The Great Karoo region surrounding Beaufort West has been identified by a number international mining companies for uranium development projects. Various prospects exist in the area. The best known prospects are Ryst Kuil, Riet Kuil, Waterval, Damsfontein/Bloemfontein and Flagfontein.

The Uranium Project Survey (2007), performed by the Department of Minerals and Energy, estimated that South African uranium production could more than double from 1400 t in 2007 to over 2800 t in 2009, and could reach 5000 t in 2011. The survey report stated that the Uramin Ryst Kuil Channel project near Beaufort West is seen as a project that is likely to go into production in the short term. Many other prospecting licenses have also been awarded for different areas surrounding Beaufort West. (Reference: http://www.karooinvest.co.za/2701/index.html.)
Besides UraMin (owned by Areva) which plans to put their Ryst Kuil project into production by 2010, two other companies are also currently prospecting in the Beaufort West region. They are Western Uranium (49% owned by Brinkley Mining Plc) and Signet Mining.

PRELIMINARY EXPLANATIONS

The following submission include extracts of the Proceedings of the Third International Seminar on Mine Closure, 14 – 18 October 2008; “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 to the Water Research Commission, Compiled by Henk Coetzee, Council for Geoscience - WRC Report No 1214/1/06 ; ISBN No 1-77005-419-7 - March 2006; “Contamination of wetlands by Witwatersrand gold mines – processes and the economic potential of gold in wetlands” - Henk Coetzee, Jaco Venter & Gabriel Ntsume - Council for Geoscience Report No. 2005-0106; A comprehensive radiological risk assessment performed by German physicists on behalf the National Nuclear Regulator, the radiological risks to the public was published in the Report, entitled: “Radiological Impacts of the Mining Activities to the Public in the Wonderfonteinspruit Catchment Area”; “Water, mining, and waste: an historical and economic perspective on conflict management in South Africa” – Rebecca A. Adler, Marius Claassen, Linda Godfrey, and Anthony R. Turton and unless the disquisitions composing the these documents be viewed with their relations to the proposed uranium mining within the Beaufort West area and the arrangement which I give to the subject, their pertinence and importance can hardly be seen completely.

I have divided the submission in 4 parts, namely:

1. Law of Evidence
2. Historic and current management of radioactive waste
3. Case study: Radioactive waste generated from gold mining (West rand and Far West Rand):
   a. Radiological Impacts: Water
   b. Radiological Impacts: Produce
   c. Radiological Impacts: Radioactive Dust Fallout
   d. Radiological Impacts: Plants
   e. Radiological Impacts: Soil
   f. Radiological Impacts: Health
LAW OF EVIDENCE

In terms of the Law of Evidence the courts will take judicial notice of notorious facts, that is firstly, matters of general knowledge and secondly, specific facts which are notorious within a particular area. It must be notorious, either generally or within a particular area, as to be incapable of dispute among reasonably informed and educated people.

To contextualize the aforesaid legal principle within the subject matter under consideration, I argue as follows: As a consequence of the uraniferous nature of gold, the Witwatersrand tailings and other mining residues contain significantly elevated concentrations of uranium and its daughter radionuclides, with the decay series of $^{238}\text{U}$ being dominant, where uranium concentrations are expected to vary from $< 1$ ppm in the dolomitic areas to hundreds or even thousands of parts per million with more limited variation in the activities of $^{40}\text{K}$ and the $^{232}\text{Th}$ series.

Recently there has been a great deal of interest in the issue of the radiological risks within the gold mining areas of the Witwatersrand, with numerous high profile news stories dedicated to the subject. On-going concerns have been expressed by reasonably informed and educated people about the potential for these radionuclides to contaminate the natural environment, with a particular focus on the contamination of water resources. This issue is now coming to a political head in the various catchments that drain the West Rand and Far West Rand, with two being the most notable in the short-term – the Wonderfontein Spruit and the Tweelopie Spruit – draining into the Vaal and Limpopo River Basins respectively. These two drainage basins are spawning active public protests, gaining in their level of concern for human health arising from the carcinogenic properties of radionuclides and fears that radionuclides might have entered the food chain. Underpinning this is the whole issue of accountability of mine management that should have known better than to allow human beings to be exposed to potentially hazardous substances and the accountability of governmental regulatory agencies whose core function it is to protect humans for possible exposure to such harmful substances.

There are furthermore, in terms of the Law of Evidence admissibility of evidence of past misconduct or previous convictions which tends to show character.
In the context of this submission reference is made to the South African Government’s past negligence pertaining to duty to care, poor institutional control, lack of political will and commitment regarding the management of radioactive waste and enforcement of environmental legislation. With slimes dams in the goldfields of the Witwatersrand Basin covering an area of about 400km$^2$ and containing some 430 0000 tons of $\text{U}_3\text{O}_8$, they constitute an environmental problem of extraordinary spatial dimensions. Due to inadequate design, poor management and neglect, and lack of institutional control and failure by organs of state to enforce environmental laws, these tailings dams have been subjected to varying degrees of water and wind erosion. Effects range from water pollution, the result of acid mine drainage (AMD) generated mainly from sulphides in the tailings dams, and air pollution in the form of airborne dust from unrehabilitated or partially rehabilitated and reprocessed tailings dams. A number of studies carried out in the Witwatersrand have pointed to contamination of the environment in the vicinity of tailings dams by acid mine water containing elevated levels of heavy metals and radionuclides.

Direct access to mine sites may expose the public to risk due to direct external gamma radiation, inhalation and ingestion of radionuclides. To limit the risk due to external gamma radiation, the Chamber of Mines uses a guideline that each tailings deposit should have a 500m 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. Within the West Rand, East Rand and Central Rand, RDP houses have been established on the contaminated footprints of abandoned mines or directly adjacent to mines.

Figure 1 shows the surface distribution of radioactive material for the West Rand goldfield, with elevated levels of radioactivity in warmer colours. All areas shown in orange and red indicate contamination by mining activities.

Figure 1

---

1 We here allude to the:
- National Environmental Management Act, No 107 of 1998
- National Water Act, No 36 of 1998
- The Mineral and Petroleum Resources Development Act, No 28 of 2002
- The National Nuclear Regulator Act, No 47 of 1999
- The Mine Health and Safety Act No 29 of 1996
HISTORIC AND CURRENT MANAGEMENT OF RADIOACTIVE WASTE

The management and institutional control of the management of mining waste and in the case of gold mining, radioactive and chemically toxic waste, have been poor.

As at 1997, South Africa produced an estimated 468 million tons of mineral waste per annum. 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.

Legislation pertaining to the management of mining waste is currently fragmented, diverse, uncoordinated and administered by a number of different government departments.²

² Mining waste is addressed through at least two primary and eleven secondary pieces of legislation and by three primary and six secondary government departments. There is no unifying policy outlining how mining waste and mine water issues,
The interdepartmental conflicts are magnified by the shortage of governmental officials, the lack of political will and commitment on the part of some and the high turnover of government officials tasked to enforce policies pertaining to mining waste.

I could show, by many authentic and pregnant examples within the gold mining areas of the Witwatersrand, that there is a significant failure in duty of care on the part of the National Nuclear Regulator and the Department of Minerals and Energy to perform one of the weightiest of its duties, which was laid upon it, namely to protect the public, particularly the previously disadvantaged and vulnerable, from radiological and chemical toxicological risks and to enforce policies pertaining to radioactive mining waste.

CASE STUDY: RADIOACTIVE WASTE GENERATED FROM GOLD MINING (WEST RAND AND FAR WEST RAND)

I shall now argue my submissions on historical precedent and character, namely the long history of gold mining within the West Rand and Far West Rand, specifically the Wonderfonteinspruit and which are interconnected, are to be addressed. As a consequence the factors driving the management of mineral residue and mine waste are heavily fragmented between economic development and environmental protection.

The delegation of powers among agencies in the Constitution regarding the management of mining waste, has resulted in ambiguities. Until existing legislation can be enforced in a logical, organized fashion at all levels, and until the various government departments can learn how to coordinate with one another to maximize overall efficiency, conflict arising from the lack of government enforcement of current policies and their cumulative impacts will persist in South Africa.

The inability to integrate across government departments through policy leads to the mismanagement or abandonment of mine abandoned residue stockpiles and dumps that scatter the West Rand and Far West Rand. Where abandoned mine dumps remain on privately owned property, property owners have neither the mandate nor finances to remine, reuse, or rehabilitate them, making the underlying land a personal liability and difficult to sell. The result is a loss in private land value due to on-site abandoned mine dumps over which the landowners has no legal right but bears environmental and social liability, and the loss in private land value due to environmental degradation from neighbouring abandoned mine dumps. Additionally, the rock dumps and tailings dams compromise local water quality though the mobilization of chemicals from run-off and airborne particulates, which accumulate in water sources or sediment.
Tweelopiespruit Catchment areas and the historical lack of enforcement environmental legislation in the management of mine waste.

In terms of the findings of public domain official reports, I here specifically allude to the Water Research Report No 1214/1/06, entitled “An Assessment of Sources, Pathways, Mechanisms and Risks of Current and Potential Future Pollution of Water and Sediments in Gold-Mining Areas of the Wonderfonteispruit Catchment” (H. Coetzee, F. Winde and P.W. Wade), it was found that:

“…the mean values for the Wonderfonteinspruit samples … significantly 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.”

It was furthermore found that:

“...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.”
In terms of the National Nuclear Regulator’s Report, entitled “Radiological Impacts of the Mining Activities to the Public in the Wonderfonteinspruit Catchment Area”, it was found:

- The long-lasting mining related discharges of naturally occurring radionuclides from point and diffuse sources into the Wonderfonteinspruit Catchment result in a complex pattern of radioactive contamination of water bodies, sediments and soils throughout the catchment area.
- The past and present discharges of radionuclides into the Wonderfonteinspruit Catchment area as a consequence of mining activities can lead to considerable radiological impacts to the public via various exposure pathways, exceeding significantly the natural level and also the dose limit for the public of 1mSv per annum, at numerous sites.
- For approximately 50% of the 47 sampling sites, the calculated incremental doses of the respective critical group are above 1mSv per annum up to 100mSv per annum. The incremental dose at one site (Carletonville Bridge) is 578mSv per annum.
- Cattle watering at polluted surface water bodies in the Wonderfonteinspruit Catchment area causes the uptake of radioactivity with the suspended particulate matter and can cause
radioactive contamination of livestock products (milk, meat) resulting in effective doses of the public in some orders of magnitude above those resulting in the water pathway.

- Irrigation of pasture land is a very relevant exposure pathway concerning the usage of surface water bodies. Irrigation of vegetable food and fishing are important exposure pathways.
- The stay on contaminated sites and the agricultural use of land contaminated in the past, e.g. by slimes transport or dessication of former storage dams, can lead to high incremental doses.

**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.**

**Radiological impacts: Water**

The results of public domain studies indicate that uranium poses a long term hazard\(^3\) to water users in Wonderfonteinspruit catchment because of its chemical toxicity and radioactivity. The dissolved radionuclides in water and radionuclides bound to sediment determine the current and future risks to the residents within the Wonderfonteinspruit Catchment. The Wonderfonteinspruit Catchment is densely populated. The sub-population groups most at risk are the residents of informal settlements with high percentages of HIV/AIDS and chronic and acute malnutrition.

Since some of the sources of pollution are not due to direct discharge, but rather to run-off from contaminated sites, seepage from tailings dams and groundwater recharge, it can be expected that the hazards and risks identified in public domain Reports will remain for centuries after the closure of mines due to the long half life of Uranium, which is \(10^{10}\). Uranium furthermore has decay or daughter products which are radioactive as well, such as radium, radon, radon gas, strontium, bismuth, thorium and polonium. This implies a long-term responsibility to ensure that the hazard does not translate into a risk. It is also important to remember that some of the sites where these hazards exist are off mine property\(^4\).

---

\(^3\) The results of the health risk characterization are as follows: Chronic radiological (cancer) risk quotient = 2.22; Chronic chemical (nephrotoxicity) risk quotient = 6.67. An acceptable risk quotient is below.

\(^4\) Andries Coetzee Dam: 900mg/kg U
Radiological Impacts: Produce

In terms of the “Status Report on the Actions arising from the Study of Radiological Contamination of the Wonderfonteinspruit”, it was found:

- “The study undertaken by the NNR has confirmed the presence of radioactive contamination in the WCA.
- Preliminary results of analyses conducted on produce grown in the area have indicated that the dose levels are of radiological concern to the regulator.”

Radiological Impacts: Radioactive Dust Fallout

In terms of the Department of Minerals and Energy’s Regional Gold mining Closure Strategy for the Witwatersrand Goldfields (Central Rand-, West Rand- and Far West Rand Goldfields) it was found that:

- Air pollution is perceived to be a severe environmental externality which could result in health problems that include eye and skin irritations and cancers.
- Inhalation of Rn-222 daughter nuclides from radon emissions from dried out water storage dams and slimes dams.
- The inhalation of contaminated dust generated by wind erosion from slimes dams
- Contamination of agricultural crops (pasture, vegetables) by the deposition of radioactive dust particles, which can cause considerable dose contributions via ingestion.

- Upper Wonderfonteinspruit: 1 100 mg/kg U
- Klerkskraal Dam: 1 mg/kg U

16mg/kg uranium is equivalent to an activity concentration of 0,2Bq/g, the limit for regulatory control set by the NNR.

- Tudor Dam: 10 000 – 100 000 Bq/kg
- Sluice: 1 000 – 10 000 Bq/kg
- Andries Coetzee Dam: 1 000 – 10 000 Bq/kg
- Attenuation Dam: 100 – 1 000 Bq/kg
- Donaldson Dam: 100 – 1 000 Bq/kg

Regulatory Limit: 500 Bq/kg
• Because of the extremely long half-life of the major isotope of natural uranium U238 (4.7 billion a) compared with the temporal scope of this study, changes in the uranium concentration due to its radioactive decay and the migration of daughter products can be neglected.

• Particulate uranium represents an inhalation source for humans, the extent of which is dependent upon concentration and particle size. For particulate uranium to be an inhalation hazard to humans, the particulates must be in the size range of 1–10 µm (ICRP, 1979).

• Resuspension into the air can be an inhalation source even after the plume or source has disappeared.

• The health effects of uranium particles inhaled:
  o 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 (ICRP, 1994; NCRP, 1997), depending on their solubility.
  o 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.
  o Larger particles, being more susceptible to gravitational forces, tend to deposit higher in the respiratory tract. They are cleared from the respiratory tract by the formation of mucous, which is swept up into the mouth, and expurgated or swallowed into the gastrointestinal system. The latter fate of the particles is converted from the pulmonary system to the gastrointestinal system. The gastrointestinal system is more chemically aggressive than the pulmonary system, and uranium compounds that wouldn’t dissolve in the lungs may become systemically available due to chemical dissolution in the gut.
  o Acute pulmonary effects have, however, been ascribed to chemical toxicity as opposed to radiotoxicity of uranium in observations of experiments with rabbits (Morris et al., 1989).
  o However, “insoluble” particles (ICRP type S) may reside in the lungs for years, causing chronic radiotoxicity to be expressed in the alveoli.
Radiological impacts: Plants

Uranium may be transported to vegetation by air or by water. It can be deposited on the plants themselves by direct deposition or resuspension, or it can adhere to the outer membrane of the plant's root system with potential limited absorption. Similarly, uranium deposited on aquatic plants or water may be adsorbed or taken up from the water.

In terms of the Report entitled, “Radiological Impact Assessment of Mining Activities in the Wonderfonteinspruit Catchment Area” it was found that there are three significant exposure pathways that cause elevated contamination of food, namely:

- The interception of radioactive substances by the leaves from irrigation of pasture and crop vegetation;
- The uptake of suspended particulate matter by cattle during watering at the banks of surface water bodies; and
- The agricultural use of land contaminated with slimes transported by storm water runoff from slimes dams.

These three exposure pathways can lead to potential radiation exposures of the public above the effective dose limit of 1 mSv/a at about 50% of the investigated sites, with maximum estimated doses up to some tenths of mSv/a.

The plants, aquatic or terrestrial, may be eaten directly by humans, or consumed by land or aquatic animals which provide food for humans. The uptake or bioconcentration of uranium by plants or animals is the mechanism by which uranium in soil, air, and water enters into the food chain of humans.

Radiological impacts: Soil

Retention of uranium by the soil may be due to adsorption, chemisorption, ion exchange, or a combination of mechanisms (Allard et al., 1982).
In wet deposition of airborne contaminants, the uranium is washed from the atmosphere by rain, sleet, or other forms of moisture.

Uranium thus deposited (dry or wet) will usually reside on land or be deposited on surface waters.

If land deposition occurs, the uranium can incorporate into the soil or adhere to plant surfaces, be resuspended in the atmosphere as a result of wind action, or be washed from the land into surface water and groundwater.

Radiological Impacts: Health

At present, policies pertaining to mining waste and mine water management pay little attention to the short-term and long-term impacts of mining activities on human health.

Currently, the only health-related concerns that are addressed by the legislation pertain to occupational health and safety of mine workers themselves, ignoring off-mine populations.

No high-confidence epidemiological studies of off-mining populations have yet been done, and so there are no baseline data to which to compare changes in a population’s health over time.

The following are examples of decades of poor historical and current management and control of radioactive waste within the Wonderfonteinspruit Catchment Area (WCA):

Tudor Dam

The Tudor dam is located in the south eastern portion of the headwaters of the WCA. The dam was build before the establishment of Rand Water for water supply to the mine(s) in the area. The area behind the dam is currently dry and being mined to recover gold from the sediments that have accumulated as a result of inefficient mining practices by today’s standards.
At the time of the field visit it appeared that the re-mining had ceased. During the inspection there was no inflow or outflow of water and the dam was dry. There is however evidence that during rainy periods that water would flow into and out of the dam.

The soils and sediments at the site are potentially contaminated with radionuclides. There is evidence of sulphate “evaporates” on the surface of the sediments. The specific activity of uranium in the soils and sediments behind the dam are high, 8000-10000 Bq/Kg with radium 226 at 1700-2800 Bq/Kg.

Stream Bottom 150m Downstream of Tudor Dam
This site is a dry “wetland” below Tudor Dam. The channel contained well-sorted fine sediments, most likely, slimes deposited from the overflow from Tudor Dam. Uranium and radium specific activity levels were high here, at 2000 Bq/kg for uranium and 1200 for radium, as would be expected if they originated from the Tudor Dam (contamination of radioactive material exceeding clearance levels of 0.5 Bq/g per nuclide and will need to be remediated prior to the site receiving clearance).

The site presents medium-high uranium and/or radium levels, exceeding national or international standards.

Mine water from Doornfontein Shaft and Runoff Water from Slimes Dam
This area is largely problematic due to the poor housekeeping at the site. There was a leak at the pump station that was not contained and has not been addressed. There is evidence of slimes around and downstream of the pump station. There was also evidence of cattle grazing around the pump station, with relatively fresh manure directly on top of the escaped slimes. Radiation from water and the slimes was unacceptable, according to the reports, particularly in the form of radium, at 1750 Bq/kg.
The area behind the Lancaster Dam appeared to have filled with slimes that have recently been mined. The Dam had been breached by heavy equipment so as to allow acidic slimes water and fine slimes to drain into the pond and wetland immediately below the dam. On this downstream side of the dam, there is an orange pool of settled slimes, filled with acid mine drainage water, where there are few plants and signs of dead wildlife. Dry slimes were observed blowing throughout the Lancaster dam site. Drainage of water from this area was ongoing at the time of the site visit.

As the site presently exits it is suspected that acutely toxic acidic drainage is currently draining from the site through the breach in the dam into the pond and wetland immediately below the dam. Because of the lack of any flow restriction this could become an extremely serious situation following a heavy rainfall. The main pollutants are suspected of being acidic water and associated toxic metals arising from oxidation of sulphides such as iron sulphide, also known as pyrite. The stream presently passes through the breach in the Lancaster Dam, with visible seepage of slimes from the Lancaster Dam into the stream which forms the upper Wonderfonteinspruit.

The relevancy of the aforesaid findings to the proposed mining of uranium within the Beaufort West area is as follows:

1. In view of the historic and current institutional management of radioactive waste, we have little confidence in the political will and commitment and capacity, including the preservation of institutional memory, of organs of state, whether in the local, provincial or national sphere of
Government, to monitor or manage radioactive waste and to enforce infringements of the principles of environmental legislation.

2. The cumulative impacts of all pathways must be included in the impact prediction of radioactive contamination.

3. An impact prediction of all sources of risk (source term) of radionuclides and the impact upon the surface and groundwater must be conducted.

4. A high confidence, independent epidemiological study of adjacent communities must be done with baseline data to which to compare changes in the sub-population group’s health over time.

SUBMITTED BY:

MARIETTE LIEFFERINK.
CEO: FEDERATION FOR A SUSTAINABLE ENVIRONMENT

DATED: March 14, 2009