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STAKEHOLDER ACCORD ON WATER CONSERVATION

Review of Water Quality Reports and Catchment Management Plans

Summary of the Water Quality Risks

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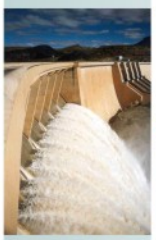

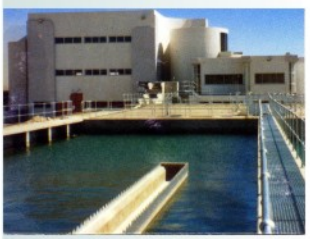

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1 INTRODUCTION

1.1 Background

The draft water quality review and recommendations for implementation was submitted to the CPG for their comments and inputs. A number of issues arose from the comments which needed to be addressed in a workshop environment where inputs, opinions and expert knowledge from water quality experts could be used to finalise the draft document.

A workshop was called for the CPG and water quality experts to review the approaches and provide input to the findings of the review. A consensus seeking workshop was held on the 1st December 2009 at which Government, Business and Labour were represented. As the water quality sector experts were limited it was agreed that the proceedings be forwarded to the representatives at the meeting who will distribute to their respective experts for input. The representatives would then consolidate the comments and provide to the PSP within 5 working days of receiving the document.

This document should be read in conjunction with the report, "*Consolidated recommendations on South African Water Quality"*, dated August 2009.

1.2 Objectives of the water quality review

1.2.1 Overall objectives

The objectives of the water quality review were to undertake the following:

- Review the risk assessment profile used in the ranking of the water quality issues discussed in the water quality document. This involved the need to agree on the rankings for the probability or frequency of occurrence and the consequences of the water quality impact occurring.
- Review the water quality categories identified in this discussion document and update the water quality indicators, if necessary.
- Using a consensus process, undertake a ranking of the water quality impacts with inputs from water quality specialists based on their expert knowledge.
- Provide recommendations on the management of the water quality risk categories in accordance with the ranking conducted in a consensus seeking workshop environment.

1.2.2 Purpose of this document

The purpose of this document is to provide a summary of the local literature review of the water quality categories and the risk based approach that was used with input from the focus group to prioritise the water quality categories in terms of the magnitude and extent of their impacts and the probability or frequency of the water quality categories occurring.

Furthermore the document presents a summary of the recommendations on the management of the water quality categories or challenges in accordance with their ranking.

1.3 Structure of the document

Chapter 1 provides an overview of the water quality review undertaken and the objectives of the review.

Chapter 2 provides an outline of the water quality challenges identified from the source material reviewed.

Chapter 3 documents the additions and changes made to the key water quality categories identified.

Discussions on the proposed approach on the water quality risk assessment are documented in Chapter 4.

Chapter 5 provides the ranking of water quality impacts.

Chapter 6 provides a summary of the recommended management options of the water quality risk categories described in chapter 5.

2 OVERVIEW OF KEY WATER QUALITY CHALLENGES

2.1 Overview

The key water quality challenges facing South Africa were identified by the review and summarised below in terms of their root causes and the typical consequences for different user groups. An indication of the prevalence of each risk is also provided. It should be noted that the water quality challenges that have been evaluated are not the full list. Other aspects, such as radionuclide contamination, oxygen depletion and solid litter have not been reviewed in more detail because of lack of sufficient data and information to undertake the review.

2.2 Salinity

Salinity was found to be a problem afflicting surface and groundwater in most WMA's.

The root causes of salinity increases were generally described as the following:

i. Leaching from geological formations due to irrigation, with the extent of contamination driven largely by the characteristics of the formation involved (Kirchner, 1995);
ii. Land use practices, specifically where underlying geology is disturbed by agricultural or mining activities (e.g. Herold and Bailey, 1996, Kirchner, 1995 and Greef, 1990, Herold et al, 1996);
iii. Point discharges from industrial and mining activities (DWAF, 2008);
iv. Non-point source pollution from evaporation pans used in the gold mining industry (Herold et al, 1996) and from mine decants;
v. Aerial deposition of pollutants from activities, such as from coal power generation emissions (Pitman, Bailey and Beater, 2002)

Salinity affects all user groups, with the magnitude of the impact dependent on the level of contamination as well as the specific ionic species involved.

2.2.1 Health-related consequences of salinity

High salinity levels pose health risks to domestic consumers as well as livestock, and cause foliar injury to plants. The specific health impacts are related to the ionic composition of the contaminants. At the concentrations typically prevalent in South African water resources, it seems as if the health impacts are moderate.

2.2.2 Economic consequences of salinity

As shown by the Middle Vaal salinity study, high salinity imposes costs on all user groups, particularly the household sector (due to the costs of personal care products, soaps and detergents and home appliance purchases), industries that treat incoming water for salinity and the agricultural sector, where crop yields are negatively impacted. In mining, the biggest impacts were found to be those associated with evaporative cooling circuits, where more water was required due to increased blow down volumes, and increased treatment chemicals

were necessary. In the services sector, the primary impact of rising salinity was found to be an increase in replacement frequency for appliances and increased maintenance costs.

2.2.3 Environmental consequences of salinity

The impact of salinity on the environment depends on concentration and ionic composition, and at extremely high levels of salinity, the environment could be modified. Increased TDS tends to increase water clarity and hence the depth of the euphotic zone, which affects algae growth. The health of fish and aquatic organisms is also negatively impacted at high salinity levels. High sodium levels were found to increase the dominance of blue-green algae at concentrations above 40 mg/l in the Vaal River (Pieterse and Janse van Vuuren,1997) demonstrating the influence of ionic composition.

2.3 Eutrophication

Both the WMA situation assessments and the WRC reports have shown that eutrophication is a widespread problem in South Africa. It is furthermore a problem that has been in existence for some time, and is not showing any signs of abating (Walmsley (2000).

Eutrophication arises when nutrient levels (specifically levels of phosphorous and nitrogen) exceed the assimilative capacity of watercourses, the root causes being largely (After Walmsley, 2000):

i. Point source discharges from wastewater treatment works, particularly where phosphorous levels are high due to insufficient treatment;
ii. Maintenance and management problems associated with sewerage infrastructure;
iii. Urban runoff, particularly where sanitation services are lacking or inadequate;
iv. Agricultural runoff, both from livestock wastes and due to fertiliser inputs and animal feeds;
v. Nutrient inputs from domestic wastes such as detergents as well as certain foods;
vi. Nitrogen contribution by the burning of fossil fuels and wood.

2.3.1 Health-related consequences of eutrophication

Certain types of algae produce toxins with serious human and animal health consequences. The cyanotoxins produced by blue-green algae are known to be carcinogenic for example, and these may be carried through into purified drinking water, or absorbed by aquatic organisms and passed up the food chain. Vulnerable groups that use raw water for domestic purposes are exposed to heightened risk. Eutrophication can also lead to the production of trihalomethanes during chlorination in water purification plants, which are known carcinogens. The health-related impacts of the root causes of eutrophication, which include exposure to pathogens, are considered under Bacterial and Viral Pathogens.

2.3.2 Economic consequences of eutrophication

Eutrophication imposes economic costs on many user groups. In agriculture, algae and aquatic macrophytes interfere with the operation of irrigation and conveyance systems. Eutrophication can impact negatively on the recreational value of water and reduce water

resource yields through increased evapotranspiration losses from floating and rooted macrophytes. Water purification costs are also increased, both for water Service Authorities as well as for industrial users that treat their own water. The impact of eutrophication on aesthetics may also affect property values.

2.3.3 Environmental consequences of eutrophication

Eutrophication leads to significant modification of water quality due to the physical and chemical changes that accompany the growth of algae and macrophytes. Rooted macrophytes can modify streamflow conditions, and together with algae, impact on predation. While algae can increase dissolved oxygen levels due to photosynthesis, the death of algae populations depletes oxygen levels and has been known to result in fish kills. The ionic composition of water resources can be altered, together with nutrient levels as a result of the metabolism of algae populations.

2.4 Estrogen and estrogen-mimicking substances

Estrogen and estrogen-mimicking substances were shown in the reports reviewed to be prevalent in a wide range of household, pharmaceutical, industrial and agricultural products. High incidence of contamination is indicated in crop-growing areas of South Africa, in areas where malaria is controlled using DDT, and in the Pretoria, Johannesburg (Witwatersrand) and Vereeniging areas. The fact that aldicarb and dioxins were excluded from the review suggests a wider prevalence than indicated, since these substances are used and produced by certain sectors of the South African economy.

The root causes of contamination, based on this review, are:

- Point discharges from industries that manufacture these substances;
- Household effluents;
- Some insecticides and herbicides used in the agricultural sector;
- Aerial deposition of substances produced through combustion, such as dioxins;
- Effluents from industries which produce these substances as by-products e.g. dioxins, furans and polychlorinated biphenyls are produced during chlorine and chlorine dioxide bleaching of pulp in the pulp and paper industry.

2.4.1 Health-related consequences of estrogen and estrogen-mimicking substances

Estrogen and estrogen-mimicking substances have severe endocrine effects on humans and animals, mimicking hormones and impacting on sexual development. Toxic effects include carcinogenicity.

2.4.2 Economic consequences of estrogen and estrogen-mimicking substances

The economic impacts of these substances are all related to their impacts on human and animal health. These are addressed elsewhere.

2.4.3 Environmental consequences of estrogen and estrogen-mimicking substances

The environmental consequences of pollution of water resources with these substances are their impact on animal reproduction and their propensity to cause birth defects. Local populations in affected areas could be reduced in number due to fatalities and a reduction in their ability to compete. Importantly, many of these substances are bio-accumulators, becoming more concentrated in receiving tissues over time with ongoing exposure. Many of them also tend to be persistent in the environment.

2.5 Pesticides/Insecticides

Pesticide/insecticide contamination is generally restricted to agricultural environments in South Africa, though it must be said that a review of the impact of household pesticides was not conducted as part of this study.

The root causes of contamination of water resources are:

i. Crop spraying in agricultural environments, with pollution of water resources arising from irrigation washoff and spray drift (Sereda and Meinhardt, 2000);
ii. Lack of practical knowledge by farmers as regards pesticide safety and disposal and the risks posed to human health and the environment;
iii. Over-use of pesticides/insecticides as opposed to an integrated pest management approach.

The consequences of pesticide contamination are human and animal-health related, comprising endocrine and toxic effects, and they have similar effects as estrogen and estrogen-mimicking substances (in fact some pesticides are estrogen-mimicking substances).

2.6 Bacterial and Viral Pathogens

Bacterial and viral pathogens are a widespread problem in South Africa's water resources, as shown by the studies reviewed. Surface water risks regarding faecal contamination are at least at a medium level within catchments in 12 of the 18 WMA's reviewed, and all WMA's reviewed exhibited risks of groundwater contamination based on aquifer vulnerability.

The root causes of microbial and viral pathogens in water resources may be summarised as:

i. Poor water and sanitation provision;
ii. Discharges of poorly disinfected treated sewage from wastewater treatment works;
iii. Discharges of raw sewage;
iv. Urban runoff;
v. Agricultural runoff, specifically from livestock and facilities such as feedlots;
vi. Harbouring of microbes in sediments, with suspension in the water column during storm events or other disturbances;
vii. Storage in animal reservoirs, with subsequent pollution of water resources;

viii. Potential infection of environmental strains by phages, leading to development of virulence factors.

2.6.1 Health-related consequences of bacterial and viral pathogens

Health-related consequences of water-borne pathogens are generally in the form of diarrhoea and dysentery, in some cases leading to fatality. Bourne and Coetzee (1996) found that mortality as a result of water-related diseases was widespread, and that mortality as a result of water-related diseases comprised almost 3% of all deaths in South Africa in 1990. It is generally the poor; the immune-compromised; the young and the elderly, who do not have access to treated potable water that are most at risk.

2.6.2 Economic consequences of bacterial and viral pathogens

Heavy pollution can affect the cost of disinfection at water purification plants. Irrigation with contaminated water can also affect the economic value of crops, and prevent access to markets. There are also costs associated with the productivity losses that accompany illness and public health costs due to illness and deaths.

2.6.3 Environmental consequences of bacterial and viral pathogens

The environmental consequences of bacterial and viral pathogens are limited to those organisms that affect both animals and humans. None of these is considered to have serious environmental impacts, based on the studies reviewed.

2.7 Suspended Solids

Suspended solids are a problem in evidence in most WMA's, as indicated by the sediment yields identified by the review and contained in Table 26 of the Consolidated recommendations report. It receives special mention as a particular problem in the Upper Orange WMA, and is highlighted in the review of water quality problems in the Umtata River (Fatoki and Muyima, 2003) and as a consequence of small-scale mining (Heath, Moffet and Banister, 2004). O Keefe *et al* (1996) also reported turbidity problems in the Buffalo River.

The root causes of suspended solids problems in water resources are generally related to land use practices, particularly those involving removal of natural vegetation. In the case of agriculture, farming practices can have an impact e.g. the use of mulching can assist in reducing erosion. Mining is shown to have a serious impact over the entire life cycle of the mining process, including at the end of a mine's life, when rehabilitation becomes critically important. Activities in the instream and riparian zones are of particular importance in terms of their impact on erosion. Urbanisation also contributes to erosion as developments replace natural vegetation, and also due to the extensive disturbances during the building phase.

2.7.1 Health-related consequences of suspended solids

In themselves, suspended solids are not responsible for serious health effects. They do however harbour pathogens and other harmful substances such as heavy metals, which is discussed under the Pathogens and Heavy metals sections.

2.7.2 Economic consequences of suspended solids

High levels of suspended solids can increase water purification costs for Water Services Authorities and for industrial abstractors and mines. Suspended solids also reduce the effective capacity of impoundments.

2.7.3 Environmental consequences of suspended solids

Filter feeders are particularly affected, and ecological changes could also occur due to the impacts on predation, as predators find it more difficult to see their prey.

3.1 Heavy metals / Toxic trace elements

The review material did not carry extensive coverage of heavy metal contamination in South African water resources, aside from cadmium and lead pollution identified in the Umtata River (Fatoki and Muyima, 2003). The WMA situation assessments did however indicate a number of cases of metal pollution involving heavy metals and other metals. Included here are radionuclides arising from gold mining in the Middle Vaal WMA, chrome and vanadium pollution in the Olifants WMA, arsenic in the Mzimvubu to Keiskamma WMA and several cases of iron and manganese pollution. The number of failures in treated water at WSA's nationally also suggests that heavy metal pollution in raw water is potentially widespread.

Heavy metals form a natural part of the geology, and may be leached into water resources through natural processes. It is however when the geology is disturbed that contamination is promoted, and also when natural resources are beneficiated in industrial processes. The root causes of heavy metal pollution include the following:

i. Leaching from mine wastes such as tailings stockpiles and dams;
ii. Aerial deposition. For example, mercury is deposited on land and in water resources as a consequence of coal combustion;
iii. Mobilisation due to changes in redox potential arising from problems such as acid mine drainage.
iv. Industrial effluents may contain heavy metals, which may be components of some of the process aids and raw materials used.

2.7.4 Health-related consequences of heavy metals

Heavy metals are bio-accumulators, toxic at high concentrations, carcinogenic and also result in neurological defects.

2.7.5 Economic consequences of heavy metals

Heavy metals can increase water treatment costs. They can also interfere with chemical and biochemical processes in some industries, impacting on product quality and yields. In agriculture, livestock health can be affected with economic consequences.

2.7.6 Environmental consequences of heavy metals

Heavy metals affect the health of animals, in some cases leading to death, and pollution can affect population dynamics.

2.8 Acid Mine Drainage (AMD)

Acid mine drainage primarily arises from gold and coal mining activities, and is hence geographically restricted to these mining areas. It is specifically mentioned as a concern in the Olifants WMA Situation Assessment, and by Hodgson *et al* (2007), who estimate that discharges from Mpumalanga's coal mines will eventually reach 360 ML/day. Hence while the problem may initially be localised, the destructive capacity of AMD can be substantial.

The root causes of AMD are to do with the oxidation of pyrite in coal and gold mining. There are management actions that can be taken to alleviate AMD, specifically the exclusion of air through mine flooding at the end of the life of the mine.

2.8.1 Health-related consequences of AMD

The health-related consequences of AMD are a combination of the impacts of increased salinity and heavy metals contamination, including radionuclide contamination.

2.8.2 Economic consequences of AMD

The economic consequences of AMD are similar to those for salinity and heavy metal pollution. They include costs to users that are associated with water treatment.

2.8.3 Environmental consequences of AMD

The consequences of AMD include increased salinity, the mobilisation of heavy metals (including radionuclides) and reduced pH, all of which impact negatively on the aquatic environment as well as on animals and birds using the affected resource.

2.9 Solid Litter

The review did not contain sufficient information to evaluate the national extent of the solid litter problem.

The root causes of solid litter pollution involve issues of education and capacity building in communities and issues of service delivery.

Solid litter pollution can affect the instream and riparian habitat through the transport of pathogens and interference with natural streamflow. Municipal stormwater infrastructure can also be impacted.

2.10 Dissolved Oxygen

The review did not contain sufficient information to evaluate the national extent of the dissolved oxygen problem.

The root causes of low dissolved oxygen levels in surface water resources are related to the presence of organic materials arising from the following sources:

i. Discharges of effluents from wastewater treatment works;
ii. Discharges of raw and partially treated sewage;
iii. Discharges of industrial wastes containing organic materials, for example from agro-processing facilities;

iv. Discharges of domestic wastes and leaching from landfills;

Low oxygen levels also arise from secondary effects of the above, for example the death of algae, or the impact that algae have on dissolved oxygen levels at night (during the day algae increase the dissolved oxygen level due to photosynthesis)

The consequences of low oxygen levels are firstly on aquatic life, which is negatively impacted at dissolved oxygen levels below 5 mg/l (Fatoki, Gogwana and Ogunfowokan, 2003). This is then followed by impacts on water quality due to the impact on the natural assimilative capacity of the water resource.

2.11 Water Quality Categories

2.11.1 Overview

It is acknowledged that the list of the water quality challenges provided and discussed in the previous sections of this chapter is not comprehensive. However, the lack of source material limited the consideration of variables. Through a water quality workshop environment, other water quality categories or variables were identified and debated for their inclusion into the existing water quality categories risk assessment.

The DTI noted that the water quality list was approved by the CPG and requested that if a sector wants to add a variable to the list it should be recorded in the document but no further work will be done in this project. Other variables considered by the workshop include:

- Carbon dioxide in the form of Acid rain
- Radioactive nuclides which can be considered under metals
- Pesticides which rather be debated under Hormone disruptors

Labour questioned the inclusion of river health variables into the list, however it was indicated that these are not impacts or challenges but rather relate to resource management. The request for the ecological variable requirement was later withdrawn as it was agreed that water quality variables impact on the ecology and health of the ecosystem.

2.12 Estrogen and estrogen-mimicking substances

Although the water quality review focused on estrogen and estrogen mimicking substances, this category is much broader. Through the workshop discussions, this water quality category was broadened to include hormone or endocrine disruptors emanating from the plastics production chain.

Therefore in undertaking the water quality risk assessment, the estrogen and estrogen mimicking substances have been included into the Persistent Organic Pollutants (POPs) and hormone disruptors water quality category.

2.13 Acid Mine Drainage

Much discussion was had as to whether Acid Mine Drainage (AMD) should be listed as a water quality variable as it is a process or a consequence rather than a variable. It was

argued that AMD is a risk to the source rather than a risk to the resource as are the other variables listed. It was finally agreed that AMD should remain on the list as it is a water quality challenge. ADM and salinity should be closely linked in the prioritisation of risks and when considering recommendations in addressing the water quality challenges.

3 APPROACH ON UNDERTAKING WATER QUALITY CATEGORIES RISK ASSESSMENT

3.1 Overview

The approach for the risk assessment of the water quality categories that were reviewed in the previous chapter based on a risk based approach was a generally accepted methodology. The quantification of the water quality risks is typically carried through the assessment of the impact (i.e. the consequence) of each water quality category and the probability of its occurrence.

In order to manage the risks related to the water quality challenges, a risk based approach was adopted for the prioritisation of the different water quality issues. This is the likelihood of a specified water quality event occurring within a specified time period or under specified circumstances. The magnitude of the water quality risk and therefore the ranking of such as risk can be illustrated on a plot of the probability or frequency of occurrence versus the consequences of the water quality risk occurring.

The risk equation used is as follows:

*Risk = Frequency * consequences of failure; or*

*Risk = Probability * consequences of failure*

Before undertaking a risk assessment of the water quality categories / challenges one needs to question what the risks are and to whom. There are three major dimensions that society is concerned about. The three dimensions include: (i) the consequences to human health, (ii) the consequences to the environment and (iii) the socio-economic consequences of the risk occurring.

A consensus seeking facilitated workshop approach with water quality specialists was used to prioritise the identified water quality challenges.

3.2 Outcomes of discussion around approach to water quality risk assessment

It was agreed that a multi-dimensional risk analysis be conducted, considering the ecology, economic and health risks. It was further agreed that the social dimension be added to the risk analysis profile. This will incorporate factors such as impacts on livelihoods and subsistence and cultural norms, values and beliefs.

The workshop also highlighted that the definition of economy should not just be GDP, but rather be described at two levels. Certain impacts can have an impact on society, for example employment while not having a great impact on the contribution to the macro-economics. For example small scale farmers are also affected by salinity and a recommendation from this study for the WRC to look at water quality impacts on poor, small scale farmers should be made.

The Labour representative noted that chronic diseases are under reported and have a political cost due to hospitalisation fees, etc. The chronic nature of some of the variables must be considered. The long term exposure risks do not kill a person immediately, but can cause long terms effects.

He also noted that the effects of carcinogenics and POPs are not easily identified.

It was requested that the human health and where appropriate the other consequences be captured in 2 dimensions, namely direct and indirect. The Team was referred to work done by Scorgie in 2004 specifically in the Vaal River for the methodology to assist in relating the consequences to scale of impact.

Based on the outcome of the workshop, where there is not enough data on a variable to do the risk assessment, the best risk assessment from input of the focus group was used.

The ranking scale used for the consequences is contained in **Table 1**.

Table 3:1: Ranking Scale Used to Assess Consequences of Water Quality Challenges

RANKING	HUMAN HEALTH		ENVIRONMENT	ECONOMIC	SOCIAL
	Direct Impacts	Indirect Impacts			
5	Fatalities Hospitalisation with long term effects.	Complete loss of skills due to health	Irreversible impact on national or primary catchment scale	> billions .	High number of people experience Loss of livelihood
4	Hospitalisation with no long-term effects, Medical treatment with long-term effects	80% of working days lost	Serious but resilient to recover on a national or primary catchment scale.	<billion but > 100 million.	Moderate impact on loss of livelihood (<50%). Difficult to recover High cultural impact
3	Medical treatment with no long term effect.	50% of working days lost	Moderate impact at a local or quaternary catchment scale.	>1 million but < 100 million.	Moderate impact on loss of livelihood (<50%), can recover by next season Moderate cultural impact (loss of rituals)
2	Discomfort with minimum treatment.	20% of working days lost	Minor to moderate impact at a local or quaternary catchment scale.	< 1 million.	Minor impact on livelihood
1	No health impact or	No of working days	No measurable impact on the	No measurable	No measurable impact on the

RANKING	HUMAN HEALTH		ENVIRONMENT	ECONOMIC	SOCIAL
	Direct Impacts	Indirect Impacts			
	injuries.	lost	environment.	associated costs.	livelihoods or culture of people

3.3 Outcomes of discussion around probability ranking

The workshop attendees thoroughly discussed the probability ranking to be used. It was agreed that the frequency description under ranking 5 be changed to Certain or Very Likely rather than Almost certain. It was noted that the percentage probability is a classic standard approach used.

The agreed to ranking of probability of occurrence of water quality risks is provided in **Table 3.2 below.**

Table 3:2: Ranking scale to determine the probability of the risk occurring

RANKING	DESCRIPTION	FREQUENCY	PROBABILITY (%)
5	The event is expected to occur most of the time	Very Likely	90.1 - 100
4	The event will probably occur	Possible	30.1 - 90
3	The event may occur	Low	15.1 - 30
2	The event may occur under exceptional circumstances	Unlikely	5.1 – 15
1	The event is no foreseen to occur	Unforeseen	< 5

4 SCORES AND RANKING OF WATER QUALITY IMPACTS

4.1 Scoring of water quality impacts

A consensus seeking approach was used in the determination of the probability and impact scores of the updated water quality categories**.**

Some changes were requested to the water quality classes for example:

- pH (acidity of water) was requested to be changed to AMD.
- Fish kill was removed as it is not a water quality class.
- Estrogen and estrogen mimicking substances were changed to Hormone disruptors and POP as agreed to at the beginning of the meeting.

The frequency was based on the regularity of the variable getting into the resource and the extent of the problem.

Table 4:1: Scoring for water quality classes

WATER QUALITY CLASSES	FREQUENCY	CONSEQUENCES			
		Environment (ecosystem)	Health	Economic	Social
Nutrients (Eutrophication)	4	5	3	5	4
Heavy metals	3	3	4	3	2
AMD impacts	4	4	3	5	4
Salinity	3	4	2	5	3
Suspended solids	2	4	2	3	3
Dissolved Oxygen	2	4	2	3	4
Bacterial & Viral pathogens	5	3	5	5	5
Hormone disruptors / POPs	3	4	4	3	3
Pesticides/Insecticides	3	3	3	3	3
Solid Litter	3	4	2	2	4

4.2 Scoring for frequency

The scoring for AMD was difficult, with the final score for frequency equalling 4 as agreed to by Business and Government. Labour felt strongly that is should score a 5 with regard to its frequency of occurrence. According to Government there is a 100% certainty of mines producing AMD, however the potential of it entering the resource was less likely resulting in a frequency less than 5.

Labour felt a scoring of 3 on frequency of occurrence of Hormone disruptors and POPs was reasonable due to all urban areas dependent on pharmaceuticals and plastics and the spraying for malaria control purposes. Government and Business considered a score of 2 for

frequency to be appropriate. The final recommendation however was a score of 3 on frequency.

4.3 Scoring for consequences

Nutrients (cause of eutrophication) affected all dimensions, with ecological environment and economics receiving a very high score. The motivation for the scoring provided includes:

- Resultant algal blooms are problematic for all sectors, particularly on the economic costs.
- Nitrates are harmful to young babies – health impacts
- Consequences of algal blooms affects the quality of life, recreation (economic), property values,
- Certain types of algae produce toxins with serious human and animal health consequences. Cyanotoxins may be carried through into purified drinking water or absorbed by aquatic organisms and passed up the food chain.
- Eutrophication leads to significant modification of water quality due to the physical and chemical changes that accompany the growth of algal and macrophytes.
- Oxygen depletion and fish kills are common results of algal blooms.

The consequences of **Bacterial & Viral Pathogens** were found to impact the economic, human health and social dimensions greatly. The motivation for the high scoring includes:

- Economic effects on export market (fruit) and domestic water supplies - treatment costs.
- Health related - diarrhoea and dysentry, in some cases can be fatal.

The impacts of **AMD** on the economic sector were found to be the greatest, followed by the social and environmental dimensions. The consequences of AMD in the resource affect the following:

- Economic costs associated with water treatment, similar to those of heavy metal and salinity pollution;
- social amenities, livelihoods;
- health related impacts which are a combination of increased salinity and heavy metal contamination, including radionuclide contamination.

Motivation for the scoring of **heavy metals** includes:

- Heavy metals affect the health of animals in some cases leading to death.
- Heavy metals can increase water treatment costs and can interfere with chemical and biochemical processes in some industries, impacting on product quality and yields.
- Livestock health can be affect with economic consequences.
- On human health, they are bio-accumulators, toxic at high concentrations, carcinogenic and result in neurological defects.

The impact of **salinity** was the highest on the economic dimension followed by the environment. The impacts include:

- Health risks to domestic consumers and livestock.
- Imposed costs on all user groups, particularly the household sector.
- High requirement to use more water to dilute salinity, or example in the Vaal Barrage.

- High salinity affects health of aquatic organisms and fish and can increase the dominance of blue-green algae.

Suspended solids seem to effect the environment the most followed by the economic and social dimensions. The effects include:

- The cloaking of pathogens and other harmful substances such as heavy metals.
- Can increase water purification costs.
- Reduce the effective capacity of impoundments.
- Filter feeders are affected
- Ecological changes occur due to impacts on predation.
- Limited light penetration affecting aquatic life.

Dissolved oxygen has a high media effect due to fish kills, possibly related to algae die-off and thereby having an impact on the social dimension including recreation.

Hormone disruptors and Persistent Organic Pollutants scored highest for the environment and human health dimensions, resulting in severe endocrine effects on humans and animals. These products are carcinogenic.

Pesticides and Insecticides scored equally across all sectors at 3. The impacts related to human and animal health comprising endocrine and toxic effects.

Solid Litter scored a 4 for the environment and social areas. Solid litter can affect instream and riparian habitat, through transport of pathogens and interference with natural streamflow and thereby negatively affect the biota. It can also affect municipal stormwater infrastructure.

4.4 Results of the water quality risk assessment

It was recommended that a priority ranking be done for the 4 areas (economic, social, human health and environmental) only and no aggregate ranking conducted. Labour however indicated that they would like to have an aggregate score in order to identify the priority across all sectors/areas to show the priority or sense of social urgency. The risk per dimension is provided in **Table 4.1**.

These risks were then prioritised in terms of **Table 4.3**.

Table 4:2: Priority ranking for the water quality classes

WATER QUALITY CLASSES	RISK

	Environment (ecosystem)	Health	Economic	Social
Bacterial & Viral pathogens	15	25	25	25
Nutrients (Eutrophication)	20	12	20	16
AMD impacts	16	12	20	16
Salinity	12	6	15	9
Hormone disruptors / POPs	12	12	9	9
Heavy metals	9	12	9	6
Pesticides/Insecticides	9	9	9	9
Suspended solids	8	4	6	6
Dissolved Oxygen	8	4	6	8

Table 4:3: Risk categories

Risk	Risk category
21-25	very high risk
16-20	high risk
6-15	Moderate risk
1-5	low risk

The top three water quality risk categories across all dimensions include the Pathogens presenting the highest risk, followed by nutrients causing eutrophication and acid mine drainage.

5 CONSOLIDATED RECOMMENDATIONS AIMED AT ADDRESSING WATER QUALITY CHALLENGES IN SOUTH AFRICA

5.1 Overview and Methodology

The authors of the reports reviewed in this study made various recommendations. These recommendations address specific problems or risks identified in the course of carrying out the research covered in each report. The recommendations, outlined in detail in Appendix 1 of the report, "*Consolidated recommendations on South African Water Quality",* vary widely in terms of:

i. The level of detail they entail;
ii. The geographic scope of their applicability i.e. some apply to local environments while others are applicable at the national or policy level;
iii. Their relevance, given their age – some of the recommendations are from studies that are over a decade old. The relevance of these studies, particularly those entailing operational management type issues is questionable;
iv. Their practical relevance to the stakeholders who commissioned this study – this applies particularly to those studies which are focused on research, and whose recommendations are aimed at promoting further research on the study topic;

It should be clear from the above, and from a first-hand review of the recommendations outlined in Appendix 1 that many of the recommendations are not in a form that is suitable for the purposes of this study. The recommendations therefore were converted to a suitable form using the following approach:

i. Recommendations pitched at a policy level were presented in their original form;
ii. Situational recommendations dealing with operational issues in local environments were excluded;
iii. Recommendations dealing with specific research topics were considered to be outside the scope of this review and were hence excluded;
iv. Where recommendations were not made, but were deemed necessary, recommendations were proposed;
v. Similar recommendations were clustered together and used to synthesise policy-level recommendations suitable for discussion.

5.2 List of Recommendations for the very high risk water quality categories

Table 5:1: Recommendations Regarding Bacterial and Viral Pathogens

CLUSTERED RECOMMENDATIONS	FINAL RECOMMENDATION
An interdisciplinary working group representing research councils in the medical and water fields as well as the government departments of Health and Water Affairs and the agency responsible for water and sanitation provision should be established to look into the extremely high prevalence of mortality from intestinal infectious diseases.	Multidisciplinary task team to be established to determine the root causes of the high prevalence of mortality from intestinal infectious diseases propose solutions and oversee their implementation.
Ongoing surveillance of mortality due to intestinal infectious diseases should be carried out.	Ongoing surveillance of national mortality due to intestinal infectious diseases to be carried out.
Identify microbiological hotspots requiring urgent attention.	Microbiological hotspots requiring urgent attention in different parts of the country to be identified and action plans developed together with responsible local authorities.

Note that while it may appear that there are a limited number of recommendations to address bacterial and viral pathogens, many of the root causes of these problems are dealt with through the recommendations that address the eutrophication problem. Eutrophication was identified in the risk assessment to be high risk

5.3 List of Recommendations for the high risk water quality categories

Table 5:2: Eutrophication

CLUSTERED RECOMMENDATIONS	FINAL RECOMMENDATION
The national eutrophication problem to be quantified in terms of its extent, trends, the sources of nutrients and the extent of nutrient enrichment of aquatic systems and the social and economic costs of the problem; Implement nutrient source monitoring plans; A eutrophication monitoring information system to be developed and managed.	A national eutrophication monitoring system to be developed and implemented.
A National Eutrophication Strategy to be established within the National Water Resource Strategy; A Eutrophication Strategy to be established within each Catchment Management Strategy; Land-based control measures to be incorporated into eutrophication policy; A eutrophication workshop to be held to develop cooperative structures, identify research gaps and priorities and develop a programme of action.	A National Eutrophication Strategy, developed with input from all stakeholders, is to be established within the NWRS. This strategy is to take due consideration of the impact of land use practices on eutrophication, and each CMA must develop a Eutrophication Strategy for its respective WMA that is aligned to this National Eutrophication Strategy.
Manage formal and informal settlements to prevent faecal pollution; Water supplies and sanitary facilities in the squatter section in Zwelitsha to be upgraded; Breakages in the sewer and reticulation systems in Mdantsane to be controlled and mended Low flows from the four streams in Mdantsane to be intercepted by means of weirs and diverted to the sewage works in order to prevent spillages from Mdantsane entering Bridle Drift dam; Amenities (sanitation facilities) to be provided to all rural and peri-urban settlements on the banks of the Umtata River.	All formal and informal settlements are to be provided with adequate sanitation facilities that are inspected and maintained regularly.
Implement flow manipulation to manage algal blooms in the middle reaches of the Vaal River.	Investigate and implement opportunities for flow manipulation in rivers affected by eutrophication.
Eutrophication concepts to be incorporated within the National Classification System for aquatic ecosystems;	Eutrophication concepts to be incorporated within the National Classification System for aquatic ecosystems and resource management objectives that include

CLUSTERED RECOMMENDATIONS	FINAL RECOMMENDATION
Resource management objectives that include eutrophication problem criteria to be set.	eutrophication problem criteria to be set.
Audit Wastewater Treatment Works in the Vaal; Permits to be implemented for discharges of treated and untreated sewage; Implement a WWTP upgrade and retrofit project in hotspot areas in the Vaal; All existing sewage treatment works in the Buffalo River catchment to be upgraded to comply with the 1 mg/l P effluent standard;	All Wastewater Treatment Works nationally to be audited to ascertain their permit status, compliance to operational standard practice, performance levels (particularly sterility and phosphorous level of discharge) and technological capabilities. Upgrade and retrofit projects are to be planned and implemented where required, with progress reported centrally.
A long-term eutrophication research and capacity building programme to support other eutrophication-related activities to be established; Eutrophication management guidelines to be developed; Farmers, particularly those in high-risk catchments, to be made aware of the impacts of their activities on pollution levels, and encouraged to take action to reduce these impacts; Education of rural community on river pollution and the need for a clean and hygienic environment; Information days to inform local people of the consequences and financial implications caused by vandalism to their sewage and reticulation systems to be organised.	Design and implement a eutrophication capacity building programme to assist and educate all water user groups in affected catchments as to their contribution to eutrophication and the actions they can take to minimise this impact.
Implement nutrient balances and a nutrient model from Vaal Barrage to Bloemhof Dam and apply this model to investigate alternative eutrophication control strategies; Additional investigations into environmental variables are carried out to allow improvement of the mathematical model developed for algal growth predictions in the Vaal.	A model to be developed that can be applied nationally (in local catchments) to project expected algal growth patterns based on nutrient status.

Table 5:3 Acid Mine Drainage

CLUSTERED RECOMMENDATIONS	FINAL RECOMMENDATION
Best practice guidelines for management and control of AMD need to be developed, addressing the life cycle of mines.	Best practice guidelines for management and control of AMD, addressing the life cycle of mines, to be developed and disseminated.
Mining regulations regarding impacts on water quality to be implemented.	Mining regulations regarding impacts on water quality to be implemented.

* These recommendations have been synthesised from findings contained in the Mpumalanga coal mines study (Hodgson et al (2007)

5.4 Recommendations for the moderate water quality risk categories

Table 5:4: Recommendations Regarding Heavy Metal Contamination

CLUSTERED RECOMMENDATIONS	FINAL RECOMMENDATION
Waste sites along the river banks to be removed and relocated to more appropriate locations; Rubbish dumps next to the river to be monitored to assess the effect of leachates on water quality during rainfall events. If they are found to be contributing to water quality deterioration they are to be removed or sealed;	A national policy regarding the location and management of waste sites in close proximity to water resources to be developed and implemented.
Investigate the reasons for high levels of non-compliance nationally to SANS: 241 drinking water heavy metals specifications.	Investigate the reasons for high levels of non-compliance nationally to SANS: 241 drinking water heavy metals specifications.

*Synthesised from the Western Cape Drinking Water Study (DWA, 2008)

Table 5:5: Recommendations Regarding Salinity

CLUSTERED RECOMMENDATIONS	FINAL RECOMMENDATION
Continue with the dilution of the Vaal Barrage water with releases from the Vaal Dam.	Continue with the dilution of the Vaal Barrage water with releases from the Vaal Dam.
Implement a waste discharge charge in the Vaal, with revenues to be used to compensate downstream users for “dis-benefit”.	Implement a waste discharge charge in the Vaal, with revenues to be used to compensate downstream users for “dis-benefit”.
Implement an upgraded water quality monitoring system in the Vaal; Water quality monitoring systems to be improved in the OFS Goldfields region;	Implement an upgraded water quality monitoring system in the Vaal River System.
Evaluation of the impact of increased TDS export from the Vet River on Bloemhof Dam and the downstream river system to be carried out.	Evaluation of the impact of increased TDS export from the Vet River on Bloemhof Dam and the downstream

	river system to be carried out.
Implement targeted saline effluent treatment schemes in the Vaal; Differential desalination to be considered as an option in the Middle Vaal, since the household sector was found to bear high costs, with lower costs borne by other sectors;	Identify and implement opportunities to employ desalination of discharges and treated water in all areas impacted by high salinity, in order to reduce the impacts of salinity on users.
All dischargers in the Vaal River System to reduce TDS load by 50-60% by 2014.	All dischargers in the Vaal River System to reduce TDS load by 50-60% by 2014.
Remediation of historical mining operations; Rehabilitation bonds to be increased by the DME such that they are sufficient to cover projected costs; Responsibilities for rehabilitation need to be clarified in the cases of State and privately owned land; Hands-on training as regards rehabilitation to be provided to small-scale miners.	Quantify the extent of the mine remediation problem, identify the root causes for inadequate remediation of mining operations and implement a project to correct the problem.
Uncontrolled development of new irrigation areas that entail the deep ripping of thin Bokkeveld shales to be restricted.	Land use practices that have increase the salinity of water resources to be controlled.
The effect of a doubling or trebling of the Vaalharts irrigation return flow TDS on the Vaal River to be urgently assessed; The existing flow and water quality monitoring system at the Vaalharts scheme to be improved; A new intensive TDS monitoring system to be employed to allow close monitoring of the potential threat of sudden increases in salinity in the Vaal River; A detailed study to be done to verify groundwater storage states, groundwater quality and percolation rates and the processes governing the behaviour of the Vaalharts system. The aim should be to predict when TDS loads returned to the Harts River are likely to increase and to what level they will rise; An improved irrigation model to be developed for the Vaalharts scheme that integrates soil chemistry, groundwater modelling, irrigation practices and advanced crop water modelling and infiltration/surface runoff/soil moisture processes.	The risks of a sudden salinity increase in the Vaal River due to salt retention in the Vaalharts scheme to be assessed and a detailed response plan to be developed and implemented.

Catchment Management Plan to be formulated for the OFS Goldfields region and the downstream portions of the Sand-Vet River system; Development of a catchment management programme for the Umtata River catchment.	Catchment management Plans for all catchments to be expedited, beginning with priority catchments.
As an interim measure, public warnings to be posted against drinking water from the worst affected river reaches, specifically the Sand River Canal, the Sand River downstream of this canal, the Doring River and the Theronspruit.	Warning signs to be placed at all sites nationally where salinity levels pose a risk to human health.

Table 5:6: Recommendations Regarding Estrogen and Estrogen-mimicking Substance

NO.	CLUSTERED RECOMMENDATIONS	FINAL RECOMMENDATION
37.	Dioxins to be taken into consideration for future investigations.	National capability to analyse samples for dioxins and aldicarb to be established, and these substances to be included in future studies on estrogen and estrogen-mimicking substances.
38.		National prevalence of estrogen and estrogen-mimicking substances in water resources, including drinking water, to be mapped and monitored on an ongoing basis.

Table 5:7: Recommendations Regarding Pesticides/Insecticides

CLUSTERED RECOMMENDATIONS	FINAL RECOMMENDATION
Established international health-based standards (e.g. those developed by the WHO and the EPA) to be adopted by DWA in order to afford a level of protection consistent with the provisions of the South African Constitution; Risk assessment in relation to pesticides to include exposure through a number of pathways, to recognise farm workers' additional exposures and vulnerability factors, should take account of cumulative impacts and should be used to set water standards for drinking and other uses.	Established international health-based standards (e.g. those developed by the WHO and the EPA) to be adopted by DWA in order to afford a level of protection consistent with the provisions of the South African Constitution.
A representative sample of all agricultural areas to be mapped in order to characterise the overall state of water pollution due to pesticides; Continuous monitoring of insecticide residues in the study area to be carried out and coordinated with the National River health Programme; DWA to actively pursue surveillance and monitoring methodologies to protect water supplies from pollution by pesticides; Assessment of the impacts of the use of pesticides in the Umtata River catchment; Data in support of surveillance activities on farms to be effectively captured, in particular toxic release inventories and pesticide use inventories.	A national pesticide monitoring programme to be established to determine, on an ongoing basis, the extent and impacts of pesticide pollution.
Policy measures that seek to avoid potential contamination of environmental media and reduce leaching to be encouraged (e.g. integrated pest management, containment liners at mixing sites, training, pesticide reduction); Strict control on the use and distribution of pesticides to be established (Departments of Agriculture and Health) More rigorous policy-based standards to be considered, within the framework of an appropriate national multi-stakeholder process e.g. the National Chemicals Profile; Alternative control measures to chemical control in agriculture and in the malaria control programme to be investigated.	Holistic policy measures governing the use of pesticides to be developed and implemented in order to minimise the impacts on water resource quality and human health.
Communication network to be established between the agricultural sector, the health sector and scientists for the planning and implementation of intervention actions; Workshop a strategic plan for further water related environmental research,	Input from the agricultural sector, the health sector, scientists and specialists to be obtained in devising and planning interventions for

CLUSTERED RECOMMENDATIONS	FINAL RECOMMENDATION
development of a decision support system for insecticide use in the study area and the establishment of a policy on pesticide use in malaria areas if necessary (WRC and ARC-PPRI).	affected areas, and in the determination of policy.
Local government capacity to implement monitoring of pesticides to be audited and strengthened, particularly in rural areas; Practical guidelines for water monitoring for pesticides to be developed for all personnel charged with inspection and enforcement functions; Health, safety and environment training to be provided to employers and employees in farming communities, particularly as regards the empowerment of rural residents in terms of protecting themselves and their communities from the adverse consequences of unintended pollution with pesticides; Training module on pesticide use in the emerging farming sector to be developed and implemented in the study area Rural communities to be provided with simple, cost-effective tools to undertake pesticide monitoring of their own water supplies; Information on safety aspects and the potential impacts of pesticides on human and environmental health to be developed and disseminated in the study area;	A capacity building programme for pesticide monitoring and management targeting all stakeholders to be developed and implemented.

5.5 Recommendations for the low risk water quality categories

Table 5:8: Recommendations Regarding Suspended Solids

CLUSTERED RECOMMENDATIONS	FINAL RECOMMENDATION
Implement land use strategies for afforestation and erosion control; A land use policy to be implemented to prevent soil erosion in the upper and middle reaches of the Umtata river.	Each CMA to develop and implement catchment-based land use strategies and policies to control the level of suspended solids in surface water resources.
Illegal small-scale mining to be addressed, since these operations show disregard for environmental standards.	Illegal small-scale mining to be addressed, since these operations show disregard for environmental standards.
Small scale miners and communities to be trained on environmental management and health and safety.	Small scale miners and communities to be trained on environmental management and health and safety, including the impacts of mining activities on water quality.
Ongoing health and safety and environmental monitoring of small-scale miners by the DME (now Department of Mining) required; Capacity of regulators with regards to small-scale mining to be increased.	Ongoing environmental monitoring of small-scale miners required to ensure that water quality impacts are minimised.
Tax relief and incentives must be promoted for environmentally acceptable mining.	Tax relief and incentives must be promoted for environmentally acceptable mining, specifically including water quality impacts.

5.6 Other water quality related recommendations

Table 5:9: Other Recommendations: Non-point Source Management

CLUSTERED RECOMMENDATIONS	FINAL RECOMMENDATION
A National Non-point Source Strategy (NNPSS) to be developed as part of the National Water Resource Strategy (NWRS), setting out DWA's intentions for non-point source management in South Africa over the next five years and the requirements of water management institutions, sectors and stakeholders; The National Non-point Source Strategy to be supported by procedures and guides for regulatory personnel for the promulgation of statutory and non-point source management measures and the implementation of non-statutory non-point source management approaches; Generic registration, licensing and water use charging processes (outlined in the Business Process Models as part of WARMS) to be interpreted in order to identify the elements that are important for non-point source management; An implementation plan for the NNPSS to be developed.	A National Non-point Source Strategy (NNPSS) to be developed as part of the National Water Resource Strategy (NWRS).

Table 5:10: Other Recommendations: Water Quality management Systems

CLUSTERED RECOMMENDATIONS	FINAL RECOMMENDATION
DWA to reinstate the POLMON database in order to improve the state of available data on known point sources of pollution; More detailed studies into pollution sources in significant catchments to be carried out, beginning with catchments with known salinity and nutrient problems; Water quality monitoring points were proposed for the Umtata River in order to ensure that the safety of the water (from a health perspective) may be monitored; Improve the monitoring system for point and non-point sources along the Berg River catchment; Systematic water quality monitoring should be continued throughout the country, paying particular attention to temperature and nutrient data sampling;	National water quality data, pollution source data and pollution modelling needs to be assessed and a programme implemented to ensure that water quality management in all catchments is adequately supported.

CLUSTERED RECOMMENDATIONS	FINAL RECOMMENDATION
A water quality data-patching package to allow estimation of pollutant loads from deficient data to be developed. Modelling of water quality issues in South Africa's important agricultural catchments to be carried out; Gather site-specific meteorological data specifically for important impoundments and proposed impoundments (particularly Skuifraam Dam in terms of this study).	

Table 5:11: Other Recommendations: Drinking Water Quality*

CLUSTERED RECOMMENDATIONS	FINAL RECOMMENDATION
Compliance to SANS 241 measurement standards to be enforced at all WSA's.	Compliance to SANS 241 measurement standards to be enforced at all WSA's.
Action plans for each WSA to be formulated to address water quality deficiencies, and a monitoring programme to be implemented to assess progress.	Action plans for each WSA to be formulated to address water quality deficiencies, and a monitoring programme to be implemented to assess progress.
A national audit of water purification skills at individual WSA's to be undertaken and a strategy to address skill gaps to be formulated.	A national audit of water purification skills at individual WSA's to be undertaken and a strategy to address skill gaps to be formulated.
Preventive maintenance programmes for all purification plants to be developed and implemented.	Preventive maintenance programmes for all purification plants to be developed and implemented.
The capacity of individual plants to be reconciled to demand, and investments planned to enable the requisite capacity to be installed.	The capacity of individual plants to be reconciled to demand, and investments planned to enable the requisite capacity to be installed.

*All recommendations in Table 5.12 above have been synthesised based on the Western Cape drinking water study, which did not propose recommendations and Mackintosh and Jack (2008), a study considered more representative of the national situation. Hence "clustered" and "final" recommendations are identical.

Table 5:12: Other Recommendations: Solid Litter

CLUSTERED RECOMMENDATIONS	FINAL RECOMMENDATION
All CMA's to produce an integrated strategy as part of the Catchment management Strategy for the management of solid litter.	All CMA's to produce an integrated strategy as part of the Catchment management Strategy for the management of solid litter.

Table 5:13: Other Recommendations: Radionuclides

CLUSTERED RECOMMENDATIONS	FINAL RECOMMENDATION
The extent of radionuclide contamination of South African surface and groundwater resources, both in the form of dissolved metals and immobilised contaminants in sediment to be determined and risks to human and animal health to be assessed.	The extent of radionuclide contamination of South African surface and groundwater resources, both in the form of dissolved metals and immobilised contaminants in sediment to be determined and risks to human and animal health to be assessed.