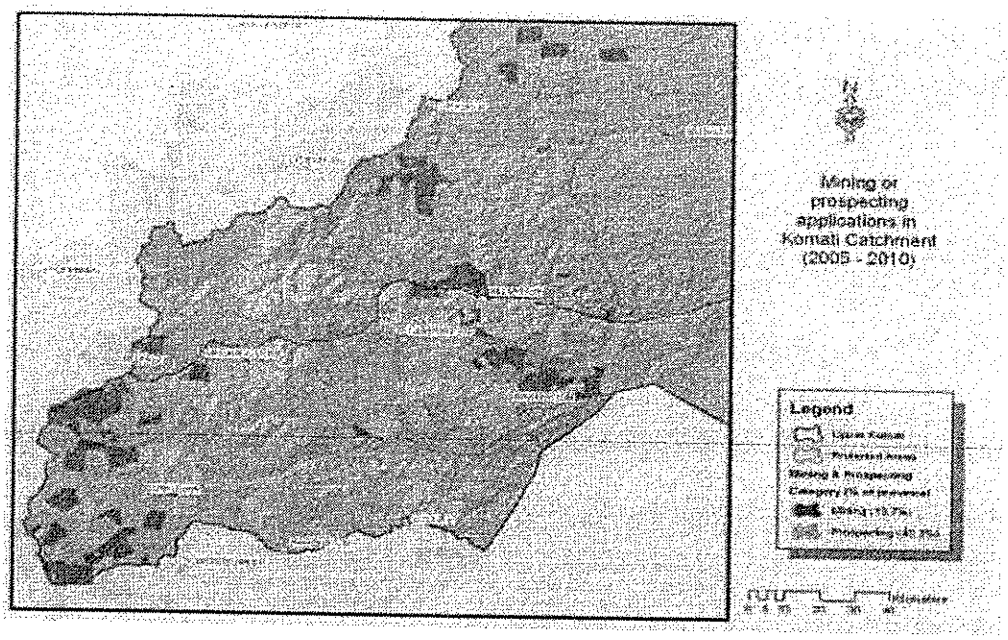
[23] T S McCarthy and K Pretorius. Coal mining on the Highveld and its implications for future waterquality in the Vaal River system.

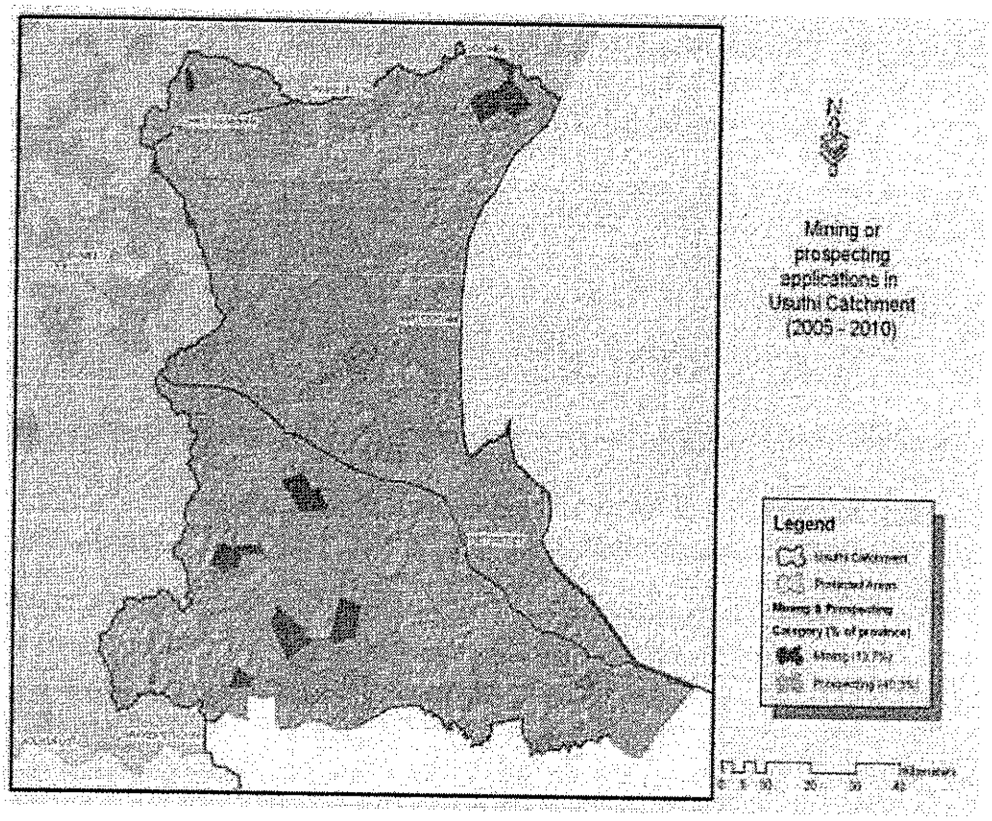
A disturbing development is the large number of applications that have been made to open new coal mines in Vaal River catchment. If all of the coal resources of the upper Vaal River basin are exploited, it will result in the undermining of the entire basin from the headwaters to a position downstream of the Vaal dam. In the future, once these mines are closed and commence decanting, it is likely that the water quality in the upper Vaal River will suffer the same problems as the Olifants River system.



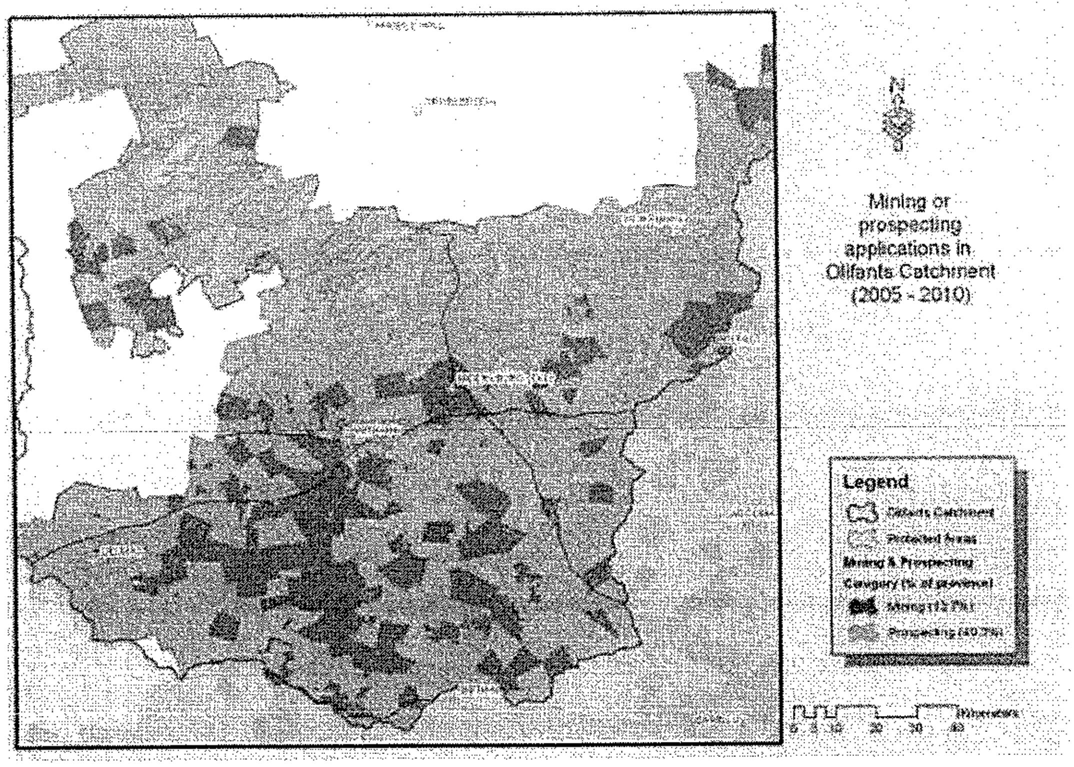
The red areas are currently being mined. The current prospecting applications are in yellow.



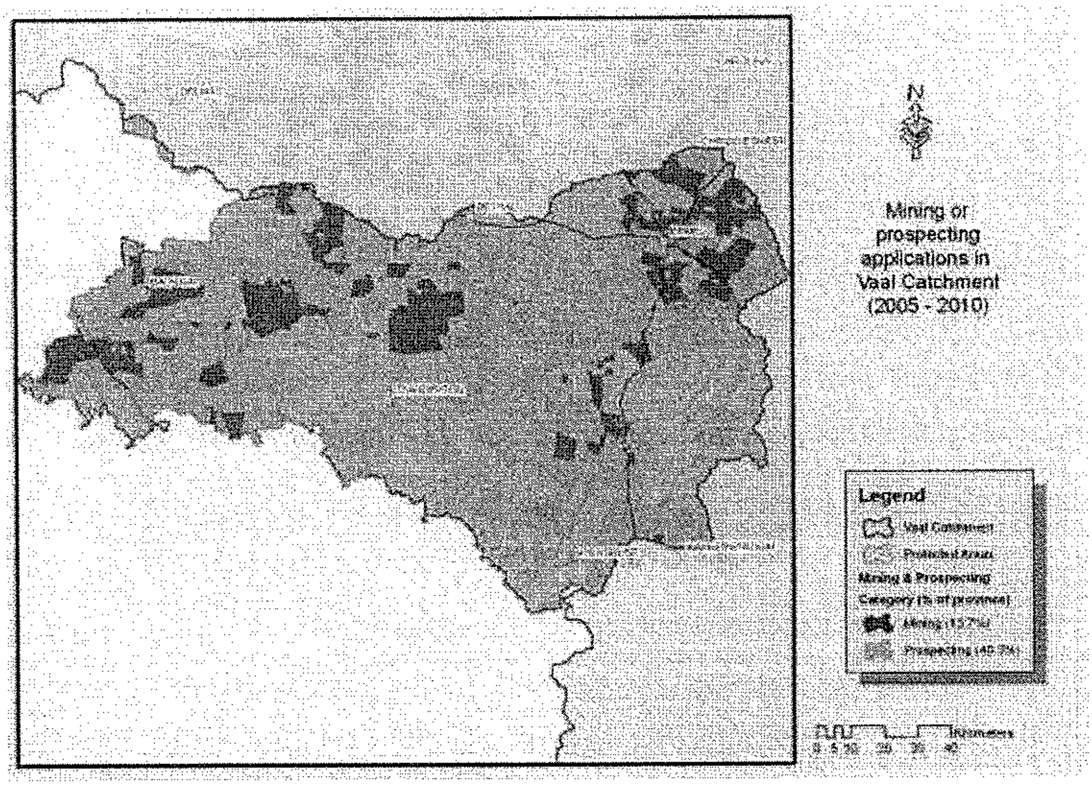
Mining or prospecting applications in the Komati Catchment



Mining or prospecting applications in the Usuthi Catchment



Mining or prospecting applications in the Olifants Catchment



What does the future hold for the Mpumalanga coalfield? Prof. Terence McCarthy[24] of the Witwatersrand University sketched out a scenario for the future of the coalfield once the coal reserves have been fully exploited and mining has ceased.

"At this time, perhaps a century from now, all of the mines will be flooded and leaking acid water. In their upper reaches, the rivers will run red , and both river and ground water will be undrinkable. Aquatic animal life will be minimal, and only very hardy aquatic vegetation will survive. The rivers will also be choked with sediment. Extensive areas of the region will have become devoid of vegetation due to acidification of the soil, setting in motion severe erosion which will strip the soil cover and eat into the backfill of the old opencast workings. The eroded sediment will choke the rivers and all dams will be filled with sediment. In short, the region could become a total wasteland.

This scenario might seem melodramatic and emotive, but are the currently employed mitigation procedures adequate to prevent such a scenario from arising? We believe they are not. Acid water will be generated by the closed mines, making the ground water in the region unpotable. Uncontrollable seeps of this water will become widespread, seriously degrading surface water resources. There is no large scaled master plan either in place or planned to prevent this based on knowledge of the impact and within a decision making framework taking all of the impacts into account. Applications are dealt with on a single application basis without a larger development framework context being in place."

The scale of the problem is going to increase enormously in the future as the mines close and water management becomes more difficult. The future costs of water purification will be massive, far greater than any mitigation fund could cover, and will have to be borne by the State (that is taxpayers) in the absence of the closure cost provisions of the Department of Mineral Resources also catering for water rehabilitation. There is also likely to be major loss of future

[24] T S McCarthy and K Pretorius. Coal mining on the Highveld and its implications for future waterquality in the Vaal River system.

revenue from reduced agricultural potential of mined land, partly due to the loss of ground water resources, but also because of the threat to the soil itself.

Whether the current procedures are adequate to protect the soil cover over former opencast mines remains to be seen – the current experience seems to suggest it is not. The Olifants River catchment is in trouble, but the most serious long term threat that coal mining poses is to the water resources of the Vaal River, Usuthu and Komati basins, which provides drinking water to possibly a third of the country's population and supplies Eskom with water for its power stations. The Komati and other rivers from the escarpment also supply the Lowveld as well as neighbouring southern Mozambique and Swaziland, are also under threat. In the absence of adequate, fail-safe environmental protection procedures which include passive and active treatment systems that are sustainable over the long term, we believe that a moratorium should be declared on new mining applications in all of these catchments until such time as cumulative impact of mining is fully understood and adequate sustainable mitigation measures can be guaranteed. In addition, there should be a concerted research programme to assess the future impact of current and past mines, to find ways of reducing acid discharge from mines and of passively treating sulphate-rich mine water. If adequate, low cost mitigation procedures cannot be discovered, then no further mining should be permitted in sensitive catchments.

To inform the drafting of the white paper, the Department of Environmental Affairs commissioned research in five thematic areas. We refer to the draft output from the research conducted by Andrew Marquard et al (*"South Africa's international commitment, proposed national emissions trajectory and costs and magnitude of sectoral mitigation measures."*)

Nuclear Energy in the Future Energy Mix and the Current Management of Radioactive Waste

In terms of the above-mentioned research paper, nuclear energy is considered one of the feasible low-carbon technologies for centralized generation (zero-carbon electricity case) and an option for reducing emissions from the electricity supply sector. In terms of mitigation, extended nuclear is considered as one of the favoured energy options, a move away from coal.

We express no opinion for or against the use of nuclear energy. Our submission is limited to the failures and challenges of the current regulatory regime for the management of radioactive and nuclear waste. The National Nuclear Regulator (NNR) regulates nuclear safety, monitoring the nuclear industries and their waste production. It is funded by government grants and on the licensing of nuclear facilities. It is required to protect the public from exposure to radioactivity from sources like mining, nuclear research, nuclear electricity production and other industries.

Grounded upon the historical and current management of radioactive mining waste[25] within the Witwatersrand goldfields, we express grave concern regarding the responsible future management of nuclear and radioactive mining waste. Failure to address current weaknesses in the regulation of radioactive waste will exacerbate the adverse impacts of climate change instead of ameliorating its impacts.

The Witwatersrand[26] has been mined for more than a century. It is the world's largest gold and uranium mining basin with the extraction, from more than 120 mines, of 43 500 tons of gold in one century and 73 000 tons of uranium between 1953 and 1995. The basin covers an area of 1600 km^2, and led to a legacy of some **400 km^2 of mine tailings dams** and 6 billion tons of pyrite tailings containing **430 000 tons of low-grade uranium[27].**

(Interpolation: Following an increase in uranium spot prices in 2005/2006, more countries with low ore grades have recently become interested in U extraction. Especially if uranium can be mined as a by-product of gold mining, or if existing mine residue deposits can be re-mined to

[25] Uranium is a by-product of gold mining in the Witwatersrand region. Relatively few mining companies active in South Africa have exploited uranium, even though many ores are rich enough in uranium to make this kind of mining feasible. However, gold being a more attractive metal, providing miners with better revenues, it was often the sole product of a mine. The miners altogether dug up some hundred thousand tonnes of uranium, and several times this amount is still extractable from ores and from existing tailings dams. In the many cases where the uranium was never extracted from the ore, or where only small proportions of the uranium were extracted, the tailings dams still contain, high, extractable concentrations of uranium.. (Uranium from Africa. A joint report by WISE and SOMO. June 2011.)

[26] The Witwatersrand Mining Basin is composed of the Far East Basin, Central Rand Basin, Western Basin, Far Western Basin, KOSH and the Free State gold mines.

[27] *A Remote-Sensing and GIS-Based Integrated Approach for Risk Based Prioritization of Gold Tailings Facilities – Witwatersrand, South Africa* – S. Chevrel et al. 2008.

recover gold and uranium, mines with ore grades lower than 0.1% can still produce uranium profitably. As long as uranium prices are high, uranium extraction from low grade ores is economically viable. A disadvantage of low ore grades is that the environmental footprint of a mine increases with diminishing ore grades. If resources are low grade, larger volumes of ore need to be processed in order to extract smaller amounts of uranium, and more waste (tailings) is produced. At an ore grade of 0.1%, 1 000 kg (1 Tonne) of ore need to be processed in order to obtain 1 kg of uranium. Processing of larger volumes of ores leads the mines to a higher consumption of energy, water and chemicals. This implies that future extraction of uranium resources will inevitably lead to an increase in environmental damage created by the mines, and **to a significant increase in CO_2 emissions**[28].)

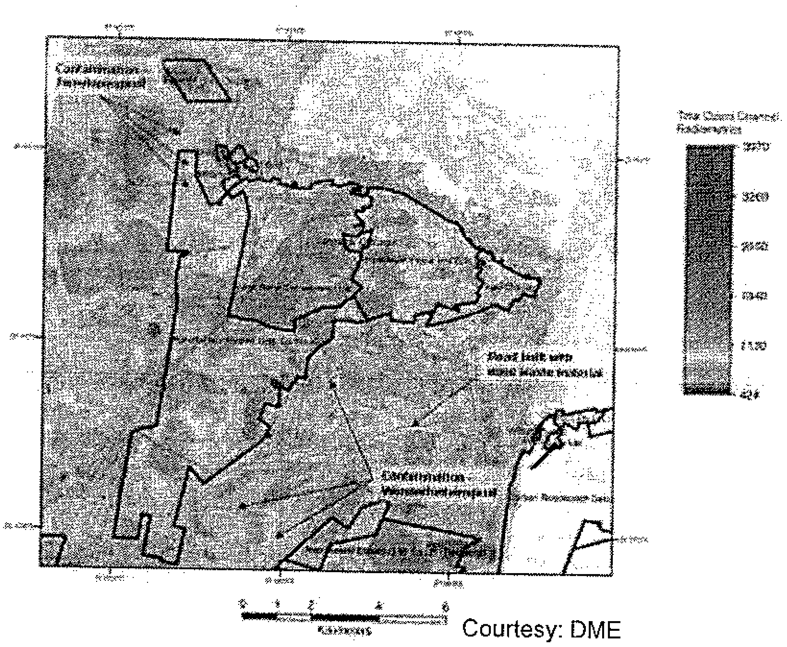
As a consequence of the uraniferous nature of the ore, Witwatersrand tailings and other mining residues often contain significantly elevated concentrations of uranium and its daughter radionuclides, with the decay series of ^{238}U being dominant[29].

An airborne radiometric survey of the Central, East-, West and Far West Rand goldfields and the KOSH goldfield was done for the Department of Water Affairs by the Council of Geoscience. Interpretation of the data show many of the residential areas (e.g. the CBD of Johannesburg, Carletonville, Westonarea, Khutsong) fall within areas of high risk of **radioactivity contamination**[30].

[28] *Uranium from Africa. Mitigation of uranium mining impacts on society and environment by industry and governments.* A joint report by WISE and SOMO. June 2011.

[29] 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.

[30] DMR Draft Regional Mine Closure Strategies for the Witwatersrand goldfield. 2008.



Courtesy: DME

An airborne radiometric survey of the WR and FWR was done for DWAF. Interpretation of the data show many of the residential areas (Carletonville, Westonarea, Khutsong) fall within areas of high risk of **<u>radioactivity contamination.</u>** (Department of Mineral Resources. Regional Mine Closure Strategy for the West Rand Goldfield. 2008.

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

- the airborne pathway, where radon gas and windblown dust disperse outwards from mine sites,
- the waterborne pathway, either via ground or surface water or due to direct access, where people are contaminated,
- or externally irradiated after unauthorized entry to a mine site,

– by living in settlements directly adjacent to mines or in some cases, living in settlements on the contaminated footprints of abandoned mines[31].

The measured uranium content of many of the fluvial sediments 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.

For approximately 50% of the 47 sampling sites, the calculated incremental doses of the respective critical group are above 1 mSv per annum up to 100 mSv pa. The radioactive contamination of surface water bodies in the Wonderfonteinspruit catchment area caused by the long-lasting mine water discharges and diffuse emissions of seepage and runoff from slimes dams poses radiological risks to the public resulting from the usage of polluted environmental media.

The pathway sediment→SPM →cattle→milk/meat→person ("SeCa") 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 Cattle (WaCa) pathway.[32]

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[33].

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

- Inhalation of Rn-222 daughter nuclides from radon emissions of desiccated water storage dams (e.g. Tudor dam) and slimes dams.
- The inhalation of contaminated dust generated by wind erosion from these objects, and

[31]: *Land-Use after Mine Closure – Risk Assessment of Gold and Uranium Mine Residue Deposits on the Eastern Witwatersrand*, South Africa. M. W. Sutton. Mine Closure. 2008)

[32] NNR Report, TR-RRD-07-006, entitled *"Radiological Impacts of the Mining Activities to the Public in the Wonderfonteinspruit Catchment Area."*

[33] DMR Draft Regional Mine Closure Strategies for the Central Rand goldfield. 2008.

- The contamination of agricultural crop (pasture, vegetables) by the deposition of radioactive dust particles, which can cause considerable dose contributions via ingestion[34]."

"*...during the sampling strong dust emissions from slimes dams during wind events were observed. Due to the small particle size of the slimes, particulate matter can be transported over relatively long distances to agriculturally used land in his surroundings.*

"*It has to be mentioned that 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, being in the order of dose contribution of the so-called 'water pathways'"*[35].

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[34] NNR Report, TR-RRD-07-006, entitled *"Radiological Impacts of the Mining Activities to the Public in the Wonderfonteinspruit Catchment Area."*

[35] NNR Report, TR-RRD-07-006, entitled *"Radiological Impacts of the Mining Activities to the Public in the Wonderfonteinspruit Catchment Area."*)

Radioactive and Toxic Dust Fallout: West Rand Goldfield

The health effects of uranium particles inhaled:

- Small particles are carried by the inhaled air stream all the way into the alveoli. Here the particles can remain for periods from weeks up to years depending on their solubility.
- Highly insoluble uranium compounds may remain in the alveoli, whereas soluble uranium compounds may dissolve and pass across the alveolar membranes into the bloodstream, where they may exert systemic toxic effects.
- In some cases, insoluble particles are absorbed into the body from the alveoli by phagocytosis into the associated lymph nodes.

- "Insoluble" particles may reside in the lungs for years, causing chronic radiotoxicity to be expressed in the alveoli[36].

There are many receptor dams within the Witwatersrand goldfields containing elevated levels of uranium. To exemplify: The Tudor Dam, a desiccated dam has radioactivity levels of between 10 000 and 100 000 Bq/kg[37]. The regulatory limit is 500 Bq/kg. The Tudor Dam is unfenced and there are no warning signs in place. There are residential dwellings in close proximity to the Tudor Dam. The Lancaster Dam, the source of the Wonderfonteinspruit, is a declared radioactive hotspot and a highly toxic dam. The Andries Coetzee Dam contains 900mg/kg uranium. The background levels for U (e.g. the Klerkskraal Dam) are 1mg/kg. The Andries Coetzee Dam was until recently used for the irrigation of crops and watering of cattle.

Informal and formal residential settlements are established on or adjacent to uraniferous tailings dams. It may expose the residents to direct external gamma radiation, inhalation and ingestion of radionuiclides, radon and radon gas, and chemotoxic metals. 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**[38].

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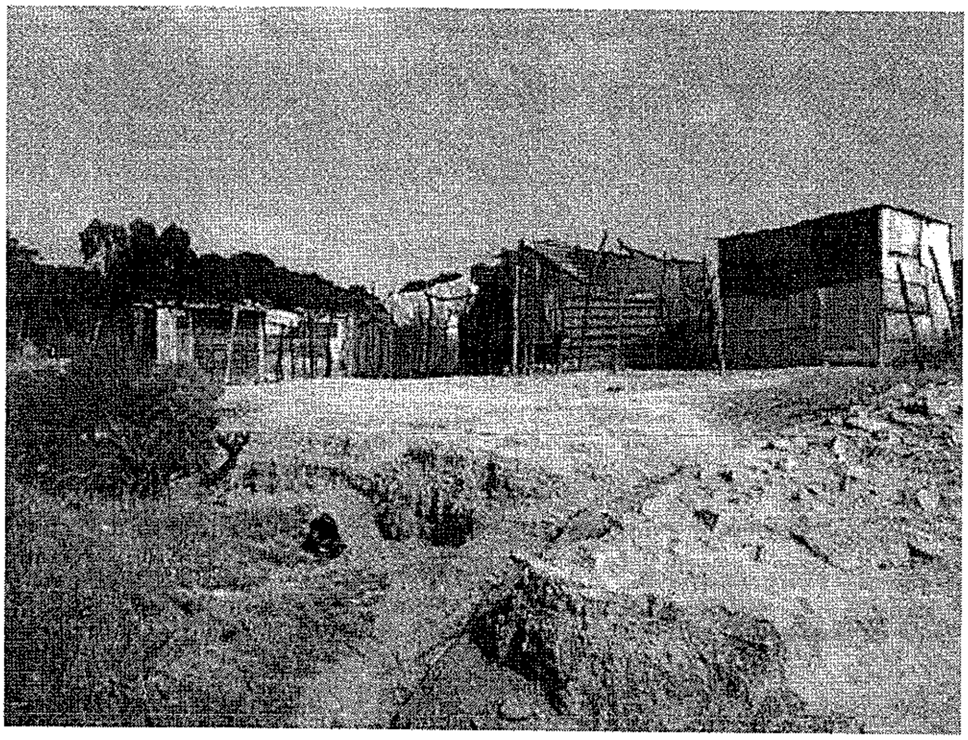
[36] "*An Assessment of Sources, Pathways, Mechanisms and Risks of Current and Potential Future Pollution of Water and Sediments in Gold-Mining Areas of the Wonderfonteinspruit Catchment.*" Report, WRC, H Coetzee *et al*, Council for Geosience. 2004. Report No 1214/1/06. 2006.

[37] "*Tier 1 Risk Assessment Of Selected Radioonuclides In Sediments Of The Mooi River Catchment*". WRC Report 1095. Peter Wade et al. 2002.

[38] "*Radiometric surveying in the Vicinity of Witwatersrand Gold Mines*". H. Coetzee. 2008.



Tudor Shaft Informal Settlement, which was established upon uraniferous tailings.

Low Cost Housing development in Kagiso adjacent to uraniferous mine residue deposit (IL15)

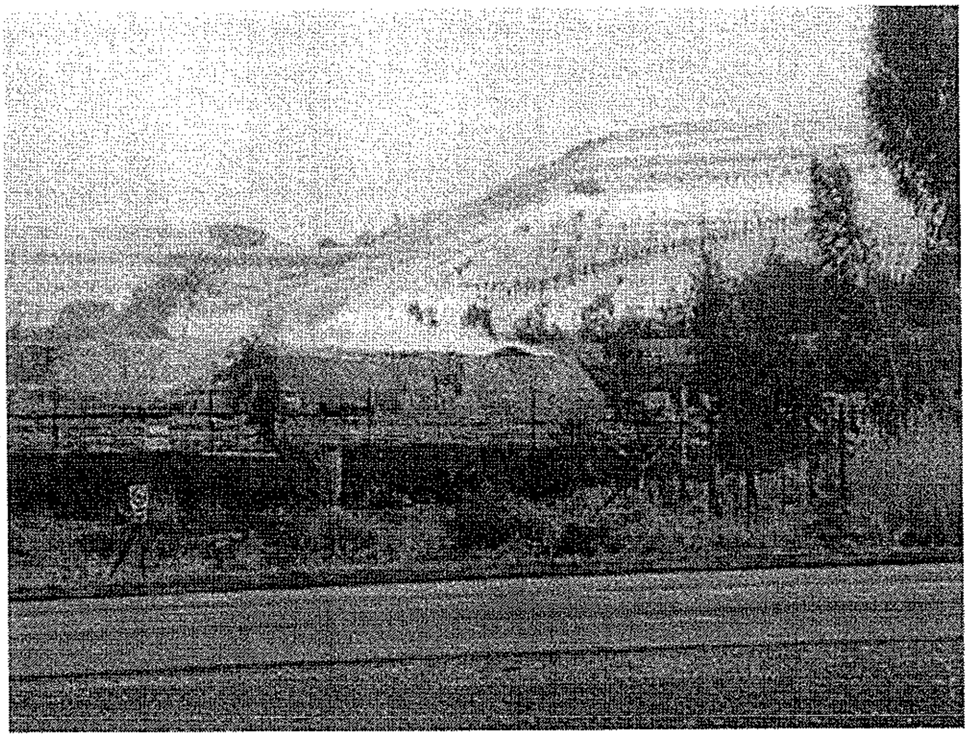
In South Africa, most tailings dams and unrehabilitated footprints of re-mined tailings dams are unfenced and thus used for recreation (e.g. quad-bikers), and as informal playgrounds by children, and for livestock grazing. In addition to increasing erosion and dust emissions, the increased hand to mouth activity (and ingestion of particles) exhibited by young children is known to place this population group at particularly high risk of metal toxicity[39].

Crops are planted in wetlands within the Witwatersrand goldfields containing elevated levels of toxic and radioactive heavy metals and on uraniferous tailings. It is well established that some plant species can accumulate metals to potentially toxic levels and that plants on tailings and AMD have elevated metal contents. Heavy metals are found to be present in a range of herbal medicines.

Risks associated with the ingestion of riverbank material by young children and pregnant mothers (the practice of geophagy — also known as 'pica' — is widespread in rural African communities) are not quantified. It is worth noticing that uraniferous salt crusts, preferably forming on low-lying floodplain sediments and river banks, were found to contain extremely high concentrations of uranium (up to 1 100 mg/kg; Winde, 2001).

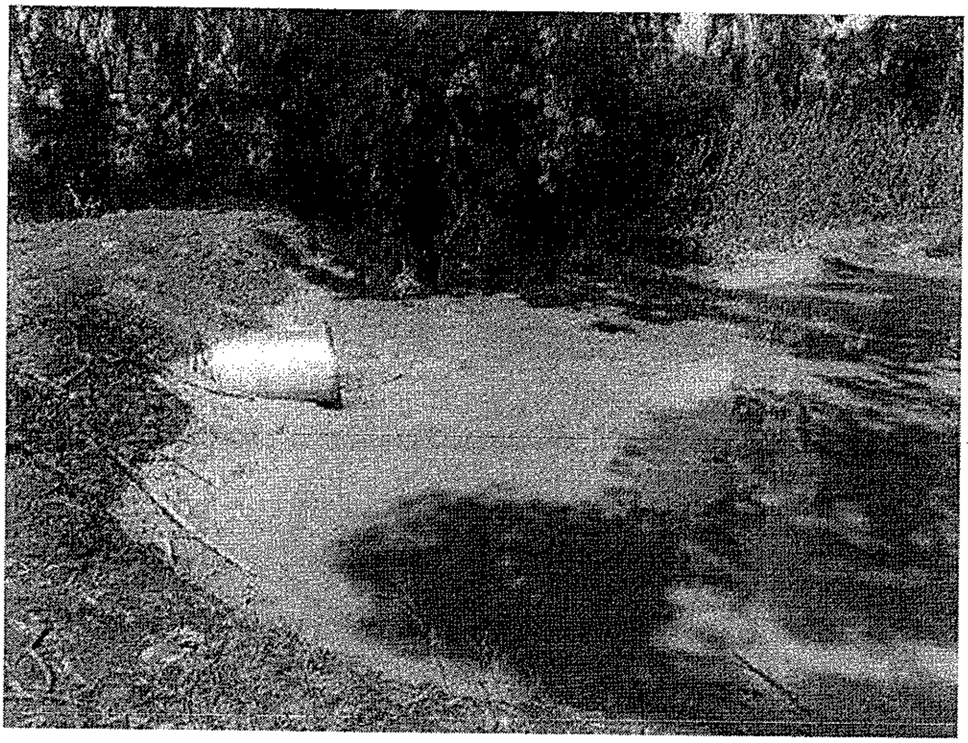
Airborne radiometric maps of the Witwatersrand goldfields show areas show the historical migration of generally elevated radioactive levels to the urban areas of e.g. the Johannesburg central business district indicating the use of mine dump and waste materials for building purposes, as well as downstream plumes in wetland areas. (Central Rand Goldfield Regional Mine Closure Strategy. DMR. 2008.)

[39] "*A GIS-Based History of Gold Mine Residue Deposits and Risk Assessment of Post-Mining Land- Uses on the Witwatersrand Basin, South Africa.*" M.W. Sutton et al. 2006.

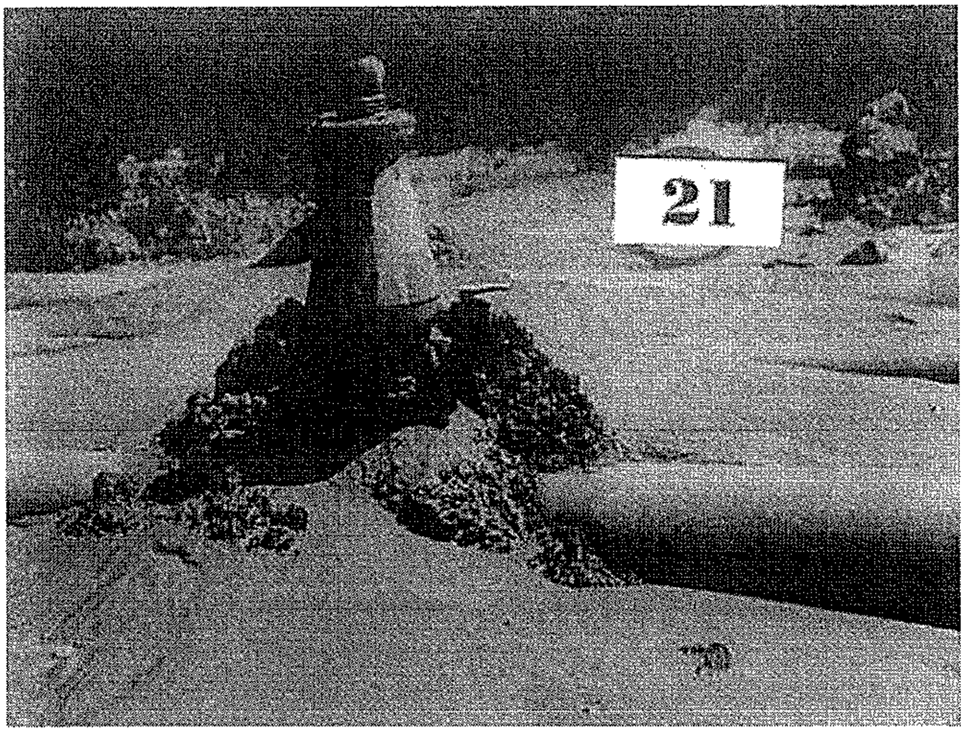


Uraniferous tailings are used for the manufacture of bricks and for construction material

Radioactive spillages continue, with little or no enforcement, mitigation or remediation, on areas that fall outside mining sites.



Radioactive spillage on public and private land flowing into Wonderfonteinspruit and adjacent to residential areas of Carletonville



Radioactive tailings spillages from tailings pipelines

The sub-population groups most at risk are the poor and inhabitants that live in informal settlements. With above-average infection rates of HIV/AIDS and chronic and acute malnutrition, this subpopulation is particularly vulnerable to additional stress of the immune system by contaminants such as uranium.

Uranium can enter the human via a number of pathways from the source, being largely tailings dams in the catchment, through groundwater, to soil, and to river water. Contaminated groundwater may also be used by humans. Principal modes of contact are ingestion of water and food products, and inhalation of dust and radon and radon gas.

In view of the South African Government's intention to include nuclear in its future energy mix and as a feasible option for reducing emissions from the electricity supply sector, there is an urgent need for regulatory decisions to be taken regarding:

a. Remediation of radioactive contamination emanating from the 120 years of poor disposal of mining wastes within the Witwatersrand Goldfield.

b. Inappropriate residential developments on or adjacent to uraniferous tailings dumps.

c. The use of uraniferous tailings for construction material for residential dwellings.

d. Uranium contamination as a result of the flooding of the mining basins with Acid Mine Water and the radon risks to informal settlements where the radioactive gas (formed ongoingly through the radioactive decay of uranium contained in the mine water) can easily accumulate in low-lying, poorly ventilated shacks which often lack concrete floors (radon exposure constitutes a severe health risk and is a leading cause of lung cancer in uranium miners).

e. The assessment of health impacts (high confidence independent epidemiological studies) upon communities within the Witwatersrand goldfields as a result of long term exposure to radioactivity. (The two major airborne risks will be due to airborne radon and windblown dust.)

SUBMITTED BY:

Mariette Liefferink.

CEO: FEDERATION FOR A SUSTAINBLE ENVIRONMENT.

31 October, 2011.