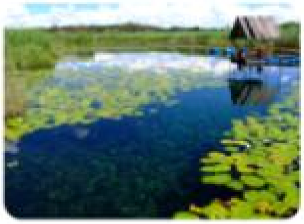
Water Resource Planning Systems Series

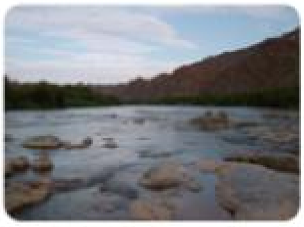
Water Quality Planning

SUB-SERIES NO. WQP 2.0

RESOURCE DIRECTED MANAGEMENT OF WATER QUALITY



PLANNING LEVEL REVIEW OF WATER QUALITY IN SOUTH AFRICA



March 2011

Final

water affairs

Department:
Water Affairs
REPUBLIC OF SOUTH AFRICA

DEPARTMENT OF WATER AFFAIRS

Water Resource Planning Systems

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ABBREVIATIONS

ARC	Agricultural Research Council
AMD	Acid Mine Drainage
COD	Chemical Oxygen Demand
DoA	Department of Agriculture
DIN	Dissolved Inorganic Nitrogen
DEA	Department of Environmental Affairs
DWA	Department of Water Affairs
DWAF	Department of Water Affairs and Forestry
EA	Environmental Agency
EDCs	Endocrine Disrupting Compounds
IWWMPs	Integrated Water and Waste Management Plans
NEMP	National Eutrophication Monitoring Programme
NGOs	Non-governmental Organisations
NMMP	National Microbiological Monitoring Programme
NTMP	National Toxicity Monitoring Programme
NWA	National Water Act
POPs	Persistent Organic Pollutants
RDMs	Resource Directed Measures
RHP	River Health Programme
RQOs	Resource Quality Objectives
RQS	Resource Quality Services
RWQOs	Resource Water Quality Objectives
SAWQGs	South African Water Quality Guidelines
TDS	Total Dissolved Salts
TIN	Total Inorganic Nitrogen
TWQR	Target Water Quality Range
UNEP	United Nations Environmental Programme
WDCS	Waste Discharge Charge System
WMA	Water Management Area
WMS	Water Management System
WQM	Water Quality Management
WQP	Water Quality Planning
WRC	Water Research Commission
WRCS	Water Resource Classification System
WWTWs	Wastewater Treatment Works

Executive Summary

South Africa is a water stressed country (<1 700 m^3 per person annually) and will probably be facing water scarcity (<1 000 m^3/p/a) by 2025 (GEO-2000, 1999). Increased stresses on the world's water are affecting quality, quantity and availability. Therefore the need to protect and not pollute valuable freshwater resources cannot be over emphasized. Rising demand for increasingly scarce water resources is leading to growing concerns about future access to water.

The availability of water and its physical, chemical, and biological composition affect the ability of aquatic environments to sustain healthy ecosystems; as water quality and quantity are eroded, organisms suffer and ecosystem services may be lost. Moreover, an abundant supply of clean, usable water is a basic requirement for many of the fundamental uses of water on which humans depend (UNEP-GEMS, 2006).

Rivers are the most important freshwater resource for man. Social, economic and political development has, in the past, been largely related to the availability and distribution of freshwater contained in riverine systems (Chapman, 1996). Deteriorating water quality not only affects aquatic ecosystems but also impacts economic growth, community health and empowerment.

Freshwater is a complex ecological system that has a number of dimensions. Surface water, groundwater, quantity and quality are all linked in a continuous cycle – the hydrological cycle – of rainfall, runoff from the land, infiltration into the ground, and evaporation from the surface back to the atmosphere. Each component may influence the other components and each must therefore be managed with regard to its inter-relationships with the others (DWAF, 2004a).

Water as a system also interacts with other systems. Human activities such as land use, waste disposal and air pollution can have major impacts on the quantity and quality of water available for human use, while the abstraction and storage of water and the discharge of waste into water resources can impact on the quality of the water resource. These interactions must also be addressed in the management of water resources.

Taking an even broader view, water must also be managed in the full understanding of its importance for social and economic development (DWAF, 2004a). Water resource management at the catchment or regional level thus occurs within a highly integrated environment, where water quality, quantity and the aquatic ecosystem are all interlinked and interdependent.

The Department recognises that, just as a quantity of water can be "used", so can water quality. For water to be regarded as "fit for use" for a number of different users in the same catchment, the water quality needs to satisfy the most demanding of those users. Water quality planning of South Africa's water resources is thus taking place to ensure that the water quality in South African water resources enables an equitable and sustainable balance to be achieved between its use by society and its protection as a critical component of a natural system so that the quality of life of all South Africans is improved and sustained in the long term. A specific objective of the Water Quality Planning function within DWA is to provide effective management solutions and policy guidance to address the current water quality challenges within the context of integrated water resource management.

In support of this objective the Department has identified the need to establish a national review on water quality status and trends that measure, assess and report on the current state and appropriate temporal trends of selected groups of water quality indicators in South African surface water resources. This is aimed at supporting strategic management decisions in the context of sustainable fitness for use of those water resources and for the protection of the integrity of aquatic ecosystems. This report is intended to provide that perspective on the water quality state of the surface water resources of South Africa and in doing so provide the water quality planning strategic interventions to be adopted to address the key challenges and threats facing water quality and fitness for use of the country's water resources.

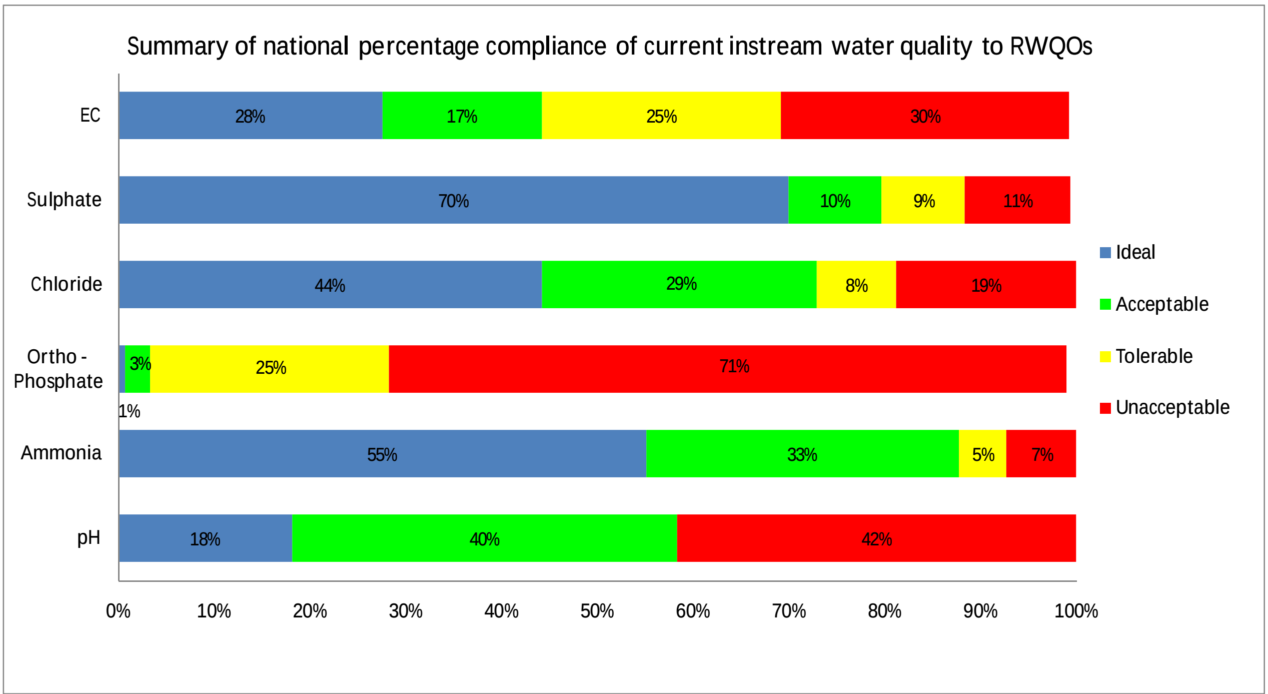
The current perspective reported on is based on the Department's routine National Chemical Monitoring (priority) Programme of the country's water resources for the period 2006 to 2008 at 276 selected surface water quality monitoring sites (3 years). A major focus of the National Chemical Monitoring Programme is on regional and national-scale assessments of water quality status and trends in streams and rivers. The nineteen water management areas (WMAs) which form the major river basins of South Africa serve as the basis for the water quality perspective assessment. The primary goals of this report are to characterize the state of surface-water quality (river chemistry); determine temporal trends at those sites that have been consistently monitored for a decade (January 1999 to February 2008); and build an understanding of how natural features and human activities have affected the water quality of our water resources. Analysis and reporting have focused on the understanding of water quality status and dominant issues at the WMA scale. The current in stream water quality was compared to a generic set of Resource Water Quality Objectives (RWQOs) for all users throughout all WMAs and reflected as ideal, acceptable, tolerable and unacceptable in terms of an indication of compliance.

This report concentrates on the chemical quality of the nation's water resources. It does not deal with the biological or microbiological status of the surface water resources as this information is not readily available on a national scale. A snapshot of some areas is however given in the context of a WMA. Groundwater quality is also not addressed in this report. A perspective is provided in terms of the National Groundwater Strategy, however to a very limited extent.

The results of the water quality review show that the levels of nutrients in the country's water resources are the water quality problem of most concern. Only 29% of the monitoring sites showed compliance to the prescribed RWQOs (≤ 0.025mg/l) for phosphate. There is currently 71% of non-compliance at a national scale. The current state is a threat to the aquatic ecosystem health of our water resources and to domestic water supply.

Salinisation is another major water issue identified at a national scale. This situation is linked to elevated levels of sulphate, sodium and chloride which pose a risk to industrial water supply and aquatic health. Salinity compliance indicates that 30% of the monitoring sites have unacceptably high levels (>85 mS/m) of salts, and 25% within the tolerable range (50 mS/m to 85 mS/m).

With regard to the levels of ammonia, 55% of the sites assessed show a compliance to the ideal RWQO of < 0.015mg/l. As aquatic ecosystems are extremely sensitive to levels of ammonia, this reflects a fairly good situation of the aquatic health of water resources. 7% of the sites assessed show unacceptably high levels (>0.073 mg/l) of ammonia. Only 48 of the (17%) monitoring points assessed at a national scale met all the RWQOs for all water quality variables.



The summary of the water quality status per WMA in terms of RWQO compliance is provided in Table E1, and the identified water quality issues that are of concern within the WMAs are listed in Table E2. These concerns were identified by a combination of the water quality data analyzed as well as consultation with regional water quality managers.

Regional consultation with stakeholders indicated that microbiological quality of the water resources is also deteriorating. Sufficient data is still required to understand the extent of the problem. Further issues identified through consultation were that of siltation/sedimentation in many catchments as well as the presence of heavy metals and perceptions of Persistent Organic Pesticides (POPs). However there is no data available for total suspended solids, heavy metals or POPs on a national scale to reflect this concern.

Major problem areas and pollution sources, include untreated or poorly treated wastewater treatment works discharges, run-off from un-serviced areas, agricultural run-off, industrial wastewater discharges and mining impacts.

Based on the planning level review of water quality obtained here at a national scale and per WMA a range of strategic water quality interventions are provided as the Department's focus areas over the short, medium and long term planning horizon. The implementation of these actions will require a co-ordinated and integrated approach in order to achieve the objectives of resource directed water quality management.
Based on the proposed strategic plan, the intention is to, provide effective guidance on how water quality considerations should be integrated into water resource management in general, thereby "making water resource management water quality friendly".

Table E1: Summary of water quality compliance to RWQOs per WMA for monitoring sites assessed

WMA	Electrical Conductivity (EC)				Sulphate (SO_4)				Chloride (Cl)				Ortho-phosphate (PO_4-P)				Ammonia (NH_3-N)				pH		
	Unacceptable	Tolerable	Acceptable	Ideal	Unacceptable	Tolerable	Acceptable	Ideal	Unacceptable	Tolerable	Acceptable	Ideal	Unacceptable	Tolerable	Acceptable	Ideal	Unacceptable	Tolerable	Acceptable	Ideal	Unacceptable	Acceptable	Ideal
1 - Limpopo		33%	17%	50%	17%			83%			50%	50%	17%	50%	33%					100%	17%	66%	17%
2 - Luvuvhu and Letaba	12%	44%		44%				100%		22%	33%	45%	44%	56%					11%	89%	11%	56%	33%
3 - Crocodile (West) and Marico	15%	62%	15%	8%			23%	77%		15%	46%	39%	69%	23%	8%		15%	8%	62%	15%	54%	46%	
4 - Olifants	43%	36%	7%	14%	43%	7%		50%	14%	14%	21%	50%	36%	64%					64%	36%	57%	36%	7%
5 - Inkomati	7%	29%	14%	50%			7%	93%			29%	71%	43%	57%					14%	86%	29%	50%	21%
6 - Usustu to Mhlatuze	19%	25%	25%	31%		7%	7%	86%	19%	6%	19%	56%	50%	50%				6%	38%	56%	31%	31%	38%
7 - Thukela		10%	40%	50%			10%	90%				100%	80%	20%				10%	30%	60%	20%	60%	20%
8 - Upper Vaal	22%	34%	16%	28%	6%	22%	9%	63%		6%	34%	60%	91%	9%			15%	9%	38%	38%	53%	31%	16%
9 - Middle Vaal	50%	24%	13%	13%	13%	31%	6%	50%	19%	19%	38%	24%	100%				19%	12%	25%	44%	50%	44%	6%
10 - Lower Vaal	78%	22%			44%	44%		12%	11%	33%	56%		56%	44%			34%		44%	22%	78%	22%	
11 - Mvoti to Mzimkulu		16%	16%	68%				100%		5%	26%	68%	32%	36%	21%	11%	5%	5%	32%	58%	16%	42%	42%
12 - Mzimvubu to Keiskamma	11%	20%	16%	53%	5%			95%	5%	11%	16%	68%	95%	5%					37%	63%	16%	79%	5%
13 - Upper Orange	16%	32%	32%	20%	5%		5%	90%	5%		32%	63%	84%	16%			16%		16%	68%	53%	47%	
14 - Lower Orange	29%	29%	43%					100%			71%	29%	43%	57%			14%	14%	14%	57%	43%	57%	
15 - Fish to Tsitsikamma	61%	18%	14%	7%	11%	18%	25%	46%	54%	7%	25%	14%	82%	18%			4%	7%	46%	43%	57%	29%	14%
16 - Gouritz	64%	18%		18%	35%	6%	18%	41%	64%	12%	12%	12%	94%	6%			6%	6%	24%	64%	47%	29%	24%
17 - Olifants Doorn	17%	17%		66%	17%			83%	17%		33%	50%	33%	67%						100%	50%	17%	33%
18 - Breede	72%		14%	14%	36%		21%	43%	72%		21%	7%	86%	14%			7%	7%	29%	57%	57%	14%	29%
19 - Berg	34%	22%	22%	22%			33%	67%	44%		44%	12%	100%						22%	78%	11%	22%	67%

	Electrical Conductivity (EC)	Sulphate (SO_4)	Chloride (Cl)	Ortho-phosphate (PO_4-P)	Ammonia (NH_3-N)	pH
Ideal range limit	30mS/m	80 mg/l	40 mg/l	0.005 mg/l	0.015 mg/l	≥6.5 - ≤8.0
Acceptable range limit	50 mS/m	165 mg/l	120 mg/l	0.015 mg/l	0.044 mg/l	>8.0 - ≤8.4
Tolerable range limit	85 mS/m	250 mg/l	175 mg/l	0.025 mg/l	0.073 mg/l	No range limit set
Unacceptable limit	> 85 mS/m	> 250 mg/l	> 175 mg/l	> 0.025 mg/l	> 0.073 mg/l	<6.5 and > 8.4

Table E2: Summary of water quality issues identified and WMAs within which they are cause for concern

Water Quality Issue	Driver	Effect	WMAs associated with WQ issue
Eutrophication	Waste water treatment works Intensive agriculture fertilizer use Dense urban sprawl un-serviced sewage	Algal growth, smell, toxic algae, water treatment extra costs, taste and odour, irrigation clogging, aesthetics, recreational water users.	All WMA's except the Gouritz WMA (16).
Microbial contamination	Waste water treatment works Informal dense settlements; Vandalism of sewage reticulation system & pumping infrastructure Sewage spills into receiving streams	Recreational users (human health risks), washing and bathing; Poor bacterial water quality Impacts on downstream users Low dissolved oxygen and ecosystem impacts; Water-borne diseases.	All WMAs except for Usutu to Mhlatuze(6); Thukela (7); Upper Orange (13); Lower Orange (14) and Fish to Tsitsikamma (15).
Salinisation	Mines (operational and abandoned) Waste water treatment works Agricultural runoff	Water treatment costs, soil salinity and irrigation system clogging.	All WMAs except for Mvoti to Umzimkulu (11).
Toxicants	Pesticides (subtropical fruits, nuts) industry, DDT for malaria control	Fish kills, human health impacts, bioaccumulation in fish, crocodile deaths.	Luvuvhu and Letaba (2), Crocodile (West) and Marico (3); Olifants (4); Inkomati (5); Upper Vaal (8)
Altered flow regime	Dams and weirs Inter-basin transfers	Turbidity (erosion), algal growth, water temperature increase, dissolved oxygen changes, taste and odour changes, changes in environmental flows. Seasonal flow changes, ecological water requirement changes, impact of recreational water users	Luvuvhu and Letaba (2), Olifants (4); Inkomati (5); Middle Vaal (9); Lower Vaal (10); Upper Orange (13); Lower Orange (14)
Acid mine drainage	Mines (operational and abandoned), Controlled releases	Mobilisation of metals, Fish and crocodile kills, bioaccumulation, low pH, elevated sulphur and iron, elevated salts and dissolved metals.	Olifants (4); Inkomati (5); Usutu to Mhlatuze(6); Upper Vaal (8)
Metal contamination	Mines (operational and abandoned) Uncertain in some instances	Mobilisation of metals, fish and crocodile kills, bioaccumulation. Potentially harmful for human health and for the aquatic environment.	Olifants (4); Inkomati (5); Lower Orange (14)

Water Quality Issue	Driver	Effect	WMAs associated with WQ issue
Suspended solids (turbidity, sedimentation)	Land degradation and over grazing; soil erosion; mining Informal dense settlements, subsistence agriculture	High suspended solids during high flows; silting up of rivers, weirs and dams; loss of habitat, increased water treatment costs, irrigation clogging.	Limpopo (1), Luvuvhu and Letaba (2); Crocodile (West) and Marico (3); Olifants (4); Inkomati (5); Usutu to Mhlatuze(6), Thukela (7); Upper Vaal (8;)Mvoti to Umzimkulu (11); Mzimvubu to Keiskamma (12); Upper Orange (13)
Radioactivity	Discarded mine dumps	Bioaccumulation fish, aquatic organisms, soils, humans. Carcinogenic effects.	Upper Vaal 98); Middle Vaal (9)
Urban rivers	Poor quality stormwater runoff and dry weather flow from dense settlements	Poor bacterial water quality, human health risks, and impacts on ecosystems (low DO).	Upper Vaal (8); Fish to Tsitsikamma (15); Gouritz (16); Berg (19)
Agro-chemicals	Pesticide & herbicide residues Endocrine disrupting chemicals	Interference with hormone systems of organisms and ecosystem impacts.	Fish to Tsitsikamma (15); Olifants-Doorn (17); Breede (18); Berg (19)

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1. Introduction

Water is an indispensable natural resource, fundamental to life, the environment, food production, hygiene and sanitation, industry and power generation.

In South Africa it is recognised as a crucial element in the battle against poverty, the cornerstone of prosperity, and a limiting factor to growth. South Africa is situated in a subtropical region of the world where rainfall is unreliable, unevenly distributed, and prone to erratic, unpredictable extremes in the form of droughts and floods. On average only 9% of the rainfall reaches the river systems. Being mostly semi-arid, water is scarce compared to most other countries. Wise utilisation of this resource in a sustainable manner is, therefore, essential for the future of the country.

Groundwater resources are not easily exploitable due to the predominantly hard rock nature of the South African geology. Only about 20 percent of groundwater occurs in major aquifer systems that could be utilised on a large scale. Already the freshwater resources of the country are under stress.

Dams have been build in most of the country's major rivers to provide water for the increasing population; in some areas over 50% of the wetlands have been converted for other land-use purposes; industrial and domestic effluents are polluting the ground- and surface waters, and changes in habitat have affected the biotic diversity of freshwater ecosystems. Good management and sustainable utilisation depend on reliable information.

South Africa's water resources belong collectively to the nation. Since water is a national asset, a significant responsibility is placed on government in their capacity as the trustee of the nation's water resources. The responsibility rests specifically with the Department of Water Affairs ("the Department") acting on behalf of the Minister of Water and Environmental Affairs. However, their responsibility extends to ensuring that water shared with countries beyond our borders is also managed considerately (DWAF, 2006a).

The current political imperative for socio-economic development necessitates that the balance between the use of water resources and their protection gives preference to, from an overall national perspective, their use for socio-economic development, especially for poverty eradication and redress of past inequities. However, under no circumstances should water resources be exploited to the extent that they are "unacceptably degraded" and unable to provide adequate water quality on a sustainable basis.

It is acknowledged that the quality of life of all South Africans is inextricably linked, directly and indirectly, with maintaining the integrity of aquatic ecosystems since these provide many of the goods and services upon which society depends (particularly good quality water). Accordingly, strict protection of selected aquatic ecosystems will occur when this is considered necessary to sustain the biodiversity and general integrity of those ecosystems.

This philosophy will be implemented primarily through "Resource Directed Measures". These measures relate to the management class, the Reserve and associated Resource Quality Objectives (RQOs). These will comprise some of the most important instruments that will ultimately enable improvement of quality of life through effective water resource management (DWA, 2010a).

1.1 Water Quality

"Water quality" is a term used to express the suitability of water to sustain various uses or processes. Any particular use will have certain requirements for the physical, chemical or biological characteristics of water; for example limits on the concentrations of toxic substances for drinking water use, or restrictions on temperature and pH ranges for water supporting invertebrate communities. Consequently, water quality can be defined by a range of variables which limit water use by comparing the physical and chemical characteristics of a water sample with water quality guidelines or standards. Although many uses have some common requirements for certain variables, each use will have its own demands and influences on water quality (UNEP/WHO, 1996).

Water quality is neither a static condition of a system, nor can it be defined by the measurement of only one parameter. Rather, it is variable in both time and space and requires routine monitoring to detect spatial patterns and changes over time.

The composition of surface and groundwater is dependent on natural factors (geological, topographical, meteorological, hydrological and biological) in the drainage basin and varies with seasonal differences in runoff volumes, weather conditions and water levels. Large natural variations in water quality may, therefore, be observed even where only a single water resource is involved. Human intervention also has significant effects on water quality. Some of these effects are the result of hydrological changes, such as the building of dams, draining of wetlands and diversion of flow. More obvious are the polluting activities, such as the discharge of untreated or partially treated domestic, industrial, urban and other wastewaters into the water resource (whether intentional or accidental) and the spreading of chemicals on agricultural land in the drainage basin. A single influence (e.g. faecal pollution, eutrophication or diffuse pollution) may give rise to a number of water quality problems, just as a problem may have a number of contributing influences.

1.2 Integrated Water Quality Management in South Africa

To give effect to the interrelated objectives of sustainability and equity an approach to managing the water quality of water resources has been adopted that includes measures to protect water resources by setting objectives for the desired condition of resources, and putting measures in place to control water use to limit impacts to acceptable levels (DWAF, 2004a).

The Department's approach to integrated water quality management in South Africa comprises two complementary strategies *viz*. resource directed measures and source directed controls.

Resource-Directed Measures are measures that focus on the quality of the water resource itself. Resource quality reflects the overall health or condition of the water resource, and is a measure of its ecological status. Resource quality includes water quantity and water quality, the character and condition of in-stream and riparian habitats, and the characteristics, condition and distribution of the aquatic biota. Resource Quality Objectives (RQOs) and specifically Resource Water Quality Objectives (RQWOs) will be defined for each significant resource to describe its quality at the desired level of protection.

Specific actions in terms of resource directed measures that require attention at national level in respect of water quality management include the following (DWAF, 2004a):

- Formulation of objectives for managing sources of pollution and associated single source interventions.
- Benchmarking water resource quality.
- Identification of emerging threats to the water resource and prioritisation for action.
- Establishing priorities in relation to, for instance, remediation of water resources and degraded land as a focus for regulation using source-directed controls.

Source-Directed Controls are measures that contribute to defining the limits and constraints that must be imposed on the use of water resources to achieve the desired level of protection. They are primarily designed to control water use activities at the source of impact, through tools such as standards and the situation-specific conditions that are included in water use authorisations. Source-directed controls are the essential link between the protection of water resources and the regulation of their use.

Source directed controls may be categorised as follows (DWAF, 2004a):

- Best management practice measures that relate to measures and standards that apply nationally with respect to water use.
- Special measures related to source-related requirements dictated by and/or derived from catchment management strategies and/or plans.
- Site-specific measures related to measures arising from the process of authorising water use. They take account, among other considerations, of general authorisations specified at national or regional levels, and considerations that are specific to the water use being considered in a particular location.

Integrated water quality management can be viewed as a component of integrated water resource management. The latter is, in turn, a component of integrated environmental management, as mandated by the National Environmental Management Act (Act 107 of 1998).

Integrated water quality management (WQM) is a catchment-focused, iterative yet systematic process that should be implemented in a cyclical process aimed at continual improvement (fundamental to the principle of adaptive management). The measures range from individual (local) source and resource management initiatives (short-term) through re-consideration of the catchment management strategy (medium-term) to re-consideration of the resource directed measures and vision (long-term). Integrated WQM involves the integration of the following (DWAF, 2006a):

At pollution source scale:

- Resource directed measures with source directed controls relating to water quality management, and

At local scale:

- The achievement of resource quality objectives, and resource water quality objectives in particular,

- Water services development plans, as required by the Water Services Act (Act No. 108 of 1997),
- Integrated development plans, as required by the Municipal Systems Act (Act No 32 of 2000); and

At regional scale:

- The water quality component of catchment management strategies,
- The achievement of the water quality management goal within the catchment,
- The achievement of the catchment vision, and

At national scale:

- The National Water Resource Strategy (DWAF, 2004 a),
- Nationally consistent approaches to resource directed measures and associated source directed controls,
- The achievement of national water quality management goals.

Water quality management is the process of administering and controlling the physical, chemical, toxicological, biological (including microbiological) and aesthetic properties of the water in water resources that determine sustained healthy functioning of aquatic ecosystems, and fitness for use.

Resource directed management of water quality focuses specifically on how water quality in water resources should be managed, particularly in respect of use and protection.

The vision of the Department's Resource Directed Management of Water Quality Policy is to ensure that the water quality in South African water resources enables an equitable and sustainable balance to be achieved between its use by society and its protection as a critical component of a natural system so that the quality of life of all South Africans is improved and sustained in the long term.

1.3 Water Quality Planning

Quantity and quality water requirements of different users will not always be compatible, and the activities of one user may restrict the activities of another, either by requiring water of a quality outside the range required by the other user or by lowering quality during use of the water (e.g. discharges). Efforts to improve or maintain a certain water quality often compromise between the quality and quantity requirements of different users. The Department recognises that, just as a quantity of water can be "used", so can water quality. For water to be regarded as "fit for use" for a number of different users in the same catchment, the water quality needs to satisfy the most demanding of those users. The achievement of this desired resource water quality requires a combination of planning guidance and management actions.

The Water Quality Planning function of the Department aims to provide policy guidance specifically on how water quality in water resources should be managed, particularly in respect of use and protection. It does not concern itself with the detailed management of those activities that cause impacts on water quality. However, it does address "source management" (or "source directed controls") to the extent that such management should be driven directly by the requirements of the water resource (DWAF, 2006a).

Water quality planning is directed at addressing the following key issues facing water resource management:

- Balancing the degree to which water, and water quality, is used (e.g. for socio-economic development) with the degree of protection of water resources as natural systems (for current and future generations) requires both political and scientific considerations.
- The nature of the imbalance between the requirement for and supply of water, and water quality, is such that equitable allocation of these resources is not possible without management intervention.
- Resource directed management of water quality requires certain specialist skills, while decision-making is often complex and may have to be based on uncertain or incomplete data and information.
- Consistent nationwide application of legislation relating to management of water quality is essential.

1.4 Why the need for a Water Quality Planning Level review of the state of South Africa's surface water resources?

In support of the Department's Water Quality Planning objective to provide effective management solutions and policy guidance to address the current water quality management challenges facing South Africa, the need has been identified to undertake a national review on the water quality status of available groups of surface water quality indicators. The findings are aimed at supporting strategic management decisions in the context of sustainable fitness for use of those water resources and the integrity of aquatic ecosystems.

This analysis of water quality data in a regional (WMA) and national context is aimed at obtaining information for understanding point and nonpoint sources, natural features, and human activities affecting surface water resources and ecosystems. Improved understanding can help prioritize actions for water resources protection and remediation, reduce monitoring costs, and evaluate strategies for reducing concentrations of contaminants, such as nutrients in rivers. In addition, findings in individual WMAs and catchments can be placed within the context of the larger river systems and impoundments. This is critical because local decisions related to land-use planning and development, or other human actions, in individual catchments can contribute to the cumulative or overall impact on the quality of the water resource.

Because water resources, aquatic communities and ecosystems are interconnected across great distances, successful solutions and actions depend on local, catchment, WMA and national involvement.

Other specific applications of the water quality planning level review of the state of the country's surface water resources will help:

- Identify the water resources that are heavily polluted and impaired;
- Implement resource water quality objectives (RWQOs) by identifying water resources of good quality that need to be maintained and impaired water resources that need to be restored;
- Identify priority catchments and WMAs where good water quality must be maintained and others that need management interventions to limit pollution and specific source control measures;

- Evaluate the effectiveness of activities undertaken to manage the impacts on water quality of water resources; and
- Prioritize management actions that must be implemented.

2. Overview of South Africa's Water Resources

Due to the poor spatial distribution of rainfall, the natural availability of water across the country is also highly uneven. Most of the rain falls in the marginal zone along the eastern and southern coastlines. This situation is compounded by the strong seasonality of rainfall, as well as high within-season variability, over virtually the entire country. Consequently surface runoff is also highly variable. As a result, stream flow in South African rivers is at relatively low levels for most of the time. The sporadic high flows that do occur limit the proportion of stream flow that can be relied upon to be available for use.

Surface runoff is the main water source in South Africa. The average total mean annual runoff of South Africa under natural (undeveloped) conditions is estimated at a little over 49 000 million m^3/a, which includes about 4 800 million m^3/a and 700 million m^3/a of water originating from Lesotho and Swaziland respectively, which naturally drains into South Africa. Some highly variable rivers can have up to 10 consecutive years of less than average flow.

In addition about 10 000 million m^3 per annum is available as renewable groundwater in South Africa (Utilisable Groundwater Exploitation Potential) (DWA, 2010b). However groundwater, while also extensively utilised, particularly in the rural and more arid areas, is limited due to the geology of the country, much of which is hard rock. Large porous aquifers occur only in a few areas (DWAF, 2004a).

Total available surface water in South Africa in year 2000 was about 12 800 million m^3 per annum (DWA, 2010c).

The mean annual run-off in South Africa is not directly proportional to the mean annual rainfall. It reduces far more sharply than a reduction in rainfall due to high evaporation losses. South Africa's water supply situation may worsen if unfavourable climatic changes should arise from global warming.

To compound the situation, most urban and industrial development, as well as some dense rural settlements, has been established in locations remote from large watercourses. As a result, in several river basins the requirement for water already far exceeds its natural availability, and widely-spread and often large-scale transfers of water across catchments have, therefore, already been implemented.

To facilitate the management of water resources, the country has been divided into 19 catchment-based water management areas.

2.1 Major River systems

The great escarpment separates South African rivers into two groups, *viz*. the plateau rivers and those of the marginal areas. The eastern marginal area, covering 13% of the country, accounts for 43% of the total run-off. This is derived from several short steep rivers which rise on the slopes and flow directly into the Indian Ocean. The longer east-flowing rivers in the north, such as the Limpopo, the Komati, the Crocodile and the Olifants rise on the interior plateau and have broken through the escarpment (Sancold, 1994).

Most of the plateau is drained by the large Orange River System which flows westwards to the

Atlantic Ocean. Although its catchment area comprises 48% of South Africa, it contributes only 22% of the total mean annual runoff because the rainfall reduces towards the west where evaporation is high. Its major tributaries are the Caledon and Vaal rivers. Downstream of its confluence with the Vaal, there is almost no addition to its runoff over a distance of 1200 km. No water is known to have reached this reach of river from the large Molopo-Nossob system situated to the northwest for millennia. In the south-western Cape the major rivers are the Gamtoos, Gouritz, Breede, Berg and Olifants progressing westwards from the year round rainfall area to the winter rainfall area.

Only one quarter of South Africa has perennial rivers. These are mainly in the southern and south western Cape and on the eastern marginal slopes. With no inland lakes and permanent snows to stabilize flow, these rivers flow irregularly and they are often seasonal. Rivers that flow only periodically are found in a further quarter of the country. Over the entire western interior, rivers are episodic and flow only after infrequent storms (Sancold, 1994).

2.2 Dams

Water resources are highly developed over most of the country as South Africa depends mainly on surface water resources for most of its urban, industrial and irrigation requirements. Storage is necessary to be able to make best use of runoff.

About 320 major dams, each with a full supply capacity exceeding 1 million m^3, have a total capacity of more than 32 400 million m^3, equivalent to 66 per cent of the total mean annual runoff (DWAF, 2004 a). The major dams command virtually all the run-off from the interior plateau. The undeveloped resources are mainly along the coast. However it is accepted that natural processes occurring in rivers, wetlands and estuaries require a share in the water resources of the country.

2.3 Types of water quality of South Africa's water resources

As South Africa is water deficient, wastewater has to be purified and returned to water resources. With the growing industrialization, urbanization, irrigation and the use of agrochemicals, the quality of receiving waters is deteriorating by increased return flows. Poor water quality is becoming more critical than reduced availability in some areas, particularly in the interior of the country.

To meet the country's growing water requirements, water resources are highly developed in large parts of the country. As a result of the many control structures (dams and weirs), the abstraction of water and return flows to rivers, as well as the impacts of land use, the flow regime in many rivers has also been significantly altered. This has significantly changed the quality of water and the integrity of aquatic life in many rivers.

South Africa's surface and groundwater resources show pronounced regional differences and changes in water quality. The changes in those areas where water quality has deteriorated significantly are due to anthropogenic activities.

Exceptions are the ambient salinity levels of certain rivers of the eastern (e.g. Great Fish and Sundays rivers) and western Cape (e.g. lower Berg River) where natural salinisation is of geological origin.

2.4 Drivers of water quality in South Africa's

The quality of water resources in many areas of South Africa is driven by man-made causes. However in some instances the quality related problems are inherent in the geological characteristics of the area.

Currently much of the water quality of the country's water resources is influenced by wastewater discharges and land-based activities. Major impacting sources include agricultural drainage and wash-off (irrigation return flows, fertilisers, pesticides and runoff from feedlots), urban wash-off and effluent return flows (bacteriological contamination, salts and nutrients), industries (chemical substances), mining (acids and salts) and areas with insufficient sanitation services (microbial contamination).

The quality of groundwater is influenced by mining activities, leachate from landfills, human settlements and intrusion of sea water.

2.5 Inter-basin Transfers

Due to the spatial imbalances in the availability of and requirements for water in the country, inter-catchment transfer of water is a necessary reality in South Africa. Inter-basin water transfer schemes have been implemented throughout the country to augment the supply of freshwater. A total of 26 major inter-basin water transfers have been completed to date.

The transfer of water between water management areas amounts to about 3 000 million m^3/a (DWA, 2010c).

Some of these transfers are from upper to lower water management areas through releases along rivers, as in the Vaal and Orange rivers, while others are affected through inter-catchment water transfers. It has become evident that more water will have to be transferred in future. In comparison, the total surface water yield in the year 2000 amounted to about 12 800 million m^3 (DWA, 2010c).

The physical transfer of water within or between catchments has physical, chemical, hydrological and biological implications for the recipient catchment. Inter-basin transfers cause a disruption of the river continuum downstream of the transfer in the following ways:

- Water quality: sediments, nutrients, turbidity, salinity, alkalinity, temperature effects and toxic chemicals; and
- Land implications: erosion, sedimentation, salinity, alkalinity, waterlogging, changes in land use patterns, changes in mineral and nutrient contents of soils, and any other hydrogeological factors.

In particular some water quality implications for inter-basin transfer schemes in South Africa include the transfer of more salinity which has been rising dramatically in recent years for example in the Vaal and Orange River Systems. A further key concern is the threat to the water quality in the Grootdraai Dam. Inadequate management of the impacts from the defunct and abandoned coal mines in the upstream catchment could potentially affect the water quality of the Grootdraai Dam and thus the water transferred to existing power stations in the Olifants and Inkomati catchments.

2.6 Groundwater quality

Groundwater occurs widely and, geographically, and a significant portion of South Africa's population depends on it for their domestic water needs. The groundwater quality management policy for South Africa is aimed at providing an adequate level of protection to groundwater resources and securing the supply of water of acceptable quality in an integrated and sustainable manner (DWAF, 2000). The value and vulnerability of groundwater represents a strategic component of water resources of South Africa. Security of groundwater supplies is thus essential and protection of groundwater has become a national priority. The major reason for poor management of groundwater has been a lack of a structured approach to management and a lack of knowledge and information about groundwater (DWA, 2010b). Management is often focused on the long-term sustainability of the resource in terms of quantity or yield. However water quality is often neglected in many areas where groundwater is the sole source of water supply.

Groundwater has a natural dissolved mineral content that includes ions such as chloride, sodium, iron, etc. Natural groundwater quality depends on factors such as aquifer material and groundwater residence times. The natural level of groundwater electrical conductivity in South Africa is indicated in Figure 1 (DWAF, 2010b). In some parts of South Africa the natural mineral content (highly saline or brackish) of groundwater renders it unsuitable to consume. Monitoring is the key to understanding natural groundwater quality variations.

Groundwater pollution and over-abstraction are serious problems in certain parts of South Africa. Poor and deteriorating groundwater quality is widespread and can be attributed to diverse sources in various sectors such as mining, industrial activities, effluent from municipal wastewater treatment works, storm water runoff from urban and especially informal settlements (where adequate sanitation facilities are often lacking), return flows from irrigated areas, effluent discharge from industries, etc.(DWA, 2010b)

Measurements and/or observations (i.e. groundwater monitoring systems) are inadequate when used to define the status of, and trends in, groundwater quality and in determining its "fitness to use". Pollution and over-abstraction are dealt with in existing legislation and strategies, but implementation of such strategies is hampered by a lack of capacity and coordination between different governmental departments and between the different levels of water resource management. The localized nature of groundwater means that it is generally more effectively managed at the local or catchment level rather than at the national level (DWA, 2010b).

The strategy of the Department is to address areas where serious pollution or over-abstraction threatens the integrity and reputation of groundwater resources. Groundwater monitoring is to be improved at all levels. Hydrogeological support to locally based catchment and municipal managers involved in water resource management needs to be improved. Inter-governmental co-operation has to be enhanced to facilitate decision-making (DWA, 2010b).

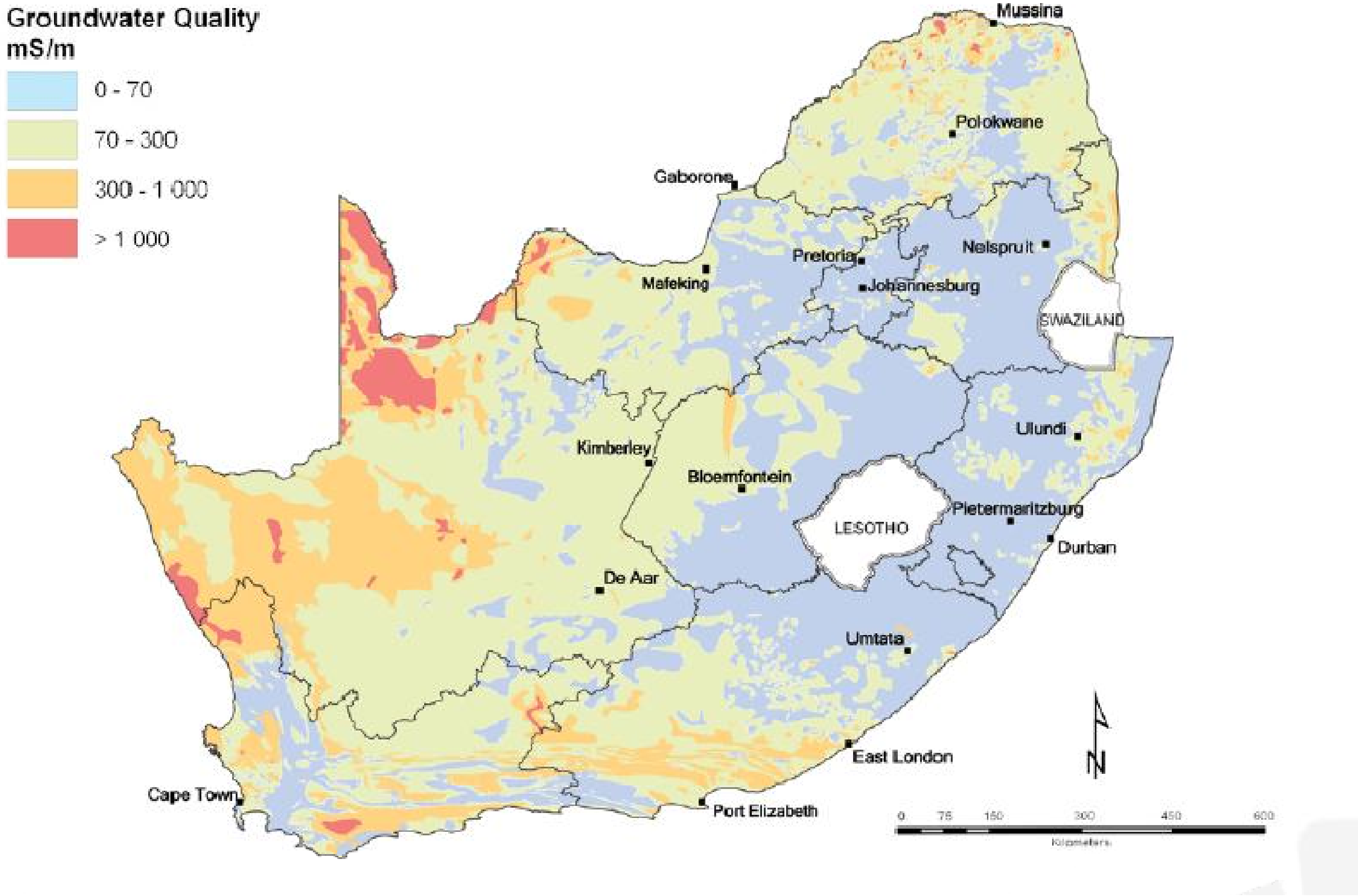


Figure 1: Electrical conductivity map of groundwater in South Africa (DWA, 2010b)

2.7 River Health Programme

As a means to serve as a source of information regarding the overall ecological status of river ecosystems in South Africa, the Department of Water Affairs (DWA) initiated the River Health Programme (RHP) in 1994. The RHP primarily makes use of in-stream and riparian biological communities (e.g. fish, invertebrates, vegetation) to characterize the response of the aquatic environment to multiple disturbances. The rationale is that the integrity or health of the biota inhabiting the river ecosystems provides a direct and integrated measure of the health of the river as a whole.

The objectives of the RHP are to:

- Measure, assess and report on the ecological state of aquatic ecosystems;
- Detect and report on spatial and temporal trends in the ecological state of aquatic ecosystems;
- Identify and report on emerging problems regarding aquatic ecosystems; and
- Ensure that all reports provide scientifically and managerially relevant information for national aquatic ecosystem management.

The National Water Act (Act no. 36 of 1998) acknowledges the importance of protecting aquatic ecosystems in maintaining the full suite of goods and services that people rely on for their livelihoods, and requires that a national aquatic ecosystem health monitoring system be established. To date, the implementation of the RHP has largely been driven by provincial implementation teams consisting of amongst others, DWA Regional Offices, provincial departments of the environment, conservation agencies, universities and municipalities. Implementation in the provinces has largely been voluntary and is influenced by various factors such as the enthusiasm of provincial champions and provincial task teams, buy-in from their respective organisations, as well as the availability of financial and human resources. This makes the RHP very vulnerable and affects its long-term sustainability (www.csir.co.za/rhp/).

To date a number of the state of the rivers reports have been compiled for many of the South African River Systems through the RHP and a Rivers Database has been set up for the collation of biomonitoring data.

3. Resource Directed Water Quality Management

Resource Directed Management of water quality pertains specifically to management of the use and protection of the water quality component of inland water resources, including rivers, dams, groundwater, estuaries and wetlands.

Although the water quality component is specifically considered, it must be managed holistically, within the general framework of "resource directed measures", with water quantity (flows) and the habitat and biota components that comprise the overall water resource quality (see Text Box 1) . Resource directed management of water quality also focuses on how the management of anthropogenic activities that modify the water quality in water resources should be influenced.

The Department envisions in the application of resource directed management of water quality an equitable and sustainable balance between the use and protection of water quality in water resources to the benefit of all South Africans. To achieve this, the Department's planning function has developed policy direction describing how water quality considerations should be integrated into water resource management. This has included the development of the associated strategy and management instruments to support detailed implementation (see Text Box 2)(DWAF, 2006a).

Text Box 1: Resource Quality

Resource quality does not mean water quality alone. It refers to all aspects of the water resource including water quantity, water quality, character and condition of in-stream and riparian habitats, and the characteristics, condition and distribution of the aquatic biota.

3.1 Allocatable Water Quality and Stress

The Department recognises that, just as a quantity of water can be "used", so can water quality. For water to be regarded as "fit for use" for a number of different users in the same catchment, the water quality needs to satisfy the most demanding of those users. Typically this will be quantified in terms of individual water quality attributes. This is the basis for the concept of "allocatable water quality" which can be defined from two points of view.

First, it can be regarded as that water quality, if any, that remains allocatable (available) to uses other than the strategic national priority uses (the Reserve, etc,) (see Text Box 3) and current lawful uses (all contributing to current equitable access). It can also be more formally regarded as the maximum worsening change in any water quality attribute away from its present value that maintains it within a pre-determined range reflecting the desired future state (typically defined by a resource quality objective).

3.2 Resource Quality Objectives and Reserve

Setting resource quality objectives for a chosen management unit of a water resource, is a technical process of integration of water quality, water quantity and ecosystem integrity, the results of which will further inform the stakeholder engagement process. These objectives can include a wide variety of characteristics of the resource, some of which refers explicitly to water quality.

Text Box 2: Resource Directed Management of Water Quality – Management Instruments (DWAF 2006a)

Resource Directed Management of Water Quality Instruments developed to support implementation

Report number	Report title
1.4	Volume 1: *Policy Document Series*
1.4.1	Volume 1.1: Summary Policy: Resource Directed Management of Water Quality
1.4.2	Volume 1.2: Policy: Resource Directed Management of Water Quality
1.5	Volume 2*: Strategy Document Series*
1.5.1	Volume 2.1: Summary Strategy: Resource Directed Management of Water Quality
1.5.2	Volume 2.2: Strategy: Resource Directed Management of Water Quality
1.5.3	Volume 3*: Institutional Arrangements*
1.6	*1st Edition Management Instruments Series (Prototype Protocol)*
1.6.1	Appendix B: Project Document. Conceptual Review for water licence application from a Resource Directed Management of Water Quality (RDMWQ) perspective
1.6.2	**Guidelines on Catchment Visioning for the Resource Directed Management of Water Quality
1.6.3.1	**Guideline for determining Resource Water Quality Objectives (RWQOs), water quality stress and allocatable water quality
1.6.3.2	**Guideline on the conversion of the South African Water Quality Guidelines to fitness-for-use categories
1.6.3.3	**Guideline for converting Resource Water Quality Objectives (RWQOs) to individual end-of-pipe standards
1.6.3.4	Appendix D: Project Document. ACWUA Decision-making support system for Resource Directed Management of Water Quality (RDMWQ)
1.6.4	**Decision-support instrument for the Assessment of Considerations for Water Use Applications (ACWUA)
1.6.5	**Guideline on pro-forma licence conditions for the Resource Directed Management of Water Quality
1.7	Volume 4: *2nd Edition Management Instruments Series*
1.7.1	Volume 4.1: Guideline for Catchment Visioning for the Resource Directed Management of Water Quality
1.7.2	Volume 4.2: Guideline for determining Resource Water Quality Objectives (RWQOs), Allocatable Water Quality and Stress of the Water Resource
1.7.2.1	Volume 4.2.1: Users' Guide. Resource Water Quality Objectives (RWQOs) Model (Version 4.0)
1.7.3	Volume 4.3: Guideline on Monitoring and Auditing for Resource Directed Management of Water Quality
1.7.4	Appendix A: Project Document: Philosophy of Sustainable Development
1.7.5	Appendix C: Project Document: Guidelines for Setting Licence Conditions for Resource Directed Management of Water Quality (RDMWQ)
1.7.6	Introduction

** These reports are earlier versions that have been improved upon in the second edition and thus are not available for publication.

Text Box 3: The Reserve

The Reserve is the quantity and quality of water required to satisfy the basic human needs and to protect aquatic ecosystems, in order to secure ecologically sustainable development and use of the relevant water resource. The Reserve is the only water right specified as inviolable in the law. Water for basic human needs has the highest allocation priority in the country. The basic human needs Reserve includes water for drinking, food preparation and personal hygiene. In terms of water quality the intention of the basic human needs Reserve is to secure the quality requirements for basic human needs with minimal treatment.

The intention of the ecological Reserve is to secure sufficient water of an appropriate quality to maintain aquatic ecosystems in such a form that they can continuously provide the desired set of socio-economic goods and services to society.

The Department has used lower confidence standard approaches and instruments in the absence of a classification system to determine preliminary classes of water resources nationwide, based on water quality. This will be used to identify potential priority water resources exhibiting water quality stress. Preliminary resource quality objectives relating to water quality and resource water quality objectives (RWQOs) will then be set for these priority resources using more accurate (higher confidence) approaches. This provides an initial impetus to the implementation of resource directed management of water quality in accordance with the intentions of the NWA (Act No. 36 of 1998) (DWAF, 2006a).

Some impacts on water quality, particularly those relating to conservative water quality variables, will have increasingly cumulative effects towards the most downstream reaches of surface water resources.

Accordingly, the setting of resource quality objectives or resource water quality objectives for a particular catchment must take cognisance of that catchment's water quality issues (current and future) and those of upstream and particularly downstream catchments as well as those linked through inter-basin transfers. All water quality-related objectives in such catchments must be mutually compatible.

3.3 Source Directed Controls

The control and management of sources of pollution is guided by environmental legislation as well as the management classes set for identified water resources.

The precautionary approach is always applicable and will be balanced against socio-economic necessities. Preventing pollution in the first place will always be encouraged while pursuing the best practicable environmental option. Should some water quality degradation be inevitable, waste minimisation will be encouraged. The precautionary approach will be applied to point sources of pollution by enforcing uniform national minimum requirements or standards.

The degree to which they may be enforced or relaxed will depend on the degree of water quality stress (DWAF, 2006a and 2006b).

3.4 Monitoring

Sound water quality monitoring is essential for adaptive management. Monitoring of (a) overall national water quality status and trends, (b) compliance with resource quality objectives, (c) compliance with water use licence conditions, including monitoring of affected water resources, and (d) remediation efforts is crucial to sound management.

Water quality monitoring is most commonly related to adaptive water quality management, which aims to control the physical, chemical and biological characteristics of water resources.

By gathering sufficient data through monitoring, the spatial and/or temporal variations in water quality can be assessed. The quality of water may be described in terms of the chemical concentration and state (dissolved or particulate) of some or all of the organic and inorganic material present in the water, together with certain physical characteristics of the water (UNEP/WHO, 1996).

The quality of the aquatic environment is a broader issue which can be described in terms of:

- water quality,
- the composition and state of the biological life present in the water body,
- the nature of the particulate matter present, and
- the physical description of the water body (hydrology, dimensions, nature of lake bottom or river bed, etc.).

Water quality (the physico-chemical characteristics of the water) therefore forms a component in the assessment of the health aquatic environment, together with biological life, particulate matter and the physical condition of the water body.

Artificial and/or natural changes in the water quality of freshwaters can produce diverse biological effects ranging from the severe (such as a total fish kill) to the subtle (for example changes in enzyme levels or sub-cellular components of organisms) (UNEP/WHO, 1996).

Water quality is thus a driver that indicates that the ecosystem, and its associated organisms, is under stress or that the ecosystem has become unbalanced. As a result there could be possible implications for the intended uses of the water and even possible risks to human health

Chemical monitoring together with biological monitoring is therefore required to understand the total health of the aquatic ecosystem.

4. Resource Water Quality Objectives

Resource Water Quality Objectives (RWQOs) is a mechanism through which the balance between sustainable and optimal water use and protection of the water resource can be achieved. RWQOs are the water quality components of the Resource Quality Objectives (RQOs) which are defined by the National Water Act as “clear goals relating to the quality of the relevant water resources” (DWAF, 2006a).

RWQOs are descriptive or quantitative, spatial or temporal, and ultimately allows realisation of the catchment vision by giving effect to the water quality component of the gazetted (RQOs). RWQOs are typically set at a finer resolution than RQOs to provide greater detail upon which to base the management of water quality. The catchment vision is a collective statement from all stakeholders of their future aspirations of the relationship between the stakeholders (in particular their quality of life) and the water resources in the catchment. The RWQOs form part of the strategy to attain that vision. The levels at which RWQOs are set require that they are practical and cost-effective as possible.

The policy of the Department of Water Affairs (DWAF, 2005a) regarding RWQOs is that they should:

- Ultimately allow realisation of the catchment vision;
- Give effect to the water quality component of gazetted RQOs;
- Express more detailed stakeholder needs than those accounted for by the RQOs (where necessary);
- May equal these gazetted RQOs, but may be set at a finer spatial/or temporal resolution; and
- Dictate the tolerable level of impact collectively produced by upstream users.

The Department recognises the importance of a strong technical basis for defining RWQOs, and a heavy reliance on a catchment/situation assessment.

RWQOs provide the basis for determining the allocatable water quality and water quality stress.

RWQOs include three elements: the designated users of the water resource (e.g. recreational, aquatic ecosystem, industrial use, domestic etc), the criteria/numeric or descriptive in-stream goals defined to protect the water resource, and the alignment to the catchment vision and class of the water resource (see Text Box 4).

4.1 Balancing the needs of downstream water users with upstream water use and development

In setting of RWQOs, the Department strives to achieve a balance between protecting the water resource for the downstream users and allowing use and development of the water resource upstream of the river reach selected for the RWQOs. For the downstream water users, the focus is on protecting the water quality in order to ensure a healthy functional aquatic ecosystem, while also meeting the water quality requirements of the other recognised water user groups (domestic, agricultural, industrial, recreation and aquatic ecosystems) downstream of the RWQOs point. However, the selected RWQO might also restrict the type and extent of water use upstream of the point. Water uses refer to those described in Section 21 of the NWA (DWAF, 2006a).

It must also be borne in mind that in terms of DWA policy the RQOs (and related RWQOs) will be used as the basis for the setting of waste discharge standards (Section 26[h] of the NWA) and waste discharges charges in each catchment. Thus the setting of RQOs and RWQOs become central to balancing the needs of the upstream "impactors" with downstream user requirements.

4.2 Fitness for use

Fitness for use is a scientific judgement, involving objective evaluation of available evidence, of how suitable the quality of the water is for its intended use. Water quality can therefore only be expressed in terms of fitness for use. Water quality assessment to determine fitness for use is based on resource water quality objectives (RWQOs) that have been set for the water resource.

In South Africa, the South African Water Quality Guidelines (SAWQGs) have been developed as discrete values that depict the change from one category of fitness for use to another (DWAF, 1996). The SAWQGs recognises only one management category, namely the Target Water Quality Range (TWQR). Above this value / range, the categories describe an ever increasing negative impact with respect to the use of the water. Thus, for any resource it is necessary to determine whether or not the effect is acceptable to the user (DWAF, 2006c).

The water quality guidelines describe the "fitness for use" of a water resource, while the water quality objectives define "what management action is required" for a water resource. The fitness for use of water is a judgement as to how suitable the quality of water is for its intended use. The following fitness for use categories are linked to the SAWQGs:

- Ideal – the use of water is not affected in any way; 100% fit for use by all users at all times; desirable water quality (TWQR);
- Acceptable – slight to moderate problems encountered on a few occasions or for short periods of time;
- Tolerable – moderate to severe problems are encountered; usually for a limited period only; and
- Unacceptable – water cannot be used for its intended use under normal circumstances at any time (DWAF, 2006c).

The descriptions are related to an associated effect of a particular water quality variable for a water user category. The South African Water Quality Guidelines also serve as a common basis for the development of RWQOs for water resources.

The Department strives to maintain a balance between the need to protect and the need to use the country's water resources. The TWQR is a management objective that is used to specify the ideal concentration range and / or water quality requirements for a particular constituent. This is the range of concentrations or levels within which no measurable adverse effects are expected on the health of the user, and should therefore ensure their protection (DWAF, 2006c).

The TWQR has been used to define the Ideal category, while the upper limit of where negative effects are seen has been defined as the tolerable category. Assuming that a linear distribution in the data was used to derive the TWQRs (DWAF, 1996), the acceptable category was interpolated to be the average of the Ideal category (*i.e*. TWQR) and the tolerable level. The unacceptable category is regarded as any concentration / level above the upper limit (*i.e.* Tolerable) (DWAF, 2006c).

The assessment of the water resource to rate its current water quality status in terms of fitness for use and associated water quality range usually supports or links to water quality management related targets and goals, a management action or objective that is required. This can range from no action (ideal) to immediate intervention (unacceptable).

Text Box 4: National Water Resource Classification System

Classification system

Resource Directed Measures, together with Source Directed Controls are the key strategic approaches designed under the National Water Act (NWA) (Act 36 of 1998) to achieve equity, sustainability and efficiency in Integrated Water Resources Management in South Africa. These measures comprise the classification system, the Reserve and Resource Quality Objectives. Together they are intended to ensure comprehensive protection of all water resources.

The Water Resource Classification System (WRCS), which is required by the NWA, is a set of guidelines and procedures for determining the desired characteristics of a water resource, and is represented by a Management Class (MC). The Management Class outlines those attributes that the custodian [Department: Water Affairs (DWA)] and society require of different water resources. The WRCS is a consultative process to classify water resources (Classification Process) to help facilitate a balance between protection and use of the nation's water resources. The outcome of the Classification Process will be the Minister or her delegated authority setting the MC and Resource Quality Objectives (RQOs) for every significant water resource (river, estuary, wetland and aquifer) which will be binding on all authorities or institutions when exercising any power, or performing any duty under the NWA. Only three management classes are acceptable, Class I: Minimally Used, or Class II: Moderately Used, or Class III: Heavily Used. The management classes essentially describe the desired condition of the resource, and conversely, the degree to which it can be utilised. In other words, the MC of a resource sets the boundaries for the volume, distribution and quality of the Reserve and RQOs, and thus the potential allocable portion of a water resource for off-stream use.

The Classification Process is not carried out in isolation, but is integrated within the overall planning for water resource protection, development and use. A key component of classification is therefore the ongoing process of evaluating options with stakeholders in which the economic, social and ecological trade-offs will be clarified and decided upon (DWAF 2006c).

5. Objectives of this report

The main objective of the report is to provide a critical planning level review of the state of water quality of South Africa's surface waters. In doing so, national water quality planning interventions, strategy guidance and management actions have been identified. The review also provides an assessment of the fitness of use of water resources and their sustainability in terms of maintaining aquatic ecosystem integrity.

The report concentrates on the water quality state of the nation's surface water resources in terms of chemical quality. The report deals with surface water resources (including outlet quality of dams) only and does not include a review of groundwater, estuaries or dams. It also does not deal with the biological or microbiological status in detail (a summary is given in Text Box 5) of the surfaces water resources, as this information is not readily available on a national scale.

The objectives of the report are:

- To provide a critical review of the water quality status of the country's surface water resources;
- To provide information on the major factors and aspects that are impacting on the water quality status of our surface water resources;
- To identify strategic issues and key challenges that need to be addressed and important information gaps regarding water quality considerations and aspects, and
- To provide recommendations for future actions regarding water quality planning and management.

The results of this review is also aimed at informing the review of policy objectives including, the resource directed quality management policy and the associated implementation strategy and instruments.

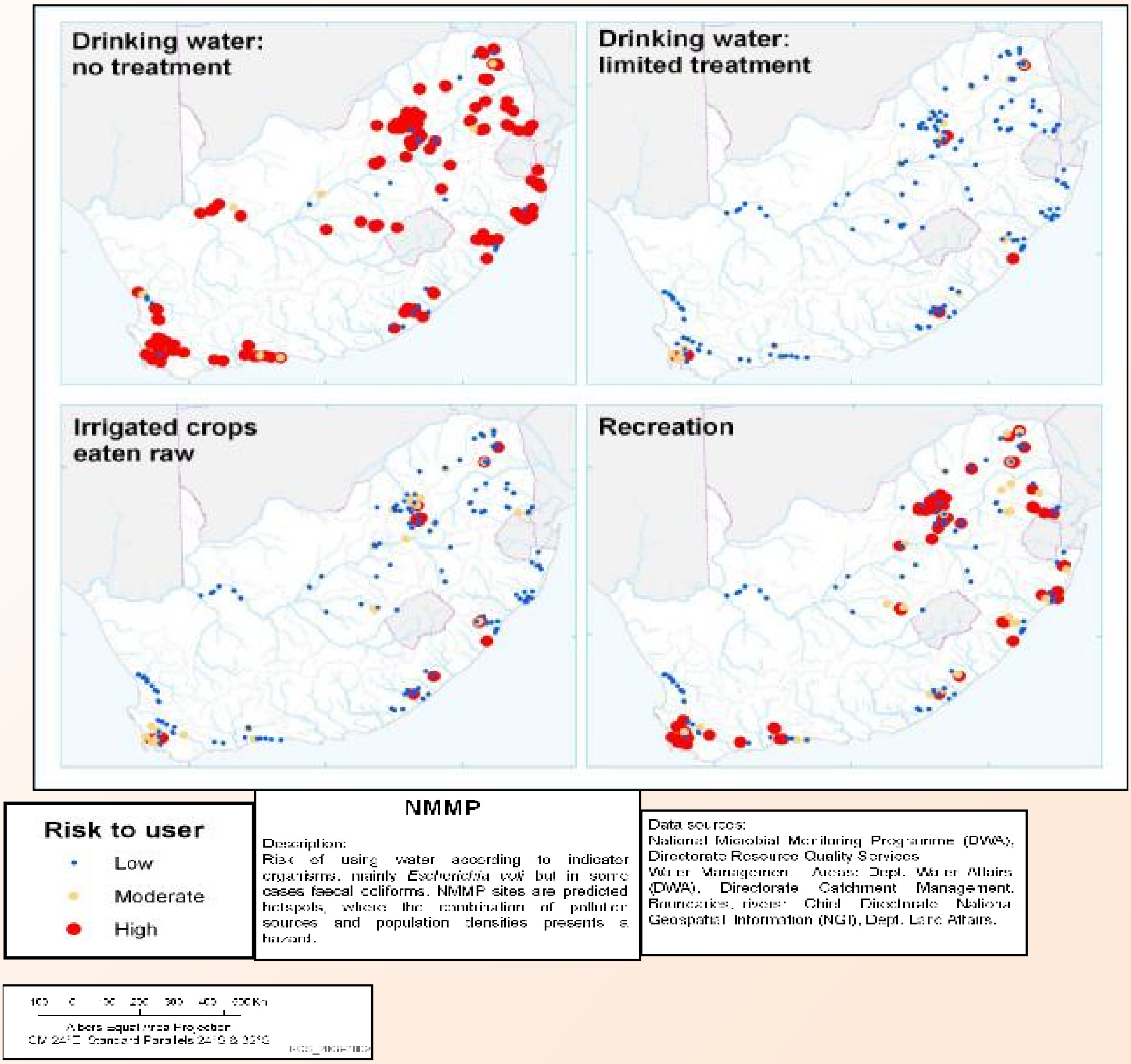
The degree to which individual catchment visions are being realised through catchment management strategies and the degree to which these are influencing achievement of national water quality goals will also be reviewed through this process.

Text Box 5: Microbiological Status of water resources of South Africa at selected hotspot areas

Microbiological Status

In terms of microbiological status, the Department of Water Affairs monitors feacal pollution through the National Microbial Monitoring Programme (NMMP). The NMMP provides information on the status and trends of the extent of faecal pollution in surface water resources especially in selected high risk settlement areas. Water related diseases include cholera, typhoid fever, viral gastroenteritis, dysentery, shigellosis etc.

The programme identified 163 high-risk or "hotspot" areas across the country for the 2007/2008 hydrological period and the number was increased to 182 for the 2008/2009 hydrological cycle. *Escherichia coli* (*E. coli*) was used as a bacterial indicator for faecal pollution in all the hotspots. There is a high risk associated with the use of water directly from the river for drinking purposes with no treatment as indicated in the figure below for most of the hotspot sites. Limited or domestic treatment of water will result in a low risk level for healthy individuals. The data also revealed that there will be no risk associated with eating raw crops (*i.e.* tomatoes etc.) that have been irrigated with the water abstracted from the hotspot areas. Around 40% of the sites are not good spots for recreational activities, *i.e.* partial or full contact (DWA, Resource Quality Services, Annual National State of Water Resources Report 2008/2009- *in publication*).



6. Water Management Areas

To facilitate the management of water resources, the country has been divided into 19 catchment-based water management areas (Figure 2).

The boundaries of the water management areas lie mostly along the divides between surface water catchments. Pronounced differences are evident among the water management areas with respect to water availability and water requirements, which are attributable to the large spatial variations in climate, the level and nature of economic development and population characteristics. Similarly, there are large differences within water management areas with respect to hydro-meteorological conditions and economic activity which cannot be adequately represented or managed without further spatial differentiation.

WMAs were therefore divided into sub-areas to enable improved representation of the water resources situation in the country and to facilitate the applicability and better use of information for strategic management purposes. Delineation of the sub-areas was based on practical considerations such as the size and location of sub-catchments, the homogeneity of natural characteristics, the location of pertinent water infrastructure such as dams, and economic development. It is foreseen that the catchment management agencies may later introduce smaller or alternative subdivisions (DWAF, 2004a).

For the current status assessment water quality was reviewed at a WMA scale so as to identify local perspectives that the national scale review cannot provide.

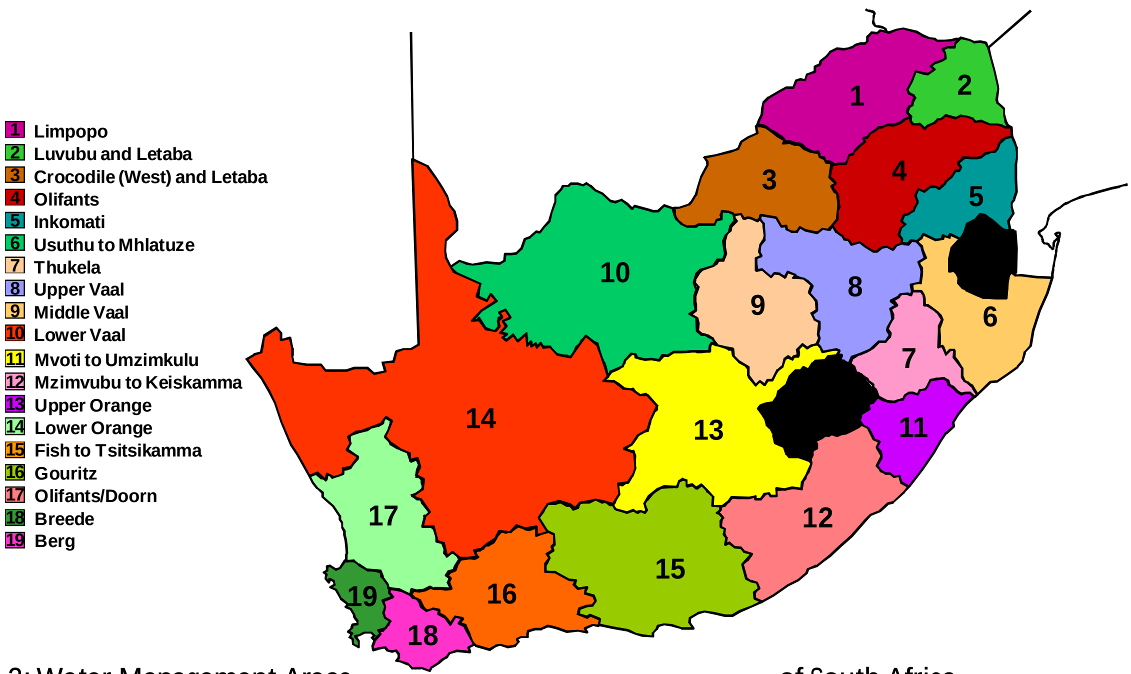


Figure 2: Water Management Areas of South Africa

7. Methodology

The water quality state of the country's surface water resources is provided here at planning review level. The current state is represented in terms of the key water quality variables considered indicative for reporting of water quality. Six parameters have been selected to provide an indication of the fitness for use of water resources by the designated user groups.

In-stream water quality of surface water resources was assessed using chemical monitoring data at a range of monitoring sites throughout the country (in each of the 19 WMAs) which was compared to a generic set of conservative level RWQOs to determine compliance for the selected water quality variables.

7.1 Collection of Data

The data was extracted from the WMS (Water Management System) on 15 February 2010 with a stipulated date range of 1st January 1999 to 31st December 2008. The monitoring sites selected were from the National Chemical Monitoring (Priority) Programme. This programme has a spatial resolution covering South Africa with approximately 330 sites that are situated predominantly on rivers and for which surface water quality samples are taken to analyse the levels of specific inorganic and physico-chemical attributes. The sites that had at minimum 25 samples taken over the period 01 January 2006 to 31 December 2008 were selected for the current state assessment. This resulted in 276 monitoring sites being assessed (Appendix A). An assessment of trends was done at the sites where a 10 year data range was available from 1st January 1999 to 31st December 2008.

7.2 Collection of Samples

These sites are sampled predominantly by the Hydrometry staff from the various DWA Regional Offices during their routine visits to flow gauging structures. It is at these flow gauging structures where most of the water quality sites are also located. The sampling frequency varies from twice to once a month, with some samples being taken less frequently when the sites are in very remote locations. Selected sites are sampled by private individuals or institutions where it is not possible or feasible for the DWA Regional Offices to assist. The water quality samples are immediately preserved with $HgCl_2$ to prevent uptake of any of the components (especially nutrients) by biological processes and the samples are then sent to the laboratories at Resource Quality Services (RQS) of DWA.

There the samples are logged at Sample Reception, and sent to the appropriate laboratory where they are analysed and the results entered onto the WMS via the Laboratory Information Management System (LIMS).

The results are subjected to the following quality control procedures:

- Metered Electrical Conductivity (EC) values are compared with calculated EC values;
- A cation/anion balance is conducted;
- Proficiency testing between laboratories using a common sample is conducted;
- Certified Reference Materials are used to check and calibrate the instruments;
- Calibration of the older instruments was forced to occur at a specified frequency; and

- In-run control standards are utilized during routine analysis (e.g. every tenth analysis is performed on a standard solution).

7.3 Identification of Key Water Quality Variables

Due to the scale and extent of the assessment it was considered necessary to select indicator water quality variables to represent the water quality status of the country's water resources.

While the 17 physico-chemical water quality variables of the National Chemical Monitoring (Priority) Programme were analysed only six are depicted on the water quality maps for reporting for planning purposes. These six variables were selected as they serve as suitable indicators of the general water quality status within the present data constraints, in that they provide insight into the salinity and eutrophication status, mining related impacts and variability of the country's water resources. The perspective provided by these variables gives a critical review and "the worst scenario water quality map." In addition, the other eleven water quality variables do not show much variance with regard to compliance to the RWQO limits (generally compliant) and thus do not provide any critical perspective of water quality.

The variables include Electrical Conductivity (EC), Orthophosphate (PO_4-P), Ammonia (NH_3-N), Chloride (Cl^-), Sulphate (SO_4^{2-}) and pH as they are representative of the water quality issues prevalent in the country and for which data is available. While it is accepted that there are a range of other variables that could be included (e.g. Total suspended solids, total phosphate, *E. coli* counts, metals, etc.) the reality is that there is insufficient data available for these on WMS to support a national scale water quality assessment of this nature.

The selection of the variables was based on the following reasoning:

- Electrical Conductivity (EC) (mS/m): to provide an indication of salinisation of water resources (increase in salinisation of the country's water resources);
- Orthophosphate (PO_4-P) (mg/l): as an indicator of the nutrient levels in water resources (eutrophication is becoming a threat). Nitrate (NO_3+NO_2-N) (mg/l) was assessed but showed a 97% compliance to ideal RWQO due to the fact that the upper limit is set at 6 mg/l based on the most sensitive user.
- Sulphate (SO_4^{2-}) (mg/l): as an indicator of mining impacts (a major issue in many catchment areas);
- Chloride (Cl^-) (mg/l): as an indicator of agricultural impacts, sewage effluent discharges and industrial impacts;
- Ammonia (NH_3-N) (mg/l): as an indicator of toxicity; and
- pH (pH units): as a indicator for mining impacts as well as natural variability nationally.

7.4 Water Quality Data Analysis

The water quality status (fitness for use) of the surface water resources in the 19 WMAs is presented as hexagons at the selected monitoring points on the map of each WMA.

Each piece of the hexagon represents the compliance of the water quality variable along the river with a generic set of RWQOs applicable to all the rivers across the entire country.

The 95th percentile values were used to assess EC, sulphate, chloride, ammonia compliance, while the 50th percentile values were used to assess phosphate compliance, and 5th and 95th percentile values to assess pH compliance.

7.5 Assessment of water quality (RWQO Compliance)

A generic set of RWQOs for the country's surface water resources was used to assess compliance and determine the current water quality status. While it is known that water resources vary considerably and different management RWQOs are in place in many catchment areas, it was necessary to provide a generic set of assessment RWQOs which would provide a consistent indication of fitness for use of water resources anywhere in the country. The RWQOs used for the compliance assessment (Table 1) were derived using the Resource Water Quality Objectives (RWQOs) Model (Version 4.0) (DWAF, 2006d) which uses as its basis the South African Water Quality Guidelines (DWAF, 1996), Quality of Domestic Water Supplies: Assessment Guide, Volume 1 (WRC, 1998) and Methods for determining the Water Quality Component of the Reserve (DWAF, 2008a) and are based on the strictest water user criteria (thus represent fairly conservative limits).

7.6 Water Quality Trends

Where data is available, the water quality trends of the above six variables for the period 1999 to 2008 were determined by calculating the R^2 of the straight line of the time series graphs. The trends were determined per water quality monitoring point per WMA. The trend per water quality variable is depicted as a face on the map within the hexagon (Section 9). An improving trend is indicated by smiley face, a deteriorating trend by a frowny face and no trend by a dash (-).

Table 1: Generic Resource Water Quality Objectives at a National Level

Variable	Units	Bound	Ideal	Sensitive user	Acceptable	Sensitive user	Tolerable	Sensitive user
Alkalinity ($CaCO_3$)	mg/l	Upper	**20**	AAq	**97.5**	AAq	**175**	AAq
***Ammonia (NH_3-N)**	mg/l	Upper	**0.015**	Ecological	**0.044**	Ecological	**0.073**	Ecological
Calcium (Ca)	mg/l	Upper	**10**	Dom	**80**	BHN	**80**	BHN
***Chloride (Cl)**	mg/l	Upper	**40**	In2	**120**	In2	**175**	In2
***EC**	mS/m	Upper	**30**	In2	**50**	In2	**85**	Ecological
Fluoride (F)	mg/l	Upper	**0.7**	Dom	**1**	Dom	**1.5**	Dom
Magnesium (Mg)	mg/l	Upper	**70**	Dom	**100**	Dom	**100**	Dom
NO_3 (NO_3-N)	mg/l	Upper	**6**	AIr	**10**	AIr	**20**	AIr
***pH**	units	Upper	**≤ 8**	In2	**<8.4**	In2		
		Lower	**≥6.5**	AIr AAq In2	**>8.0**	AIr AAq In2		
Potassium (K)	mg/l	Upper	**25**	Dom	**50**	Dom	**100**	Dom
***PO_4-P**	mg/l	Upper	**0.005**	Ecological	**0.015**	Ecological	**0.025**	Ecological
SAR	mmol/l	Upper	**2**	AIr	**8**	AIr	**15**	AIr
Sodium (Na)	mg/l	Upper	**70**	AIr	**92.5**	AIr	**115**	AIr
***SO_4**	mg/l	Upper	**80**	In2	**165**	In2	**250**	In2
TDS	mg/l	Upper	**200**	In2	**350**	In2	**800**	In2
Si	mg/l	Upper	**10**	In2	**25**	In2	**40**	In2

Basic Human Needs	BHN	Agriculture - Aquaculture	AAq
Domestic use	Dom	Industrial - Category 2	In2
Agriculture - Irrigation	AIr		

*Selected water quality variables used for the water quality status planning review

8. Current Water Quality Status of South Africa's Surface Water Resources

8.1 National Water Quality Status

The water quality of South African surface water resources was assessed based on the fitness for use generic RWQOs that have been set for the country (refer to Table 1). Only 48 of the 276 (17%) monitoring points assessed at a national scale complied with the RWQOs for all water quality variables.

This implies that approximately 83% of water resources have some implication for the fitness for use for one or other user group. The water quality variables assessed included electrical conductivity (EC), Sulphate (SO4), Chloride (Cl-), Orthophosphate (PO4-P), Ammonia (NH3-N) and pH. The summary results of the assessment are reflected in Figure 3 below. A national water quality status map (2006 to 2008) (A2 size) is available in Appendix D as a fold out at the back of this report.

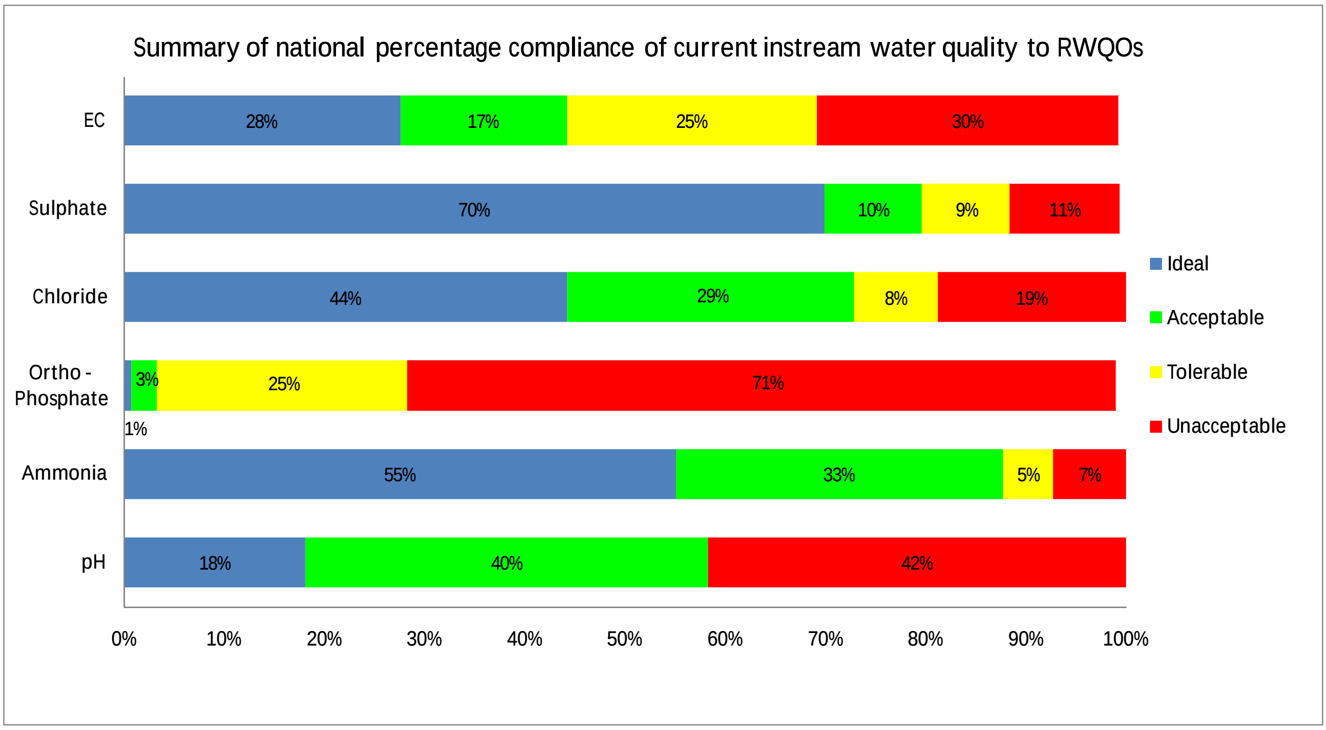


Figure 3: Summary of the national percentage compliance of in stream water quality with RWQOs at the 276 selected monitoring sites (2006 to 2008)

8.2 Results

8.2.1 Salinity

EC is proportional to the TDS concentration of water and thus is an estimate of TDS concentration. TDS is generally used as an aggregate indicator of the presence of a broad array of chemical contaminants. The primary sources of TDS in receiving water resources are agricultural runoff, point source water pollution from industrial and domestic wastewater and leaching of soil contamination. Salinisation is another major water quality issue identified at a national scale.

EC compliance indicates that 30% of the monitoring sites have unacceptably high levels (>85 mS/m) of salts, and 25% within the tolerable range (>50 to ≤ 85 mS/m). Figure 4 presents the compliance rating of monitoring sites for EC.

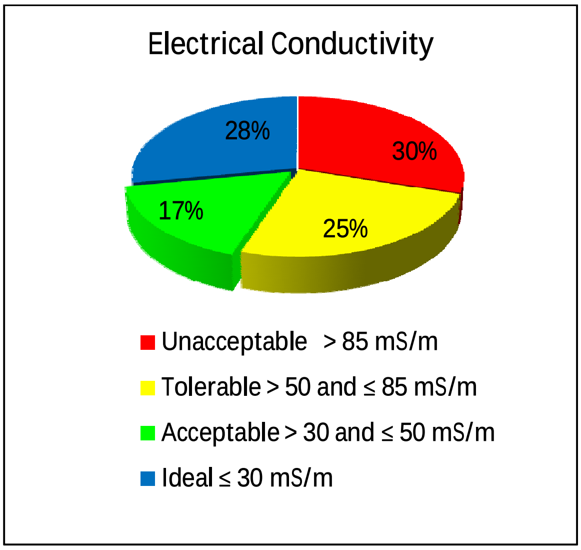


Figure 4: Percentage compliance of water quality with the EC RWQO set at monitoring points assessed

Results of the compliance assessment of sulphate and chloride with their respective set RWQOs indicate that neither poses a significant national scale threat to water users. Compliance indicates that 11% of monitoring sites show unacceptably high levels of sulphate and 19% unacceptably high levels of chloride (Figure 5 and Figure 6).

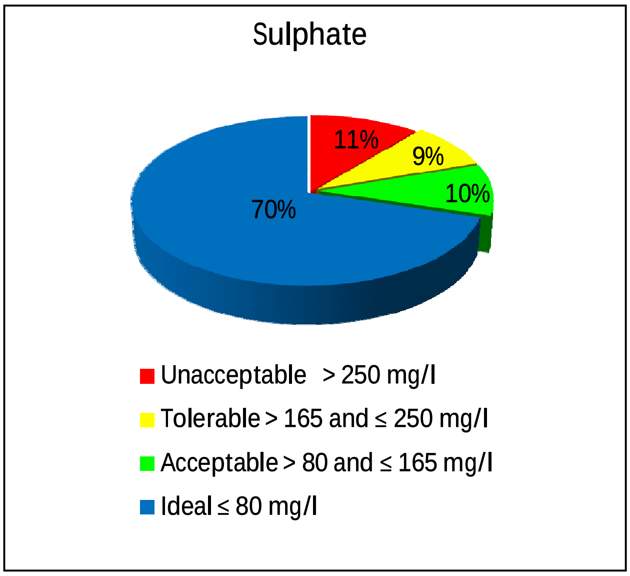


Figure 5: Percentage compliance of water quality with the sulphate RWQO set at monitoring points assessed

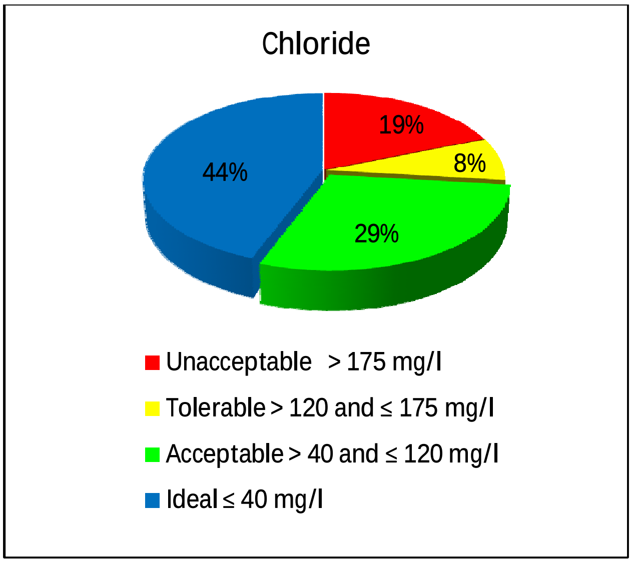


Figure 6: Percentage compliance of water quality with the chloride RWQO set at monitoring points assessed

8.2.2 Nutrients

Results show that the levels of nutrients in the country's water resources are the most concerning water quality problem. Only 29% of the monitoring sites showed compliance to the prescribed RWQO ranges (≤0.025mg/l) for phosphate (see Figure 7). There is currently a 71% non-compliance at a national scale. The current status and the resulting eutrophication is a threat to the aquatic ecosystem health of our water resources and to domestic water supply (see Text Box 7 and Text Box 8).

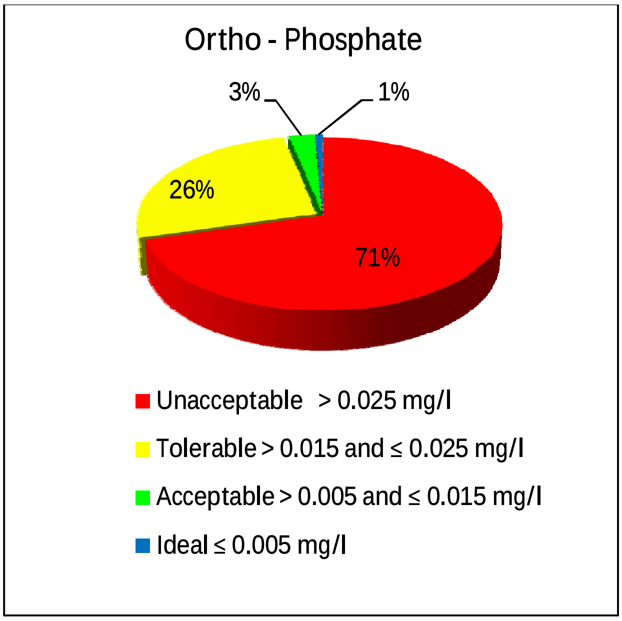


Figure 7: Percentage compliance of water quality with ortho-phosphate RWQO set at monitoring points assessed

Nitrate was not selected as a variable as part of this planning level review of surface water quality used as nitrate indicated a 100% compliance to the RWQO limits. This is due to the lenient RWQO of 6 mg/l defined for the ideal level. The current status indicates that nitrate concentrations pose no threat to domestic water supply. However the implications for aquatic health still need to be determined.

With regard to the levels of ammonia, 55% of the sites assessed show a compliance to the ideal RWQO of ≤ 0.015mg/l. This reflects a fairly good situation of the aquatic health of water resources. Only 7% of the sites assessed show unacceptably high levels (>0.073 mg/l) of ammonia (Figure 8).

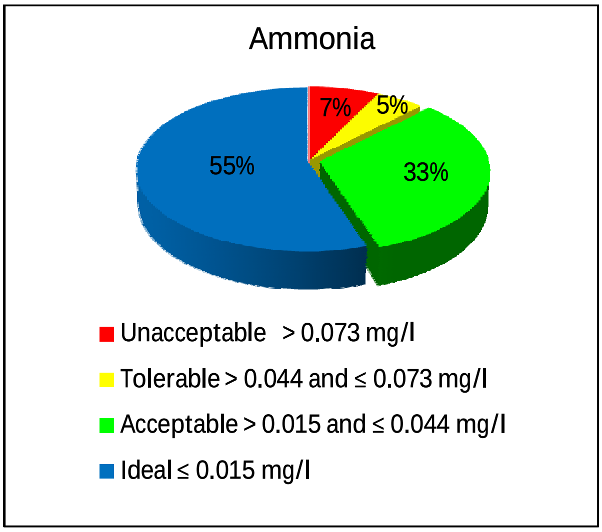


Figure 8: Percentage compliance of water quality with the ammonia RWQO set at monitoring points assessed

8.2.3 pH

In terms of the pH of the country's water resources, 42% of the monitoring sites are non-compliant in terms of the RWQO. Of these sites 86% exceed the upper limit of 8.4 pH units. Four sites displayed low pH (<5) which is due natural characteristics of the system. All these sites are located on water resources in the Gouritz WMA in the K primary drainage region, which are influenced by natural humic acid concentrations during low flows.

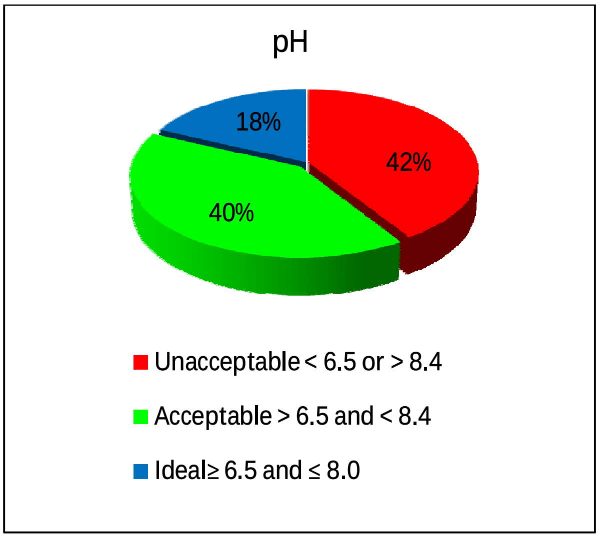


Figure 9: Percentage compliance of water quality with the pH RWQO set at monitoring points assessed

8.2.4 Water Quality Trends

Water quality trends where they could be determined are summarized in Table 2 and detailed in Appendix B, and are depicted on the water quality status maps in Section 9 and Appendix D. The results reflect that for the monitoring points assessed 69% show a deteriorating chloride trend, the highest for the six variables assessed, followed by ammonia at 63% of the points and then EC at 51% of the points.

Phosphate in terms of the current status assessment is at an unacceptable quality range at 71% of the monitoring points assessed however 37% of the points indicate an improvement, with 20% being stable and 35% deteriorating. The pH of water resources shows the highest improving trend (at 58% of points).

8.2.5 General Remarks

Overall current state water quality at a national scale appears to be at an acceptable level, with the only major threat to fitness for use being phosphate concentrations (indicative of possible eutrophication). Eutrophication is a looming threat, and the country's water resources are considered to be a high risk from elevated nutrient levels.

The status assessment has identified that high salinity concentrations is currently a problem and 51% of the sites have a deteriorating trend.

A summary of the water quality issues and concerns and possible consequences per WMA is presented in Section 9.

Text Box 6: Percentiles

Did you know?

A percentile is the value of a variable below which a certain percent of observations fall. So the 95th percentile is the value (or score) below which 95 percent of the observations are found. The term percentile is often used in descriptive statistics.

Analysis of water quality data is very often reported on in terms of percentiles (usually 5th, 50th, 75th and 95th percentile values). The percentile value is used to describe the main features of the water quality data set quantitatively (descriptive statistic)

For example:

A 95th percentile value for ortho-phosphate of 1.0 mg/l implies that 95% of the data set of phosphate values are below 1.0 mg/l.

Table 2: Summary of National Water Quality Trends per variable at the monitoring points assessed

Trend		Water Quality Variable					
		Electrical Conductivity	Sulphate	Chloride	Ortho-phosphate	Ammonia	pH
Improving	J	37%	38%	30%	37%	11%	58%
Deteriorating	L	51%	30%	69%	35%	63%	16%
Stable	-	8%	26%	0.4%	20%	22%	22%

Where: % indicates the number of water quality monitoring sites that have either improved, deteriorated or remained stable over the assessment period.

Text Box 7: Eutrophication and its effects

"Eutrophication" is an ecological term that is used to describe the process by which a water body becomes enriched with plant nutrients such as phosphorus and nitrogen. This results in a range of undesirable changes, including over-production of algae and aquatic plants (rooted and free floating macrophytes), and the deterioration of water quality and other symptomatic changes which may interfere with water uses. This process is reversible through the management of nutrient sources.

The trophic status of a water body describes the degree of enrichment with plant nutrients. Oligotrophic means the presence of low levels of nutrients and no water quality problems; Mesotrophic means intermediate levels of nutrients, with emerging signs of water quality problems; Eutrophic means high levels of nutrients and an increased frequency of water quality problems; and Hypertrophic means excessive levels where plant production is governed by physical factors. Water quality problems are almost continuous.

The link between aquatic plant growth, nutrients and human activities (eutrophication) was first noted in the early part of this century. However, it was not until after the 1960s that a clear scientific understanding of eutrophication was developed. Phosphorus is recognised as the fundamental cause of eutrophication because clear correlations have been observed between algal growth and phosphorus concentrations in lakes and reservoirs, and phosphorus availability determines the influence of the other nutrients. Nitrogen plays a secondary role, but can become important at a high level of eutrophication. In this case nitrogen-fixing cyanobacteria can cause a much more significant nuisance than other types of algae.

Water quality problems associated with excessive eutrophication are numerous and may be either long- or short-term. The problems include, amongst others:

- Increased occurrence and intensity of nuisance algal blooms;
- An increasing dominance by cyanobacteria and occurrence of toxic cyanobacteria;
- Increased occurrence of floating and rooted aquatic macrophytes;
- Increased occurrence of taste and odour problems in final drinking water;
- Increased occurrence of deoxygenation in reservoir bottom waters with associated chemical effects (hydrogen sulphide and elevated levels of heavy metals);
- Increased fish and invertebrate mortality;
- Changes of ecological community structure and loss of biodiversity;
- Increased water treatment costs due to the need for filter cleaning and toxin removal in water treatment works (WTW);
- Increased interference in recreation activities (boating, fishing, swimming);
- Increased occurrence of human health problems (gastroenteritis, skin complaints);
- Loss of property values;
- Interference with irrigation and livestock agriculture (e.g. clogging of irrigation nozzles and livestock mortality);
- Undesirable aesthetic conditions (e.g. turbidity, foam, discolouration, odours).

Summarised from Walmsley, R.D. (2000). Perspectives on Eutrophication of Surface Waters: Policy/research needs in South Africa. WRC Report No KV129/00. Water Research Commission.

A typical cyanobacterial bloom – dense algae scum

Water hyacinth – Inanda Dam

Algal bloom – Krugersdrift Dam

Text Box 8: Eutrophication status of water resources of South Africa at selected impoundments

Eutrophication Status

The National Eutrophication Monitoring Programme (NEMP) of the Department provides information on the trend and status of nutrient enrichment in the country's reservoirs and lakes. The 2008-2009 report entails information or data from 78 priority reservoirs. The 2007-2008 hydrological report took into account sites from the inlet and outlet of the reservoirs to constitute the reported 106 NEMP sites. The 2008-2009 report (refer to figure below) indicates that the dams in the Crocodile-West and Marico, Upper Vaal, Middle Vaal, Lower Vaal and Berg WMAs are hypertrophic and show symptoms of serious eutrophication (e.g. the Erfenis, Allemanskraal and Koppies Dams). Other WMAs are not that affected e.g. the Levuvhu-Letaba WMA.

There is a need to focus more on methods that can be implemented through policies to reduce nutrient enrichment in our water resources. In the 1980s, the Department of Water Affairs issued a special phosphorus standard (1 mg P/ℓ) on effluent discharged into sensitive catchments in an attempt to reduce nutrient enrichment in surface water resources. A stricter approach of phosphorus standard in Wastewater Treatment Works (WWTWs) and other related industries need to be enforced. A number of initiatives funded by different stakeholders including the Department have been put in place to develop in-lake eutrophication or nutrient enrichment management.

Harties Metsi-a Me Project (Hartebeespoort Dam) is an over-arching project that looks at a wide variety of short-term and long-term methods to control the eutrophication status of the Hartbeespoort Dam. Tshwane Metropolitan Council funded the acquisition and installation of six (6) Solar-Bee's pump stations at Rietvlei dam (11 July 2008). Solar-Bee, a solar powered aeration pump system, is a step towards finding solutions to in-lake eutrophication. The Water Research Council (WRC) is funding/has funded a number of eutrophication management studies in which the Department is supporting in various ways (DWA, Resource Quality Services, Annual National State of Water Resources Report 2008/2009 - *in publication*).

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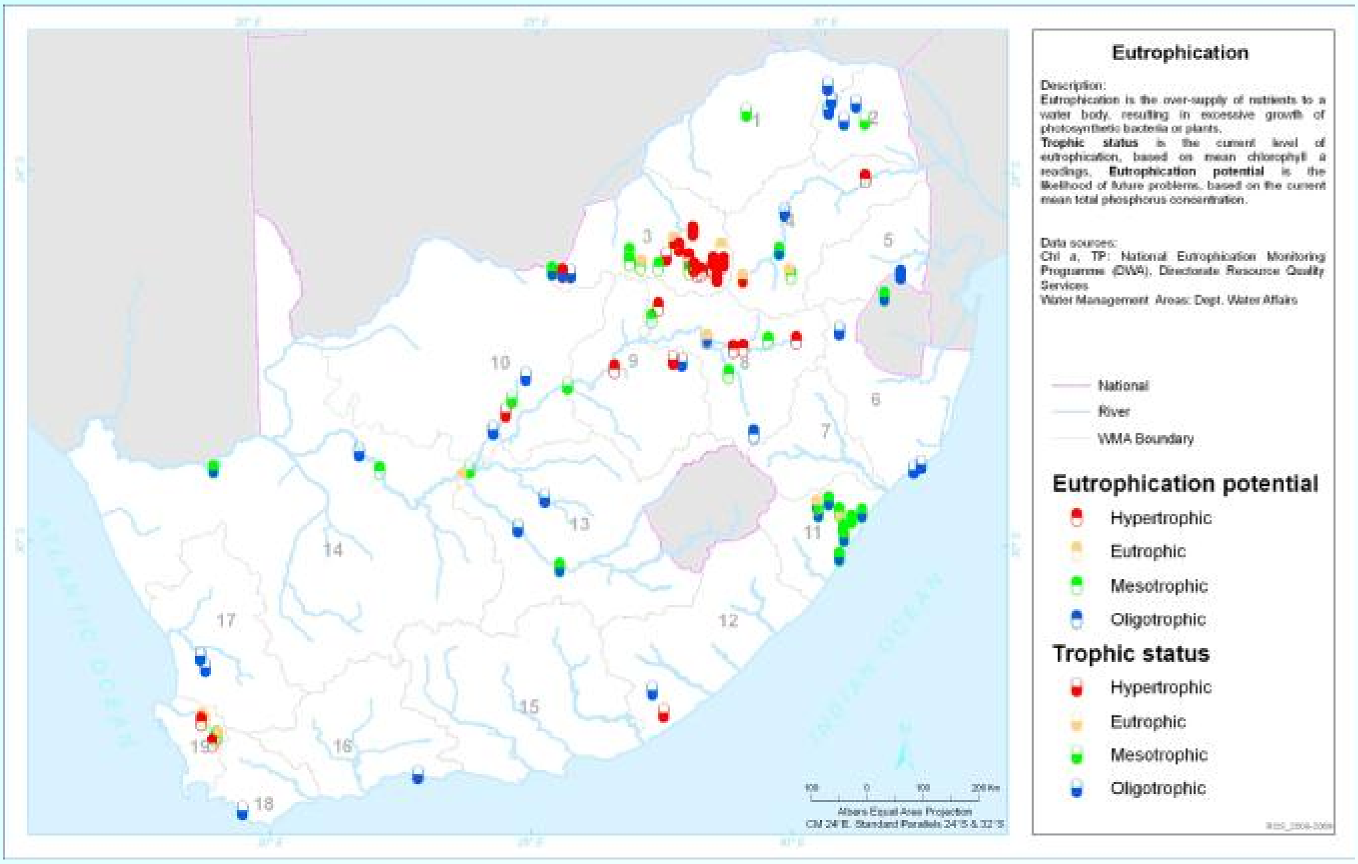

9. Water Quality Status per Water Management Area

In the following sections the water quality status per WMA is described in detail. The current water quality status is presented, as well as trends observed from 1999 to 2008. In addition the water quality issues of concern and important WMA related considerations are described.

A summary of the water quality issues and associated drivers and water quality status in terms of fitness for use are described below in Table 3 and Table 4 respectively. The water quality issues were identified and confirmed through four regional stakeholder workshops held in Cape Town, Bloemfontein, Pretoria and Durban. Regional DWA personnel from all offices and identified stakeholders from each province attended the workshops and made contributions to the water quality status assessment of surface water resources to support the planning level review (see Appendix C for list of participants). The water quality results of the status assessment were discussed and fitness for use confirmed. Associated sources of impact and related consequences were also documented.

Table 3: Summary of water quality issues identified within each of the WMAs

WMA	Water Quality Issue	Driver	Effect
WMA 1: Limpopo	Eutrophication (Nutrient enrichment)	Waste water treatment works, Intensive agriculture fertilizer use and dense urban sprawl un-serviced sewage.	Algal growth, smell, toxic algae, water treatment extra costs, taste and odour, irrigation clogging, aesthetics, recreational water users.
	Microbial contamination	Waste water treatment works, Informal dense settlements.	Recreational users (human health), washing and bathing.
	Turbidity	Informal dense settlements, subsistence agriculture, Mining and agriculture.	Water treatment costs, irrigation clogging.
	Salinisation	Mines (operational and abandoned), Waste water treatment works and agricultural runoff	Water treatment costs, soil salinity, irrigation system clogging.

WMA	Water Quality Issue	Driver	Effect
WMA 2: Luvuvhu and Letaba	Eutrophication (Nutrient enrichment)	Wastewater treatment works, Intensive agriculture fertilizer use, and dense urban sprawl un-serviced sewage.	Algal growth, smell, toxic algae, taste and odour, irrigation clogging, aesthetics, recreational water users.
	Microbial contamination	Wastewater treatment works and Informal dense settlements.	Recreational users (human health), washing and bathing.
	Turbidity	Informal dense settlements Urbanisation, forestry, mining, agriculture,	Dam and weir sedimentation, irrigation clogging.
	Salinisation	Wastewater treatment works, agricultural (intensive irrigation) and mines (operational and abandoned).	Increased water treatment costs, soil salinity and irrigation system clogging.
	Toxicants*	Pesticides (subtropical fruits, nuts) industry and DDT for malaria control.	Fish kills, human health impacts, bioaccumulation of pollutants in fish and crocodiles and crocodile deaths.
	Altered flow regime	Dams and weirs, Inter-basin transfers.	Increased turbidity (erosion), algal growth, water temperature increase, dissolved oxygen changes, taste and odour changes, impact on recreational water users, fish kills, and habitat reduction due to changed environmental flows.

*see Text Box 9 for more information on Toxicants

WMA	Water Quality Issue	Driver	Effect
WMA 3: Crocodile West and Marico	Eutrophication (Nutrient enrichment)	Wastewater treatment works, Intensive agriculture fertilizer use, and dense urban sprawl un-serviced sewage.	Algal growth, smell, toxic algae, water treatment extra costs, taste and odour, irrigation clogging, impact on aesthetics and recreational water users.
	Microbial contamination	Wastewater treatment works, Informal dense settlements.	Impact on recreational users (human health), washing and bathing.
	Turbidity	Informal dense settlements, Urbanisation, mining, agriculture, and point source discharges.	Dam sedimentation, increase in water treatment costs and irrigation clogging.
	Salinisation	Wastewater treatment works agricultural (intensive irrigation) and mines (operational and abandoned).	Increased water treatment costs, soil salinity and irrigation system clogging.
	Toxicants*	Pesticides industry	Fish kills, bioaccumulation of pollutants in fish and crocodiles.

WMA	Water Quality Issue	Driver	Effect
WMA 4: Olifants	Eutrophication (Nutrient enrichment)	Wastewater treatment works, Intensive agriculture fertilizer use and dense urban sprawl un-serviced sewage.	Algal growth, smell, toxic algae, increased water treatment costs, taste and odour problems, increased irrigation clogging, impact on aesthetics and recreational water users.
	Microbial contamination	Wastewater treatment works and informal dense settlements.	Impact on recreational users (human health), washing and bathing.
	Turbidity	Informal dense settlements, urbanisation, mining, agriculture and point source discharges.	Dam sedimentation, increased water treatment costs and irrigation clogging.
	Salinisation	Mines (operational and abandoned), wastewater treatment works and agricultural (intensive irrigation).	Increased water treatment costs, soil salinity and irrigation system clogging.
	Toxicants*	Pesticides (subtropical fruits, nuts) industry	Fish kills, bioaccumulation of pollutants in fish and crocodiles and crocodile deaths.
	Altered flow regime	Dams and weirs	Turbidity (erosion), algal growth, water temperature increase, dissolved oxygen changes, taste and odour changes, impact on recreational water users, fish kills and changes in environmental flows.
	Acid mine drainage	Mines (operational and abandoned) and controlled releases .	Mobilisation of metals, fish and crocodile deaths, bioaccumulation of pollutants in fish and crocodiles.
	Metal contamination	Mines (operational and abandoned)	Mobilisation of metals, fish kills, bioaccumulation and crocodile deaths in Loskop Dam.

*see Text Box 9 for more information on Toxicants

WMA	Water Quality Issue	Driver	Effect
WMA 5: Inkomati	Eutrophication (Nutrient enrichment)	Wastewater treatment works, Intensive agriculture fertilizer use and dense urban sprawl un-serviced sewage.	Algal growth, smell, toxic algae, increased water treatment costs, taste and odour changes, irrigation clogging, impact on aesthetics and recreational water users.
	Microbial contamination	Wastewater treatment works and informal dense settlements.	Impact on recreational users (human health), washing and bathing and potential for water borne diseases.
	Turbidity	Informal dense settlements, urbanisation, forestry, mining, agriculture and point source discharges.	Dam sedimentation, increased water treatment costs and irrigation clogging.
	Salinisation	Wastewater treatment works, agricultural (intensive irrigation) and mines (operational and abandoned).	Increased water treatment costs, soil salinity and irrigation system clogging.
	Toxicants*	Pesticides (subtropical fruits, nuts) industry	Fish kills, bioaccumulation of pollutants in fish and crocodiles and crocodile deaths.
	Altered flow regime	Dams and weirs Inter-basin transfers	Turbidity (erosion), algal growth, water temperature increase, dissolved oxygen changes, taste and odour changes, impact on recreational water users, fish kills, habitat reduction due to altered flows.
	Acid mine drainage	Mines (operational and abandoned) and controlled releases.	Mobilisation of metals, fish and crocodile deaths, bioaccumulation of pollutants in fish and crocodiles.
	Metal contamination	Mines (operational and abandoned)	Mobilisation of metals, fish kills, bioaccumulation of pollutants into fish and the food chain (crocodiles and birds).

*see Text Box 9 for more information on Toxicants

WMA	Water Quality Issue	Driver	Effect
WMA 6: Usutu to Mhlathuze	Eutrophication (Nutrient enrichment)	Irrigation runoff rich in nutrients, and treated wastewater return flows.	Eutrophication problems in upper reaches of Pongolapoort Dam, animal deaths due to toxic algae and eutrophication of Klipfontein Dam (Upper Mfolozi).
	Microbial contamination	Faecal pollution in rural catchments. Poor sanitation. Wastewater treatment works Informal dense settlements.	Water borne disease Outbreaks of cholera and diarrhoea High health risk to infants, elderly and immuno-compromised individuals
	Salinisation	High salinity in irrigation return flows	Increased salts in downstream rivers and dams (Pongolapoort Dam, middle & lower Mhlathuze, lower Mkuze/Hluhluwe)
	Acid mine drainage	Coal mining activities in headwaters of Pongola, Mfolozi & Mkuze rivers	Low pH, elevated sulphur and iron. Elevated salts and dissolved metals.
	Suspended sediment loads	Land-degradation and over-grazing	High suspended solid loads during high flows and silting up of rivers.

WMA	Water Quality Issue	Driver	Effect
WMA 7: Thukela	Eutrophication (Nutrient enrichment)	Poor wastewater treatment works (Green Drop Report, 2009), intensive agriculture fertilizer use, informal settlements, high rural population density (56/km^2). Poor sanitation.	Algal blooms, toxic cyanobacteria (health risk), increased water treatment costs, taste and odour problems, impacts on aesthetics and recreational water users, etc.
	Salinisation (especially Buffalo River)	Coal mines (operational and abandoned) – AMD, Industries from New Castle and Dundee area, wastewater treatment works and agriculture (irrigation).	Increased water treatment costs, soil salinity, drip irrigation system clogging.
	Suspended sediment loads	Soil erosion, severe overgrazing (e.g. subsistence agric area, Mweni valley, etc.)	Siltation of rivers, weirs, and dams and loss of habitat.
	Paper pollution (air, water and land)	Sappi Paper Mill at Mandini (toxic POP dioxine, high BOD, DOC, etc.)	Environmental health, reduction in biodiversity and fish kills.

WMA	Water Quality Issue	Driver	Effect
WMA 8: Upper Vaal	Eutrophication (Nutrient enrichment)	Wastewater treatment works, intensive agriculture fertilizer use and dense urban sprawl un-serviced sewage.	Algal growth, smell, toxic algae, taste and odour, greater treatment costs, irrigation clogging, fish kills, impact on aesthetics and recreational water users.
	Microbial contamination	Wastewater treatment works and informal dense settlements.	Impact on recreational users (human health), washing and bathing.
	Salinisation	Mines (new, operational and abandoned), wastewater treatment works agricultural (intensive irrigation) and atmospheric deposition.	Increased water treatment costs, soil salinity, irrigation system clogging and increased vulnerability to the water that is transferred.
	Turbidity	Informal dense settlements, urbanisation, mining and agriculture.	Dam and weir sedimentation, irrigation clogging and habitat loss.
	Toxicants*	Wastewater treatment works, intensive agriculture fertilizer use and dense urban sprawl un-serviced sewage.	Fish kills, bioaccumulation of pollutants into fish and the food chain (crocodiles and birds).
	Acid mine drainage	Mines (operational and abandoned) and controlled releases.	Low pH, elevated sulphur and iron, elevated salts and dissolved metals.

*see Text Box 9 for more information on Toxicants

WMA	Water Quality Issue	Driver	Effect
WMA 9: Middle Vaal	Eutrophication (Nutrient enrichment)	Poor wastewater treatment works (see Green Drop Report, 2009), dense urban sprawl un-serviced sewage – informal settlements and intensive agriculture fertilizer use.	Algal blooms (increasing), toxic cyanobacteria (health risk), increased water treatment costs, taste and odour problems, undesirable aesthetics condition and impeding of recreational water use, etc.
	Microbial contamination	Wastewater treatment works and dense informal settlements.	Impact on recreational users (human health), health risk to drink raw water, washing and bathing.
	Salinisation	Gold mines (operational and abandoned) – especially KOSH area (~150 Mℓ/d, EC 500 mS/m), wastewater treatment works and agriculture (irrigation).	Soil salinisation, lower crop yield, drip irrigation system clogging and increased water treatment costs.
	Altered flow regime and less flow in river (River Regulation))	Dams and weirs	Seasonal flow changes, ecological water requirement changes, turbidity (erosion), algal growth, smell, water temperature increase, fish kills and changes in environmental flows.
	Radioactivity	Discarded mine dumps	Bioaccumulation of pollutants into fish and the food chain (crocodiles and birds), aquatic organisms, soils and humans. Carcinogenic effects.

WMA	Water Quality Issue	Driver	Effect
WMA 10: Lower Vaal	Salinisation (Vaal, and Harts rivers)	Agriculture (intensive irrigation – Vaalharts scheme) return flows (82% water requirements) and wastewater treatment works.	Degrade soil (79 - 280 t salts/ha), salt-induced water stress reduce the crop yield, impact on sustainability of agriculture and increased water treatment costs.
	Eutrophication (Spitskop Dam - eutrophic)	Intensive agriculture fertilizer use, nutrients from Upper and Lower Vaal WMA, wastewater treatment works and dense urban sprawl un-serviced sewage.	Toxic cyano-bacterial blooms, increased water treatment costs, taste and odour problems, irrigation clogging, impacts on aesthetics, limit recreational water use, etc.
	Microbial contamination	Wastewater treatment works and informal dense settlements.	Impact on recreational users (human health), washing and bathing.
	Altered flow regime and less flow in river (River Regulation)	Dams and weirs	Seasonal flow changes, ecological water requirement changes, turbidity (erosion), algal growth, smell impact on recreational water users, fish kills and habitat reduction due to altered flows temperature increase.

WMA	Water Quality Issue	Driver	Effect
WMA 11: Mvoti to Umzimkulu	Eutrophication (Nutrient enrichment)	Poor wastewater treatment works (e.g. Msunduzi local municipality), agriculture fertilizer use, feedlots, dairies, piggeries and dense informal settlements.	Toxic cyanobacterial blooms – health risk, bad tasting water, macrophytic growth – e.g. hyacinths in lower Umgeni and increased water treatment costs.
	Microbial contamination	wastewater treatment works, dense informal settlements – (Umhlanga River mouth, Msunduze River, Umzinto area, Phosphorus and *E. coli* are increasing in Midmar)	Health risk for recreational users, drinking raw water, washing and bathing.
	Sediments (Suspended solids – Turbidity)	Soil erosion (especially Mdloti catchment), due to settlement patterns, overgrazing, poor agricultural activities and sand mining.	Siltation of dams, e.g. Hazelmere (20 % reduction capacity)
	Paper Mill pollution	Effluent from sugar and paper mills	Impact on environmental health, lower biodiversity.

WMA	Water Quality Issue	Driver	Effect
WMA 12: Mzimvubu to Keiskamma	Eutrophication (Nutrient enrichment)	Poorly treated wastewater, urban runoff and failing sewage infrastructure.	Eutrophication of Laing and Bridledrift Dam . Poor microbial water quality.
	Microbial pollution (point and diffuse sources)	Untreated or partially treated wastewater enter river systems, poor maintenance of wastewater infrastructure, inadequate design of sanitation systems (Mthatha, Tsolo, Ugie, Maclear, East London etc.).	Health risks to local residents and water users and outbreaks of water-borne diseases such as cholera.
	Salinisation	Semi-closed loop system in Buffalo River system.	Increase in salinity only alleviated during floods.
	Suspended sediment loads	Degradation and overgrazing of communal lands	High sediment loads during flood events Silting up of structure.
	Leaching from solid waste sites	Unlicensed and/or poorly designed solid waste sites in rural towns	Organic loads to streams and rivers Heavy metals.

WMA	Water Quality Issue	Driver	Effect
WMA 13: Upper Orange	Eutrophication (especially Modder River)	Wastewater treatment works, dense urban sprawl un-serviced sewage and intensive agriculture fertilizer use.	Algal blooms, toxic cyanobacteria, increased water treatment costs, taste and odour, impeding of recreational water use, etc.
	Salinisation (especially Riet and Modder; lesser extent Caledon and Orange)	Agricultural (intensive irrigation – return flows), wastewater treatment works.	Degradation of soil, salt-induced water stress reduces the crop yield, impact on sustainability of agriculture and increase in water treatment costs.
	Sediment (Turbidity) (especially Orange & Caledon rivers)	Erosion – naturally high, enhanced by poor farming methods and sand mining.	Siltation of Dams (e.g. Welbedacht –86 % storage capacity).
	Inter-basin transfers (Orange River)	Growing population and an expanding economy; Vaal River, Gauteng, Great-Fish, Eastern Cape.	Less flow in river, seasonal flow changes and ecological water requirement changes.
	Reduced stream flow (especially Orange River)	Dams and weirs, domestic and agricultural use.	Altered flow regime, homogenized the flow, blockage of fish migration, impact on recreational water users, fish kills and habitat reduction due to altered flows.

WMA	Water Quality Issue	Driver	Effect
WMA 14: Lower Orange	Eutrophication (Nutrient enrichment)	Intensive agriculture fertilizer use and wastewater treatment works.	Algal blooms, toxic cyanobacteria (health risk), irrigation clogging, impact on aesthetics and recreational water users, etc.
	Salinisation	Agricultural intensive irrigation – return flows, high evaporation, wastewater treatment works and reduced flow.	Soil salinisation – lower productivity and irrigation system clogging.
	Less sediment (lower turbidity in Orange River)	Sedimentation in impoundments, lower flow.	Increased under water light climate – stimulate algal growth.
	Reduced stream flow (e.g. Orange 60 % at Upington, over the past 70 years)	River diversions (primarily for irrigation), inter basin transfers and evapo-transpiration.	Increases the susceptibility of the river to pollution; reduces its capacity to attenuate and degrade wastes; Concentration of pollutants and increased salinity and Reduced dilution effects.
	Metal contamination (Aluminium, Cadmium, Copper and Lead)	Uncertain, Mines (operational and abandoned)	Potentially harmful for human health and for the aquatic environment.

WMA	Water Quality Issue	Driver	Effect
WMA 15: Fish to Tsitsikamma	Salinisation	Fish and Sundays rivers naturally saline. Flat topography, low MAR, high evaporation, underlying mudstones, saline groundwater and resulting saline base flows.	Affects on fruit growing industries, negative impacts on crop yields, corrosion of appliances and domestic water supply.
	Urban rivers	Poor quality stormwater runoff and dry weather flow from dense settlements.	Poor bacterial water quality. Human health risks and impacts on ecosystems (low DO).
	Compliance to effluent standards	Poor operations at wastewater treatment works result in poor quality effluent discharges.	Poor microbiological quality downstream of discharge points. Eutrophication problems in rivers and dams.
	Industrial impacts	Industrial impacts in Uitenhage/Port Elizabeth area	Heavy metal pollution and ecosystem impacts.
	Agrochemicals	Pesticide and herbicide use in intensive irrigation agriculture residues, Persistent Organic Pollutants[#](POPs) and Endocrine Disrupting Chemical (EDCs).	Hormonal imbalances, bioaccumulation of pollutants in fish, aquatic organisms, soils, humans and up and the food chain. Carcinogenic effects.

[#]see Text Box 10 for more on Persistent Organic Pollutants (POPs)

WMA	Water Quality Issue	Driver	Effect
WMA 16: Gouritz	Salinisation	Natural geology High evaporation	Water unsuitable for irrigation agriculture. Corrosion of appliances and equipment. Alteration of the taste of domestic water.
	Urban impacts on water quality	Densely populated urban areas on coast, urban runoff, treated wastewater not meeting standards and runoff from informal settlements.	Poor bacterial water quality. Impacts on downstream users. Human health risks. Low dissolved oxygen & ecosystem impacts.
	Microbial and organics contamination	Vandalism of sewage reticulation system and pumping infrastructure. Sewage spills into receiving streams Oudtshoorn for example.	Poor bacterial water quality. Impacts on downstream users. Human health risks and low dissolved oxygen & ecosystem impacts.
	Wood processing waste	Disposal of wood processing waste in the coastal catchment. Some saw mill operators are without permits.	Leachate with high organic acids and COD. Low dissolved oxygen and ecosystem impacts.

WMA	Water Quality Issue	Driver	Effect
WMA 17: Olifants/Doorn	Nutrient enrichment in upper Olifants	Agricultural return flows, effluent from fruit and wine industries high in nutrients and high P concentrations in effluent discharges.	Algal growth potential in Clanwilliam and Bulshoek dams. Stimulation of growth of filamentous algae in canals. Interference with canal structures and irrigation equipment.
	Microbial contamination in the upper Olifants	Poor quality effluents from Citrusdal and Clanwilliam.	Negative impacts on export fruit industry (Eurepgap certification). Endangers household use of irrigation canal water.
	Salinisation of middle and lower Olifants	Intensive irrigation agriculture (LORWUA). Irrigation return flows to Olifants River.	Increase in salinity. Water unusable for downstream users, Tastes, corrosion, etc.
	Agro-chemicals	Pesticide and herbicide residues and endocrine disrupting chemicals.	Hormonal imbalances Bioaccumulation of pollutants into fish, aquatic organisms, soils, humans and up and the food chain. Carcinogenic effects.

WMA	Water Quality Issue	Driver	Effect
WMA 18: Breede	Nutrient enrichment of Breede	Leaching of fertilisers and wastewater high in nutrients.	Algal blooms in some reaches of Breede. Excessive growth of filamentous algae in river and canals.
	Microbial contamination	Discharge of inadequately treated wastewater, irrigation with untreated winery and industrial effluents and diffuse pollution from high density settlements.	Affect export fruit industry. Human health impacts. Recreation impacts .
	Salinisation of Breede River	Natural geology and soils. Irrigation return flows, leaching of salts from new lands and salinisation of Riviersonderend.	River water unusable for irrigation users downstream of Zanddrift canal. Corrosion of appliances and equipment. Possible inefficient water use.
	Agrochemicals	Pesticide residues found in Hex River. Probably present in rest of basin.	Hormonal imbalances. Bioaccumulation of pollutants into fish, aquatic organisms, soils, humans and up and the food chain. Carcinogenic effects.

WMA	Water Quality Issue	Driver	Effect
WMA 19: Berg:	Nutrient enrichment	Wastewater discharges, fertiliser wash off, winery effluents and informal settlements.	Nuisance algal blooms in lower Berg and Voëlvlei Dam. Filamentous algae in shallow rivers and increased water treatments costs.
	Microbial contamination	Runoff from informal and high density settlements. Inadequate wastewater treatment.	Human health impacts. Impacts of fruit export industry. Ecosystem impacts.
	Salinisation of middle and lower Berg	Natural geology, irrigation return flows and agricultural practices.	Increased salinity in middle and lower Berg River. Water less suitable for irrigation users and impacts on industrial and domestic users.
	Urban rivers	Urban rivers conduits for treated wastewater. Toxic spills and high COD.	Eutrophication problems, excessive growth of aquatic weeds and ecosystem impacts.
	Agrochemicals and EDCs	Residues of pesticides and herbicides, endocrine disrupting chemicals and persistent organic pesticides (POPs).	Hormonal imbalances. Bioaccumulation of pollutants in fish, aquatic organisms, soils, humans and up and the food chain. Carcinogenic effects.
	Change in state of Voëlvlei Dam	Low water levels in drought of 2004/5 changed state from clear to turbid reservoir.	Increased frequency of algal blooms. Increased water treatment costs.

Table 4: Summary of water quality compliance with RWQOs per WMA for monitoring sites assessed

WMA	Electrical Conductivity (EC)				Sulphate (SO_4)				Chloride (Cl)			
	Unacceptable	Tolerable	Acceptable	Ideal	Unacceptable	Tolerable	Acceptable	Ideal	Unacceptable	Tolerable	Acceptable	Ideal
1 - Limpopo		33%	17%	50%	17%			83%			50%	50%
2 - Luvuvhu and Letaba	12%	44%		44%				100%		22%	33%	45%
3 - Crocodile (West) and Marico	15%	62%	15%	8%			23%	77%		15%	46%	39%
4 - Olifants	43%	36%	7%	14%	43%	7%		50%	14%	14%	21%	50%
5 - Inkomati	7%	29%	14%	50%			7%	93%			29%	71%
6 - Usustu to Mhlatuze	19%	25%	25%	31%		7%	7%	86%	19%	6%	19%	56%
7 - Thukela		10%	40%	50%			10%	90%				100%
8 - Upper Vaal	22%	34%	16%	28%	6%	22%	9%	63%		6%	34%	60%
9 - Middle Vaal	50%	24%	13%	13%	13%	31%	6%	50%	19%	19%	38%	24%
10 - Lower Vaal	78%	22%			44%	44%		12%	11%	33%	56%	
11 - Mvoti to Mzimkulu		16%	16%	68%				100%		5%	26%	68%
12 - Mzimvubu to Keiskamma	11%	20%	16%	53%	5%			95%	5%	11%	16%	68%
13 - Upper Orange	16%	32%	32%	20%	5%		5%	90%	5%		32%	63%
14 - Lower Orange	29%	29%	43%					100%			71%	29%
15 - Fish to Tsitsikamma	61%	18%	14%	7%	11%	18%	25%	46%	54%	7%	25%	14%
16 - Gouritz	64%	18%		18%	35%	6%	18%	41%	64%	12%	12%	12%
17 - Olifants Doorn	17%	17%		66%	17%			83%	17%		33%	50%
18 - Breede	72%		14%	14%	36%		21%	43%	72%		21%	7%
19 - Berg	34%	22%	22%	22%			33%	67%	44%		44%	12%

WMA	Ortho-phosphate (PO_4-P)				Ammonia (NH_3-N)				pH		
	Unacceptable	Tolerable	Acceptable	Ideal	Unacceptable	Tolerable	Acceptable	Ideal	Unacceptable	Acceptable	Ideal
1 - Limpopo	17%	50%	33%					100%	17%	66%	17%
2 - Luvuvhu and Letaba	44%	56%					11%	89%	11%	56%	33%
3 - Crocodile (West) and Marico	69%	23%	8%		15%	8%	62%	15%	54%	46%	
4 - Olifants	36%	64%					64%	36%	57%	36%	7%
5 - Inkomati	43%	57%					14%	86%	29%	50%	21%
6 - Usustu to Mhlatuze	50%	50%				6%	38%	56%	31%	31%	38%
7 - Thukela	80%	20%				10%	30%	60%	20%	60%	20%
8 - Upper Vaal	91%	9%			15%	9%	38%	38%	53%	31%	16%
9 - Middle Vaal	100%				19%	12%	25%	44%	50%	44%	6%
10 - Lower Vaal	56%	44%			34%		44%	22%	78%	22%	
11 - Mvoti to Mzimkulu	32%	36%	21%	11%	5%	5%	32%	58%	16%	42%	42%
12 - Mzimvubu to Keiskamma	95%	5%					37%	63%	16%	79%	5%
13 - Upper Orange	84%	16%			16%		16%	68%	53%	47%	
14 - Lower Orange	43%	57%			14%	14%	14%	57%	43%	57%	
15 - Fish to Tsitsikamma	82%	18%			4%	7%	46%	43%	57%	29%	14%
16 - Gouritz	94%	6%			6%	6%	24%	64%	47%	29%	24%
17 - Olifants Doorn	33%	67%						100%	50%	17%	33%
18 - Breede	86%	14%			7%	7%	29%	57%	57%	14%	29%
19 - Berg	100%						22%	78%	11%	22%	67%

	Electrical Conductivity (EC)	Sulphate (SO_4)	Chloride (Cl)	Ortho-phosphate (PO_4-P)	Ammonia (NH_3-N)	pH
Ideal range limit	30mS/m	80 mg/l	40 mg/l	0.005 mg/l	0.015 mg/l	≥6.5 - ≤8.0
Acceptable range limit	50 mS/m	165 mg/l	120 mg/l	0.015 mg/l	0.044 mg/l	>8.0 - ≤8.4
Tolerable range limit	85 mS/m	250 mg/l	175 mg/l	0.025 mg/l	0.073 mg/l	No range limit set
Unacceptable limit	> 85 mS/m	> 250 mg/l	> 175 mg/l	> 0.025 mg/l	> 0.073 mg/l	<6.5 and > 8.4

Text Box 9: Toxicants

Did you know? TOXICANTS

Exposures to toxic chemicals can occur through contaminated food and water, skin absorption, inhalation, or transmission from mother to child across the placenta, and in breast milk. It is quite evident that the impacts of toxicants on people and animals warrant concern and attention. Monitoring the degree to which toxicity and individual toxicants exist in water resources is one important component of establishing the extent to which these substances are a problem in South Africa.
Inorganic toxicants (like heavy metals) and organic toxicants (like many pesticides, petroleum products, pharmaceuticals, etc.) can enter water resources and have devastating impacts on ecosystem integrity. The following summarises the critical ecological issues:

- Besides occasional immediate and highly visible impacts of accidental spills (like fish kills), many toxicants have more subtle, though no less serious, long-term impacts on aquatic biota.
- Some impacts, like endocrine disruption, manifest at extremely low concentrations of toxicants.
- The nature of many long-term impacts makes them difficult to detect and quantify.
- Some toxicants are highly resistant to degradation in the environment and may persist for decades.
- Some organic toxicants degrade rapidly in the environment, or are metabolised, to other chemicals that may also be toxic.
- Many organic toxicants and some heavy metals (like mercury) have an affinity for animal tissue (*e.g.* in fish) and sediments in water resources. They can gradually accumulate in these media to levels many thousands of times the original background levels.
- Contaminated animals can be eaten by other animals up the food chain (including humans).
- Contaminated sediments can be scoured during floods, mobilising trapped toxicants and increasing the risks of exposure downstream.
- Some toxicants, like the persistent organic pollutants (POPs) (see Text Box 10) addressed in the Stockholm Convention (2001), are highly volatile. They can be transported vast distances through the atmosphere away from their original sources. POPs have even been found in the Arctic, Antarctic and remote Pacific islands [UNEP, 2002].

The complexity and the potential severity of the problems evident in the above further emphasizes the necessity for programmes like the NTMP. However, the NTMP should be seen as only one of a suite of approaches that South Africa should adopt. These should include better characterisation of sources of toxic substances and associated risks and formulation of focused policy and legislation. These should focus on minimising risks to humans and ecosystems without unnecessarily compromising much needed socio-economic development.

Examples of potential sources of various toxicants in natural waters

Toxicant	Typical sources
Heavy metals	Mining industry, chemical industry, tanning
Inorganics	Mining industry
Pesticides	Pesticide manufacture and formulation; Agriculture
Petroleum products	Petroleum industry
Petrochemicals	Petrochemical industry
Surfactants	Household aqueous waste, industrial laundering and other cleansing operations
Pharmaceuticals	Pharmaceutical industry, agriculture, hospitals

Examples of toxicants are given for each class.

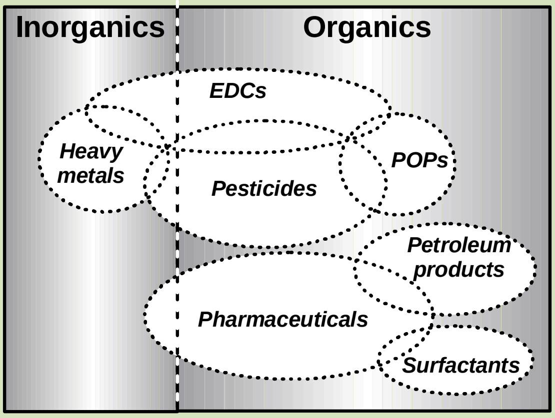

Illustration of some of the overlaps between some classes of toxicants (EDCs = Endocrine Disrupting Compounds, POPs = Persistent Organic Pollutants).

Text Box 10: Persistent Organic Pollutants

Persistent organic pollutants (POPs) are organic compounds that are resistant to environmental degradation through chemical, biological, and photolytic processes. Because of this, they have been observed to persist in the environment, to be capable of long-range transport, bioaccumulate in human and animal tissue, biomagnify in food chains, and to have potential significant impacts on human health and the environment.

Many POPs are currently or were in the past used as pesticides. Others are used in industrial processes and in the production of a range of goods such as solvents, polyvinyl chloride, and pharmaceuticals. Though there are a few natural sources of POPs, most POPs are created by humans in industrial processes, either intentionally or as by products.

In May 1995, the United Nations Environment Programme Governing Council (GC) decided to begin investigating POPs, initially beginning with a short list of the following twelve POPs, known as the 'dirty dozen': aldrin, chlordane, DDT, dieldrin, endrin, heptachlor, hexachlorobenzene, mirex, polychlorinated biphenyls, polychlorinated dibenzo-p-dioxins, polychlorinated dibenzofurans, and toxaphene. Since then, this list has generally been accepted to include such substances as carcinogenic polycyclic aromatic hydrocarbons (PAHs) and certain brominated flame-retardants, as well as some organometallic compounds such as tributyltin (TBT).

POPs released to the environment have been shown to travel vast distances from their original source. Due to their chemical properties, many POPs are semi-volatile and insoluble. The indirect routes include attachment to particulate matter, and through the food chain. The chemicals' semi-volatility allows them to travel long distances through the atmosphere before being deposited. POP exposure can cause death and illnesses including disruption of the endocrine, reproductive, and immune systems; neurobehavioral disorders; and cancers possibly including breast cancer. Exposure to POPs can take place through diet, environmental exposure, or accidents.

South Africa is a signatory of the Stockholm Convention on Persistent Organic Pollutants which is an international environmental treaty that aims to eliminate or restrict the production and use of POPs. Co-signatories agree to outlaw nine of the dirty dozen chemicals, limit the use of DDT to malaria control, and curtail inadvertent production of dioxins and furans. Parties to the convention have agreed to a process by which persistent toxic compounds can be reviewed and added to the convention, if they meet certain criteria for persistence and transboundary threat.

DDT is still used in South Africa for malaria control in the Limpopo and Inkomati WMA's and studies have shown elevated levels of DDT in fish and humans. These WMA's are subject to ongoing research by the University of Pretoria and Cape Town University.

9.1 WATER MANAGEMENT AREA 1: LIMPOPO

Background

The Limpopo (WMA) is the northern most water management area in the country and represents part of the South African portion of the Limpopo Basin which is also shared by Botswana, Zimbabwe and Mozambique. The WMA borders on Botswana and Zimbabwe, where the Limpopo River forms the entire length of the international boundary before flowing into Mozambique. The region is semi-arid and the mean annual rainfall ranges from 300 mm to 700 mm. Economic activity is mainly centred around game, livestock and irrigation farming, together with increasing mining operations. Approximately 760 rural communities are scattered throughout the water management area, with little local economic activity to support these population concentrations (DWAF, 2004 b).

The main catchments are the Matlabas, Mokolo, Lephalala, Mogalakwena, Sand, Nzhelele and Nwanedi.

Due to the aridity and flatness of the terrain few sites are available for the construction of major dams and the surface water potential has largely been developed. Relatively favourable formations for groundwater are found in the area and groundwater is therefore used extensively. However, over exploitation occurs in certain areas. Several inter-water management area transfers exist, all of which bringing water into the WMA.

The Mokolo River Catchment covers 8 387 km^2, stretching from the Waterberg Mountains through the upper reaches of the Sand River to its confluence with the Limpopo River. A number of tributaries are present in the catchment, e.g. the Tambotie River, Poer-se-Loop and the Rietspruit. The largest water user, particularly in the upper catchment, is agriculture, with crops such as tobacco, maize, sunflower, vegetables and fruit predominating. Approximately 87% of the present water use in the catchment is therefore taken up by agricultural activities along the Mokolo River, with the remaining 13% being committed to industry, mining, power generation and domestic water supply. The sub-catchment has very unreliable supplies of water and there seems to be little opportunity for expansion of the irrigated areas without the importation of additional water supplies (Midgley *et al*., 1999). There are only two mining concerns in this sub-catchment (Ashton *et al*., 2001), with large water users in this mining/industry sector including the Matimba Power Station and Kumba Resources' Grootgeluk coal mine, both situated outside Lephalale. Matimba is the world's largest dry cooling power station and Grootgeluk the largest coal mine in the country.

All of the towns and settlements in the sub-catchment rely on water supplied from the water supply impoundments, from run-of-river abstraction points and, occasionally (in the lower reaches) from local boreholes. A few informal settlements have sprung up around the periphery of the minor towns in the sub-catchment.

These settlements lack access to basic services such as clean water supplies and suitable sanitation systems. In addition, the large numbers of subsistence farmers in the north-eastern portion of the sub-catchment have to rely on boreholes and hand-dug wells for water supply (Ashton *et al*., 2001). The Mokolo Dam was built in the 1970s primarily to serve the power station, and now also supplies the coal mine, downstream farmers and Lephalale.

The land-use is agriculture, with private and provincial nature reserves as well as coal mining.

Water Quality Status

The current surface water quality of the Mokolo River is generally good upstream of the Mokolo Dam with all variables either acceptable or ideal with the exception of tolerable phosphates. Groundwater quality in much of the Mokolo area is generally poor due to the coal and gas fields and cannot be used for domestic use, although surface water quality is generally good (DWAF, 2004 a).

The current surface water quality of the Mokolo River downstream of the Mokolo Dam is either acceptable or ideal with the exception of phosphates which are unacceptable. Flows are variable, with reductions in low and moderate flows and unseasonal releases from Mokolo Dam still having an impact.

The current surface water quality of the Lephalala River is either acceptable or ideal with the exception of pH, phosphates and sulphates which are unacceptable. The land use of the Lephalala River is mainly agriculture. Witpoort is a small town with the waste water treatment not operating efficiently.

The new planned Mokolo pipeline coming from the Crocodile (West) will potentially result in water quality changes in the Mokolo catchment due to the poor water quality originating in the Crocodile River. The water quality of the Crocodile (West) catchment is impacted by high nutrient and salinity due to numerous wastewater discharges and flow regulation in the catchment.

WMA 1: WATER QUALITY STATUS MAP

There is no current water quality monitoring point on Mokgalakwena River. The drivers of water quality in this catchment are the towns of Nylstroom, Dimune, Nylsvlei, Mokupane and Naboomspruit all of which have the challenges of waste water treatment works (WWTWs).

Furthermore there are large platinum mines in the upper catchment with nitrate problems from blasting as well as season turbidity levels from runoff from mining activities. Glen Alpine Dam is used for commercial agriculture of potatoes and tomatoes.

There is no current water quality monitoring point on the Sand River. There are coal mines in the catchment that have potential for acid mine drainage and sulphate contamination. There are many areas of sand mining. The water quality is impacted by effluent from three WWTWs in the area. There is also intensive agricultural activities which contribute to the nutrient levels in the river.Nzhelele catchment is dominated by agriculture (citrus) both up and downstream of the Nzhelele Dam. The sewage treatment works discharges do not meet appropriate discharge standards. There is some forestry around Louis Trichardt and associated industries (timber, etc.).

Nwandezi River land usage is game farming, some agriculture and use of pesticides. The Limpopo River's water quality is driven by the seasonal flows from Botswana, intensive irrigated agriculture and mining activities. The water quality of the Limpopo River deteriorates downstream to tolerable salinity and nutrients due to accumulated irrigation runoff and coal mining impacts.

There have been recorded cholera outbreaks in the Limpopo River that originated from Zimbabwe, around Messina area. The Beit Bridge town's infrastructure completely collapsed and this has further impacted downstream abstraction boreholes for Messina town.

The rapid and uncontrolled growth of informal settlements in the upper Mokolo River (around Vaalwater and Alma) may in future impact on surface and groundwater quality in this area. The water quality trend in the Mokolo River indicates a deterioration of variables downstream due to urbanisation, agricultural runoff and mining activities. The Lepalale River has a deteriorating water quality trend due to agricultural runoff and mining activities in the catchment. The water quality trend of the Limpopo River improves downstream.

9.2 WATER MANAGEMENT AREA 2: LUVUVHU AND LETABA

Background

The Luvuvhu and Letaba WMA lies entirely within the Limpopo Province and borders on Zimbabwe and Mozambique. It forms part of the Limpopo basin, which is shared by South Africa, Botswana, Zimbabwe and Mozambique. While the Luvuvhu River is a direct tributary of the Limpopo River, the Shingwedzi and Letaba rivers flow into the Olifants River, which is a tributary of the Limpopo. A unique feature of the WMA is the Kruger National Park along its eastern boundary, which occupies approximately 35% of the area and through which all the main rivers flow into Mozambique. Due to the topography, rainfall varies from well over 1000 mm/a to less than 300 mm/a. Economic activity is characterised by irrigation, afforestation, tourism and informal farming. Over 90% of the area's population of about 1.5 million live in rural communities (DWAF, 2004 c).

The main urban areas are Tzaneen and Nkowakowa in the Groot Letaba River catchment, Giyani in the Klein Letaba River catchment, and Thohoyandou in the Luvuvhu River catchment. The rural population is scattered throughout the WMA. The mean annual temperature ranges from about 18 °C in the mountainous areas to more than 28 °C in the northern and eastern parts of the WMA with an average of about 25,5 °C for the WMA as a whole. Maximum temperatures are experienced in January and minimum temperatures occur on average in July.

The Letaba River catchment is highly regulated particularly in the upper catchments where most of the runoff is generated. Surface water mainly originates in the mountainous areas and is regulated by several dams in the upper (Magoebaskloof and Ebaneezer dams) and middle reaches of the river. The Letaba River is further regulated by a series of irrigation weirs that limit the flows of water into the Kruger National Park. There are further regulatory weirs and dams with the Kruger National Park (Mingerhout Engelhardt dams).

Intensive irrigation farming is practised in the upper parts of the Klein Letaba River catchment (upstream and downstream of the Middle Letaba Dam), the Groot Letaba (downstream of the Tzaneen Dam) and Letsitele rivers, as well as in the upper Luvuvhu River catchment. Vegetables (including the largest tomato production area in the country), citrus and a variety of sub-tropical fruits such as bananas, mangoes, avocados and nuts are grown. Large areas of the upper catchments have been planted with commercial forests in the high rainfall parts of the Drakensberg escarpment and on the Soutpansberg.

Groundwater is utilised extensively and limited potential remains for further development. Significant over exploitation of groundwater occurs in parts of the WMA particularly near Albasini Dam and in the vicinity of Thohoyandou. Water transfers occur from this WMA to both neighbouring WMAs to supply amongst other Polokwane with drinking water and some inter catchment transfers within the WMA also take place (DWAF, 2004 c).

Water Quality Status

Groot Letaba River

Typically the water quality issues in the Letaba study area are driven by diffuse pollution, such:

- Afforestation: upper catchment (turbidity, fertilizers)
- Agricultural runoff from intensive cultivated lands – banana and citrus (fertilizers, salts, nutrients, pesticides)
- Villages close to rivers (microbiological, litter, turbidity)
- Animal grazing and watering (microbiological, turbidity)

The point sources of pollution in the Letaba River are limited to effluents from wastewater treatment works from Tzaneen and Giyani and are consequently not a major contributor to the water quality in the Letaba catchment. The current water quality down the Letaba River indicates ideal values of ammonia, sulphates and nitrates. Acceptable pH values occur. There are tolerable salt values (electrical conductivity and TDS) which are as a result of afforestation and runoff from the intensive agriculture. The unacceptable phosphate values that occur all the way into the KNP are as a result of the use of fertilizers for the intensive agriculture and a lesser extent due to waste water treatment plant effluents. Elevated levels of Chlorophyll-a and algal growth are recorded along the length of the Letaba River as a result of the high nutrients, river regulation and high lowveld temperatures.

There are records of acute and chronic toxicity relate to the use of pesticides and herbicides in the Letaba River. The Letsitele River, a tributary of the Letaba River is unregulated, with a small dam on the Thabina tributary. The water quality at this site is influenced by upstream stream flow reduction (forestry) and a township, with no formal sanitation system. In the lower catchment the main land-use is irrigation agriculture, namely citrus plantations (mangos and bananas) and afforestation. Water quality impacts are expected to relate to salinisation, the release of pesticides / herbicides into the environment and elevated nutrient levels

Klein Letaba River is in a moderately modified to modified state mostly due to dense settlements and

WMA 2 WATER QUALITY STATUS MAP

agriculture above the Middle Letaba Dam and upper Klein Letaba River. The primary land-use is dense rural / urban settlements (limited subsistence agriculture, with livestock), with a very dry landscape. Water quality impacts may relate to sewage effluent leading to eutrophication. The current water quality down the Klein Letaba River indicates ideal values of ammonia, sulphates and nitrates. There are tolerable salt values (electrical conductivity and TDS) which are as a result of afforestation and runoff from the intensive agriculture. The unacceptable phosphate values are as a result of a number of WWTWs and waste disposal sites leading to eutrophication. The unacceptable pH values are due to releases from Mid Letaba Dam.

The Molototsi River's main land-use is rural informal settlements e.g. Ka-Dzumeri (limited subsistence and cultivated agriculture, with livestock). The landscape is dry and when the river flows it carries a high sediment load due to the informal settlements and cultivated agriculture that takes place into the flood plain of the river.

The water quality trends in the Letaba River indicate that the TDS values are increasing due to land use practices such as increased subsistence agriculture and afforestation. This results in a continuous sediment movement down the length of the river into the KNP. The increased pH trend is due to algal blooms in the highly regulated river raising the pH. The raised trend in phosphate and nitrogen values upstream of the KNP is a result of the continued intensive irrigated agriculture on the banks of the Groot Letaba.

Luvuvhu River

The water quality status of the Luvuvhu River is driven by intensive agriculture of sub-tropical fruits and afforestation in the upper catchment, the urban sprawl of Thohoyandou in the middle catchment and the KNP in the lower end of the catchment. The unacceptable phosphate values that occur all the way into the KNP are as a result of the use of fertilizers for the intensive agriculture, a lesser extent due to waste water treatment plant effluent from Thohoyandou and the lack of formal treatment for the dense urban sprawl outside the KNP.

The water quality trends in the middle to lower Luvuvhu River indicate a deterioration of the phosphates, nitrates and ammonia levels. This deterioration in water quality is a result of the intense agriculture and domestic wastes associates with Thohoyandou and the un-serviced intense dense settlements upstream of the KNP. The Luvuvhu River is subject to ongoing research into the human health and fish impacts associated to the use of DDT for malaria control in the catchment.

The Shindwezi River

The majority of the catchment of the Shindwezi River's catchment falls within the KNP. Outside the land use is mainly subsistence agriculture and informal urban settlements. The unacceptable pH, phosphates and EC values are due to runoff from these land use practises that take place into the flood plain of the river. There is an improved water quality trend in the river.

Water quality issues and concerns

Regulation and water shortages

The water shortages experienced in the Letaba Catchment area have led to intense competition for the available water resources between different sectors. A substantial portion of the population does not have access to the basic level of service and planned extensions to irrigation have consequently been put on hold. The Kruger National Park (KNP) is located at the lower end of the catchment, is internationally renowned as a conservation resource, and is responsible for significant tourism and contribution to South Africa's GDP. In order to sustain the flow of the Letaba River in the KNP and ultimately aquatic biota, riparian vegetation and terrestrial animal life, water has to be released from the series of dams and weirs starting at the headwaters of the catchment. Furthermore, there is an international obligation to release water to Mozambique at the eastern boundary of the KNP.

The most ecologically modified sections in the Groot Letaba River are those between Tzaneen Dam and the is due to the reduction in flow due to upstream impoundments (Tzaneen and Ebeneezer Dams), large weirs (Junction, Yamorna, Prieska and Jasi) as well as direct abstraction for irrigation. The water quality problems are associated with intensive irrigated agriculture (fertilizer, salts and pesticide runoff).

More than 20 major in-stream dams and weirs have been constructed in the Groot Letaba catchment, which has resulted in this catchment being highly regulated. The existing limited water resources in the Letaba Catchment have been severely overexploited at the expense of the environment in order to meet the commercial (irrigation, afforestation and industry) and rapidly increasing domestic water demands. The dense afforestation that takes place in the upper catchment and the intensive irrigated agriculture, of mainly sub tropical fruits, on the banks of the Groot Letaba outside the KNP, are the major water users in the study area. The in stream dams are used for the supply of irrigation water for this intensive irrigated agriculture.

International obligations

The rivers that leave South Africa and flow into Mozambique are subjected to an international agreement between the two countries. The National Water Act (Act 36 of 1998) make reference to international obligations being as important as basic human needs and the ecological Reserve with regards to water allocations. The rivers that are subject to this agreement are the Letaba/Olifants, Komati and Shindwezi.

Pesticides

The intensive irrigated agriculture in the Letaba and Luvuvhu River has resulted in the use of a wide range of pesticides over the past decades. Most of these pesticides are categorised as Persistent Organic Pesticides (POPs). South Africa is a signature of the Stockholm Convention on POPs (see Text Box 9).

DDT is an approved malaria control in the Luvuvhu catchment and there are records of DDT bioaccumulation in the fish and humans in this catchment. There is evidence of human health impacts on this catchment as a result of the use of these pesticides and this is the subject to ongoing studies by the Universities of Pretoria and Cape Town's medical fatalities.

9.3 WATER MANAGEMENT AREA 3: CROCODILE (WEST) AND MARICO

Background

The Crocodile West and Marico WMA's have boundary on Botswana in the north-west. It includes two major river systems the Crocodile West and Marico, which give rise to the Limpopo River at their confluence. The climate is generally semi-arid, with the mean annual rainfall ranging from 400 mm to 800 mm. Average temperatures range between 15 and 30°C.

The water resources of the Crocodile West and Marico WMA support major economic activities of the WMA and a population of approximately 5.0 million people. It is the second most populous WMA in the country with the largest proportionate contribution to the national economy, generating almost a third of the country's Gross Domestic Product. The WMA is highly altered by catchment development, with economic activity dominated by urban areas and industrial complexes of northern Johannesburg, Midrand and Tshwane and with platinum mining north-east of Rustenburg. Extensive irrigation activities occur along the major rivers, with game and livestock farming occurring in other parts of the WMA.

The two major rivers in the Crocodile (West) – Marico WMA, the Crocodile (West) River and the Groot Marico River form the south-western part of the Limpopo River basin (Drainage Region A), which eventually drains into the Indian Ocean in Mozambique. The WMA also includes the headwaters of the Molopo River, which is a tributary of the Orange River, draining westwards to the Atlantic Ocean. The WMA includes the tertiary drainage regions A10, A21 to A24, A31, A32 and quaternary drainage region D41A. The WMA covers a total catchment area of 47 565 km^2.

Development and utilisation of surface water occurring naturally in the water management area has reached its full potential. Large dolomitic groundwater aquifers occur along the southern part of the area. The aquifers are utilised extensively for urban and irrigation purposes. Localised over-exploitation of groundwater occurs in the Molopo area. Some aquifers also underlie the border with Botswana and are shared with that country. A substantial portion of the water used in the WMA is transferred from the Vaal River and further afield. Small transfers out of the WMA are to Gabarone in Botswana and to Modimolle in the Limpopo WMA.

Increasing quantities of effluent return flow from urban and industrial areas offer considerable potential for re-use, but the effluent is at the same time a major cause of pollution in some rivers. Population and economic growth, centred on the Johannesburg - Pretoria metropolitan complex and mining developments, are expected to continue strongly in this area. Little change is foreseen in population and economic development in rural areas (DWAF, 2004 d).

Water Quality Status

Crocodile Catchment

Water quality is a driver of the status of rivers in the catchment. The river is highly impacted in terms of water quality while some sub-catchments, such as the Upper Elands displaying a good to fair condition in terms of water quality.

Water quality issues are mainly related to nutrient status and salinity impacts due to wastewater discharges and flow regulation in the catchment. Microbial water quality issues are also known to be a problem in the upper catchment but there is insufficient monitoring data to confirm this.

The water quality of the Upper Crocodile River is impacted by urbanisation and large volumes of wastewater discharges (WWTWs and industrial). Water quality in the rivers is relatively poor with high levels of nutrients and salt concentrations. There is a general non-compliance to phosphate RWQO throughout the WMA.

The water quality of the Magalies River is relatively good with localised impacts from land based activities. The dams in the system impact on the water quality in the rivers.

Water quality of the Elands River catchment is good in the upper reaches. However the middle and lower reaches are of a fair quality with mining activities in the catchment impacting on the river. Water quality has also deteriorated as a result of erosion and high sediment loads. The Hex River shows elevated concentrations of salts and nutrients as well as toxicants. There are impacts from agricultural (intensive irrigation) activities in the catchment.

The water quality of the Apies Pienaars catchment is of poor quality with certain areas being impacted by nutrients and salinisation. There are thirteen point source discharges into the system from industries and wastewater treatment works. The water quality of the upper catchments is deteriorating even further in certain areas. pH is high but salts are stable. Sources of pollution are mainly from urban return flows, WWTWs and land based activities.

The Lower Crocodile River is deteriorating in terms of water quality. Salts and nutrients are high. There are also increased levels of toxicants in the middle reaches of the river. Urbanisations, industrial diffuse sources and high agricultural return flows are the major impacting activities.

WMA 3 WATER QUALITY STATUS MAP

Eutrophication due to increasing nutrient concentrations is posing as the major threat to the Crocodile River system and needs to receive attention. The phosphate RWQO is in the unacceptable range at all the monitoring sites. Salinity impacts need to be managed.

Marico Catchment

The water quality of the Upper Marico River is relatively good with localised impacts from land based activities. The tributaries are impacted to some extent by slate mining activities and agricultural impacts. Turbidity and erosion are the main water quality issues. The Marico Bosveld Dam impacts on the water quality in the river.

Water quality of the Klein Marico River catchment is good in the upper reaches. However the middle and lower reaches are of a fair water quality with urbanisation and the dams in the catchment impacting on water quality. Water quality has also deteriorated as a result of erosion and sedimentation. The Klein Marico River shows elevated concentrations of nutrients. There are impacts from agricultural activities in the catchment.

The water quality of the middle and lower Marico River is of fair to poor quality with certain areas being impacted by nutrients, erosion and salinisation. The impoundments impact on the river water quality downstream due to flows being managed by demands for irrigation purposes. There are also increased levels of toxicants in the middle reaches of the river.

The Lower Marico River is deteriorating in terms of water quality. Nutrients are high. High agricultural return flows are the major impacting activity.

Water quality issues and concerns

Wastewater Discharges

The biggest impactors on water quality in the area are the large scale water and land users. The sprawling urban areas in the south-east of the catchment, with their undersized water systems and large waste problems contribute to poor water quality downstream. This is evident through the eutrophication problems being experienced in both dams. The discharges from WWTWs are also a major contributing factor and local authorities struggle to comply to discharge standards. The effluents from wastewater treatment works are a major contributor to the water quality in the Crocodile catchment. Other contributors to the poor water quality include industries and old abandoned mines.

Agricultural Run-off

Fertilizers and pesticides from agricultural activities are also having a negative impact on water resources in the WMA, which is also a contributing factor to the increase in nutrient levels that are observed. However the exact extent of this impact has not been quantified yet.

Use of Return flows

The Vaal River System is directly linked to the Crocodile River West System through the Rand Water potable water distribution network. The discharges from Tshwane and northern suburbs of Johannesburg contribute large volumes of water to the Crocodile River West catchment. The planning scenarios developed for the Crocodile River West and Marico River catchments show that there are projected short falls where a future Coal to Liquid (CTL) plant and coal fired power station at Lephalale are included in the water requirement projections. There is the option available of using some of this excess wastewater from the Vaal River System to support the Crocodile River West catchment.

Water Transfers

The water resources that naturally occur in the Crocodile catchment have already been fully developed and most of the tributaries as well as the main stem of the Crocodile (West) River are highly regulated. Treated wastewater return flows from the Upper Vaal WMA play an important role as the water is used in the Crocodile West catchment area (makes up approximately 27% of available water - 356 million m^3/annum). The quantities of return flows are increasing and while serving as potential source of water for future development in the catchment, the cascading effect of the return flows and the associated water quality have to be monitored and its impact determined.

There is an elaborate network of inter-basin water transfers into and out of the Crocodile (West) and Marico WMA. The Marico River is also used for an international transfer to Botswana downstream of Tswasa Weir in the Madikwe Game Reserve. Furthermore there is the planned transfer of water out of the Crocodile River to the Mokolo catchment (Lephalale) for the water requirements of the Madupi Power Station. There are also plans to transfer treated waste water from the Klip River catchment in the Vaal River System into the Crocodile River system to meet the increasing water demand in the Crocodile (west) and Mokolo catchment. The date of this transfer system has not been finalised as yet.

9.4 WATER MANAGEMENT AREA 4: OLIFANTS

Background

The Olifants River originates at Trichardt to the east of Johannesburg and initially flows northwards before gently curving in a generally eastward direction through the Kruger National Park and into Mozambique, where it joins the Limpopo River before discharging into the Indian Ocean. The Olifants water management area corresponds with the South African portion of the Olifants River catchment (excluding the Letaba River catchment). It falls within three provinces, *viz*. a small part to the west within Gauteng, with the southern part mainly in Mpumalanga and the northern part in Limpopo Province. The main tributaries are the Wilge, Elands and Ga-Selati rivers on the left bank and the Steelpoort, Blyde, Klaserie and Timbavati rivers on the right bank.

Distinct differences in climate occur; from cool Highveld in the south to subtropical, east of the escarpment. Mean annual rainfall is in the range of 500 mm to 800 mm over most of the WMA.

The main economic activity is related to coal, platinum, vanadium, chrome, copper and phosphate mining. The coal mining is located in the upper reaches of the catchment around Witbank, Middelburg and Delmas. There are large thermal coal fired power stations associated with the coal mining. The platinum, chrome and vanadium mines are located in the Steelpoort and middle areas of water management area while the copper and phosphate mining occurs in the lower Olifants around Phalaborwa. There are also large steel foundries located in Middelburg and Witbank.

Extensive irrigation occurs in the vicinity of the Loskop Dam, along the lower reaches of the Olifants River, near the confluence of the Blyde and Olifants rivers, as well as in the Steelpoort valley and upper Selati catchment. Much of the central and north western areas of the water management area are largely undeveloped, with scattered rural villages where the people are mainly dependent on income from migrant workers in the Gauteng area, Witbank, Middelburg and Phalaborwa are the largest urban centres. Land use in the water management area is characterised by rain-fed cultivation in the southern and north-western parts, with grain and cotton as main products. While most of the water management area remains under natural vegetation for livestock and game farming as well as conservation, severe overgrazing is prevalent in many areas. Afforestation is found in some of the higher rainfall areas, with notable plantations in the upper Blyde River valley.

With the Olifants River flowing through the Kruger National Park, which is located at the downstream extremity of the water management area, the provision of water to meet ecological requirements is one of the controlling factors in the management of water resources throughout the water management area (NWRS).

Most surface runoff originates from the higher rainfall southern and mountainous areas. There are 9 major dams constructed in the Olifants River and the major tributaries which regulate the flow in the river system.

Large quantities of groundwater are abstracted for irrigation in the north-west of the water management area, as well as for rural water supplies throughout most of the area. Potential for increased groundwater utilisation has been identified on the Nebo Plateau north-east of Groblersdal. Substantial amounts of water are transferred into the water management area as cooling water for power generation, while smaller transfers are made to neighbouring water management areas.

Water Quality Status

The water quality data covering the period 2006 to 2008 was analysed statistically and compared to Resource Water Quality Objectives (RWQO) to determine the water quality variables of concern in the different parts of the catchment. Trends were also analysed for over the period 1999 to 2008.

The analysis results highlight the following:-

- The salinity related impacts due to mining, power generation and industries in the upper areas of the WMA are highlighted with EC and sulphate concentrations at unacceptable levels.
- The unacceptable EC concentrations in the lower reaches of the Elands River are due to irrigation return flows and concentration due to evaporation of water from the low flows.
- The pH in places marginally exceeds the 8.4 upper limit. There are however localised acid conditions in sub-catchments associated with acid mine drainage. The acid mine drainage generally emanates from defunct coal mines.
- The trophic status in the dams is mesotrophic. However in the upper reaches of the Loskop Dam, eutrophic conditions have been observed. These have resulted in blooms of blue-green algae. The eutrophic conditions in the upper reaches of Loskop Dam are due to high nutrient inputs from the WWTWs discharging below Witbank Dam.
- There are unacceptable phosphate concentrations in the Selati and in the lower Olifants below the Selati confluence. These are associated with sewage return flows and effluents from the mining and industrial activities around Phalaborwa. .

WMA 4 WATER QUALITY STATUS MAP

- There is limited heavy metal concentration information in the catchment. The available data however shows unacceptably high levels in parts of the catchment. In fact high aluminium concentrations have been cited as a possible cause of the fish deaths in Loskop Dam.
- The intensive agricultural activities in the Elands and Moses River catchments could contribute pesticides and herbicides to the local river systems. These are not currently monitored.

Water quality issues and concerns

Coal mining – threats of decants

The coal mining in the upper areas of the Olifants WMA is extensive and is still growing.

A number of the mines are reaching the end of their economic lives and the mine workings will start filling up to ultimately decant. This water will be polluted and the volumes will be large enough to impact significantly on the regional water quality. The major mining houses are aware of this problem and plans are being developed to treat the excess mine water. Mine water reclamation schemes have already been constructed which are supplying water for potable use to the local municipalities. These schemes have to be developed and coordinated to address the future decants. The reclamation of the excess mine water has been earmarked as the future source of water to meet the growing water requirements in the upper areas of the Olifants WMA (see Text Box 11).

Seeps and Spills from Mine and industrial water management systems

The mine water management systems are required to comply with Regulation 704 of the National Water Act of 1998 and to meet best practice. Although not strictly applicable to industries, Regulation 704 serves as a good guide for industrial systems. The new mines and industries are being designed to achieve compliance with the Regulation. However the majority of the mines and industries are old with legacy issues which require upgrades of the water management systems. The excess water in these systems has been managed using the controlled release scheme which started in 1996. However with the growth in the volumes of excess water, there is insufficient assimilative capacity available in the system for the controlled release scheme to deal with the excess water. Urgent attention is required to upgrade the water management system to achieve compliance with Regulation 704.

Defunct mines

There are a number of defunct mines in the WMA. Some of these mines are abandoned (ownerless) and are decanting into the river system. A strategy needs to be developed and implemented to deal with the water discharging from the defunct mines.

Nutrients and Performance of WWTWs

The majority of the wastewater treatment works associated with the local municipalities are producing an effluent which does not meet their license requirements. The works are discharging water which contains high organic, nutrient and microbiological loads to the river systems. The organics result in reduction in dissolved oxygen concentrations and anaerobic conditions which detrimentally impacts on the health of the aquatic system. The high nutrient concentrations lead to eutrophic conditions in the river systems and dams. The trophic status of the upper reaches of Loskop Dam which receives effluent from the major treatment works of the Emalahleni and Steve Tshwete Local Municipalities has been classified as eutrophic with periodic outbreaks of the toxic blue green algae. Not only do the wastewater treatment works have to be operated and maintained correctly but the license conditions should be reviewed to implement more stringent discharge standards regarding nutrients in particular phosphorus.

Agricultural Run-off

Agricultural runoff has the potential to contribute nutrients and toxic organic chemicals associated with herbicides and pesticides to the water resource. The potential certainly exists in the Olifants WMA for contributions of these pollutants to the river system from agricultural areas. The water quality monitoring network has not allowed for the quantification of the contribution of organic pollutants from agriculture, in particular the intensive irrigation areas to the river system.

Text Box 11: Mine water Re-use

Mine Water Re-use

The threat of acid mine drainage (AMD) to the environment will not be solved in the short to medium term, and is likely to persist for centuries to come (as has been seen in Wales where the Roman's mined). It is also not solved by a single intervention, but will require the integrated implementation of a range of measures. Such measures include active water treatment (as demonstrated by the Emalahleni and Optimum treatment plants), passive water treatment systems, controlled placement of acid-generating mine waste, and prevention of water ingress into mine voids and of AMD loss from mine voids.

One of the options for mine water is to make in into a resource rather than a waste product. The Emalahleni Water Reclamation Plant in Mpumalanga, which treats 25ML/day of acid mine water generated by coal mining to a drinking water standard is the first example of large scale project. These initiatives provide benefits, not only to the potential users of the treated water, but also the receiving aquatic environment. There is an estimated 62ML/day post-closure decant from coal mines in the Highveld Coalfield and around 50ML/day of AMD discharging into the Olifants River Catchment, reducing the quality of water for irrigation and municipalities, as well as damaging freshwater ecosystems. The same principle of mine water treatment is being also being used in the newly constructed Optimum Colliery water treatment works.

There is still a tremendous need for further technical research and innovation in the treatment of AMD, to enable cost-effective treatment of the range of AMD waters present in South Africa. Many treatment processes give rise to new large waste streams (such as brines or gypsum), and there needs to be ongoing effort to develop near zero waste processes. Near zero waste processes have a further benefit in that they allow for the recycling of a large portion of treatment chemicals. This recycling not only has the benefit to generate income through the recovery of saleable by-products, thereby reducing operational costs of treatment, but also allows for the reuse of chemicals such as lime and limestone. These chemicals are likely to be in short supply soon, as they are used increasingly in AMD and other forms of remediation. When the value of treated water and by-products exceeds the cost of treatment, it is feasible to create enterprises that will provide economic benefits while dealing with the environmental problems (Source: Manders, P; Godfrey, L and Hobbs, P (2009) Acid Mine Drainage in South Africa Briefing Note 2009/02)

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9.5 WATER MANAGEMENT AREA 5: INKOMATI

Background

The Inkomati WMA is situated in the Mpumalanga Province, in the north-eastern part of South Africa and borders on Mozambique and Swaziland. All rivers from this area flow through Mozambique to the Indian ocean. The population in the WMA is estimated at 1 462 000 people, of which 64% is estimated to be urban and semi-urban. The WMA covers an area of 28 757 km^2. Important urban centres are Nelspruit, White River, Komatipoort, Carolina, Badplaas, Barberton, Sabie, Bushbuckridge, Kanyamazane and Matsulu. The WMA borders with Mozambique on the east and Swaziland on the south east, the Olifants WMA to the northern and western part, and to the south it borders on the Usuthu to Mhlatuze and Upper Vaal WMAs.

The mean annual runoff (MAR) from the entire WMA is estimated at 3 022 million m^3/annum (DWAF, 2003a). This excludes the MAR from Swaziland (517 million m^3/annum), which is not part of the WMA, although it is part of the catchment. Annual rainfall varies from close to 1 500mm in the mountainous areas to 400mm in the lower lying areas. The famous eco-tourism haven, the Kruger National Park occupies almost 35% of the WMA.

The water resources of the Inkomati WMA are an important asset to the country and its people, supporting major economic activities and eco-tourism. The main rivers in the WMA include the Sabie, Crocodile and Komati rivers which form the three major catchment areas. The Komati River first flows into Swaziland and re-enters South Africa before flowing into Mozambique to form the Inkomati River in Mozambique. The WMA comprises the primary drainage region X within the water management drainage regions of South Africa.

Economic activity in the WMA is mainly centred on irrigation and afforestation, with related industries and commerce, and a strong eco-tourism industry. There is an emergence of increased coal mining in upper parts of the catchment. The Kruger National Park is a key feature of the WMA. The Sabie River which flows through the park is ecologically one of the most important rivers in South Africa.

Dams have been constructed on all the main rivers or their tributaries, and surface water resources in the WMA are generally well regulated. An important feature is the joint management by South Africa and Swaziland of part of the water resources of the Komati Basin Water Authority (KOBWA). Because of the well-watered nature of most of the area, groundwater utilisation is relatively small. Most of the present yield from the Komati River west of Swaziland is transferred to the Olifants WMA for power generation (DWAF, 2003a). The Vygeboom and Nooitgedacht dams are used to supply this water.

The Inkomati River is subject to an international cooperative agreement with Mozambique which obligates South Africa to have a minimum of $2m^3/s$ supplied to Mozambique.

Water Quality Status

The water quality of the WMA is varied and will be discussed per catchment.

Sabie

The upper catchment of the Sabie River is densely commercially afforested. The land use of the middle reaches is a mixture in sub-tropical fruits and dense informal settlements. The lower reach is with the KNP. The upstream water usage has resulted in a winter cessation of flow in the Sabie River within the KNP for the first times on record in the past two decades.

The water quality in the Sabie River indicates unacceptable levels of phosphates throughout the catchment. This is due to return flows from waste water treatment works, the large surface area dense settlements in Bushbuckridge that are mainly un-serviced and runoff from the intensive fertilised cultivation of subtropical fruits.

The water quality trends in the Sabie River indicate increasing nutrient and turbidity levels. The turbidity trend is due to over grazing, the removal of vegetation for firewood from the slopes of the river in the Bushbuckridge area. The increasing nutrient levels are due to the use of fertilizers for the growth of sub-tropical fruits and sewage waste (both formal and un-serviced).

Crocodile

The upper Crocodile River catchment has intensive afforestation and agriculture of sub-tropical fruits and nuts. The flow of the Crocodile River is regulated by the Kwena Dam in the upper catchment.

The current water quality status of the Crocodile River deteriorates downstream with unacceptable values of salts (EC), turbidity, pH and phosphates occurring from below the Kaap River confluence. The major drivers of the phosphate deterioration are a combination of waste water effluent (Nelspruit, Kanyamazane, Matsulu, Hectorspruit, Malelane and Komatipoort) and runoff from fertilisers used for the intensively irrigated sugar cane and subtropical fruits. The increased salt values are from diffuse returns from the intensive agriculture and the gold mining activities in the Kaap and Queens rivers. The increased pH values are due to algal growth, due to nutrients, causing pH values to be become more basic.

In the Elands River there is a recorded increasing trend in salts and chloride associated with the pulp and paper mill in the catchment. There are some recorded industrial pollution incidents around Nelspruit which have resulted

WMA 5 WATER QUALITY STATUS MAP

in high manganese levels in the river, sediments and bioaccumulation into fish. There are also recorded cyanide and arsenic pollution incidents in the Kaap and Queens rivers associated with the gold mining operations.

The water quality trend in the Crocodile catchment indicates and increasing trend upstream of the Kaap River confluence of turbidity and nutrients (phosphates and nitrogen) due to increased urbanisation (treated and untreated waste water returns to the river).

The water quality trend below the Kaap River confluence indicates increased turbidity and sulphate values. The increased turbidity is due to runoff from dense settlements in Matsulu, agricultural runoff and mining. The increased sulphate values are due to the mining activities in the Kaap and Queens rivers.

Komati

The Komati River upstream of Swaziland is regulated by the Eskom transfers out of the catchment via the Nooitgedacht and Vygeboom dams. Water quality problems relate to changes in river discharges caused by the transfers from the Nooitgedacht Dam by Eskom. Only surface warm water spills from Nooitgedacht Dam. Despite this there are no difference in water quality between the Nooitgedacht Dam and Vygeboom Dam.The current water quality status indicates unacceptable phosphate values which originate from sewage effluent generated, from Badplaas and Teespruit and in the lower reach of the river due to cattle watering, subsistence agriculture into the flood plain of the river as well as and un-serviced dense urban communities.

Water quality problems in the Komati before it enters Swaziland indicates increased phosphates and ammonia due to returns flows of both treated and untreated waste water, catchment slopes being highly degraded due to over grazing, the removal of vegetation for firewood and many villages on the slopes of the river. Typical water quality variables of concern are microbiological, nutrients and turbidity.

The Komati River below Swaziland's flow is controlled by releases from the Maguga and Driekoppies Dams as well as many in-stream irrigation weirs. Water quality problems associated with coal and sand mining on the banks of the river, runoff from burgeoning urban population, intensive irrigated sugar cane, many diversion weirs that result in the majority of the river being dammed up from below Tonga to the confluence of the Crocodile River. Many weirs will result in temperature increases in the lower reaches and diurnal dissolved oxygen fluctuations. Typical water quality problems are unacceptable nutrient enrichment (phosphates, nitrates, nitrites, ammonia), aquatic algae, higher salinity values (electrical conductivity), increased temperatures, dissolved oxygen, possible toxicity (due to pesticide usage), microbiological contamination an tolerable values of EC and turbidities. The increased nutrient, salt and turbidity values are due to a combination of this system being highly regulated by many irrigation weirs, high ambient temperatures and runoff from intensive sugar cane culture and subtropical fruit farming (fertilizers and salts).

Water quality issues and concerns

Currently the major stresses facing the WMA are the high water demands by Eskom, irrigation, afforestation and industry and rapidly increasing domestic water demands. The water shortages experienced in the area have led to intense competition for the available water resources among user sectors. In addition, a substantial portion of the population in the WMA does not have access to basic level of services.

Furthermore the large number of dams in the study area not only changes the flow regime but also impacts the water quality. Impacts include increased turbidity (erosion), algal growth, smell, toxic algae, water temperature increase, dissolved oxygen changes, taste and odour, fish kills, and changes to environmental flows.

9.6 WATER MANAGEMENT AREA 6: USUTU TO MHLATHUZE

Background

The Usutu to Mhlathuze WMA is situated in the northern KwaZulu-Natal province, but also occupies the south-eastern corner of the Mpumalanga province, covering a catchment area of 56 231 km^2. The primary drainage region is W, which consists of the W11, W12 and W13 secondary drainage catchments. Climate conditions across the WMA vary significantly. The mean annual temperature ranges between 12 and 14 °C in the west to 20 and 22 °C at the coast, with an average annual temperature for the whole WMA of 16 to 18 °C. The mean annual rainfall ranges between 1 500 mm and 600 mm per annum and the evaporation ranges from 1600mm to 1800 mm in the west to 1800 mm to 2000 mm at the coast.

The Usutu to Mhlathuze WMA borders on Mozambique and Swaziland and two of its major rivers, the Usutu and the Pongola are shared with these countries. Other major rivers within the WMA include the Mhlatuze, Mfolozi and Mkuze rivers.

Large quantities of water are transferred to the Upper Vaal and Olifants WMA, by the Heyshope, Morgenstond Dam and Westoe dams. The natural inflow into the Goedertrouw Dam is supplemented by transfers from the Thukela River. The Usutu to Mhlathuze WMA is one of the smaller contributors to the South African economy, contributing only 1.94% to the Gross Domestic Product of the country. The WMA partakes in the industrial, agricultural and transportation economic sectors. Land use in the WMA, from a water resources perspective, is dominated by irrigation and afforestation. A large portion of the WMA is tribal land which is typically used for stock farming. There are old mining areas in the vicinity of Vryheid. The Richards Bay area is a fast growing industrial hub with a number of industrial complexes.

In the Usutu to Mhlathuze WMA, diffuse waste from rural settlements pollutes the water and is responsible for Cholera outbreaks. Industrial effluent within the WMA does pose a pollution threat to the ground and surface water and the marine environment.

The total population of the Usutu to Mhlathuze WMA is approximately 2.3 million people, of which 80% is in KwaZulu-Natal and the remaining 20% in Mpumalanga province. The majority of the population in the WMA live in rural areas, whereas 18% of the population are classified as urban. The WMA includes the world famous St Lucia estuary (see Text Box 13).

Water Quality Status

Water quality in the headwaters of the Usutu River and its tributaries (W5H024Q01, W5H025Q01 and W5H026) is in an “ideal” category except phosphates which is in a “tolerable” category. This good water quality is the reason for transferring water into the Vaal and Olifants WMA’s to be used as cooling water in coal fired power stations. In the Assegaai River downstream of Piet Retief (W5H002Q01), water quality is “ideal” except for phosphate and ammonia which is in an “unacceptable” category probably due to effluent discharges from the Piet Retief WWTW.

Water quality in the headwaters of the Pongola River and its main tributary, the Bivaan River (W4H004Q01), is “ideal”. However, downstream of the Pongola irrigation scheme at W4H008Q01, the salinity has increased to a “tolerable” category with elevated phosphates concentrations and pH values (“unacceptable” categories) and ammonia concentrations (“acceptable” category) due to irrigation return flows. There is still sufficient dilution available in Pongolapoort Dam to ensure that salinity in the dam is in an “acceptable” category but trends show that Pongolapoort Dam may change to a “tolerable” category if long-term salinity trends continue. By the time the Pongola River joins the Usutu River near W4H009Q01, salinity has again increased to a “tolerable” category largely due to the natural geology (saline groundwater) of the region.

Water quality in the Mkuze River at W3H032Q01 is high in salinity, phosphates and pH which are all in an “unacceptable” category. This is due to intensive irrigation agriculture and return flows in the middle reaches and acid mine drainage problems in the upper reaches of the river. Water quality in the Hluhluwe River at W3H015Q01 is also in an “unacceptable” category due to elevated salinity, phosphates and pH values. Intensive irrigation agriculture and irrigation return flows are the cause of this situation. The lack of fresh water from the these two rivers have contributed to occurrences of hyper-saline conditions in Lake St. Lucia with severe detrimental impacts on the aquatic ecosystem of the lake.

Water quality in the upper reaches of the Black Mfolozi River is also affected by acid mine drainage problems, and salinity and sulphate concentrations are in an “acceptable” category at W2H028Q01. Further downstream at W2H006Q01 the situation is largely unchanged for salinity but pH has changed from an “ideal” to “acceptable” category and phosphates to an “unacceptable” category. Water quality in the middle reaches of the White Umfolozi is similar to those in the Black Umfolozi with salinity in an “acceptable” category and pH in an “unacceptable” category. However, in the lower reaches at W2H032Q01, after the confluence of the two rivers, salinity, phosphates and pH are in “unacceptable” categories, largely due to intensive

WMA 6 WATER QUALITY STATUS MAP

irrigation and reduced flows in the lower reaches. Water quality in the Mhlatuze at W1H009Q01 and W1H032Q01 is in a "tolerable" category for salinity due to intensive irrigation and return flows in the area, pH is in an "acceptable" category and phosphates in an "unacceptable" category.

The elevated phosphate concentrations are probably the result of fertilizer wash off in the middle to lower reaches of the river. Trend analysis indicate increasing trends in salinity in the Black Mfolozi, lower Umfolozi and Mkuze rivers.

Water quality issues and concerns

Impacts of coal mining activities

Acid mine drainage from abandoned and operational coal mines in the Vryheid and Paulpietersburg areas have impacted on the headwaters of the Pongola River, Mkuze River and Umfolozi River. This has resulted in problems with low pH streams and elevated iron, TDS and sulphate concentrations in rivers draining those areas. The buffer capacity of the bigger rivers have to date ensured that the low pH problems remained localised but this does not mitigate the elevated salt concentrations.

Nutrient enrichment

Concerns have been expressed about the impacts of nutrient enrichment downstream of WWTW discharges and irrigation schemes. Incidents of toxic algal blooms and game fatalities have been reported in the upper reaches of the Pongolapoort Dam. Excessive growth of filamentous algae has occurred in the Assegaai River downstream of Piet Retief which impacted on the habitats of aquatic organisms. Concerns have also been expressed about algal blooms in the Klipfontein Dam near the town of Vryheid (Upper Umfolozi River).

Irrigation return flows

The practice of returning irrigation seepage water to the river has lead to increases in salinity downstream of large irrigation schemes. Such increases have been observed in the Pongola River downstream of the Pongola irrigating scheme, in the Mkuze River, Hluhluwe River, lower Mfolozi River, and the middle and lower Mhlathuze rivers. The increase in salinity reduces the fitness for use for downstream users and in the case of Lake St. Lucia, contributes to an increase in the incidence of hyper-saline conditions in the lake.

Suspended sediment loads

Poor management of communal lands and over grazing in the upper reaches of the Black and White Mfolozi rivers have increased suspended sediment loads in the Mfolozi River. This, along with reduced flows, can lead to silting problems in the river channel, equipment problems for irrigation farmers, and negative impacts on aquatic organisms and the estuary ecosystem.

Water borne diseases

Outbreaks of cholera and diarrhoeal diseases have been reported in the rural areas of the WMA. These have been attributed to poor sanitation, use of bush toilets, and taking untreated water directly from rivers for domestic purposes. Infants, the elderly and immuno-compromised people are vulnerable to such diseases.

Aquatic weeds

Concerns have been expressed about infestations of aquatic weeds such as water hyacinth and water lettuce in rivers in the WMA. These affect access to open water, increased evaporation and oxygen exchange at the water surface.

Transportation and pollution risks

There is no registered hazardous waste site in the WMA. Concerns have been expressed about the transport of hazardous industrial wastes on the N2 to Durban and the risk of accidents and pollution into water courses. Such incidents have occurred in the past.

Text Box 12: Sea Outfall pipelines

MANAGEMENT OF SEA OUTFALL PIPELINES

The Department's policy for the disposal of land-derived water containing waste to the marine environment of South Africa is in line with international trends and national objectives of efficient and effective management of the nation's resources, priority is thus given to a resource water quality management approach. Previously the focus was on 'end-of-pipe' pollution control with little attention to the receiving environment, whereas this new approach focuses on the capacity of the receiving marine resource to assimilate waste and hence ensure water that is fit for use by all its other intended users.

In recent years, the discharge of land-derived water containing waste to the marine environment has been receiving increasing attention in many parts of the world due to the environmental sensitivity of the oceans and the cumulative impact of these discharges on the marine environment. In South Africa there are more than forty discharges of water containing waste formalized through authorisations issued in terms the Water Act, 1956 (Act 54 of 1956) and the National Water Act, 1998, (Act 36 of 1998).

These discharges vary widely from surf zone and estuarine discharges of municipal sewage or industrial wastewater to discharges through well designed offshore marine outfalls fitted with hydraulically efficient diffusers operating in water depths of more than 20 metre.

The DWA operational policy provides basic principles and ground rules as the framework within which disposal practices of land-derived water containing waste could be evaluated when marine disposal is a possible alternative. It also provides a management framework within which such disposal needs to be conducted.

Text Box 13: Estuaries

Did you know….

In the southern African context the following is a generally accepted definition of an estuary. "It is a partially enclosed, coastal body of water which is either permanently or periodically open to the sea and within which, there is a measurable variation of salinity due to the mixture of sea water with fresh water derived from land drainage". Such water bodies are therefore linked to a river, stream or other freshwater input at one and to the sea at the other. The absence of a recognizable source of freshwater, would exclude any such systems from inclusion in this definition although they may display many of the typical estuarine characteristics (e.g. Langebaan Lagoon).

Estuaries are dynamic systems and virtually any physical or chemical feature associated with them is subject to rapid and sometimes extreme changes. The mouths of South African estuaries unless pinned by some rocky feature tend to meander under the influence of currents, wind and wave action and sediment movement.

Estuaries are well known for their high productivity, high carrying capacity and ability to support, apart from the resident species, a variety of migratory fish, birds and invertebrates. The maximization of this capacity depends on a variety of interacting attributes or features several of which reflect the significance of processes in the catchment and the need for a holistic approach for successful estuarine management.

Biodiversity in estuarine systems is enhanced by a number of factors such as, the size of the system, the habitat diversity, the presence of intertidal areas whether salt marsh, mangrove, sand or mud flats and by the presence of an axial salinity gradient, i.e. a gradient from full seawater at the mouth to freshwater or significantly reduced salinities at the head of the estuary. (source: http://www.nmmu.ac.za/cerm)

9.7 WATER MANAGEMENT AREA 7: THUKELA

Background

The Thukela water management area (WMA) covers primary drainage region V. The Thukela River originates in the Drakensberg Mountain Range along the border between Lesotho and the KwaZulu-Natal Province of South Africa. The river meanders through central KwaZulu-Natal and discharges into the Indian Ocean. The Little Thukela, Klip, Bloukrans, Bushmans, Sundays, Mooi and Buffalo rivers are the major tributaries of the Thukela.

The Thukela River catchment experiences a wide variety of weather conditions ranging from generally wet and cold in the Drakensberg Mountains, to dry and hot in the Thukela Valley from Colenso down towards the coast, and hot and humid and reasonably well watered at the coast.

The average rainfall ranges from about 1 500 mm per annum in the mountains to about 650 mm per annum in the central parts of the catchment. Annual runoff varies from 600 mm in the Drakensberg to as little as 50 mm in the dry bushveld areas with an estimated natural Mean Annual Runoff (MAR) of 3 799 Mm^3/a at the river mouth. Rainfall is however erratic and years of prolonged drought in the central and lower catchment alternate with very wet periods. The reliable yield (2000) of the Thukela WMA is 776 Mm^3/a.

The wetlands and sponges in the upper and middle Drakensberg are at present not under major threat of destruction due to their remoteness and the fact that this is a protected area. These resources need to be preserved as far as possible due to their critical role in supplying base flows in all the rivers (DWAF, 2004e). The Thukela estuary also needs to be preserved.

The resources of the Thukela River are predominantly used to support requirements for water in other parts of the country, with large transfers of water to all three neighbouring WMAs – see below. Eight major dams in WMA with a combined firm yield of 950 Mm^3/a. include: Woodstock, Spioenkop, Zaaihoek, Driel Barrage, Kilburn, Ntshingwayo, (formerly Chelmsford Dam), Craigie Burn and Wagendrift Dams.

Many people in the WMA are dependent on agriculture for their livelihood. Agriculture is most productive in the Dundee and Escourt districts. Subsistence farming is practised on communal land, which covers much of the WMA.

Water Quality Status

The water quality in the Thukela River at Colenso (V1H001) and at Mandini (V5H002), the Little Thukela at Winterton (V1H010), and Klip River at Ladysmith (V1H038) was generally good with low nitrate (<0.60 mg/ℓ) ammonia (<0.015 mg/ℓ) and acceptable salts (<350 mg/ℓ) concentrations. Although the phosphates were relatively high, the concentrations were generally <0.050 mg/ℓ.

The Little Boesmans River at Estcourt (V7H012) show signs of nutrient enrichment (eutrophication) with relatively high nitrate (1.94 mg/ℓ), ammonia (0.018 mg/ℓ) and unacceptable high phosphate concentration (0.182 mg/ℓ). The sources of these nutrients are agricultural and industrial waste.

The water quality at the upstream point in the Buffels River at Schurvepoort (V3H002) was good, but with relative high phosphate concentrations (0.056 mg/ℓ). However, at the downstream point (V3H010 at Tayside) the quality was poor with high salts (396 mg/ℓ), high ammonia (0.06 mg/ℓ), high nitrate (5.74 mg/ℓ), unacceptable high pH (8.62) and phosphate concentration (0.139 mg/ℓ). The high salts and nutrients (especially ammonia) indicate organic pollution, probably sewage pollution.

The water quality in the Sundays River at Kleinfontein (V6H004) was very good with low salts (87 mg/ℓ), low nutrients concentrations (ammonia, 0.004; nitrate, 0.168; and phosphate, 0.024 mg/ℓ) and ideal pH (7.8).

The Mooi River at Keate's drift (V2H008) shows high dissolved salts (366 mg/ℓ), high pH (8.49) and high phosphates (0.044 mg/ℓ), thus poor quality.

Water quality issues and concerns

Impacts of the mining activities

The upper Buffalo River is the most severely impacted on (water quality) of all the Thukela River's tributaries. Acid mine drainage from numerous old coal mines and industrial pollution from the Newcastle area and the Ngagane River area, requires special intervention. Water quality in the Buffalo River all the way down to its confluence with the Thukela has been described by the Regional Office as being very poor (DWAF, 2004e).

The natural drainage from geological formations but especially from coal mine workings also contains appreciable amounts of nitrates and phosphate. There are two dormant and six closed coal mines that are located in the Sundays River Key Area. There is evidence of salt deposition in the Upper Sundays River at gauging point V6H004 with sulphate concentrations reaching 214 mg/ℓ (compared with 18 mg/ℓ further upstream at V6H006).

WMA 7 WATER QUALITY STATUS MAP

Industry

The most significant water quality impact on the Thukela River is caused by the Sappi Paper Mill at Mandini, which requires sufficient river flows to dilute its effluent releases. Also, fibres from this industrial process could be affecting the biota downstream to the river mouth. Releases from the Spioenkop Dam have been made in the past to dilute Sappi's effluent, but if the surplus in the Thukela WMA is to be allocated then this practice must cease or Sappi must apply for a water use licence for the use of this water.

Agriculture

Soils of the Drakensberg Mountain Range are relatively shallow. Pressure from human activities outside of the protected areas, particularly in the subsistence agriculture areas, is resulting in soil erosion with the consequent loss of habitat and siltation of dams in the upper catchment.

In the Bushmans River below Escourt, water quality problems are experienced due to the leaching of fertilisers and agro-chemicals from the soil and the discharge of industrial waste from the various factories in the town. This pollution impacts on the Weenen Nature Reserve and irrigators in the Weenen area. Agro-chemicals from intensive farming activities also threaten the quality of the water resource in the Mooi River.

Severe overgrazing and soil erosion problems are being experienced in the Driefontein Block and Matiwaneskop areas to the north-west and north of Ladysmith. Soils in the Drakensberg Mountain Range are relatively shallow and highly dispersive. Pressure from human activities is resulting in soil erosion with the consequent loss of habitat and siltation of dams in the upper catchment. This has long-term consequences for the Thukela-Vaal Transfer Scheme. These lower Drakensberg areas and specifically the Mweni Valley are the most affected. Intervention and mitigation measures are required to deal with this.

The naturally good water quality in the Little Thukela Key Area is threatened by large concentrations of tourism activities (e.g. Champagne Valley), agro-chemicals and fertilisers as a diffuse source of pollution. These problems need to be better understood before they can be adequately addressed (DWAF, 2004e).

Rural settlements

The high rural population density in many of the tribal / communal areas (about 56 people/km^2) contributes to the occasional high P concentrations observed in the Sundays River (up to 0.450 mg/ℓ) and Wasbankspruit (1.320 mg/ℓ).

Large rural settlements and poor sanitation facilities along the Lower Thukela River could cause water quality problems during low-flow conditions. The water quality problems are currently mitigated by the reasonably large volumes of water that flow down this lower section of the Thukela River from the well-watered tributary sub-catchments upstream.

Eutrophication

Poor performing waste water treatment works (WWTW) are a major source of nutrient enrichment of aquatic systems. The Newcastle Local Municipality (Charlestown, Kilbarchan, Madadeni, Newcastle, and Osizweni) WWTW performance was less satisfactory and has scored on average only 41% in Green Drop evaluation. Equally poor performances (average 34%) were recorded in the uThukela District Municipality (Escourt, Wembezi, Colenso, Ezakheni, Ladysmith, Bergville and Winterton).

Limited information is available on algae in the WMA. However, the water quality indicator is occasionally outside the acceptable levels for recreational use at some locations due to toxic cyanobacteria having been found. Microbial contamination may also limit use, but insufficient valid data precludes meaningful comment on this at a catchment scale.

Cyanobacteria or ‘blue-green algae’ are natural inhabitants of many inland waters, estuaries and the sea. In still waters, such as lakes, ponds, canals, and reservoirs, they may multiply sufficiently in summer months to discolour the water so that it appears green, blue-green, or greenish brown. The toxic variants of these algae pose a health hazard to humans and livestock (DEAT, 2006).

Urbanisation

The effluent from the industrial area and untreated sewerage from the Ezakheni complex outside of Ladysmith has resulted in very poor quality water flowing down the Klip River into the Thukela River.

The water quality in the Mooi River was generally good, but the ammonium concentration in Mearns Dam is increasing drastically (150% past 3 years), which is a matter of concern for eutrophication status. High ammonia usually indicates a high organic load to the system (DWAF, 2008b).

Water Transfers

There are a number of large dams in the Thukela WMA, some of which make up the Thukela-Vaal Transfer Scheme. The largest of these is Woodstock Dam, from which water is released to the Driel Barrage near Bergville. Water is then pumped into a canal that conveys this water to the Kilburn Dam, from which it is pumped over the escarpment from the Kilburn Dam into the Driekloof Dam (at the upper end of the Sterkfontein Dam). Spioenkop Dam supplies the downstream requirements of Ladysmith and irrigated agriculture. In future the dam could be used to supplement flows in the lower Thukela to ensure that the water requirements of the Fairbreeze Mine, the Sappi mill at Mandini and the ecology are met. Other significant infrastructure is Zaaihoek Dam on the Slang River with its related pump station and pipeline.

This scheme was constructed primarily to transfer water to the Eastern Vaal sub-system. Some water is also released to local users. The estimated impact of these transfers on the available yield in the Thukela WMA is 541 Mm^3/a.

The implementation of the Reserve will have an impact on the water reconciliation and the availability of water for transfer out of the WMA. Potential for further development of surface water resources exists (DWAF, 2004e). The need for increased and additional transfers in future have been identified and investigated in detail although no decision on this has as yet been made (DWAF, 2004e).

9.8 WATER MANAGEMENT AREA 8: UPPER VAAL

Background

The Upper Vaal WMA is centrally located in the country covers a catchment area of 55 562 km^2. It includes parts of Gauteng, Mpumulanga, Free State and North-West Provinces and consists of the C1, C2 and C8 secondary drainage catchments. The Drakensberg mountains forms the eastern and boundary, while the Maluti Mountains are found to the south and the Witwatersrand in the north. The average temperature for the WMA is 15˚C with mean annual rainfall ranging between 600m and 800mm per year and evaporation between 1300mm and 1700mm per year.

The Vaal River is the major river in the WMA contributing 46% of the surface flow in the WMA. It is fed by a number of tributaries of which the most significant are the Wilge River, Liebensbergvlei River, Klip, Waterval River, Suikerbos, Mooi River and Klip (Gauteng). From a water resources point of view the most important tributaries are the Wilge and Liebenbergsvlei (Lesotho Highlands Water Project). Important wetlands occur along the Klip River and there are several vlei areas throughout the WMA. The surface water resources occurring in the WMA have been well developed and the system is highly regulated (DWAF 2004f).

There are several large dams that have been developed *viz.* Grootdraai Dam, Vaal Dam and Sterkfontein Dam. Large quantities of water are transferred into the WMA to augment local water resources. The Upper Vaal WMA is an economically important region of South Africa, contributing nearly 20% to its Gross Domestic Product. The WMA displays a well diversified economy and a strong industrial and financial base. Land use in the WMA is characterised by expansive urban, mining and industrial areas in the northern and western parts between the Grootdraai Dam and Mooi River catchments. This urbanised area is situated mainly in the province of Gauteng and extends beyond the WMA boundary. Other development in the WMA relates to dry land agriculture. The WMA includes several large towns located around the mining, industrial and agricultural development areas.

Water Quality Status

The water quality of the Vaal River in the Upper Vaal WMA can be divided into the area upstream of the Grootdraai Dam, Grootdraai Dam to Vaal Dam and Vaal Dam to the Mooi River confluence.

The water quality in the Vaal River in the upstream catchment to Grootdraai Dam is good and suitable for use for domestic and industrial supply. The TDS ranges from 150 mg/L to 200 mg/L which falls well within the requirements for domestic use. The water quality of the Grootdraai Dam water is currently suitable for use by Eskom and Sasol. However there is poor quality water in the Leeuspruit, Witpuntspruit and Blesbokspruit tributaries of the Vaal River due to mining impacts (acid mine drainage). The Leeuspruit also has eutrophication issues due to the discharges from the wastewater treatment plants. The water quality in the Grootdraai Dam is under threat in the long term unless the mine water is managed, in particular the closure situation.

The water quality in the Vaal River and its tributaries from Grootdraai Dam to Vaal Dam is suitable for supply as potable and industrial water and for irrigation. The TDS concentrations are about 140 mg/L. The only reach of the Vaal River where the TDS concentrations and eutrophication issues could affect water supply is from the confluence of the Waterval River to Villiers at the upper end of the Vaal Dam. In this reach the TDS concentration exceeds 450 mg/L during the dry season. The reasons are the contribution of saline and high nutrient water from the Waterval catchment.

The water quality of the Vaal River between Vaal Dam to the Mooi River confluence is highly impacted on by the discharges from the wastewater treatment works, mines and industries. Specific catchments are of concern in terms of their contributions to the deteriorating water quality of the Vaal River include the Suikerbosrand, Rietspruit,Klip River (Gauteng) and Mooi River

Dilution releases from Vaal Dam are used to maintain the TDS concentrations in this reach of the Vaal River at a suitable concentration. Currently the TDS concentration is maintained at 600 mg/L in the Vaal Barrage. This ensures that the salinity in the middle reaches of the Vaal River meets the Class 1 water requirements *i.e* less than 1000 mg/L. The trophic status of the water in this reach of the Vaal River (to Bloemhof Dam) is categorized as hypertrophic.

Water quality issues and concerns

Impacts of the mining activities and mine closure

The management of mining activities in the WMA is crucial to the management of water quality both in the short term to alleviate the current salt loads being released and long term to manage the impacts of mine closure and mine decants. While the complex dynamics of this situation is accepted in terms of maintaining base flows in the system, permitting active mining, and promoting wider socio-economic imperatives, a major intervention in terms of current mining development practices is required if the situation in the Vaal Barrage (and towards the Middle Vaal River) is to be alleviated. Of further concern is the final decant points within the system once all the mines within this area close and pumping ceases. This is unknown at this stage but will

WMA 8 WATER QUALITY STATUS MAP

have future ramifications for all surrounding catchments. Closure plans need to be developed by the mines. The water quality of the Grootdraai Dam is currently acceptable. However, there are a number of operational and defunct coal mines in the catchment which need to be managed pro-actively. Estimates of the of water volumes decanting from the mines post closure is 48 million m^3/a. The post closure plans need to be finalized and implementation of the plans need to be managed.

Management of wastewater treatment works discharges

The lack of compliance of wastewater discharges from the many smaller wastewater treatment plants in the WMA to discharge standards is deeply concerning. There is a general non-compliance to the phosphate RWQO throughout the WMA. This situation appears to be continuing unabated, and until such time as this matter is addressed by all the role players at the appropriate levels, water quality management goals will not be achieved. The Vaal Barrage water quality cannot be maintained or improved if this aspect is not prioritised by the local authorities of the smaller towns. The Department needs to develop an intervention strategy as this is a problem throughout the Vaal River System and in other WMA's. The poor water quality is impacting on downstream treatment costs for drinking water.

Urbanisation

The issue of urbanisation is linked to the above concern related wastewater treatment works to some degree, however it also related to the uncontrolled development and urban sprawl that is being experienced in many of the urbanised centres of the Vaal Barrage and Mooi River catchment areas. Lack of, poor and improper planning is leading to large quantities of pollutants entering stormwater return flows which are draining to various tributaries that report to the Vaal River. This issue requires integrated planning approaches that need to be taken up with the appropriate structures if the situation is meant to improve.

The loss of wetlands due to urbanisation and increased discharges of poor water quality is a cause of concern in the Upper Vaal WMA. The WMA had a high concentration of wetlands which play a significant role in maintaining water quality in the rivers (especially the tributaries).

Water Transfers

The water quality in the Grootdraai Dam and Vaal Dam are dependent on the water quality of the water transferred into the Vaal River System. Large quantities of water are transferred from the Lesotho Highlands Project. The water quality in the Wilge River and Vaal Dam is strongly dependent on the water quality of the transfer water. The water quality of the transfer water is currently good, however, any deterioration in quality will impact on the water quality in the Vaal River System. The recent water quality history shows that the water quality in Heyshope Dam is deteriorating, impacting on the water quality of Grootdraai Dam. An increase in the illegal abstraction of water being transferred is impacting on water availability and reducing dilution capacity especially in the Wilge River catchment.

Vaal Barrage

The salinity in the Vaal Barrage and the middle reaches of the Vaal River is currently being managed by dilution releases from Vaal Dam to maintain a TDS concentration of 600 mg/ℓ in the water leaving the Vaal Barrage. The dilution releases of water from Vaal Dam are in effect another water demand on the system and thus play a role in the date of the next Vaal River System transfer scheme. The Vaal Dam releases also influenced the extent to which excess water builds up in Bloemhof Dam. The volume of the Vaal Dam dilution releases depends on the salinity loads and volumes discharged. Thus the management strategy for the saline mine and industrial discharges play an important role in the date of the next Vaal River System augmentation scheme.

Text Box 14: Use of excess water from the Upper Vaal WMA

Strategies for the use of excess water from the Upper Vaal WMA

The recent Integrated Water Quality Management Strategy study of the Department for the Vaal River System (DWAF, 2009a) considered some options for the use of excess water in the system.

The water requirements of Rand Water are expected to grow in the future which implies that the return flow volumes from the wastewater treatment works will also grow. The point source discharges to the Vaal River are currently 492 million m3/year from the domestic wastewater treatment works and 91 million m3/year from the mines. A major portion of the point source discharges is into the Vaal Barrage and Mooi River catchments. This discharge water together with the water released from Vaal Dam is currently used to meet the irrigation and domestic water requirements of the downstream Middle and Lower Vaal River reaches.

Application of the Water Resource Planning Model (WRPM) in investigating future reconciliation and water quality management scenarios for the Vaal River System showed that excess water would start accumulating in Bloemhof Dam from 2015. This scenario is based on a continuation of the current practice of releasing sufficient water from Vaal Dam to meet the downstream resource water quality objectives. This excess water is available to meet the water requirements of the water users along the Lower Orange River or the water could be used directly at the source of discharges by further treating the effluent for direct re-use.

The Vaal River System is also directly linked to the Crocodile River West System through the Rand Water potable water distribution network. The discharges from Tshwane and northern suburbs of Johannesburg contribute large volumes of water to the Crocodile River West catchment. The planning scenarios developed for the Crocodile River West and Marico River catchments show that there are projected short falls where a future potential Coal to Liquid (CTL) plant and coal fired power station at Lephalale are included in the water requirement projections. The possibility of using some of this excess water in the Vaal River System to support the Crocodile River West catchment is also a possibility.

Text Box 15: Re-use of Wastewater

RE-USE OF WASTEWATER

In order to extend the use of SA's limited water resource, DWA is strongly promoting water re-use as one of the options to prevent or minimise water shortfalls in the interim periods before major augmentation schemes can, or have to be implemented. The DWA gives prominence to water re-use in management strategies, like its Water for Growth and Development Strategy. The re-use of treated domestic sewage is being investigated in the Western Cape, KwaZulu-Natal and the Eastern Cape.

There are various types of re-use options that have evolved both nationally and internationally, namely planned or unplanned, potable or non-potable and direct or indirect re-use. Unplanned indirect use has been an integral part of the water supply system in inland areas where the treated effluent of upstream towns is returned to the rivers to become part of the water available to downstream towns or irrigation areas. Planned direct use is where effluent is directly treated to particular standards to be directly put back into a water supply system for use.

The concept of water re-use is thus not new. In fact 14 % of the water use in South Africa is already provided from the use of return flows. What is now being investigated is intensifying of water re-use as a source of water. Water re-use is not seen as the only solution to supplementing water resources but rather one of several options. It is technically possible to implement water re-use much quicker than for instance a large dam development.

Water re-use is also environmentally friendly as it will in fact improve the quality of water in rivers, natural resources will be protected because less water will be taken from rivers and the building of expensive dams will be avoided, or at least postponed.

9.9 WATER MANAGEMENT AREA 9: MIDDLE VAAL

Background

The Middle Vaal WMA is situated in the central part of South Africa, in the Free State and North West Provinces. It is situated between the Rietspruit and Bloemhof Dam and also borders on the Crocodile (West) and Marico as well as the Upper Orange WMA. The Vaal River is the only main river in the WMA. It flows in a westerly direction from the Upper Vaal WMA, to be joined by the Koekemoer-spruit, Skoonspruit, Rhenoster, Vals and Vet rivers as main tributaries from the Middle Vaal WMA, before flowing into the Lower Vaal WMA and then into the Orange River.

Climate over the WMA is temperate with frost occurring in winter, and is generally semi-arid. The mean annual temperature ranges between 18 °C in the west to 14 °C in the east, with an average of about 16 °C for the catchment as a whole. Mean annual rainfall ranges from 700 mm in the south-east to 400 mm in the west. The potential evaporation, which can be as high as 1 900 mm per year is well in excess of the rainfall.

Vegetation is mainly grassland, with sparse bushveld in patches. The topography is relatively flat with no distinct features. Hilly terrain occurs to the south-east. The geology is varied, which also gave rise to different soil types. A large dolomitic formation occurs from Orkney and extends towards the northern part of the WMA (DWAF, 2003b; 2004g).

Present land use in the WMA is characterised by extensive dry land cultivation, particularly in the central parts. Irrigation is practised downstream of dams along the main tributaries as well as at locations along the Vaal River. The remainder of the WMA is natural grassland used for livestock farming.

There are several dams that have been developed *viz*. Bloemhof Dam on the Vaal River, Allemanskraal Dam on the Sand River, Erfenis Dam on the Vet River, and Koppies Dam in the Renoster River.

The WMA includes several large towns located around the mining, industrial and agricultural development areas. The largest urban areas are the North West Goldfields (KOSH, Klerksdorp-Orkney-Stilfontein-Hartbeesfontein area) and the Free State Goldfields (Welkom, Virginia, etc). The MidVaal Water Company (Stilfontein) is the main supplier of bulk water to urban areas in the North West Goldfields and Sedibeng Water (Bothaville) is the main supplier of bulk water in the Free State Goldfields.

The economy in the WMA is mainly based on mining and agriculture as primary production sectors. Numerous inactive mines are found in the north and west of the WMA, many of which were small diamond claims. The Middle Vaal WMA is relatively sparsely populated, with just over 3% of the national population, which is somewhat less than the proportionate contribution to the economy (DWAF, 2003b).

Water Quality Status

The water quality of the Vaal River in the Middle Vaal WMA was generally poor due to high dissolved salts and high nutrients, e.g. the Vaal River at Orkney (C2H007) was characterised by unacceptable high EC (90 mS/m; ~630 mg TDS/ℓ), phosphate concentration (0.224 mg/ℓ) and pH (9.11).

The water quality in the Renoster River (C7H006) and Sandspruit (C2H067) was fair in terms of salts (331 & 373 mg/ℓ), but poor in terms of nutrients, 0.080 and 0.118 mg PO_4-P/ℓ respectively.

Koekemoerspruit (C2H139) and Skoonspruit (C2H073) are hotspot areas with unacceptable high salts concentrations, 1 760 and 987 mg/ℓ respectively. The salt load evidently originates from the mining activities and the high nutrients draining from the KOSH urban area.

Another problem area is the Sand River at Bloudrift (C4H016) with unacceptable high salts (2 415 mg/ℓ) from the Welkom-Virginia gold mines and very high nutrients (nitrate, 1.05; P, 0.50 mg/ℓ), evidently from poorly treated sewage effluent.

The water quality in the Vals River at Kroonstad (C6H007) was fair with ideal ammonia, sulphate and nitrate concentrations, acceptable pH (8.39), and salts (316 mg/ℓ), but with unacceptable high phosphate concentration (0.080 mg/ℓ). However, the Vals River at Bothaville (C6H002) was in a poor state with high salts concentration (837 mg/ℓ), probably originating mainly from seepage water and return flows from irrigation, unacceptable high pH (8.69) and phosphate concentration (0.90 mg/ℓ).

The water quality in Erfenis Dam (C4R002) was generally good except for the very high phosphate concentrations (0.126 mg/ℓ) that indicate a serious potential for algal productivity. However, the water quality in the lower section of the Vet River (C4H004) was poor with high salts (666 mg/ℓ) and high nutrients concentrations (phosphate, 0.088 mg/ℓ).

All the parameters in Heuningspruit at Dankbaar Mispah (C7H003) were ideal, except for the unacceptable P concentrations (0.194 mg/ℓ) that results in a poor quality.

WMA 9 WATER QUALITY STATUS MAP

Water quality issues and concerns

Impacts of the mining activities and mine closure

The economy of the Middle Vaal WMA is dominated by the mining sector, with a contribution of 45.6 % to GGP, particularly gold mining. However, discharges from mines impact significantly on both the hydrology and water quality of the Middle Vaal system. The impacts from the gold mining activities on groundwater have been recognised as early as 1960 when localised dewatering became an issue at Stilfontein Gold Mine. Only more recently have the impacts on the quality of the groundwater and the interaction with the Vaal River becomes a concern. The largest volumes are abstracted at Stilfontein Gold Mine's Margaret Shaft. Although Stilfontein's underground operations has ceased for more than ten years, pumping at Margaret shaft continues for the safety of the downstream mines. The volume of water abstracted daily is estimated at 32 Mℓ/d. The water is utilized by a number of users and any excess is discharged to the Koekemoer Spruit. Groundwater is also abstracted from other operating shafts in the KOSH mining area for safety and the water is utilized as process water Due to the large quantities of water present in the mined Witwatersrand rocks, a large quantity of water (120 -150 Mℓ/d) is pumped to the surface for accessibility each day. This groundwater however has average conductivities of 500 mS/m (~3 500 mg/ℓ) and cannot be used for drinking or irrigation purposes (DWAF, 2004g).

Water quality in the Vaal River is of serious concern because of high salinity and nutrient content, which mainly results from urban and industrial return flows as well as mining activities in the Upper Vaal WMA. The closure of mines may have further water quality impacts.

Management of wastewater treatment works discharges

A large proportion of the sewage emanating from SA urban areas is not treated properly prior to discharge, because the sewer systems are incomplete, or sewage treatment plants are overloaded (Oberholster & Ashton, 2008; Green Drop, 2009a).Matjhabeng Local Municipality (Welkom, Odendaalsrus, Virginia, Hennenman, Allanridge and Ventersburg) with 11 sewage purification plants and the Moqhaka municipality (Kroonstad, Maokeng, Steynsrus and Viljoenskroon) have failed to present information to DWA for the Green Drop certification and are classified with zero Green Drop scores. These local municipalities have been implicated for polluting the local rivers and lakes with poorly treated sewage and occasionally raw sewage spills.

Municipal wastewater treatment plants, not complying with effluent standards and informal, unsewered human settlements along the river banks or in the close vicinity of the Vaal River, pose a threat to regional water quality, especially eutrophication (nutrient enrichment) and human health. There is a general non-compliance to phosphate RWQO throughout the WMA.

Sewage wastewater, by its nature, is teeming with microbes. Therefore, from a social perspective, the discharge of sewage effluent into the natural environment can have negative impacts on human health, primarily from bacteriological and other forms of pathogens that survive the biological treatment process and inadequate disinfection of the effluent.

However, municipal wastewater effluent is also one of the impacts that is most easy to mitigate because they are easily identified, measured, and susceptible to control by policies and regulation.

Eutrophication

The Vaal River, in the Middle Vaal WMA, experience regular algal blooms and has been classified as hypertrophic (nutrient over-enriched), which causes several problems to man and the environment. Eutrophication effects and problems are profound in the Vaal River and have become a matter of major concern to all water users. The impacts of eutrophication are ecological, social and economical. Infestations of alien vegetation are also found along the Vaal River (DWAF, 2009d).

Erfenis, Koppies and Allemanskraal Dams are classified as oligotrophic, however, toxic cyanobacterial incidents have been recorded. Bloemhof Dam is eutrophic and experience cyanobacterial blooms usually dominated by *Microcystis* spp. and *Oscillatoria* sp. (Van Ginkel, 2004).

Cyanobacterial blooms (frequency and intensity) in the Vaal River are increasing. As cyanobacterial blooms become more common, the likelihood grows that people will be exposed to increased doses of toxins and the risk of animal die-offs grows as well (DWAF, 2009d).

Urbanisation

Over 75 % of the population in the WMA are classified as living in urban areas, and about 25 % as rural. Most of the population are concentrated in the main urban and mining centres of Klerksdorp, Orkney and Stilfontein in the Middle Vaal sub-area; Welkom and Virginia in the Sand-Vet sub-area, as well as Kroonstad (which is not a mining town) in the Rhenoster-Vals sub-area. South Africa's freshwater resources are under increasing stress from a growing population and an expanding economy.

Water Transfers and availability

Substantial transfers take place from the Upper Vaal to the Middle Vaal (790 Mm^3/a). However, there are no large control structures with respect to the regulation of flow in the Vaal River within the Middle Vaal WMA, and both the quantity and quality of water in the Vaal River are largely influenced by management practices in the Upper Vaal WMA. There are existing weirs on the Vaal River at Orkney and Balkfontein. Water from tributaries as well as from groundwater in the water management area is fully utilised, mainly for irrigation and for towns remote from the Vaal River (DWAF, 2003b).

Text Box 16: Acid Mine Drainage

Acid Mine Drainage

The South African mining sector is one of the critical pillars and drivers of the South African economy. South Africa is globally recognised as being a leading supplier of a variety of minerals and mineral products. Not only are gold, diamond, coal and platinum production responsible for the largest contribution to the national economy but in general the mining of these commodities is a potential sources of water pollution.

The chemical composition of the product mined also determines the chemical composition of the waste produced and the contribution to pollution. Typical pollutants from the mines include sulphates, acidity, salinity and metals (including aluminium, iron and manganese). These pollutants may contribute to pollution (both point and diffuse) of the surface water, groundwater and atmosphere.

Mining activities are also associated with environmental contamination such as acid mine drainage (AMD). AMD is highly acidic water, usually containing high concentrations of metals, sulphides, and salts as a consequence of mining activity. The major sources of AMD include drainage from underground mine shafts, runoff and discharge from open pits and mine waste dumps, tailings and ore stockpiles, which make up nearly 88% of all waste produced in South Africa. Drainage from abandoned underground mine shafts into surface water systems (decant) may occur as the mine shafts fill with water. Although the chemistry of AMD generation is straightforward, the final product is a function of the geology of the mining region, presence of micro-organisms, temperature and also of the availability of water and oxygen. These factors are regionally variable making the prediction, prevention, containment and treatment of AMD site specific. The major contributors of AMD are from the gold and coal mining industry.

The Witwatersrand gold mining industry has been active for 120 years and the post-closure decant of AMD poses an enormous threat (currently and in the future). This threat will worsen if remedial activities are delayed or not implemented. For example, acid mine water started to decant from defunct flooded underground mine workings near Krugersdorp on the West Rand in August 2002, leading to polluted surface water. Randfontein and the Wonderfonteinspruit are also problematic. These cases have received substantial media attention, which has been critical of the efforts so far to address the problems. In the absence of remediation, there is likely to be substantially more decant in future, with potentially severe implications for aquatic systems, leading to increased water treatment costs as well as making this water not suitable for downstream users.

AMD from coal mining is problematic in the Highveld Coalfield in Mpumalanga, and has been reflected by media attention on the consequences of severe pollution seen in the Loskop Dam and the Olifants River Catchment.

(Sources: (1) Manders, P; Godfrey, L and Hobbs, P (2009) Acid Mine Drainage in South Africa Briefing Note 2009/02.
(2) Pulles, W., Heath, R., Howard, M. (1996). A manual to assess and manage the impact of gold mining operations on the surface water environment. WRC Report No. 647/1/96.

9.10 WATER MANAGEMENT AREA 10: LOWER VAAL

Background

The Lower Vaal WMA (between the Bloemhof Dam and Orange River) is one of five WMAs in the Orange River Basin. The Vaal River is the only major river in the WMA. It flows across the south-eastern corner of the WMA, connecting it to the Middle Vaal and Lower Orange water management areas. The Harts River is the only significant tributary to the Vaal River from the Lower Vaal water management area.

Climatic conditions are fairly uniform from east to west across the area. The mean annual temperature ranges between 18.3 ºC in the east to 17.4 ºC in the west. Maximum temperatures are experienced in January and minimum temperatures usually occur in July. Frost occurs throughout the study area in winter, typically mid-May to late August.

Rainfall is strongly seasonal with most rain occurring in the summer period (October to April). The peak rainfall months are December and January. Rainfall occurs generally as convective thunderstorms and is sometimes accompanied by hail. The mean annual precipitation (MAP) for the Lower Vaal WMA is low at only 100 mm.

The land use in the Lower Vaal WMA is primary livestock farming, with some dry land cultivation in the northeast. Intensive irrigation is practiced at Vaalharts as well as locations along the Vaal River. Water use in the water management area is dominated by irrigation, which represent 80% of the local requirements for water (643 Mm^3/a). Development of surface water naturally occurring in the water management area has reached its potential and all the water is being fully utilised, thus limited growth in the water requirements is projected.

Diamond bearing intrusions occur near Kimberley (the most important urban area) and alluvial diamonds are found near Bloemhof. Iron ore and other minerals are found in the south-eastern parts of the WMA. Diamond mining in and around the lower Vaal River is a major concern (habitat destruction and increased turbidity).

The economy in the water management area is mainly based on mining and agriculture as primary production sectors. The economy of the Lower Vaal WMA is relatively small and contributes less than 2 % of the GDP of South Africa. The WMA is relatively sparsely populated, with just over 3% of the national population.

The main storage dams are: Bloemhof Dam on the Vaal River. The dam wall and outlet works are located within the Lower Vaal WMA immediately where the river enters the WMA from the Middle Vaal WMA. Most of the reservoir basin falls in the Middle Vaal WMA. The yield from the dam, however, is available in the Lower Vaal WMA, mainly for irrigation purposes. Vaalharts Weir is a main diversion weir on the Vaal River while the Douglas Weir falls just inside the WMA, immediately upstream of the confluence of the Vaal River with the Orange River. Wentzel, Taung and Spitskop dams on the Harts River.

Barberspan is an off-channel pan in the upper reaches of the Harts River, known for its rich bird life. It has been declared a Ramsar wetland, but currently under threat because of poor water quality.

Water Quality Status

The Vaal River at Vaalharts weir (C9H008) displays high salts (479 mg/ℓ) and unacceptable high phosphate concentrations (0.117 mg/ℓ). The high nutrients stimulate algal and water hyacinths growth (DWAF, 2009a).

The water quality in the Harts River was extremely poor; 5/7 parameters were in the unacceptable range. The TDS concentration in the Harts at Delportshoop, Lloyds weir (C3H016) was unacceptable at 1 322 mg/ℓ and shows an increasing trend. The Harts River contributes significant amounts of salts to the lower Vaal River.

The water quality in the Vaal River at Schmidtsdrift (C9H024) was unacceptable because of the high salts (EC, 117 mS/m; ~820 mg TDS/ℓ) and high nutrients, especially high ammonia (0.147 mg/ℓ).

Water quality issues and concerns

Irrigation and salinisation

Irrigation use about 82 % of the total water requirements in the WMA. Over 85 % of the requirements for irrigation are in the Harts sub-area, mainly at the Vaalharts irrigation scheme, with the balance being along the Vaal River. The Vaalharts irrigation scheme serves the purpose of beneficially utilising lower quality water discharged from the Upper Vaal water management area and thus prevents the accumulation of salinity in the lower reaches of the Lower Vaal WMA.

Water in the Harts River downstream of the Vaalharts irrigation scheme is of exceptional high salinity as a result of saline leachate from the irrigation fields, and needs to be carefully managed through blending with fresher water.

Because of salinisation problems experienced at the Vaalharts irrigation scheme an efficient subsurface drainage system was installed, resulting in large quantities of irrigation effluent being returned to the river and which could potentially be re-used downstream. The resultant balance at the downstream end of the water management area is reflected as a surplus for the Lower Vaal water management area, and not as a transfer to the Lower Orange water management area (DWAF, 2003c).

WMA 10 WATER QUALITY STATUS MAP

Water quality in the lower reaches of the Vaal River is also impacted upon by irrigation return flows from the Harts River as well as from the Riet/Modder River further downstream, necessitating further blending with low salinity water from the Orange River at the Douglas.

In arid and semi-arid regions irrigation tends to degrade soil and water quality through salt accumulation with devastating effects on some crops. A recent study in the Lower Vaal WMA showed that the addition of salts to the soils as a result of farming practices varied between 79 t/ha and 280 t/ha, with irrigation water being the major contributor of salt. Soils had been irrigated for periods of between 17 to 53 years. However, predictions showed that if the current practices are sustained for the next 50 years the osmotic potential of 6 soils will decline to below the threshold of -100 kPa for maize. In two of these soils the threshold of -280 kPa for wheat will also be exceeded. Hence salt-induced water stress could reduce the yield of maize and even wheat significantly in future if appropriate precautionary measures are not introduced (Van Rensburg *et al.*, 2008).High dissolved salts concentrations in the Vaal River could be the tipping factor that may shift the algal composition in favour of undesirable highly toxic cyanobacterium species (notably *Cylindrospermopsis sp.*) that was already observed in the lower part of the Vaal River and Orange River (Van Ginkel, 2004).

Eutrophication and Algal blooms

Spitskop Dam is classified as an eutrophic system and toxic cyanobacterial blooms have been recorded. The occurrence of cyanobacterial species, *Cylindrospermopsis sp.*, is a major concern because of the potent toxin produced by these algae and the difficulty to remove it from the water during water treatment process.

During 2000 the first major cyanobacterial outbreak in the Orange River downstream of the confluence of the Vaal and the Orange River was recorded. The findings of a study during this event indicated that the problem species (*Cylindrospermopsis sp.*) originated in the Spitskop Dam. During high flows the cyanobacterial species were transported downstream causing problems for all the treatment works that was designed to handle high turbidity in the supply waters and not cyanobacterial or algal blooms (Van Ginkel, 2004).

Water Transfers

The bulk of the surface water found in the water management area is in the Vaal River, most of which is transferred along the river from the Upper Vaal water management area and via the Middle Vaal water management area, to the Lower Vaal water management area. Water is also transferred into the water management area at Douglas Weir, from the Upper Orange water management area, for water quality management purposes.

The only direct international obligation affecting the water resources of the Vaal River System is in the Lower Vaal WMA, in particular the Molopo River catchment.

The transfer of water between water management areas and arrangements with neighbouring countries resort under national control. The following reservations are made in the National Water Resource Strategy with respect to water transfers in to and out of the Lower Vaal water management area: Currently 500 Mm^3/a is transferred from the Middle Vaal water management area to the Lower Vaal water management area. As an upper scenario this may increase to about 555 Mm^3/a during the period of projection – Reserved in the Middle Vaal WMA.

A reservation applies to the transfer of 18 Mm^3/a from the Upper Orange WMA to the Douglas Weir in the Lower Vaal WMA – Reserved in the Upper Orange WMA. The Lower Vaal WMA also forms part of the Vaal River System which extends over several water management areas. As water resource management in the Vaal River System impacts to some degree on water quantity and quality in all the inter-linked water management areas, management of water resources in the Vaal River System is to be controlled at a national level (DWAF, 2003c).

9.11 WATER MANAGEMENT AREA 11: MVOTI TO UMZIMKULU

Background

The Mvoti to Umzimkulu WMA encompasses the entire Southern KwaZulu-Natal Province, bounded by the Thukela River Catchment to the North, the Drakensberg Mountains to the west, the Transkei Region of the Eastern Cape Province to the south and the sea in the east - covers primary drainage region U and tertiary drainage regions T40, T51 and T52.

The main river systems in this WMA flow from west to east discharging to the sea and are as follows: The Mvoti River which rises in the Greytown area and passes through Stanger. The Mgeni River which rises above Pietermaritzburg and passes through Durban. The Illovo and Mlazi rivers, both rising in the Richmond area and discharging south of Durban. The Mkomazi River, rising in the Drakensberg along the Lesotho Border and discharging at the town of Umkomaas. The Mzimkulu River also rising in the Southern Drakensberg above Underberg and discharging to the sea at the town of Port Shepstone (DWAF, 2003 d).

Climatic conditions vary significantly from west (Drakensberg mountain range) to east (Indian Ocean) across the WMA. The mean annual temperature ranges between 12 ºC in the west to 20 ºC at the coast with an average annual temperature for the whole WMA of 17 ºC. Mean annual precipitation ranges from in excess of 1 500 mm in the west to between 800 mm and 1 000 mm in the central area to over 1 000 mm at the coast. The WMA incorporates a total catchment area of over 27 000 km^2 and a MAR of 4 798 Mm^3. However, the total available water is 644 Mm^3/a and total water requirements is 776 Mm^3/a, thus a deficit 240 Mm^3/a. Especially the Mvoti Key Area is highly stressed with water requirements far in excess of the available resource and the Mkomazi Key Area is experiencing serious deficits due to the high demands placed on the undeveloped resource. As a result, no new water allocations are possible.

Mvoti to Umzimkulu WMA makes the fourth largest contribution of 10.7 % to the GDP of the national economy. The manufacturing sector is well developed and the most important sector in terms of contribution to GGP (28.4 %). This WMA includes the Durban-Pinetown Metropolitan Area (DWAF, 2003 d).

Water Quality Status

The water quality in the Umgeni River at (i) Midmar Dam (U2H048) was good with low salts (EC, 9.1 mS/m; ~65 mg TDS/ℓ) and acceptable nutrient concentrations; (ii) Fair in Albert Falls Dam (U2H014), due to high pH (8.6) and ammonia (0.053 mg/ℓ) concentration; (iii) Good at Nagle Dam (U2H043) with all parameters in the ideal and acceptable range and (iv) poor in Inanda Dam (U2H055) because of relative high P concentration (0.057 mg/ℓ). All above 4 dams have earlier been classified as Oligotrophic (low productivity), based on their low mean annual chlorophyll-*a* concentrations (Van Ginkel, 2004). However, toxic cyanobacterial incidents have been reported in 3 of the dams, *i.e.* Albert Falls, Nagle, and Inanda. Recent dense water hyacinths in Inanda dam indicate eutrophic conditions.

The water quality in the Umsunduze River at Hampstead park (U2H041) was very poor with high salts (EC, 52.4 mS/m; TDS, ~367 mg/ℓ) and unacceptable high nutrients (phosphate, 0.197 mg/ℓ). The high ammonia concentration (0.18 mg/ℓ) indicates sewage pollution.

The water quality was good (6/7 parameters in the ideal range) in: (i) Mvoti River at Mistley (U4H002), (ii) Karkloof River at Shafton (U2H006), (iii) Mkomazi River at Camden (U1H005), (iv) Fafa River at Cowick (U8H001), (v) Polela River at Coxhill (T5H003), (vi) Mzimkulu River, upper reach at the Banks (T5H004) and (vii) downstream at Bezweni (T5H007), (viii) Bisi River at Nooitgedacht (T5H002), and (ix) uMtamvuna River at Gundrift (T4H001).

Only the phosphate concentrations at these sites were relatively high (ranged between 0.017 – 0.043 mg/ℓ), but are considered to be largely natural. In these rivers, concentrations >0.050 mg/ℓ, would be considered as unacceptable.

The water quality in Hazelmere Dam on Mdloti River (U3H005) and Nungwana Dam on Nungwana River (U7H008) were good with all the parameters in the ideal or acceptable range. However, toxic cyanobacterial incidents have been reported in Hazelmere Dam.

The water quality in the uMlazi River at Umlaas road (U6H003) was fair, but poor at Shongweni Dam inflow (U6H004) with high EC value (51.5 mS/m; TDS ~360 mg/ℓ), and unacceptable pH value (8.54) and phosphates concentration (0.047 mg/ℓ).

The ecological importance and sensitivity of the Mkomzana and Mkomazi rivers are considered to be high to very high. Ecological sensitivity refers to the ability of the ecosystem to tolerate disturbances and to recover from certain impacts. Therefore, the more sensitive the system is, the lower its tolerance will be to various forms of alteration and disturbance..

WMA 11 WATER QUALITY STATUS MAP

Monitoring sites and data constraints identified were: Several sites don't have nitrate concentrations; no data points were in estuaries, whilst estuaries are generally a big concern. Towns, dense population, and developments (thus potential pollution sources) occurred in a narrow strip along the coast but no monitoring sites are located here, therefore no indication of urban pollution and environmental impact. A site downstream of dams does not necessarily indicate the conditions within the dam.

Water quality issues and concerns

Management of wastewater treatment works discharges

The pollution levels are unacceptable in the middle and lower Msunduze River. The high faecal coli contamination in the river poses a threat to human health. The health problems experienced annually by canoe paddlers during the Dusi marathon are well known. Due to the high faecal coliform counts in the Msunduze River, it is evident that raw sewage and diffuse urban runoff is entering the river system. The waste water quality management performance of the Msunduzi Local Municipality, as a whole, is not satisfactory with an average Green Drop score of 43 %. The source is largely the spills from the water borne systems and runoff from the informal urban areas rather than the underperforming Darvill Works. This raw sewage puts downstream users at risk. The fact that many rural communities are directly reliant on raw water from the rivers and streams emphasizes the importance of improving this situation. The previous cholera epidemic in northern KZN bears grim testimony to this (DWAF, 2008b).

The eThekwini Municipality (Durban) currently have a licence to discharge treated sewage at a rate up to 30 Mℓ/day into the Umhlanga River. Due to potential impacts on recreational activities at the Umhlanga River mouth the eThekwini Municipality have investigated alternative options of disposing of this waste. However, recently 12 waste water treatment works in the Ethekwini Metro (Durban) received the Green drop status (2009a). Faecal pollution in the Umzinto area, affecting the Mzimayi River has resulted in high *E. coli* counts, algae and bad tasting water in the EJ Smith Dam.

The cause of this is the inadequately serviced areas and sewer infrastructure in dire need of maintenance (DWAF, 2004h). Poor performing WWTWs (Green Drop score <50 %) in the Ugu Distric Municipality (South Coast Key area) are: Umzinto, Pennington, Eden Wilds, Gamalakhe, Melville, Mbango, Munster, Murchison Hospital, Ramsgate, RedDessert, SouthBroom, Harding, and KwaBonwa.

The South Coast Key Area as a whole also suffers from seasonal load variations to local small treatment plants along the coastal strip. This is due to the seasonality of the tourism industry. The consequence of this is sewage effluent that does not meet the minimum standard.

KwaDukuza (Stanger) has limited faecal and small industry pollution. The Potential Health Risk Index (*E. coli* index), derived from the national DWA Pollution Health Risk Index, shows the catchment to have a low-moderate pollution health risk, with the lower Mvoti catchment being the most impacted and classified as eutrophic. The phosphate and *E. coli* concentrations are also increasing in Midmar Dam (DWAF, 2008b).

The water quality problems in the Mkomazi catchment are due to faecal contamination from over-loaded sewers, poor services in the dense informal settlement around Mzinto and excessive seasonal loads on the small sewage plants during holiday periods. Sewage discharges from Verulam have resulted in the eutrophication of the Mdloti River and poor quality water. District Municipalities, DWAF and affected operators need to develop a strategy for dealing with this problem (DWAF, 2004h).

Agriculture

Erosion problems are prevalent in the upper Mdloti catchment due to settlement patterns, overgrazing, poor agricultural activities and sand mining operations upstream of Hazelmere Dam. This has resulted in rapid sedimentation of Hazelmere Dam, which has lost more than 20 % of its original storage capacity. Hazelmere Dam is one of the most turbid systems (mean, 47.3 NTU) in the study area (DWAF, 2008b). The large-scale irrigation in the Mvoti catchment has not as yet resulted in a noticeable deterioration in water quality. Steep over-utilised subsistence agriculture is present in the moderately populated areas in the Valley of a Thousand Hills, with moderate to high erosion and limited faecal contamination.

Eutrophication

Toxic cyanobacterial blooms were recorded in Albert Falls, Nagle and Inanda Dam, which is a sign of eutrophication (Van Ginkel, 2004; DWAF, 2008b). As cyanobacterial blooms become more common in the aquatic ecosystem, the likelihood grows that people will be exposed to increased doses of toxins and the risk of animal die-offs grows as well.

Water hyacinths have also become a problem in the lower Umgeni River (DWAF, 2008b). An integrated approach to control aquatic weeds comprising biological control and herbicide spraying was undertaken. A major concern was development of large amounts of water lettuce in the Albert Falls system which required periodic introduction of biological control and herbicide application.

Data does show deterioration in the water quality in the Midmar Resource Unit. The increase in the nutrient concentrations, in particular phosphorus, is significant.

The decline in water quality could be ascribed to poor sewage effluents and agriculture, in particular dairies, piggeries and maize production, impacting moderately on river health through excessive nutrient input into rivers. However the increased pollution from the growing Mphophomeni settlement and future expansion in urban areas around Midmar Dam requires management (DWAF, 2008b).

Effluent return flows downstream of Hazelmere Dam and sewage discharges from Verulam have resulted in the eutrophication of the Mdloti River and poor quality water.

Industry

The only current significant water quality problem in the Mvoti catchment area is effluent from the sugar and paper mill situated near the mouth of the catchment. The effluents have at times had a pollution impact on the estuary. There are also potential groundwater pollution in Durban South from the large industrial activities.

The main water uses in the Mkomazi River catchment are large industry (SAPPI-SAICCOR situated at the mouth of the catchment) and the irrigation sector. There are also discharges of effluent by SAPPI into the Mkomazi River.

Water quality problems in the WMA can best be addressed through co-operative governance between the Regional Office and local authorities. Local authorities must accept responsibility for the quality of effluent arising from state-owned infrastructure in their jurisdiction (DWAF, 2004h).

9.12 WATER MANAGEMENT AREA 12: MZIMVUBU TO KEISKAMMA

Background

The Mzimvubu to Keiskamma Water Management Area is bounded in the east by the Mvoti to Mzimkulu WMA, in the north west by the Upper Orange WMA, in the west by the Fish-Tsitsikamma WMA and in the north by Lesotho. Although the area shares an international boundary with Lesotho, there are no shared watercourses between them.

The Mzimvubu River (the largest undeveloped river in South Africa) flows through deep gorges across the coastal plain before discharging into the Indian Ocean at Port St Johns. The Amatola coastal catchments features the main rivers of the Buffalo, Keiskamma and Nahoon that drain in a south-easterly direction into the Indian Ocean along the coastline either side of East London, while the Great Kei catchment drains the northern slopes of the Amatola mountain range and the southern slopes of the Stormberg / Drakensberg range with the Great Kei River exiting into the Indian Ocean at Kei Mouth north of East London.

The climate and temperature variations are closely related to elevation and proximity to the coast. The study area experiences a mild, temperate climate along the coast to more extreme conditions inland with most rainfall occurring during the summer months. Annual rainfall ranges from between 600 mm to 800 mm in the upper areas of Matatiele and Maluti to between 1000 mm and 1500 mm in the coastal regions of the Mbashe key area.

The total population of the Mzimvubu to Keiskamma WMA in 1995 was estimated at 3.45 million. The majority of the population of the area is situated in rural areas where their incomes are directly linked to the agricultural sector, which is mainly subsistence. Other main economic activities include tourism and commercial forestry activities, as well as manufacturing - vehicle manufacturing being the dominant industry in the Buffalo City Municipal Area.

The only area expected to experience significant growth in the future is the Buffalo City Municipal area where employment opportunities will attract people from the smaller urban centres and rural areas. The levels of education and training in the rural areas are low and approximately 49% of the people are unemployed.

The Mzimvubu to Mbashe area is one of the areas with the highest mean annual runoff in the country. Small hydro-electric developments exist in the water management area, and inter-basin water transfer occurs between the Kei and the Mbashe catchments. Future large waterwork schemes that will be required within the next eight to ten years include an additional water supply for Queenstown (possibly from Xonxa Dam) and an additional water supply for the Buffalo City Municipality.

Water Quality Status

Water quality in the Mzimvubu River and its major tributaries is good and salinity in the Mzintlava River (T3H004Q01), Mzimvubu River (T3H008Q01 and T3H007Q01), Tina River (T3H005Q01) and Tsitsa River (T3H006Q01) was mostly in an "ideal" category although some of the TDS concentrations were categorised as "acceptable". Phosphate concentrations were all classified as "unacceptable" which may be a reflection of some manmade activities in the catchment. pH values were slightly elevated and were regarded as "acceptable".

Similarly, water quality recorded at monitoring points in the Mngazi River and the Mbashe River were "ideal" in terms of salinity, ammonia, nitrate and sulphate, "acceptable" in terms of pH values, and "unacceptable" in terms of phosphates.

Water quality in the Kei River varied between "acceptable" and "unacceptable". Salinity in the south flowing tributaries of the Kei River, the White Kei at Xonxa Dam (S1R001Q01) and the Tsomo River (S5H002Q01) were in an "acceptable" category for salinity, "ideal" for ammonia, sulphate and nitrate, and "acceptable" for pH. However, the rivers originating in the western part of the Kei River catchment were quite saline with salinities varying between "unacceptable" in the Klaas Smits River near Queenstown (S3H006Q01) and "tolerable" in the Kei River at S3H013Q01. The high salinities are due to the geology of that part of the catchment, some agricultural impacts (irrigation return flows), and impacts from Queenstown on phosphates and ammonia concentrations. In the lower Kei River, the salinity is in a "tolerable" category, phosphates and pH in an "unacceptable" category.

On the Buffalo River at R2H027, upstream of Bridledrift Dam, the conductivity was in a "tolerable" category, and the other constituents in an "ideal" to "acceptable" category. This is probably the most impacted river in the WMA and water quality is affected by urban and industrial return flows, WWTW discharges, and aging infrastructure in King Williamstown and Mdantsane. Reservoirs such as Laing Dam and Bridledrift Dam show signs of severe eutrophication.

Salinity in the Keiskamma River at R1H015Q01 is in a "tolerable" category, pH in an "acceptable" class and

WMA 12 WATER QUALITY STATUS MAP

phosphates in an "unacceptable" category. The other constituents are in "ideal" categories.

Water quality issues and concerns

Nutrient enrichment in the Buffalo River

Laing Dam and Bridledrift Dam in the Buffalo River and Nahoon Dam in the Nahoon River show symptoms of nutrient enrichment and eutrophication. Nuisance algal blooms affect water treatment from these reservoirs. The causes of nutrient enrichment are treated wastewater rich in nutrients being discharged into the catchments of these reservoirs, urban runoff rich in organic material, and failing sewer infrastructure resulting in sewage leaking into the dams or into the catchment of the dams.

Localised microbiological pollution

The aging sewerage infrastructure and sanitation systems that have not kept pace with the rate of expansion of many of the rural towns (Umtata, Butterworth, Ugie, Maclear, etc.) and East London have resulted in untreated or partially treated wastewater entering the river systems. Poor maintenance and vandalism of the wastewater infrastructure has also contributed to this problem. This has resulted in health risks to local residents and downstream water users and outbreaks of water-borne diseases such as cholera and severe diarrhea.

Suspended sediment loads

Degradation and overgrazing of communal lands have resulted in high sediment loads during flood events. This has lead to silting up of structures and smothering of aquatic habitats, and inhibition of rooted aquatic plants.

Salinisation in the Buffalo River

Salinity problems in the Buffalo River are related to the discharge of treated industrial (e.g. textile factories) wastewater into the Buffalo River upstream of Laing Dam. Water is abstracted from Laing Dam, treated for domestic water supply, and supplied to domestic and industrial users in King Williams town, upstream of Laing dam. This creates a semi-closed system leading to a gradual increase in salts which is only reduced when a major flood event flushes the saline water downstream.

Salinity problems in the Kei River are largely due to geological sources (Karoo mudstones) and to a lesser degree, manmade activities such as irrigation return flows.

Leaching from solid waste sites

Concerns have been raised about leaching of wastewater high in organics from poorly designed solid waste sites in rural towns and villages. The concern related to increased organic loads and the impacts on dissolved oxygen concentrations as well as heavy metal pollution. This was not regarded as a significant problem at a WMA scale.

9.13 WATER MANAGEMENT AREA 13: UPPER ORANGE

Background

The Orange-Senqu River catchment spans four Southern African countries (Botswana, Lesotho, Namibia and South Africa) and is one of the largest river basins in Southern Africa. About 60% of the almost 1 000 000 km^2 area of the Orange River catchment lies in South Africa. The remainder falls within Namibia (25%), Botswana (13%), and Lesotho (2%). It originates as the Senqu River in the Maluti Mountains in the highlands of Lesotho, from where it drains westward to cut through the dry Richtersveld Mountains (Augrabies Falls), before it discharges into the Atlantic Ocean at Alexander Bay, stretching over 2300 km. Co-operation amongst the Orange River Basin countries is facilitated through the Orange-Senqu River Commission (ORASECOM), with membership by the basin countries.

The Upper Orange WMA stretches from its origin in Lesotho to its confluence with the Vaal River at Douglas. Major rivers include the Modder, Riet, Kraai, Caledon and Orange. The average temperature for the WMA is 15°C with mean annual rainfall ranging between 600 mm and 800 mm per year and evaporation between 1 300 mm and 1 700 mm per year. In Lesotho, which is the source of most of the water in the Upper Orange WMA, rainfall varies between 600 mm per year to about 1 500 mm per year (DWAF, 2003e).

The main storage dams in the Orange River are Gariep and Vanderkloof. Welbedacht Dam in the Caledon River, Rustfontein, Mockes, and Krugersdrift Dams in the Modder River with the Tierpoort and Kalkfontein Dams in the Riet River.

Land use in the WMA is mainly under natural vegetation with livestock farming (sheep, cattle and some game) as main economic activity. Extensive areas under dry land cultivation, mostly for the production of grains, are found in the north-eastern parts of the WMA. Ficksburg is famous for the cherry orchards in the region. Large areas under irrigation for the growing of grain and fodder crops have been developed along the main rivers, mostly downstream of irrigation dams.

Bloemfontein, Botshabelo and Thaba 'Nchu represent the main urban, and industrial development, in the WMA. Two large hydropower stations were constructed at Gariep and Vanderkloof Dams. Mining activities have significantly declined and currently mainly relate to salt works and small diamond mining operations. Approximately 5% of the GDP of South Africa originates from the Upper Orange WMA (DWAF, 2003e).

Water Quality Status

The water quality and quantity in the uppermost reaches of the Orange River, above Gariep Dam, is still in a quite natural state. The water is moderately soft, relatively low in salt concentrations. For example, at Aliwal North (D1H003) the TDS was low at 215 mg/ℓ, with ideal concentrations of ammonia, sulphate and nitrate. The relatively high phosphate concentrations (0.020 – 0.040 mg/ℓ) in the upper Orange River are considered to be largely natural (DWAF, 2009b).

The general water quality in Kornetspruit (D1H006) and Kraai River (D1H011) was good. Due to the good ecological present state of the Kraai River and because of the good quality of water with little impacts, this site was recommended as a global baseline monitoring site (DWAF, 2009c).

The water quality in the Caledon River is highly variable but generally in a fair condition, however, clear signs of eutrophication because of the high phosphate concentrations are noticeable.

The high salt concentration (832 mg/ℓ), phosphate (0.062 mg/ℓ), and pH (8.6) were unacceptable in the Seekoei River (D3H015), however high natural background concentrations are present. The stream flow in the river has decreased dramatically and indicates over-extraction of the water (DWAF, 2009b).

The water quality in the Modder River was poor, especially because of high dissolved salts and unacceptable nutrients (Nitrate & Phosphate) concentrations and very high pH values. However, the trends (C5H003) show decreasing values.

The pollution levels are unacceptably high in the Stormbergspruit at Burgersdorp (D3H015). The high nutrients (Nitrate & Phosphate) and faecal coliforms contamination indicate that poorly treated sewage is entering the system.

The general water quality of the Riet River at Jacobsdal (C5H030) was good, except for the high pH (8.47), but it shows a decreasing trend. However, the water quality in the lower end of the Riet River at Zoutpansdrift (C5H048, before confluence with the Vaal River) is unacceptable primarily because of very high salt concentrations (TDS, 1 396 mg/ℓ). Water quality in the Lower Riet River is of concern, and also impacts on water quality in the Lower Vaal River and at the Douglas Weir.

WMA 13 WATER QUALITY STATUS MAP

Water quality issues and concerns

Soil erosion

The most severe ecological problem in the upper reaches of the Orange River is the high degree of soil erosion experienced in Lesotho. Approximately 2% of top-soil is lost in the country each year, with adverse effects on habitats as well as agricultural productivity, and negative impacts on water resources. The natural vulnerability is intensified by the impact of unsuitable agricultural practices and overgrazing. As a result of the cultivation of areas not suitable for agriculture, wind erosion, mostly during winter when fields lie bare, adds to the soil losses caused by the summer rains (Earle *et al*., 2005). The Caledon River is characterized by extreme seasonal fluctuations in turbidity and with a mean value of 400 NTU is probably the most turbid river in South Africa. Due to siltation, the storage capacity of the Welbedacht Dam (in Caledon River) reduced rapidly from the original 115 Mm^3 to approximately 16 Mm^3, *i.e.* by 86%, during the twenty years since completion (DWAF, 2009b).

Wetland degradation

The wetlands in the Lesotho Highlands are of great importance for the environmental integrity of the Orange's upper reaches. They accumulate run-off from the surrounding mountain slopes and regulate the release of water into the river systems. Through their filtering system they contribute to the maintenance of the required water quality and quantity in streams and springs. In addition to their important role for the river systems they are unique habitats, which represent a large part of the country's biodiversity.

In recent decades the wetlands in Lesotho have seriously degraded and more wetlands are under threat. The most common causes for wetland destruction are overgrazing, the building of roads and the encroachment of settlements. Efforts to curb erosion thus far have had limited success (Earle *et al.*, 2005).

Management of wastewater treatment works discharges

The persistent discharge of treated sewage is one of the most obvious sources of degradation of urban freshwater ecosystems. Major pollution sources in the Modder River are sewage effluent from Mangaung local municipality (Bloemfontein-Botshabelo-Thaba Nchu) and return flows from irrigation along river.

Pollution levels (nutrients and faecal contamination) in the Caledon River at Ficksburg and Maseru is a matter of concern. The pollution in the Stormbergspruit at Burgersdorp (D1H001) is also associated with poor sewage effluent (DWAF, 2009b).

The Sterkspruit was polluted with sewage effluent indicated by high *E. coli* counts, high DOC concentration, and high nutrient (N & P) concentrations (DWAF, 2009b).

Eutrophication

Limited information is available on the trophic status of the water bodies in the Upper Orange WMA. The trophic statuses of dams are as follow: Gariep and Vanderkloof Dams – Oligotrophic; Welbedacht Dam – Mesotrophic and Krugersdrift dam – serious potential for algal productivity. However, cyanobacterial blooms have been observed in Gariep, Vanderkloof, Rustfontein, and Krugersdrift Dam (Van Ginkel, 2004; DWAF, 2009b).

Agriculture and urbanisation

Irrigation return flows has a major impact on salinity in the lower Riet River and water is transferred to the Riet River from Vanderkloof Dam, partly for blending and water quality management purposes. A natural pan below Krugersdrift Dam also adds salinity to the Modder River.

General trends in the Upper Orange WMA are the continued concentration of economic development and population in the Bloemfontein region, and a decline in rural population. In addition, water has been allocated for 12 000 ha new irrigation development for poverty relief to be sourced from the Upper Orange WMA, which will result in an approximate balance situation once implemented (DWAF, 2003e).

Water Transfers

The Upper Orange WMA is a major source of water, and of pivotal importance for several other WMAs which receive large quantities of water either directly or indirectly from the Upper Orange WMA through inter-basin transfers or via the Orange River. The Orange is a recipient basin for three inter-basin transfers schemes (IBTs); a donor basin for three IBTs; with four intra-basin transfers also in existence. Through a number of dams and transfer schemes, water is moved in and out of the Orange River.

The Lesotho Highlands Water Project has resulted in large volumes (770 Mm^3/a) of low salinity water being diverted from the Orange River into the Vaal River catchment. This has lead to an increase in salt levels in the Gariep and Vanderkloof dams. The implementation of the new Polihali Dam (second phase of the LHWP) in Lesotho will influence (reduce) the flow of water into the dams, which in turn will have a negative influence on water quality and availability in the lower reaches of the Orange River.

Flow regulation

The construction of the Gariep and Vanderkloof Dams in the Orange River made a great contribution towards the establishment and maintenance of irrigated crops throughout large sections of the Orange River, however, with a negative impact on the environment. The controlled releases of water from the dams have also homogenized the flow regimes, chiefly through modification of the magnitude and timing of ecologically critical high and low flows. It also has greatly dampened the seasonal and inter-annual stream flow variability of the Orange River, thereby altering natural dynamics in ecologically important flows and to blockage of fish migrations (DWAF, 2009b).

Climate change

Results from a recent study on the impacts of climate change in the Orange-Senqu River basin (Knoesen *et al.*, 2009), confirm the widely accepted notion that climate change will cause increases in temperature and evaporation in the future. However, rainfall in the future is projected to generally increase over the Orange-Senqu basin, with consequential amplified increases in stream flow and the occurrence of flooding, especially for shorter return periods. The upper reaches of the basin in the east could be particularly affected since this area has the highest historical rainfall already. Rainfall and stream flows are predicted to become more variable in the future (Knoesen *et al.*, 2009).

9.14 WATER MANAGEMENT AREA 14: LOWER ORANGE

Background

The Lower Orange WMA refers to the stretch of Orange River between the Orange-Vaal confluence and Alexander Bay where the river meets the Atlantic Ocean, approximately 1 200 km. The Orange River, which forms a green strip in an otherwise arid but beautiful landscape, also forms the border between South Africa and Namibia over about 550 km to the west of the 20 degree longitude.

The Vaal River, the main tributary to the Orange River, has its confluence with the Orange River about 13 km west of Douglas. Other tributaries are the Ongers and Hartebeest rivers from the south, and the Molopo River (an endoreic tributary) and Fish River (Namibia) from the north. There are a number of highly intermittent water courses along the coast which drain directly to the ocean.

The Lower Orange WMA is the largest, but also the driest and most sparsely populated WMA in South Africa. The area experiences the lowest mean annual rainfall in the country, which ranges between 20 mm at the coast and 400 mm on the eastern boundary, yet one of the highest users of water. Potential evaporation can be as high as 3 000 mm per year and in general is several times more than the rainfall (DWAF, 2003f).

Minerals and water from the Orange River were the key elements for economic development in the region, and still remain so. Irrigation is by far the dominant water use sector in the Lower Orange WMA, representing 94% of the total requirements for water (1 082 Mm^3/a). The exotic tree, *Prosopis* species has invaded large areas of the riparian vegetation in the Lower Orange WMA.

The importance of the agriculture sector is attributable to the climate which is particularly suitable for the growing of some high value crops, together with the availability of water along the Orange River. Due to the climate, a window of opportunity exists for the provision of high quality table grapes to Europe early in the season when prices are at their highest. Other products include dates, raisins, wine, flowers, vegetables, grain and fodder crops. The wine grapes of Oranjerivier Wine Cellars originate from 930 producers all along the Orange River. These pockets of vineyard land stretch over a distance of more than 300 kilometers between Groblershoop and Blouputs. Five wineries have been established in Kakamas, Keimoes, Grootdrink and Groblershoop. The Oranjerivier Wine Cellars is one of the biggest wine cellars in South Africa.

Less than 1% of the Gross Domestic Product (GDP) of South Africa originates from the Lower Orange WMA, which is the second lowest of all WMAs in the country.

Water Quality Status

The water quality in the Douglas Barrage on Vaal River (C9R003) was generally poor because of high TDS (740 mg/ℓ), pH (8.44) and high phosphate concentration (0.044 mg/ℓ).

The water quality in the Orange River at Marksdrift (D3H008) was good with most of the parameters in the ideal or acceptable range. The mean phosphate concentration of 0.030 mg/ℓ is considered to be largely natural. Similar phosphate concentrations were also encountered at Upington, Pella and Vioolsdrift.

The water quality at Boegoeberg Dam (D7H008) was also good apart from for the unacceptable high phosphate concentration (0.090 mg/ℓ). High phosphate concentrations usually stimulate algal growth.

The salt concentrations show an increasing trend downstream with high concentration at Pella (447 mg/ℓ). Long-term studies indicated that the overall dissolved salt concentrations in the Orange River are increasing significantly (in time and space), especially in the Lower Orange River (below Marksdrift) (DWAF, 2009b).

Flow regulation and increased salinity are recognised as the two main factors that have impacted (and continue to impact) negatively on the environmental health of the lower Orange River (DWAF, 2009b).

Water quality issues and concerns

Impacts of agriculture

One of the key issues is the arid climate of the region and limited potential of water resources which naturally occur in the WMA. Surface and groundwater are already fully developed and utilized. The virtual total dependence of the Lower Orange WMA on water released from the Upper Orange WMA, and the dominant influence of water utilization in upstream WMA on water resource management in the Lower Orange WMA. Another issue is insufficient measurement, monitoring and control of water used by irrigation, which is by far the largest water use sector in the WMA (94%). Water use efficiency by irrigation is also subject to improvement (DWAF, 2003f).

Huge volumes of irrigation return flows enter the Orange River. These return flows have a major impact on the water quality of the river. The extent of the impact is not well understood. The regularly exceeds of 500 mg/ℓ TDS between Boegoeberg Dam and Kakamas is concerning.

WMA 14 WATER QUALITY STATUS MAP

Impact on sustainability of agriculture is a concern. Salinisation of irrigated soil could lead to greater salt loads on the river, ultimately to the point where quality may be impaired and the uses of the water restricted. The salt load from the Vaal River needs to be taken into account in the siting of future dams.

The concentration of some metals, aluminium, cadmium, copper and lead, were occasionally unacceptable high and potentially harmful for human health and for the aquatic environment – the reason for the high metal concentrations in the lower Orange are unclear and should be investigated further. (DWAF, 2009b).

Groundwater

Groundwater plays a pivotal role in especially rural water supplies. The quality of groundwater is largely good, and unpolluted in the eastern, high rainfall, portions of the basin, but becomes mineralised and brackish in the drier western areas and in the vicinity of salt pans.

Mean annual groundwater recharge in the Orange Basin increases from <5 mm in the western regions near the river mouth to 25 - 50 mm in the upper reaches. In parts of the Kalahari, groundwater quality is poor, and in places it may be too saline for use (DWAF, 2003f).

In terms of groundwater usage, of strategic importance are the so-called “lenses” of fresh water occurring on top of underlying saline water. It has been identified that there is a need for monitoring of this water to ensure that the boreholes are not over-extracted, which will permanently destroy the availability of fresh water in the Northern Cape and most likely else-where (DWA, Northern Cape Regional Office 2011, Personal Communication).

Eutrophication and Algal blooms

During 2000 the first major cyanobacterial outbreak in the Orange River downstream of the confluence of the Vaal and the Orange River caused uproar in the sparsely populated area (Van Ginkel & Conradie 2001). The findings of a study during this event indicated that the problem species originated in the Spitskop Dam. During high flows the cyanobacterial species were transported downstream causing problems for all the treatment works that was designed to handle high turbidity in the supply waters and not cyanobacterial or algal blooms. Since March 2003 to the present the Orange River has again shown a major *Oscillatoria* and *Cylindrospermopsis* bloom. The Orange River incident has resulted in the initiation of an eutrophication-monitoring programme in the Orange River itself, as well as in dams on the river (Van Ginkel, 2004).

Boegoeberg Dam is classified as an oligotrophic system because of the general low chlorophyll-*a* concentrations (algal biomass), but cyanobacterial species (*Microcystis spp., Oscillatoria sp.,* and *Cylindrospermopsis sp.*), have occasionally dominate the algal assemblage.

Water Transfers and Stream Flow changes

Substantial transfers take place from the Upper Orange to the Lower Orange (1 886 Mm^3/a). However, the water volume flow has been much reduced in the Lower Orange River, as has the frequency, duration and magnitude of flooding (DWAF, 2009b).

Inter- and intra-catchment water transfer schemes, river diversions (primarily for irrigation), and evapotranspiration have reduced the natural stream flow in the lower Orange River (below Marksdrift) to half or less than the natural levels, e.g. from about 350 m^3/s to 150 m^3/s at Upington. Lower streamflow increases the susceptibility of the river to pollution because it will reduce its capacity to attenuate and degrade wastes, will concentrate pollutants and increase salinity, as the dilution effects of the Orange River will be reduced (DWAF, 2009b).

Major outbreaks of pest blackflies (*Simulium chutteri*) – from Hopetown to Sendelingsdrift, have resulted in annual losses to livestock farmers. These outbreaks are ascribed to the artificial and relative constant flow regime.

There continues to be a need for reliable data on water resources water demand by sector and region and with the unequal distribution of water resources and varied water demand growth there is a clear need for the development and application of integrated water resources management.

Orange River mouth

The Orange River mouth (estuary) is regarded as the sixth most important coastal wetland in southern Africa. It is an important resting site on the migration route of many aquatic bird species. However, declining water quality and river health in the lower basin has resulted in the RAMSAR status of the Orange River mouth being rescinded and placed on the Montreux Record. The lack of flow variability and the overall reduction in water volume poses a serious threat to the integrity of the river mouth Ramsar wetland.

The riparian vegetation has been severely damaged on the South African side of the river mouth. Special efforts and management strategies should be investigated and implemented to restore this Ramsar site (DWAF, 2009b). A comprehensive Reserve must however, still be determined for the Orange River.

9.15 WATER MANAGEMENT AREA 15: FISH TO TSITSIKAMMA

Background

The Fish to Tsitsikamma WMA covers an area of 97 023 km^2, of which, except for a small area that falls in the Northern Cape Province, the entire area falls in the Eastern Cape Province. The main rivers of this area are the Great Fish, Sundays, Bushmans, Kowie and Kariega rivers. All these rivers drain to the Indian Ocean.

The mean annual precipitation ranges from 150 mm in the north-western interior, where the climate is semi-arid, and rainfall generally occurs in the period from March to May, to more than 1 100 mm along the coast in the south-west, where rainfall occurs throughout the year. Mean annual evaporation in the WMA ranges from 1 450 mm (in the south-east) to 2 050 mm (in the north-west).

The population of the WMA in 1995 was approximately 1 623 000 people. Some 13% of the population lived in rural areas, and 87% of the total population lived in the towns of the WMA. About 64% of the population lives in the Algoa Coastal area, mainly within the boundaries of the Nelson Mandela Metropolitan Municipality. Much of the economic activity is concentrated in the south-western portion of the WMA, with the Port Elizabeth/Uitenhage area contributing 82% of the GGP in 1997. The GGP of the whole WMA was R21,8 billion in 1997, with the most important economic sectors, in terms of their contributions to GGP, being manufacturing (28,3%), trade (18,0%), and government (16,6%). Transport and manufacturing have comparative advantages relative to other WMAs.

Water requirements in 1995 were estimated to total 1 158 million m^3/a, excluding the requirements of the ecological Reserve, but including water use by afforestation and alien vegetation.

The natural MAR of the Fish to Tsitsikamma WMA was 2 154 million m^3/a and the yield utilised from surface water resources in 1995 was 425 million m^3/a at 1:50 year assurance. The maximum potential utilisable yield of the WMA is estimated to be 943 million m^3/a, which is 478 million m^3/a more than the utilised yield in 1995 (DWAF, 2002a).

Water Quality Status

With the exception of a few coastal catchments, the water quality in the Fish to Tsitsikamma WMA is dominated by elevated salinities mostly from natural sources. High salinity concentrations occurred in most of the Gamtoos River, even at monitoring points in the upper reaches of the river. In the Groot River tributary, electrical conductivity and total dissolved solids concentrations were in an "unacceptable" category (L3R001, L7H007Q01 and L7H006Q01). Phosphate concentrations varied between "tolerable" and "unacceptable" and elevated sulphate concentrations occurred in the lowest monitoring point, probably due to some marine impacts. An exception in the Gamtoos catchment was the Kouga River where salinity and most other constituents were in an "ideal" category (L8H005Q01 and L8R001Q01). Phosphate concentrations in the Kouga River varied from "tolerable" to "unacceptable" which may indicate some man-made impacts in this catchment (intensive vegetable and fruit production).

Water quality in the middle and lower Swartkops River (M1H012Q01) was largely in an "unacceptable" category probably due to urban and industrial impacts on water quality.

Water quality in the lower Sundays River (N4H003Q01) was also characterised by high salinity even though water was transferred from the Orange River into the upper reaches of the system. Natural salinity and irrigation return flows contributed to the elevated salinity in the river. Phosphates, sulphates and pH were also unacceptably high in the lower reaches of the river.

Salinities were also in an "unacceptable" category in the Kariega and Kowie rivers (P3H001Q01 and P4H001Q01) as were phosphate concentrations. Ammonia, nitrate nitrogen and sulphate concentrations were low and varied between "ideal" and "acceptable" categories.

Salinities in the upper Fish River (Q1H012Q01, Q1H022Q01 and Q1H001Q01) tended to be in an "acceptable" category but increased in a downstream direction to an "unacceptable" category (Q9H012Q01 and Q9H018Q01). Salinities in its south flowing tributaries like the Tarka River (Q4H013Q01), Baviaans River (Q6H003Q01), Konaap River (Q9H002Q01) and the Kat River (Q9H029Q01) tended to vary between "unacceptable" and "tolerable" categories. Salinities in the Little Fish River at Q7H005Q01 and Q8H008Q01 were in an "unacceptable" category. Phosphate concentrations throughout the Fish River basin were in an "unacceptable" category. The pH categories varied from an "acceptable" category in the upper reaches of the catchment to "unacceptable" in the middle and lower reaches due to pH values greater than 8.4. This was largely a natural phenomenon. Ammonia, nitrate and sulphate concentrations varied between an "ideal" category and "acceptable" category.

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WMA 15 WATER QUALITY STATUS MAP

"Tolerable" ranges of sulphate and ammonia concentrations were recorded in the middle and lower reaches of the Fish River (Q9H012Q01 and Q9H018Q01). Elevated ammonia concentrations are often associated with treated wastewater discharges.

Trend analysis indicated that although water quality in the Kouga River was still classified as "ideal" there was a declining trend which could indicate a slow deterioration in quality due to man-made impacts.

Water quality issues and concerns

Natural salinity in Fish and Sundays Rivers

The relatively flat topography, low MAR, high evaporation and underlying mudstones generally give rise to saline groundwater and resulting saline base flows in the Fish and Sundays rivers, irrespective of water transferred in from the Orange or irrigation return flows. It is likely that natural surface water would often have been unsuitable for most uses if not diluted with water transferred from the Orange River basin. Salinities in both rivers can vary widely over short periods. Water transfers to meet irrigation requirements and to maintain a 650 mg/l TDS target in the lower reaches reduce the salinity concentrations. However interruptions in the transfers can quickly result in short-term increases in salinity. Isolated rainfall-runoff events in the tributary catchments can also lead to a temporary increase in salinity of up to 3000 mg/l TDS. The water quality challenge in these two catchments are to even out these short-term changes by carefully managing irrigation releases, dilution releases and irrigation return flows in the system.

Impacts of dense settlements on microbial water quality

Dense settlement problems related to the informal housing areas are experienced in Grahamstown, Port Elizabeth and Uitenhage. The current level of services is often inadequate and problems are for example being experienced with nightsoil, grey water, litter and solid waste. The Bucket Eradication Programme has been implemented in Grahamstown and sanitation is being improved. The Dense Settlements Programme (see Text Box 17) has been implemented but some problems are still being experienced. There are large impacts on water resources, especially on the Bloukrans tributary of the Kowie River, which has an extremely high bacteriological population. These problems contribute to poor microbiological water quality in stormwater runoff and dry weather flows from informal settlements and poorly serviced high density settlements. These raise the risk of water-borne diseases, impacts on human health and aquatic ecosystem impacts such as low dissolved oxygen concentrations.

Orange-Fish-Sunday Water Supply Scheme

Water quality management is an important component of the management of the system, especially in the lower Fish River, where total dissolved solids can be in excess of 6 000 mg/l. Releases in the lower Fish River are made with the aim of achieving a water quality of less than 650 mg/l at Hermanuskraal Weir, where water for Grahamstown and the Lower Fish GWS irrigation is abstracted. This requires a large volume of water which is effectively lost to other users, inclusive of flows to the sea. The current operational objective of releases from Darlington Dam (where extensive citrus plantations are sensitive to chloride) is to try to keep the TDS of water released to below 600 mg/l.

Compliance to effluent standards

Concerns have been raised about poor compliance to effluent standards especially in rural areas. The 2009 Green Drop Report (DWA, 2009a) found that the average Green Drop score for the Eastern Cape was only 29% even though some of the municipalities such as the Nelson Mandela Metro scored relatively high.

Industrial impacts

Concerns have also been raised about the impacts of intensive industrial developments in the Port Elizabeth/Uitenhage area on heavy metal concentrations in the Swartkops River. Iron and manganese problems and high dissolved organic carbon (DOC) levels which lead to trihalomethane (THM) compounds in drinking water have been identified in the Kouga and Loerie dams. This has lead to increased water treatment costs. These problems were probably associated with stratification in the dams rather than man-made impacts.

Agrochemicals

Concerns have been raised about the breakdown products of agricultural pesticide and herbicide used in the Fish and Sundays River irrigation schemes. These can have a negative impact on aquatic ecosystems. Similarly intensive irrigation agriculture is practised alongside the Kouga River (Langkloof Valley) and Gamtoos River where vegetables, fruit and tobacco is produced. Pesticide residues are also associated with the production of these crops and may be an issue.

Text Box 17: Dense Settlements

Dense Settlements

Pollution from densely populated settlements is still one of South Africa's most complex pollution problems, affecting not only downstream water users, but having an impact on the community itself in creating atrocious living conditions in many settlements with consequent human health impacts.

Pollution from settlements has been demonstrated to be caused by the physical failure of waste disposal and/or sanitation services. However, these physical causes are normally underlain by social and institutional causes where social causes may stem from the misuse of the system, either through a lack of awareness or sometimes the deliberate misuse of services. On the other hand institutional causes arise when the service provider does not maintain or operate the services properly. Pollution from settlements, and in particular densely populated settlements, is usually caused by a combination of these factors. The implications or costs of dense settlements' pollution are therefore wide ranging, including human health costs, social costs, environmental and downstream water use costs.

In terms of the DWA policy, reactive interventions would be used where regional DWA, or Catchment Management Agencies, want to address downstream water quality problems associated with pollution from settlements. Proactive interventions would be aimed at planning appropriate services, as well as ensuring the ongoing effective management of waste and sanitation services, even where the impacts on the water resource are less significant. Both of these interventions would require the co-operation of National, Provincial and Local Government in collaboration with the community itself. (Source: DWAF, 2002. Managing the Water Quality Effects of Settlements:- The National Strategy: Policy Document U 1.3)

9.16 WATER MANAGEMENT AREA 16: GOURITZ

Background

The Gouritz WMA is situated in the southwest region of South Africa and falls predominately within the Western Cape Province, with small portions in the Eastern Cape Province and the Northern Cape Province. The Gouritz WMA consists of primary drainage region J and part of primary drainage regions K (K1 to K7) and H (H8 to H9). The Gouritz is the largest WMA in the Western Cape with a total surface area of 53 139 km^2. The mean annual temperature ranges between 16ºC along the south-east coast to 17ºC in the interior, with an average close to 17ºC for the catchment as a whole. The mean annual rainfall decreases from east to west, ranging from as high as 1000 mm in the south-east along the coast to as low as 160 mm toward the north of the WMA.

Gouritz River is the main river, and contributes 41% of the surface flow in the WMA. Its main tributaries are the Buffels, Touws, Groot, Gamka, Olifants and Kammanassie rivers, which drain the inland area. Several smaller rivers drain the coastal belt and all the inland rivers drain *via* the Gouritz into the Indian Ocean. The Duiwenhoks River Dam supplies 1.1 million m^3/a to the Duiwenhoks Rural Water Supply Scheme, of which 0.7 million m^3/a is transferred into the Breede WMA to supply farmers. There are no inter-basin transfers into the Gouritz WMA and approximately 70% of the available water is surface water.

The Gouritz WMA contributes less than 1% to South Africa's Gross Domestic Product (GDP), making it, from an economic perspective, one of the weakest WMAs in the country. The agricultural sector provides a wide range of products including wine grapes, fruit, fodder, vegetables, grains, hops, dairy, timber, tobacco, ostriches, sheep, cattle and goats. The fish and shellfish industry are significant for the economy of the coastal region. The ostrich industry also plays a part in the region's economy. Land use in the WMA, from a water resources perspective, is dominated by irrigation and afforestation activities.

The Gouritz WMA is one of the WMAs with the lowest population in the country. In the year 2000, the total population was estimated at 436 800 (DWAF, 2004i)). The inland region of the WMA is sparsely populated with 60% of the population situated along the coast. Of that 60%, about 90% reside in urban areas.

Water Quality Status

The water quality of the Gouritz River is characterised by elevated salt concentrations. Water quality is good in the headwaters of the tributaries but salinity increases in a downstream direction due to the geology of the region, high evaporation, and agricultural impacts. In the Buffalo River at Floriskraal Dam (J1H028) the salinity is "tolerable" but further downstream on the Groot River at Vanwyksdorp (J1H019), it has deteriorated to "unacceptable" levels. In the lower Gamka River at J2H010, the lower Olifants River at J3H011, and in the Gouritz River at J4H002, elevated EC and TDS concentrations were categorised as mostly "unacceptable". Elevated salt concentrations were also recorded in the Duiwenhoks River (H8H001) and the Goukou River (H9H005) where the water was categorised as "unacceptable". Salinity in the short coastal rivers of the K catchment is generally regarded as "ideal" in the Kaaimans River (K3H001), Knysna River (K5H002) and the Bloukrans River (K7H001). In the lower reaches of the Brandwag River (K1H004) and Moordkuil River (K1H005) salinity was "acceptable" to "tolerable". However, salinities in the lower reaches of the Groot-Brak River (K2H002), Maalgate River (K3H003), Swartvlei (K4R002) and Hoëkraal River (K4H001) were regarded as "unacceptable". Some of these monitoring points might have been affected by saltwater intrusion from the sea (like the one in Swartvlei). Nitrogen and ammonia concentrations were "ideal" in the coastal (K catchment) rivers but sulphate concentrations were "unacceptable" in the Groot-Brak River and Swartvlei, probably the effect of seawater intrusion.

Phosphate concentrations are regarded as unacceptable throughout the catchment. This could be due to the impacts of agricultural return flows in the catchment and discharges from wastewater treatment works.

In the Duiwenhoks River (H8H001) all the constituents exhibit an increasing trend over time except phosphates that shows a decreasing trend. However, in the Goukou River (H9H005), constituents show a slight increasing trend and phosphates slight decreasing trend. Constituents in the Touws River (J1H018) show an increasing trend except for phosphate and pH. In the Groot River (J1H019) and Olifants River (J3H011) constituents show a decreasing trend except for ammonia in the Groot and ammonia and nitrates in the Olifants River. Increases in nitrogen are generally associated with treated wastewater effluent discharges. The Gouritz River (J4H002) exhibits a slight increase in salinity but large increases in ammonia and nitrates.

Water quality issues and concerns

Salinity in the Great and Little Karoo

The elevated salinity found in the Gouritz River and its major tributaries occurs naturally over the inland catchments of the Great and Little Karoo as a result of the natural geology and high evaporation. This is a historical situation and one to which the ecology and the farmers have adapted.

WMA 16 WATER QUALITY STATUS MAP

The selection of crop types by farmers has allowed them to continue financially viable farming operations, making best use of the available water for irrigation. Outside of government controlled irrigation schemes, irrigation is largely opportunistic in the inland catchments. Elevated salinities do not occur to the same extent in the coastal catchments (H8 and H9) and the K catchment.

Water quality issues and concerns

Salinity in the Great and Little Karoo

The elevated salinity found in the Gouritz River and its major tributaries occurs naturally over the inland catchments of the Great and Little Karoo as a result of the natural geology and high evaporation. This is a historical situation and one to which the ecology and the farmers have adapted. The selection of crop types by farmers has allowed them to continue financially viable farming operations, making best use of the available water for irrigation. Outside of government controlled irrigation schemes, irrigation is largely opportunistic in the inland catchments. Elevated salinities do not occur to the same extent in the coastal catchments (H8 and H9) and the K catchments.

Nutrient enrichment and eutrophication

Concerns have been expressed about nutrient enrichment and eutrophication problems in the Olifants River downstream of Oudtshoorn and the Goukou River as well as estuaries such as the Hartenbosch estuary, Knysna lagoon, Goukou estuary and the estuary near Stilbaai. Nutrient enrichment is the result of farming activities (fertiliser leaching and washoff, dairy and animal wastes), and WWTW discharges high in nutrients. Problems associated with nutrient enrichment include excessive growth of rooted and free-floating aquatic plants and algae, and choking of river channels with water plants and reeds.

Urban impacts on water quality

In the developed urban areas, particularly the more densely populated coastal towns, man-made activities result in problems commonly associated with urban water use. These include discharge of water containing waste, WWTWs not meeting their required effluent water quality standards and diffuse pollution from informal settlements. Concerns were also raised about the impacts of a number of tanneries in the Oudtshoorn area.

Sewage and wastewater treatment systems

Concerns have been expressed about sewage and wastewater treatment systems in the WMA. In the larger urban centres such as Oudtshoorn, vandalism of the sewage reticulation and pump station infrastructure occasionally leads to sewage spills into the Olifants River. The industrial expansion taking place in the Oudtshoorn area would introduce additional loads on the WWTW and upgrading of the works will be necessary to avoid spills. It was the opinion of water quality managers that many of the WWTWs in the WMA were over-capacity resulting in poor quality discharges. Concerns were also expressed about the impacts these have on the microbiological quality of the receiving rivers. Runoff from informal settlements and poorly-serviced housing areas has resulted in pollution of rivers near urban areas such as the Olifants River and Knysna lagoon.

Disposal of wood processing waste

The disposal of wood processing waste is a potential problem throughout the coastal catchments (K catchment). Many saw mills operate without the necessary permits for discarding their waste. Leachate, consisting of organic acids and of high COD concentration from sawdust and woodchips, is undesirable from a water quality perspective. Woodwaste from treated wood, results in leaching of inorganic chemicals. The extent of unlawful disposal of this waste is not well known and the extent of impact on water quality has not been determined yet.

Dissolved oxygen and dairy farming

Concerns have been expressed about the organic loading of rivers and streams from dairy farming activities and dairy processing facilities in the George and Riversdal areas. The breakdown of organic compounds reduces dissolved oxygen concentrations in rivers which have a negative impact on aquatic organisms.

Sand mining and turbidity

Concerns have been raised about sand mining in the K catchment and at Wittedrift near Plettenberg Bay. Elevated turbidity cause silting of water ways, smothering of aquatic ecosystem habitats, and suspended sediment particles are good sites for adsorbing phosphates and water-borne pathogens.

9.17 WATER MANAGEMENT AREA 17: OLIFANTS DOORN

Background

The major river in the Olifants Doorn WMA is the Olifants River, of which the Doring River (draining the Koue Bokkeveld and Doring areas) and the Sout River (draining the Knersvlakte) are the main tributaries (DWAF, 2005b). It comprises the E primary drainage region.

The Olifants River rises in the mountains in the south-east of the Water Management Area and flows in a north-westerly direction. Its deep narrow valley widens and flattens downstream of Clanwilliam until the river flows through a wide floodplain downstream of Klawer. The Doring River is a fan-shaped catchment with the main river rising in the south and flowing in a northerly direction. Its main tributaries are the Groot River, Tra-Tra River and the Tankwa River. The northern part of the WMA is flatter and much of the basin lies between 500 and 900 m above sea level. In the east there are significant mountain ranges, the Hantam near Calvinia and the Roggeveld to the south, which rise to about 1 500 m above sea level. West of Nieuwoudtville lies the Bokkeveld Mountains escarpment, where the plateau elevation of about 700 m drops to about 300 m. The rolling hills and plains of the 30 to 40 km wide strip along the coast from the southern boundary of the WMA to the estuary of the Olifants River are known as the Sandveld. The deep sandy deposits overlaying the bedrock in this area are "primary" aquifers which provide a significant groundwater resource (DWAF, 2002b).

Climatic conditions vary considerably with minimum temperatures in July ranging from –3 to 3 ºC and maximum temperatures in January ranging from 39 to 44 ºC. The area lies within the winter rainfall region, with the majority of rain occurring between May and September. The mean annual precipitation is up to 1 500 mm in the Cederberg Mountains in the south-west, but decreases sharply to about 200 mm to the north, east and west thereof, and to less than 100 mm in the far north. Average gross mean annual evaporation (Symons pan), ranges from 1 500 mm (in the south-west to greater than 2 200 mm (in the dry northern). Due to the diverse soil types and variance in rainfall distribution, vegetation is varied and includes at least six veld types and several thousand plant species. Karoo and Karroid Types, False Karoo Types, Temperate and Transitional Forest Types, Scrub Types, and Sclerophyllous Bush Types occur in the Olifants/Doorn WMA.

The Olifants River and its tributary, the Doring River, are important from a conservation perspective because they contain a number of species of indigenous and endemic fish that occur in no other river systems, and that are endangered. Some of the tributaries are virtually unspoiled and are of high to very high ecological importance. The Olifants estuary is one of only three permanently open estuaries on the west coast of South Africa and represents a critical habitat to many estuarine-associated fish and bird species.

The Olifants/Doorn WMA is the least populated WMA in the country with approximately 0.25% of the national population residing in the area. Approximately 113 000 people live in the WMA (DWAF, 2005b). More than half of the population live in urban or peri-urban areas, and the rest in rural areas. About 65% of the population is concentrated in the south-western portion of the WMA. The population growth expected for the area appears to follow the general trend of decreasing rural populations which can be attributed to the lack of strong economic growth.

Water Quality Status

Water quality in the upper Olifants River, upstream of Clanwilliam Dam, is "ideal" and is suitable for all uses (E1H013 and E1H013). There is evidence of elevated phosphate concentrations which may be the result of agricultural activities and wastewater return flows in the Citrusdal area. The good quality water is stored in Clanwilliam Dam and Bulshoek Dam from where it is distributed *via* a system of canals to irrigation farmers in the middle and lower Olifants River valley. In the Olifants River downstream of Clanwilliam Dam and upstream of the Doring River confluence, the water quality remains suitable though it is progressively impacted by irrigation return flows from the highly cultivated Lower Olifants River irrigation scheme. The result is that water in the lower Olifants River just before the estuary (E1H018) is "unacceptable" and salinity exceeds the requirement for irrigation use.

Previous studies (Olifants Doring Basin Study Phase 1, 1998) found that there was a difference between unimpacted catchments and the main stem of the Olifants River that was impacted by agricultural activities. Tributaries in the upper Olifants River, like the Jan Dissels River, were largely unimpacted by human development. These rivers showed evidence of seasonal changes in quality. Salinities tended to be higher at the end of the dry summer period while low salinities were observed at the end of winter. However, in the middle and lower Olifants River it was found that there were strong seasonal variations in water quality. High salinities were observed early in winter probably originated from the wash-off of accumulated salts from the irrigated lands by the early rainfall. Lower salinities were observed at the end of winter when most of the salts have been washed off the catchment.

WMA 17 WATER QUALITY STATUS MAP

Water quality in the Koue Bokkeveld is ideally suited for all uses (E2H002). A trend of increasing TDS over time was observed in the Leeu River even though the quality is still acceptable. Marked seasonal differences were also found, with higher salt concentrations being observed in summer than in winter (DWAF, 1998).

The quality of water in the upper Doring River, when flowing, is suitable for agriculture and domestic water supplies. However, TDS concentrations in the Kruis River are very high and variable and the water quality has been classified as “tolerable” to “unacceptable” (DWAF, 1998).

Water quality in middle Doring River becomes marginal and TDS concentrations increase in a downstream direction. In the lower reaches, the water quality varies between “acceptable” at the end of winter and “tolerable” at the end of summer, probably as a result of the predominantly winter rainfall in the catchment. The water quality is still suitable for all uses but it does indicate deterioration. It has been reported that farmers stop irrigating when the water begins tasting salty.

Highly saline flows from the Tankwa Karoo tributaries have a sporadic influence on the Doring River.

The water quality status of non-perennial rivers like the Wolf, Koebee and Oorlogskloof, Sout, Krom and Hantams are not known. The Knersvlakte is a naturally saline system.

In the Sandveld sub-area water quality is “tolerable” to completely “unacceptable” in the Kruis River catchment (upper reaches of the Verlorenvlei River) due to elevated salinities. It improves slightly in a downstream direction but the lack of data precludes any concrete conclusions about water quality in the Verlorenvlei River and in Verlorenvlei. The cause of the poor water quality is the result of agricultural activities on the Malmesbury shales, which are high in salts and cover a large part of the Kruis River catchment (Sinclair et al., 1986).

Water quality issues and concerns

Microbiological water quality in the Upper Olifants River

The Olifants River supports a very important fruit export industry in the middle and lower Olifants River valley. Poor quality treated effluents from the towns of Citrusdal and Clanwilliam can put this industry at risk. The impacts of the effluent return flows should be monitored and reviewed on a regular basis in light of the European Common Agricultural Policy standards (e.g. EUREPGAP) to ensure that the export market is not jeopardised. Water quality management in the upper Olifants River should ensure that export standards for the agricultural industry are met. Many households use water from the irrigation canals for domestic purposes. Preventing microbial pollution would also protect these users.

Nutrient enrichment in the upper Olifants River

The Citrusdal valley experiences nutrient enrichment problems which are largely attributed to agricultural return-flows, especially in the summer months when the flow is relatively low in the river. Treated domestic wastewater, municipal solid waste management and informal settlements contribute towards this problem. Effluent from fruit and wine industries also needs to be monitored in Citrusdal.

Impacts of irrigation return flows

Agricultural activities in this WMA include a wide variety of crop types, many of which are high-value produce. The cultivation of wine and table grapes, rooibos tea, citrus, deciduous fruit, wheat, potatoes, flower cultivation and wildflower harvesting, livestock and fisheries contribute to the sector. Wine and dried fruit are important value-added products. Irrigation water use is the largest water user and only a small percentage of crops are dry-land crops due to the low rainfall over most of the WMA. Irrigation is with good quality water from the irrigation canals but farmers need to over-irrigate in order to leach out salts that accumulate in their irrigated soils. The leach water is returned to the middle and lower Olifants River resulting in a progressive deterioration of water quality. The irrigation farming industry should investigate alternative disposal and/or re-use practices to reduce their impact on the river.

Concerns have also been raised about the impacts of effluents from fruit and wine industries which cause seasonal water quality problems and it was recommended that the wine industry effluents from Klawer, Vredendal and Lutzville required on-going monitoring and management.

Impacts of agro-chemicals

Concerns have been raised about the impacts of residues from agricultural chemicals such as pesticides and herbicides on surface and sub-surface waters in intensive irrigation areas. Such impacts have not been studied in the middle and lower Olifants River but research in similar irrigation developments have shown that residues should at least be monitored.

Protection of upper Olifants River catchment

The high winter rainfall and the natural geology in the upper reaches of the Olifants River ensure that the water quality is good. Catchment management should focus on protecting the upper Olifants River to protect the water quality in Clanwilliam Dam, the main source of water to the Olifants River government water scheme.

Sand mining activities

Concerns have been expressed about sand mining activities in the WMA. It is poorly controlled and results in an increase in turbidity and suspended sediment concentrations, increased salinity, which causes silting of rivers and streams and smothering of habitat of aquatic organisms.

Proposed mining and impacts on Verlorenvlei

Concerns have been expressed about the proposed development of a tungsten mine in the catchment of the Verlorenvlei wetland and the impacts this may have on salinity and ecosystem health in this ecologically sensitive wetland.

9.18 WATER MANAGEMENT AREA 18: BREEDE

Background

The Breede Water Management Area (WMA) is situated in the south-west corner of South Africa, falling entirely within the Western Cape Province and is comprised of the tertiary drainage regions G40 (excluding G40A), G50 which makes up the Overberg Area and H10 to H70 which makes up the Breede River basin. Rainfall is highest in the mountainous regions in the southwest where the mean annual precipitation is as high as 3 000 mm per annum, whilst the central and north-eastern areas receive as little as 250 mm per annum. The mean annual temperature varies between 17ºC in the east to 15ºC along the south-west coast, with an average of 17ºC for the whole WMA. The average potential mean annual evaporation (measured by S-Pan) ranges from 1200 mm in the south to 1700 mm in the north of the WMA.

The Breede River is the main river in the catchment and its largest tributary is the Riviersonderend River. Other rivers in the Overberg area include the Sout, Klein, Bot and Palmiet.

A major inter-basin transfer takes place between the Breede and Berg WMAs via the Riviersonderend-Berg-Eerste River Government Water Scheme; approximately 161 million m^3/a is exported into the Berg WMA for the City of Cape Town water users. Another 9.5 million m^3/a is transferred into the Berg WMA and an additional 2.5 million m^3/a is transferred into the Olifants/Doorn WMA via the Inverdoon Canal.

The primary economic activities in the Breede WMA include irrigated agriculture, wheat cultivation and associated activities such as processing and packaging. Of the employed population in the WMA, 43% are active in the agricultural sector. The contribution of this WMA to the national Gross Domestic Product (GDP) is less than 1%, and is among the lowest in the country. Agriculture, trade and manufacturing are the most significant economic contributors in the Breede WMA. Land use in the WMA, from a water resources perspective, is dominated by intensive irrigation. Large expanses of dry land cultivation are characterised in the south of the region, where wheat is the predominant crop type.

Of the total population of 382 400, estimated in 1995, 66% reside in urban and peri-urban areas and 34% in rural areas. No significant population increase was anticipated.

Water Quality Status

Water quality in the headwaters of the Breede and many of its tributaries are ideal but it becomes progressively poorer in terms of salinity in a downstream direction. The biggest increase occurs in the middle Breede River due to intensive farming activities. Salinity measured as EC is “acceptable” in the Upper Breede near Ceres (H1H003Q01) and near Brandvlei Dam (H1H015). Further downstream at Le Chasseur (H4H017) it is still “acceptable”. However, downstream of the Zanddrift canal, salinity is “unacceptable” as measured at H5H004 near Secunda, H5H005 near Drew, and H7H006 near Swellendam. Salinity in the Breede River between Brandvlei Dam and the Zanddrift canal near Ashton is managed to meet irrigation water quality requirements through freshening releases from Brandvlei Dam. Downstream of that point salinity is high and riparian farmers can only use water during high flow conditions when there is sufficient dilution of the saline irrigation return flows. Salinities in the lower reaches of tributaries such as the Hex River (H2H010), Nuy River (H4H020), Kogmanskloof River (H3h011), and Riviersonderend River (H6H009) were “unacceptable”.

The increase in salinity in the Breede River and its tributaries is the result of poor quality irrigation return flows, irrigation and farming practices, and the geology (Bokkeveld shales) of the region (DWAF, 2000b). Sulphate concentrations range from “ideal” in the headwaters of the Breede River to “acceptable” in the lower reaches of the river.

Nitrogen concentrations along the Breede River remain “ideal” with little possibility of affecting crop yields.

The water quality in the Buffeljags River near Swellendam with respect to EC were within the irrigation and domestic water use requirements along the entire river reach (DWAF, 2000b). The river is also moderately enriched with nutrients and moderately enriched or even eutrophic conditions could exist.

In the Overberg, water in the lower Palmiet River is “ideal” for all constituents except phosphates. However, the river is highly impacted by WWTWs, discharges from fruit processing industries and urban runoff in te Grabouw/Elgin area. In the Klein River (G4H006), upper Sout River (G5H008) and lower Sout River at De Hoopvlei (G5R001) the salinity is naturally high and classified as “unacceptable”. The sulphate concentrations and pH in the entire Sout River are “unacceptable”.

Elevated phosphate concentrations are a concern throughout the WMA, probably the result of intensive agricultural activities in the basin and effluent return flows.

WMA 18 WATER QUALITY STATUS MAP

Water quality issues and concerns

Salinity in the Breede River basin

Salinisation of the middle and lower Breede River and its tributaries are the result of the irrigation return flows discharged to the rivers, the geology of the area, and agricultural practices.

Of particular concern is the intentional leaching of natural salts where new lands are cleared and soils purposefully leached to prepare those lands for irrigation. Acceptable salinity levels in the Breede River are maintained by freshening releases out of the Greater Brandvlei Dam.

Salinity is managed as far downstream as the Zanddrift Canal off-take, just upstream of the Kogmanskloof River confluence. Recommendations have been made regarding possible remedial measures such as the use of interceptor drains to limit the saline return flows entering the river. Another option is the demarcation of saline soils and the issuing of water use licences with conditions as to where new lands can be established. A more extreme (and costly) alternative is the construction of high-level canal systems to convey water directly to irrigators rather than using the river channel. Such an option would expose the river to the effects of saline return flows and place farmers and the ecosystem downstream of the water scheme in an even worse position.

Nutrient enrichment in the Breede River

Concerns were expressed about the occurrence of algal blooms and excessive filamentous algal growth under low flow conditions at certain locations within the Middle Breede River, clogging of canals by filamentous algae, and aquatic weed infestations (water hyacinth). These concerns were related to nutrient enrichment. This problem can be controlled by ensuring WWTW meet the effluent standards and by controlling fertilizer runoff from diffuse sources. Concerns were also expressed about algal blooms in the Theewaterskloof Dam which resulted in taste and odour complaints when the water was treated for domestic water use. Farmers have also complained about algal blooms in farm dams.

Microbiological quality in the WMA

The discharge of inadequately treated wastewater effluent from WWTWs, and irrigation with untreated winery and other industrial effluent are further concerns. Most municipal WWTWs and larger industries are attempting to meet licence conditions but the cumulative effect of many smaller operators irrigating with effluent which does not meet the general authorisation requirement, remains a concern. Diffuse pollution from poorly serviced informal settlements and the use of soak-aways on the banks of the Lower Breede River are also of concern to the microbiological quality of the Breede River and other rivers in the WMA. Stormwater runoff from informal settlements and poorly serviced urban areas has increased microbial counts in receiving rivers. Microbial impacts tended to be localised due to the die-off of pathogens in the water.

Agrochemicals in irrigation return flows

Studies in the Hex River valley have detected pesticide residues in irrigation return flows (London, 1999, London *et al*, 2000). It is probably reasonable to assume that the same patterns of pesticide contamination would occur in the rest of the Breede River Basin where intensive irrigation agriculture and spraying of orchards and vineyards is practised.

Dissolved oxygen and the dairy industry

Concerns have been expressed about the impacts of intensive dairy farming and dairy industries on the organic loads to rivers. In rivers the breakdown of organic compounds reduces dissolved oxygen concentrations which have a negative impact on aquatic organisms. Similar concerns have been raised about local authorities and wineries irrigating their high chemical oxygen demand (COD) effluents. These effluents can be washed into rivers during high rainfall events increasing the organic loads to the receiving rivers. The impacts of piggeries in the Bonnievale area on organic loads have also been a concern to water quality managers. Runoff and effluent discharges high in COD has negatively affected estuaries in or near coastal towns in the eastern Overberg area resulting in calls for their protection and rehabilitation.

Turbidity and impacts of sand mining

Sand mining activities in the Barrydale, Ashton and Suurbraak areas result in increased turbidity and suspended sediment concentrations in rivers. This leads to siltation problems and smothering of aquatic habitats. Bulldozing of streams and tributary rivers in the Breede valley has similar impacts on sediment loads.

9.19 WATER MANAGEMENT AREA 19: BERG

Background

The Berg Water Management Area (WMA) is situated in the extreme southwest corner of South Africa and falls entirely within the Western Cape Province. The Berg WMA consists of secondary drainage region G1 and G2, as well as the quaternary G30A in the north and G40A in the south. The mean annual temperature varies between 16 °C in the east to 18°C along the West Coast, with an average temperature of 16°C for the whole WMA. The entire Berg WMA is a winter rainfall region with the annual rainfall varying from 3 200 mm to 300 mm and the annual evaporation varies between 1 300 mm in the south and 1 700 mm in the north.

The major rivers include the Berg, Steenbras and Diep. A net transfer of 194 million m^3/a (in 2000) is exported from the Breede WMA via the Riviersonderend-Berg River Tunnel System into the Berg WMA for domestic water supply and use of farmers. No water is transferred out of the WMA.

The Berg WMA contributes about 12% to South Africa's Gross Domestic Product, of predominantly commercial trade and industrial activities. Other economic sectors that contribute towards the GDP include manufacturing, trade and agriculture. Land use in the WMA is characterised by residential, industrial and extensive irrigation areas (DWAF, 2004j).

Waste pollution from sewerage treatment plants and informal settlements along riverbanks threaten the river systems of the Berg WMA. During the late summer months (dry season) there is too little flow left in the rivers to dilute the pollutants and with a damaged river ecology pollutants can no longer be cleaned effectively. Salinity and siltation problems occur in the rivers of the southern region of the WMA. Salinity problems occur in the northern tributaries of the Berg River.

The total population of the Berg WMA is approximately 3 247 000 people, of which 95% reside in urban areas. Of that 95%, 87% of the people are concentrated in the Greater Cape Town area as they are attracted by employment opportunities. The winelands, which include the towns of Stellenbosch, Paarl, Wellington and Franschhoek, represent moderately populated areas.

Water Quality Status

Water quality in the Berg WMA varies not only between the individual river basins but also within individual river systems. The natural geology, agricultural practises, point and non-point source pollution all play a role in determining the quality of water in this WMA.

Most of the rivers in the water management area rise from the Table Mountain Group mountain catchments which provide very good quality water with total dissolved solids concentrations of less than 60 mg/l. The Berg River arises in the mountains near Franschhoek and the runoff is characterised by ideal water quality. However, the quality deteriorates in a downstream direction as a result of human activities. In Paarl (G1H020) the water is still regarded as "ideal" although phosphate concentrations are a concern. In the Upper Middle Berg area, which corresponds largely to the southern portion of the Drakenstein Municipal Area, the water quality of the Berg River has been severely impacted as a result of agricultural activities (coupled with river modification, water abstraction and runoff of pollutants) and general urban and informal settlement developments at Paarl/Wellington. Water quality at Hermon (G1H036) is regarded as "ideal" to "acceptable" although phosphate concentrations are still unacceptably high and a concern. Discharges from the Paarl and Wellington WWTWs are probably responsible for the elevated phosphate concentrations in this part of the river.

In the Lower Middle Berg area at Drie Heuwels (G1H013) the water quality has been severely affected by diversion weirs, disruption of flow patterns in the Klein Berg and Vier-en-Twintig rivers, and as a result of agricultural activities (largely the building of flood-protection levees and the use of pesticides). Water quality in this reach is regarded as "acceptable" in terms of salinity. By the time the river reaches the Misverstand Weir where water is abstracted for distribution to the West Coast towns and industries at Saldanha, salinity has increased to levels where the water is regarded as "acceptable". Phosphate concentrations are still unacceptably high. Many of the lower Berg River tributaries are underlain by Malmesbury shales of marine origin and therefore have naturally high salinity concentrations. Industrial users (steel manufacturers) in the Saldanha area need to pre-treat this water before being able to utilise it in their industrial processes.

Irrigators are limited to the types of crops they can cultivate, due to increased salinity levels. Water quality in the lower Berg River at G1H023 is poor with salinity and phosphates at "unacceptable" levels and sulphates at "acceptable" levels.

Water quality in the Klein Berg River which originates in the mountains near Tulbach is regarded as "ideal" at G1H008 where water is diverted into Voëlvlei Dam. Phosphate concentrations are high due to treated domestic and winery effluent from the Tulbach area.

WMA 19 WATER QUALITY STATUS MAP

Treated wastewater effluents and poor quality runoff from informal settlements into the Eerste River in the Stellenbosch area is a concern. By the time the Eerste River drains into the sea, the water quality is regarded as “acceptable” in terms of salinity, “acceptable” for ammonia and nitrates and phosphate concentrations are “unacceptable”.

This is a reflection of urban and intensive agricultural activities in the catchment. Serious concerns have been expressed about the microbiological quality of the Eerste River in Stellenbosch due to runoff from informal settlements with poor sanitation services.

Water quality in the upper Diep River at Malmesbury (G2H012) is regarded as “unacceptable” in the upper reaches; a result of the geology (saline Malmesbury shales) and agricultural practices. In the lower reaches at G2H042 the river was not classified in terms of salinity and phosphates but is regarded as “acceptable” to “ideal” in terms of nitrogen compounds. The Malmesbury WWTW discharges into the upper reaches of the Diep River. The Rietvlei wetland, a highly valued ecosystem, receives treated effluent from the Potsdam WWTW. Its impacts are of particular concern with respect to water quality and ecosystem health.

The Lourens River, most of the Peninsula Rivers, the Cape Flats rivers and vleis have all been impacted by urban runoff. The Kuils River and Salt River are also impacted by large wastewater discharges that have changed these seasonal rivers into perennial rivers. These urban rivers can probably not be rehabilitated but their condition must at least be maintained at levels that will not introduce social, health and aesthetic problems.

Water quality issues and concerns

Salinity in the middle and lower Berg River

A significant water quality problem in the Berg River catchment is salinisation in the middle and lower reaches. This is caused by leaching from the natural geology, which extends from the north of Paarl to the Berg River mouth and consists of Malmesbury shale, as well as agricultural practises and the wash-off of salts from irrigated and dryland agricultural practices. The problem is exacerbated during the first winter rains, when accumulated salts are washed into the river resulting in elevated salinity in the Misverstand Dam (G1H031).

Nutrient enrichment in the Berg River

A further concern in the Berg River is nutrient enrichment as a result of the discharge of treated sewage effluent from WWTWs, irrigation with treated winery effluent and the direct discharge of winery effluent. Diffuse pollution from informal settlements in the Klein Berg catchment impacts on the quality of water diverted into the Voëlvlei Dam (see Text Box 18). This has lead to increasing problems with nuisance algae in the middle and lower Berg River and Voëlvlei Dam, and higher domestic water treatment costs.

Microbiological water quality

Concerns have been expressed about the microbiological quality of rivers affected by treated wastewater effluent discharges and runoff from informal settlements. Rivers such as the Plankenberg and Eerste rivers near Stellenbosch, Stiebeul River near Franschhoek, and the Kuils River in Bellville are affected by poor quality effluents and runoff from informal settlements and high density settlements with poor sanitation services. Aging sewerage infrastructure and pump station breakdowns contribute to these problems. Some improvements in microbial water quality have in recent time been achieved in areas such as Stellenbosch and Paarl/Wellington due to interventions by the local municipalities. Concerns have also been expressed about the management and impacts of many small “package” WWTP’s that fall outside local authorities such as on golf estates and wineries.

Water quality problems in urban rivers

Many of the urban river systems in the Berg WMA serve as conduits for treated effluent discharged to the sea. The Bellville, Scottsdene, Kraaifontein, Zandvliet, Stellenbosch and Macassar WWTWs discharge treated effluent into the Kuils/Eerste River system. Borcherds Quarry and Athlone WWTWs discharge into the Black/Salt River and the Potsdam WWTW discharges into the Diep River, which feeds into the ecologically sensitive Rietvlei wetland system. The Cape Flats WWTW discharges into the canal downstream of the Zeekoevlei outlet control weir. These rivers no longer display seasonal flow patterns, and some, notably the Black/Salt and Kuils rivers have become severely modified. High residual nutrients can lead to eutrophication-related problems such as nuisance algal growth and excessive growth of aquatic weeds. Other problems associated with urban rivers include leaking sewers, contaminated stormwater runoff, litter, oil and toxic spills. The constant and high base flows in these rivers also impact on the estuaries and many have lost their tidal variation.

Agro-chemicals and endocrine disrupting chemicals

There are concerns about the accumulation of pesticide and herbicide residues in the surface waters, biota and sediments downstream of intensive irrigation areas. Concerns have also been expressed about the presence of endocrine disrupting chemicals (EDCs) in surface waters near intensive irrigation systems. EDCs interfere with the hormonal balance of organisms and can be found in the breakdown products of pesticides, pharmaceuticals, plasticizers, household products and industrial chemicals. Persistent organic pesticides (POPs) and EDCs are not monitored routinely in the Berg River WMA.

Dissolved oxygen, piggeries and organic effluents

Concerns have been expressed about the impacts of many piggeries in the WMA on the organic loads to rivers. Organic compounds consume oxygen when they decompose in rivers thereby reducing the dissolved oxygen concentrations and negatively impacting aquatic organisms. Discharges not complying with COD standards and irrigated effluents high in organic content that are washed into rivers, have similar impacts on aquatic ecosystems.

Deterioration in the quality of irrigation

There is growing concern regarding the general deterioration of water quality and the availability of good quality water for irrigation. Poor water quality impacts on the availability of irrigation water for produce earmarked for export to the European Union. This has serious consequences for the country as a whole.

Text Box 18: Berg WMA

BERG WMA

Change in state of Voëlvlei Dam

Voëlvlei Dam is an off-channel storage dam, fed with water diverted from the Klein Berg River and the Twenty Four Rivers, and it supplies domestic water to the City of Cape Town and towns in the Swartland district. In the past Voëlvlei Dam was a stable clear water dam with abundant rooted water plants and it was a favourite bass fishing venue. During the drought of 2005/6, the water level in the dam dropped very low and wind re-suspension caused an increase in turbidity. Since then the dam has remained in this turbid state even though the dam filled up again and remained relatively full. Bottom feeding carp and barbel are now the dominant fish species. Algal concentrations have also increased and the two water treatment works at the dam are experiencing more frequent problems with algal blooms and geosmin, a compound that cause taste and odours in treated drinking water.

Re-use of wastewater

The City of Cape Town is currently investigating the re-use of wastewater as part of its Integrated Water Resources Planning Study and has an objective of achieving zero effluent discharge at some future date. Treated effluent from the Greater Cape Town Metropolitan Area represents a significant opportunity for re-use. This particularly the case where there is a need to augment water supplies. The development of new water resources infrastructure will not be sanctioned by DWA until it is apparent that the potential for wastewater re-use has been determined and implemented, where it is proven cost effective to do so.

10 Climate Change

Although climate change is a natural phenomenon, there is increasing concern about the impact of human-induced climate change. While a scientifically contested concept, there is general consensus that climate change is a current reality and it is likely that climate change will affect all facets of human existence globally including the planet's economy, the health and social structure of its populations, infrastructure provision and maintenance, and the viability of natural systems.

Water availability is likely to be a significant issue, as temperature and evaporation rates increase and changes in the distribution of rainfall occur. These trends may have an impact on reservoir storage capabilities. Changes in temperature and rainfall are also likely to affect vegetation distribution. Geographical shifts in the distribution of vegetation and productivity patterns are similarly possible. Migration of animal species to areas of more suitable climate is also likely to increase.

Under these conditions, a number of health-related problems are likely to occur. For example, an increase in malaria and cholera in areas where rainfall intensity increases and flooding occurs. These problems are further exacerbated by overcrowding, poverty and poor sanitation. Agricultural productivity is also likely to be affected, especially in drought-prone areas. Major impacts on food production may arise from changes in temperature, moisture and carbon dioxide levels, and the spread of pests and diseases. This is particularly important for the poorest members of society who are directly dependant on the land for survival. Furthermore, a carbon dioxide rich climate could aggravate desertification through the alteration of spatial and temporal patterns of temperature and precipitation.

The general assessment of climate change effects on southern Africa has been done in the framework of the IPCC 4th assessment report (Christensen *et al*. 2007). Results presented indicate that by the end of 21st century temperatures are expected to increase by 2-3.5 deg C compared to values observed from 1980 to 1999. Increases at the top of this range are expected to occur in the interior, while coastal regions are expected to have increases corresponding to the lower bound of that range. Winter (June-August) temperature increases are projected to be stronger than summer (December-February) ones. Results of assessments carried out specifically for South Africa (e.g.) corroborate these results. Changes in temperature and higher ultraviolet light penetration are likely to severely affect freshwater systems and human populations which rely upon them. Projections of changes in climate (temperature, rainfall and runoff) are extremely difficult to model, and assessing projected climate impacts on freshwater ecosystems is even more challenging, particularly with regard to human influences and responses. The consequences of human-induced impacts include the following effects on aquatic systems, and are likely to be exacerbated with the effects of climate change (Kernan *et al*., 2007):

- Acidification and eutrophication by sulphur and nitrogen compounds
- Invasive species introduction, which alters flow patterns

- Mobilization of organic substances from soils
- Dam building and river diversion
- Erosion and sedimentation
- Increased ultra-violet radiation
- Habitat fragmentation.

It is important to note that algal blooms, and especially blue green algae (Figure 10), result in many human-related impacts (see Text Box 19). The potential impacts of global warming will increase the frequency of toxic algal blooms and this will have a greater chance of human related impacts such as diarrhea and even potentially toxic algal related fatalities for communities that drink water directly from the river. Management of eutrophication is of particular concern, since this presents severe problems for the treatment of water and presents a potential health threat when trihalomethanes (THMs) are formed after chlorination.

The cyanobacteria cells accumulate along shorelines because they are positively buoyant and are driven into shallow water or onshore by prevailing winds accumulation along shoreline.

Figure 10: A typical cyanobacterial bloom

Text Box 19: Impacts of algae on water use

Impacts of algae on water use

Algal blooms:

A pervasive result of enrichment of lakes and rivers with nutrients is increasing growth of algae. Algae, especially cyanobacteria (blue-green algae) respond to cultural eutrophication by the development of massive populations, including blooms, scums and mats. Such mass populations are increasingly attracting the attention of environment agencies, water authorities, and human and animal health organizations, because cyanobacteria can present a range of amenity, water quality treatment problems, and hazards to human and animal health. The increasing number of events of cyanobacterial blooms in South African impoundments and rivers is a cause of concern to the Department of Water Affairs and Forestry (Van Ginkel, 2004).

Human and animal health risk:

Freshwater toxins are produced almost exclusively by Cyanobacteria. Surveys in different parts of the world have revealed that between 25% and 75% of cyanobacterial blooms are toxic. Toxic blooms of cyanobacteria in freshwaters have been reported in many water bodies throughout South Africa (Van Ginkel, 2004). Cyanobacteria can produce a diverse range of cyanobacterial toxins, known as 'cyanotoxins', which are hazardous to human and animal health. Potential health concerns arise from exposure to the toxins through ingestion of drinking-water, during recreation and through showering.
Water treatment processes only partially filter out cyanobacteria and dilute their toxins. These toxins have caused massive mortality among wild and domestic animals and also constitute a hazard to human health, particularly by ingestion, and skin irritation and even death of humans exposed to microcystins during haemodialysis.

Perhaps the most widespread risk to human health posed by toxic algae is exposure while engaged in recreational activities in waters with blooms. Swimming, sailing and water-skiing are popular and valued pastimes for South Africans, while also being economically significant for local communities because of the associated tourist infrastructure. Human illness – ranging from minor rashes and other allergic reactions to gastroenteritis and even more severe illnesses – is known to result from contact with affected water during recreational activities. Ingestion of cyanobacterial toxins can also cause vomiting and diarrhoea and may have long-term effects such as liver damage and the promotion of tumour growth. Possibly a greater risk to humans from algal toxins comes from long-term, low level consumption of the liver toxins, as these poisons are known to promote the growth of liver tumours.

Water treatment problems:

One of the most expensive problems caused by nutrient enrichment is the increased treatment required for drinking water. Nutrient enrichment commonly cause drinking water treatment plant filters to clog with algae, impede coagulation and filtration. High algal biomass in drinking water sources require greater volumes of water treatment chemicals, increased back-flushing of filters, and additional settling times to attain acceptable drinking water quality (USEPA, 2000).
The treatment processes used at conventional surface water treatment plants are normally effective in removing cyanobacterial cells, but are not effective in removing or destroying dissolved cyanotoxins. To remove the cyanotoxins need additional water treatment, such treatment ranges from granular activated carbon filtration, followed by reverse osmosis, to more elaborate treatment including membrane filtration. Human health risks in water supplies are toxins by cyanobacteria and carcinogenic trihalomethanes may be formed when water is chlorinated during purification.
Water quality managers are frequently concerned with the effect that blooms of nuisance algae have on the taste and odour of water in municipal water supplies. Taste and odour compounds are produced by microscopic organisms such as algae, bacteria, fungi and protozoa. Periods of fishy water and periods of musty water, prompted significant consumer complaint. Control measures by water purification plants to remove taste and odour are usually expensive. Water boards are reluctant to implement expensive control measures when the ecological, environmental and health details of these compounds remain unknown. However, consumers' demands for high quality water will remain or increase. Taste and odour events erode consumer confidence in municipal drinking water supplies leading to a rise in the use of bottled water.

Other problems:

Excessive growth of nuisance algae in response to impaired water quality can reduce both the aesthetic appearance and use of rivers and lakes. Decreases in the perceived aesthetic value of the water body (amenity value degraded). Riparian property values may decrease. The effects of algal blooms on the aquatic ecosystem are severe, *inter alia*: Species diversity decreases (thus lower biodiversity), low ecological stability, extreme oscillations occur in physical and chemical parameters as well as in the growth of many planktonic organisms – growth in pulses and sudden collapses, depletion of dissolved oxygen, reduced ecosystem integrity; loss of some ecosystem components and functions, and increased probability of fish kills.
Filamentous algae may impede water flow in canals (loss of hydraulic capacity). Clogging of reticulation systems by filamentous benthic algae, and can contribute to the corrosion of pipes. High algal concentrations cause a severe clogging hazard for drip irrigation systems. The recreational use of water surfaces may also be adversely affected, e.g. closure of local waterways for swimming, fishing and boating with a threat to tourism of the affected area with a potential loss of income.

Conclusions:
The development and prevalence of dense cyanobacterial blooms is the main symptom of progressive and often uncontrolled eutrophication processes in rivers and water storage reservoirs. Cyanobacterial blooms (frequency and intensity) in South African aquatic systems are increasing. Without a radical improvement in eutrophication management approaches and treatment technologies, eutrophication will continue to decrease the benefits and increase the cost associated with use of these resources.
In the long-term, reducing nutrient inputs is the best preventative measure. Catchment management to reduce sewage spills and cutting down the input of fertilisers and other pollutants is the key to reducing the incidence of algal blooms and associated problems.

11 Role of Water Quality Planning

11.1 Water Quality

Constant media claims, in many cases backed by scientific evidence, frequently raise concerns about the deterioration over time of the water quality in many of our water resources. Resource water qualities that are unfit for use have also been reported in certain isolated cases. Such scenarios must be avoided, since it potentially poses adverse human health effects, while also jeopardizing sustainable development. It is evident that a worsening resource water quality situation can only be reversed and prevented if proper and focused planning is complemented by appropriate management interventions.

11.2 Proactive intervention

Current tendencies are emphasising the need for pro-active intervention, as far as water quality management (WQM) is concerned. This specifically applies to WQP, which in essence represent a pro-active approach towards securing water resources that are fit for use. WQP must be supported by suitable pro-active and re-active source control measures.

11.3 Water Quality Management

Prior to the 2003 Macro-Restructuring of the Department's Policy and Regulation Branch, WQM constituted the mandate of a single DWA Directorate, *viz*. the then Directorate WQM. However, today WQM no longer constitutes the responsibility of a single organisational unit. Instead – WQM constitutes a DWA effort that is serviced and maintained by different role-player directorates that fulfil specific functions which collectively make up the Department's broader WQM function.

Such an approach has a number of advantages which theoretically includes the establishment of specialised organisational units, the extension of the Department's WQM capacity and allowing for more focussed cooperation amongst individual DWA role-players. Conversely, in the absence of effective integration of these specialised functions and roles, the above said advantages are largely nullified, potentially rendering a Departmental WQM function that is largely ineffective. A co-ordinated planning role is necessary to improve the effectiveness of the Department's broader WQM function.

11.4 Planning coordination

Generally speaking, the Department's Integrated Water Resource Planning (IWRP) component provides the required Resource Planning and Management cohesion that links Resource Objectives with Water Use Management (see Figure 11). Within the Department's IWRP function WQP is focused on "connecting" Resource Water Quality Objectives with water quality Water Use Management, and hence, it functionally fulfils the coordination role from a water quality perspective.

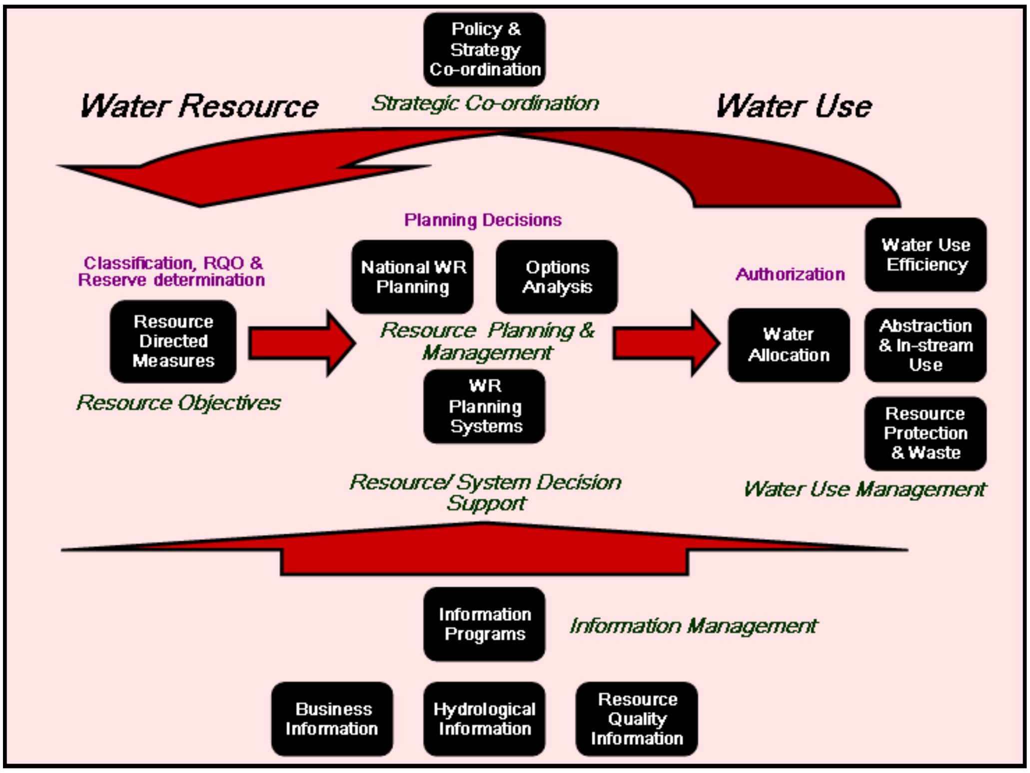

Figure 11: Planning provides the "glue" that links resource protection and source control efforts

11.5 Integration

Since the current DWA structure houses various "water quality role-player" directorates, an effective and structured collaborative effort is crucial. This is particularly true for WQP, as WQP is, on the one side, reliant on water quality and catchment data and information that are mostly to be supplied by the Department's Information Management group, while, on the other side, it is not directly involved in source control, but only responsible for the provision of strategic catchment and resource guidance to the Department's Water Use Management group. In addition, WQP is also obliged to provide WQP support and input to the Department's Resource Directed Measures (RDM) group. Large room for improvement exists when linking resource planning decisions-making with the determination of RDMs, the implementation of source control and enforcement, and the supply of useful and appropriate planning data and information. In addition, relationships within the broader water quality governance structure, such as with Catchment Management Agencies (CMAs), also deserve attention and agreement.

11.6 Water Quality Planning

The goal of the Department's WQP function is to develop and maintain integrated WQP related instruments and processes, and to generate WQP solutions that support the protection, use, development, conservation, management and control of South Africa's water resources, including water resources shared with neighbouring countries.

The roles of this function are-

- to develop (or revise), and participate in the implementation and maintenance of integrated WQP related instruments[1] and processes;
- to ensure and support long-term strategic water quality planning, scenario analysis, reconciliation, and foresight;
- to support integrated water resource planning and management, including the implementation of RDMs and water allocations;
- to support WQP related research;
- to provide WQP related strategic and specialist technical assistance to our clients;
- to build WQP related capacity, internally and externally;
- to monitor, and audit the implementation of the said integrated WQP related instruments[1] and processes; and
- to identify and support WQP related management information needs.

If translated into practice, the abovementioned means that the determination of resource objectives and the provision of water quality input to RDMs, *i.e.* the Reserve, Resource Quality Objectives (RQOs) and the Water Resource Management Class, is largely informed through WQP, while the strategies and plans on how to achieve those are also inherently products of WQP. As such the Department's WQP function includes planning assessment (CAS), forecasting and water quality trend analysis, scenario analysis, catchment visioning, determination of Resource Water Quality (planning) Objectives (RWQOs), water quality availability assessment, water quality reconciliation and water quality allocation planning, intervention planning and management implementation co-ordination, WQP information and decision support by means of modelling and other predictive and planning systems, and planning auditing and improvement (see Figure 12).

[1] WQP related instruments include policies, strategies, programmes, procedures, guidelines, models, systems, methodologies, regulations and criteria that will apply to WQP at the international, national, water management area and/ or catchment levels.

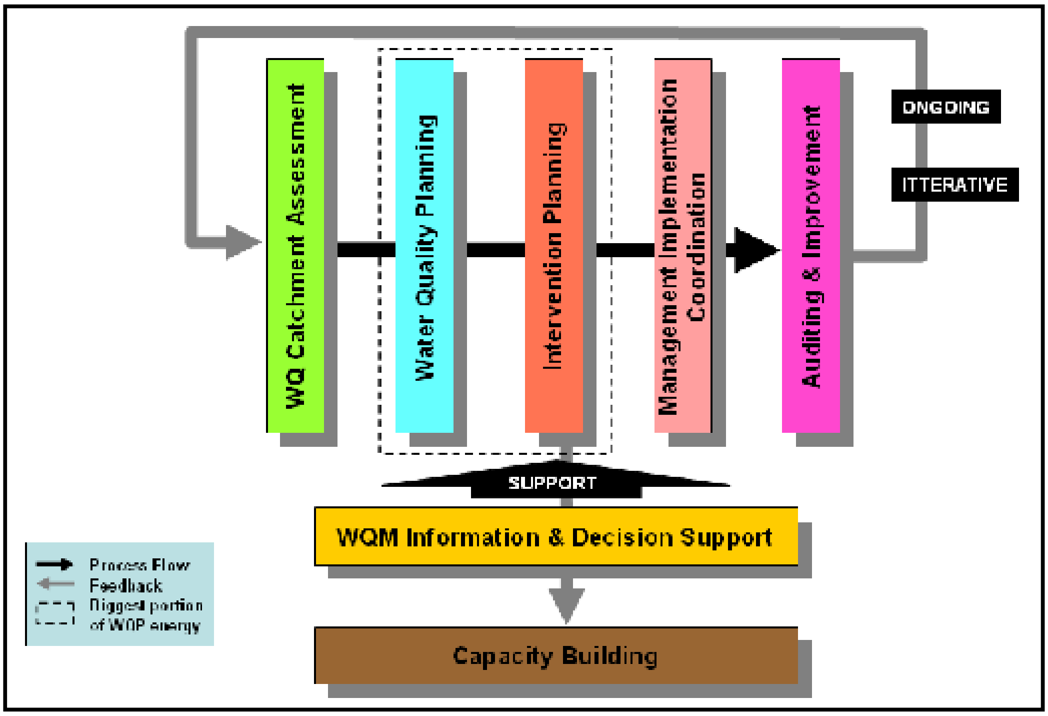

Figure 12: Water Quality Planning business flow diagram

12 Future Water Quality Management Interventions

The deterioration of the quality of our water resources is one of the major threats to South Africa's capability to provide sufficient water of appropriate quality to meet developmental needs while ensuring environmental sustainability. The water quality problems are influenced by uncontrolled sources of pollution and challenges in executing measures to manage pollution.

In the coming decade, water resources will be under increasing stress from persistent and emerging challenges including population growth, urbanization, new contaminants and climate change. Increasing population, urbanisation and expanding economies coupled with a lack of capacity, funds or willingness to apply pollution regulations are factors increasingly resulting in greater scarcity of good quality water resources.

In summary the focus areas for future water quality management intervention are discussed in the sections that follow.

12.1 Management Approaches

12.1.1 Co-operative Governance

The DWA is responsible for the management of the nation's water resources. Water quality management in South Africa is complex and requires strong institutional capacity (well-trained resources, active, effective systems and appropriate finances) at a national and regional level. Unless DWA increases its capacity and works cooperatively with the Department of Mineral Resources, Department of Environmental Affairs and Department of Agriculture and local government the water quality in the country will continue to deteriorate and the episodic fish and crocodile kills will become a more regular occurrence.

Multi-sectoral participation in water quality management is required. Sustainable management of the country's water resources will be achieved only if all sectors of society find effective means of working together in partnership. Where there is political will, it is possible to put in place policies, laws, financing arrangements and stable public institutions for water management.

We need an Environmental Agency (EA) or a legislatively effective enforcement body that is responsible for dealing with water pollution incidents in South Africa. The focus of the EA would be enforcement of regulations against polluters. The EA should be well resourced with notably qualified people so that effective enforcement actions can take place.

The overarching philosophy is that everybody is downstream and hence water quality needs to be collectively and cooperatively managed by all users in civil society.

12.1.2 Regulatory tools

The DWA has the regulatory tools but these need to be applied in an effective and consistent manner. These tools include source regulation through water use authorizations (linked to integrated water and waste management plans), guidelines and regulations and load reduction strategies.

The current suite of South African environmental and natural resources legislation provides every opportunity for the protection and conservation of natural resources. It creates a framework to rights and obligations, which bind the government and its agents, landowners and the civil society. However, the implementations of these laws are lacking.

Load reduction is crucial to the management of the water quality in rivers. This includes strategies such as centralised mine water treatment works which can be modularly expanded as more water needs to be treated. The eMalahleni and Optimum mine water treatment works are good examples of how industry and local government have cooperated to turn a waste resource (mine water) into a product (drinking water).

Compulsory licences in stressed catchments need to be applied and managed. Licence compliance reports need to be collated and regular feedback given to appropriate river forums so that water quality management becomes more transparent and collective solutions can be sought in a cooperative manner.

The Green Drop System also serves as a tool to facilitate the relationship between Regulation and Management of Wastewater Services, while also keeping relevant stakeholders informed on compliance trends of all registered systems. The system serves as information basis for the Green Drop Certification programme which is an incentive-based regulation. The poor compliance to chemical, physical and microbiological requirements is an indication of a break-down in cooperative governance and enforcement of regulations. There is an urgent need to get wastewater treatment works just to comply with their current water use authorisations.

12.1.3 Fiscal Tools

The DWA is developing a Waste Discharge Charge System (WDCS), based on the polluter pays principle, to promote waste reduction and water conservation. It forms part of the Pricing Strategy and is being established under the National Water Act 9 (Act 36 of 1998).

The WDCS aims to:

- promote the internalisation of environmental costs by impactors;
- promote the sustainable development and efficient use of water resources;
- create financial incentives for dischargers to reduce waste and use water resources in an optimal way; and
- recover the costs of mitigating the impacts of waste discharge on water quality.

The basis of the polluter pays principle is that the costs of environmental impacts should be borne by those responsible for the impacts. The National Water Act specially refers to the polluter pays principle as an economic mechanism for achieving effective and efficient water use.

To date only test cases of the WDCS have been undertaken in the Witbank Dam and Crocodile (West) catchments. The roll out and implementation of the WDCS is however becoming essential to the water quality management of water resources specifically related to load reduction and mitigation measures.

12.1.4 Self Regulation

Without a culture of self regulation water quality management in South Africa, it is going to remain the responsibility of DWA to catch the perpetrators. Most of the large water users, be they mines, industry or water treatment works, have sets of standards that they have to comply with in their processes, as well as their discharge standards.

All of the international companies have international quality systems that they need to comply with. All export companies need to comply with international standards that relate to health and safety as well as environmental compliance.

Self-regulatory management instruments such as the ISO 14000 series of environmental standards are used by industries to improve their own environmental performance. Other examples include the CEO Water Mandate which is a United Nations initiative designed to assist companies in the development, implementation and disclosure of water sustainability policies and practices. Large multinational companies such as Coca-Cola, Cadbury, SAB Miller, Pepsi and Sasol are signatories to this compact. Other examples include the adoption of cleaner production principles to enhance efficiency, industry action programmes such as "Responsible Care" and Waste Minimization Clubs.

The Department can use self-regulation or voluntary mechanisms to their advantage by giving recognition to industries and companies that actively participate in such initiatives.

Environmental auditing and the potential imposition of green taxes are important tools to assist the culture of self regulation. Without this culture the water quality status of our rivers and impoundments will continue to deteriorate.

12.1.5 Civil management instruments

These instruments are based on transparent and participative management of water resources and water quality. The involvement of catchment forums and water user associations in the development of catchment management strategies creates a mechanism through which the Department can leverage support for water quality management as well as the role out of most water management strategies. A further example is the Adopt-a-River initiative that the Department has launched to involve NGOs and communities to protect and manage water resources at a local scale. The Department should use the enthusiasm of local NGOs to monitor water quality and to bring pollution incidents to the attention of regional official's *i.e* the recommendation is for greater involvement in forums, Catchment Management Committees and other stakeholder consultative institutions.

12.2 Resource Quality Management

12.2.1 Resource Quality Objectives/ Resource Water Quality Objectives Approach to Management

Chapter 3 of the National Water Act (NWA) (Act No. 36 of 1998) lays down a series of measures which are together intended to ensure the comprehensive protection of all water resources, *i.e.* i) Water Resource Classification, ii) the determination of the Reserve, and iii) setting Resource Quality Objectives (and associated Resource Water Quality Objectives). To date a suite of instruments have been developed to support this. The challenge that is now to be faced is the implementation of these RWQO's.

The setting of the management class of the water resource (Class I, II or III) will determine its level of protection needed to allow for sustainable utilisation. Currently the water resources in three WMAs (Olifants, Vaal and Olifants-Doorn) are being classified in terms of the newly established classification system. The Reserve set together with RWQOs cater for the level of protection required by the aquatic ecosystem and water users. These then translate back to source directed measures to achieve the RWQOs. The RWQOs dictate the load reductions required, discharge qualities and standards.

This translation back to source directed controls is the current challenge being faced with regard to the implementation of Resource Directed Measures (RDMs). Attempts at implementation have been done through Integrated Water and Waste Management Plans (IWWMPs) and licence conditions and do occur in some catchments (e.g. the Vaal and Upper Olifants). However large scale consistent implementation is still required. What is required for successful implementation is installed water quality modelling systems to support the relationship between source requirements and RWQOs. Capacity building will be required so that these models can be run and maintained.

RQOs still need to be confirmed per WMA and will only become legally defendable once they have been gazetted. However RWQO's currently being used in the interim still serve as the management objectives to achieve the desired resource water quality.

12.2.2 The Reserve

Speedy implementation of the Reserve should be a high priority.

Water quality is one of the most important drivers of the ecological Reserve process and is used throughout the process.

Implementation of ecological Reserve allocations and associated environmental flows

If environmental flows are implemented and their effectiveness monitored there should be an improvement in the present ecological status of the aquatic organisms in the WMA's or catchments. It is important that the proposed Ecological specifications (Ecospecs) for water quality and associated water quality monitoring programmes are implemented and revised according to the ongoing monitoring findings.

12.2.3 Water Resource Classification

The ultimate goal of the Water Resource Classification System (WRCS) is to recommend a normative desired condition for each water resource in a given catchment. Once the management class has been determined, there is a need for catchment-scale water quality planning to account for the cumulative impacts of multiple discharges to ensure that RWQOs are not exceeded when considering a new water use licence application for effluent discharge, or when considering curtailment of existing over-allocation of assimilative capacity in order to restore water quality to meet RWQOs. Quantitative tools to support such catchment-scale planning is not well developed or commonly used. In future this gap will become crucial in the meeting of RQOs and RWQOs.

12.3 Information Management

12.3.1 Water Quality Monitoring

Good data and ongoing monitoring are the cornerstones of an effective effort to improve water quality. In order to protect and improve water quality, water managers, governments, and communities need to know what pollutants are in the water, how they entered the waterway, and if efforts to improve water quality have been effective.

The importance of water quality monitoring cannot be over emphasized. Information is critical for decision making. The lack of data has been made evident through this status assessment.

Monitoring of system change is crucial, but more importantly the system must be audited against the desired state, to ensure that the goals of management are met and the system is maintained in the desired state and if not, then DWA must respond because they have a responsibility. It has been said that our water monitoring programmes (e.g. River Health Programme- RHP) only record the deterioration of water quality and the extinction of aquatic biota, but it means nothing because no actions are taken against offenders (polluters). If somebody is violating the laws (polluting the water) then DWA must take action against them.

The RHP will need to be expanded to cover the chosen Reserve (Environmental Water Requirement) sites. This will include increased biomonitoring (typically fish and macroinvertebrates) which can be used to determine the effects of water quality on the aquatic ecosystems.

More funding and resources are required at a national level to address the current monitoring information gaps. The capacity at Regional Offices on water quality sampling, data collection, data compilation and interpretation and information reporting needs to be strengthened and expanded.

Plans to improve water quality cannot be implemented without a clear understanding of what contaminants are in the water and how they are affecting the ecosystem and human health. Addressing water quality challenges will mean tracing water contaminants to their source and identifying a prevention and/or treatment plan. Once the treatment plan is implemented, ongoing monitoring of water quality will help to ascertain whether the remediation efforts have been successful. Based on this information, the treatment plan can be continued or modified to include treatment of additional point sources and pollutants until desired levels of water quality constituents in the water resource are reached.

12.3.2 Increased variables to be monitored

The Department's Resource Quality Services (RQS) water quality database (WMS) is the national source of the chemical water quality data. The water quality variables that are analysed do not include trace metals nor organic analysis.

The National Toxicity Monitoring Programme (NTMP) only covers POPs and some of the pesticides of concern but lacks pesticides like the organophosphates, chlorpyrifos, dimethoate, fenamiphos, etamidophos, mevinphos, prothiofos and terbufos due to the lack of resources.

Many constituents accumulate in the sediment and concentrations can exceed guideline values compared to concentrations in the water. These are remobilized during flood events or when anoxic conditions develop. Sediment is therefore an important source of potential pollution. However, sediment as a sampling medium is currently not included in any monitoring programme and need to be addressed (probably in a separate monitoring programme).

An important feature of many South African rivers and reservoirs is high turbidity caused by the presence of suspended silt, thus, soil erosion, sediment transport and siltation of dams are a major issue in South Africa. However, very limited data on turbidity or suspended solids is available for aquatic systems. Turbidity influences the quantity and the quality of light penetrating water as well as the biota and the transport of chemicals. As light is a driving force for primary production, changes in light attenuation will have a direct influence on the trophic dynamics of aquatic ecosystems. Turbidity is important because it affects the growth rates of phytoplankton, transport of contaminants, and the effectiveness of disinfection. Therefore, it is recommended that turbidity (NTU) is included in the national water quality monitoring programme. The determination of turbidity is an easy and cheap method.

Existing toxicity tests (within the NTMP) did not show any response to the pesticide/ trace metal contamination in the water and did not reflect the predicted effect of water quality guidelines. An investigation is recommended to relook at various tests, including endocrine disrupting activity and other chronic toxicity tests, in order to understand the effect of these pesticides on the aquatic ecosystem.

The National Microbial Monitoring Programme should be expanded because the microbial quality of rivers receiving poor quality effluents and contaminated stormwater runoff was identified as a major concern in this study.

12.3.3 Inadequate Water Quality Guidelines

The current South African Water Quality Guidelines (DWAF, 1996) do not include many of the variables of concern and it is recommended to include frequently detected variables like DDE-4,4, DDD-4,4, phthalates, phenanthrene, dibenzo furan, chlorpyrifos, dimethoate, metamidophos and others.

It is recommended that the DWA develop guidelines that are site specific. The interaction of these chemicals in terms of toxicity need to be taken into consideration.

There are no sediment quality guidelines developed yet. The frequent detection of chemicals in the sediment requires that sediment-specific guidelines are developed.

12.3.4 Lack of Regional Office use of the Water Management System (WMS)

The DWA Resource Quality Services (RQS) water quality database Water Management System (WMS) is the national source of the chemical water quality data. Despite many years of training within the regional offices of DWA this system has not been adopted as the “one and only catch-all system” for water quality data. This has left gaps in this data base as many of the regional water quality monitoring programmes are not included in the WMS. Coupled to this is the inconsistent monitoring frequency as well as the limited numbers of monitoring sites nationally.

The WMS programme needs to be used by all regions in order to effectively manage the nation’s water quality.

12.3.5 Water Quality Information data/information management

Education and capacity building

Water quality improvements can be achieved through the difficult work of changing social norms, advocating for improved policies, and demanding smarter investments. One of the most important strategies in the arsenal of the water quality advocate is the tool of building social change through education and capacity building. Particularly in an unregulated environment, it is easy to throw things into the water, like industrial byproducts, agricultural waste, or human waste (UNEP, 2010).

Regulations and enforcement can help change behavior and lead to new technologies and financial investments to improve water quality. But all of these strategies can only be implemented once a society decides that water quality is a problem. To have societies make improving water quality a priority, they need to have knowledge about its connections to the things they care about.

Capacity building and education efforts are needed at every level. This capacity building is an important part of education so that positive results can flow from increased knowledge.

Thus,

- Implement environmental awareness campaigns and information programmes and
- Encourage environmental responsibility of individuals and communities.

Volunteer monitoring

The Department recently launched the Adopt-a-River initiative to involve communities more closely in the management of their local water resources. Volunteer monitoring is often viewed as a way to mobilise community members. The Department should encourage such activities by providing resources such as sampling manuals, booklets, etc. on the topic, as well as providing an information system where such data can be stored (refer to documentation produced for implementing the Adopt-a-River programme). Communities can act as the eyes for the Department in the early detection of water pollution.

12.4 Eutrophication

Eutrophication effects and problems are profound in several aquatic ecosystems in South Africa and have become a matter of major concern to all water users. Causes of nutrient over-enrichment or eutrophication of aquatic ecosystems can be attributed to agriculture, urbanization (mainly sewage effluent), forestry, impoundments, and industrial effluents. Increased rates of primary production typical of eutrophic ecosystems is often manifest as excessive growth of algae and the depletion of oxygen, which can result in the death of fish and other animals. Mass mortality and anoxia is the ultimate stage of eutrophication. The impacts of eutrophication are ecological, social and economical – discussed elsewhere. Various preventative and control options are available for eutrophication, but only major input and output controls are listed.

12.4.1 Nutrient reduction

Control of eutrophication can only be reached effectively by drastic reduction of the total nutrient load of an overloaded water system. Controlling phosphorus should be the primary focus of any nutrient control strategy. Although wastewater effluent is the principal contributor to the degradation of the aquatic system, it is also one of the impacts that is most easy to mitigate. It is easy to focus on point sources because they are easily identified, measured, and susceptible to control by policies and regulation.

12.4.2 Upgrading infrastructure

Frequent exceeding of water quality standards by sewerage treatment works (see Green Drop Report, 2009a) constitutes a serious risk to South Africa's aquatic ecosystem. Therefore, urgent attention should be given by the municipalities to upgrade the sewerage infrastructures and minimise operational spillages.

12.4.3 Chemical treatment

Sediments play a significant role in the process of eutrophication of water bodies. Major controls of nutrients inputs have been implemented in many instances however their recovery may be delayed due to the very high levels of nutrients contained in the sediment. Chemical remediation may be used to reduce sediment phosphate (P) flux. The use of alum may be a viable option to treat and reduce elevated levels of readily exchangeable sediment phosphate in impacted streams, such as downstream from wastewater treatment plants (WWTPs). Thus, alum or iron chloride treatment of streams may be a feasible option to mitigate P release from benthic sediments after external P sources are reduced.

12.4.4 Biological filters

Establishment of artificial wetlands at wastewater treatment plants must seriously be considered – this ecological purification process is economical and could be a useful alternative way of treating sewage in rural areas, smaller towns and townships. Establishment of riparian buffers could control and mitigate the impact of non-point source pollutant loading (e.g. modern agriculture) into surface water. Numerous studies have shown the effectiveness of riparian buffers in reducing sediments, pathogens and nutrient loads into surface and groundwater in agricultural catchments.

12.4.5 Flow manipulation

Flow manipulation appears to be a most promising area for management of eutrophication in rivers because it addresses both of the key drivers of algal blooms: water residence time and stratification. Altering the timing and size of the discharge through the river system must be seen as a potential cyanobacterial management strategy. Thus, much greater attention needs to be given to flow management to provide flushing flows, to reduce pollution levels, and endeavouring to provide flows that are closer to the natural situation.

12.4.6 Monitoring

Strengthen and expand the National Eutrophication Monitoring Programme (NEMP). The key for the success of these policies in providing solutions to the problems of pollution is the ability to conduct continuous and routine monitoring. Ideally, chlorophyll-*a* concentrations should be monitored weekly or biweekly.

12.4.7 Modelling

Modelling of salinity has progressed to a level that has been incorporated into the planning models. Nutrient models need to be developed to the same level as salinity. This is more difficult as nutrients are non-conservatives. Modelling of nutrients will allow planning-level decisions to be made regarding source management and discharge standards. Modelling needs to feed back into discharge standards for sewage and industrial waste discharges.

12.4.8 Integrated management

An important rule for the management of freshwater ecosystems is to remember that the conditions, water quality and biota of any body of freshwater are the product and reflection of events and conditions in its catchment. An extremely important factor is that substances added to the atmosphere, land, and water generally have relatively long time scales for removal or clean up.

Environmental and conservation issues need to be placed within the context of social and economic uses of the river by the community and therefore requires the perception of local residents, landowners, the water industry and other stakeholders to be taken into account. Science has an important role to play in the decision-making process.

Finally, the concept that eutrophication is permanent and will remain, should be considered in these new approaches to the problem. Therefore, the integrated management should be adaptive, constantly producing new mechanisms, ideas and tools. This can only be achieved with solutions and activities at the local level with political and managerial support. In this context education at all levels plays a fundamental and unique role. Public participation and awareness, practical focus, institutional capacity, articulation continuity and adequate scope should be some of the essential components of integrated water management focusing on eutrophication and related issues.

Successful control of the phosphorus in the aquatic environment requires the following:

- Effective legislative measures and their strict implementation by the national and regional governments.
- Surveillance by monitoring programs to check compliance with the regulations.
- Starting the control measures early before the eutrophication process becomes irreversible.
- Strong public support by the citizens and stakeholders.

Therefore, policy alone will not solve many of the degradation issues, but a combination of policy, education, scientific knowledge, planning, and enforcement of applicable laws can provide mechanisms for solving the rate of degradation and provide human and environmental protection. Such an integrated approach is needed to effectively manage land and water resources.

12.4.9 Nutrient Limits

Nutrients (primarily nitrogen and phosphorus) are the major driving force for eutrophication and algal blooms. The nitrogen (nitrate) concentration ranges used for the Status Report is based on the effects of nitrate on human health (drinking water), but is unacceptable from an eutrophication point of view.

The average NO_3-N concentration for the 300 sites studied was only 1.08 mg/ℓ, therefore 95+% of the sites were in the 'Ideal' range, which give a false impression in terms of plant nutrients in the aquatic systems. A NO_3-N concentration of 6 mg/ℓ (current Ideal) is already in the range of a hypertrophic system. To limit nitrogen concentrations and thus eutrophication we therefore propose a new set of nitrate concentrations for aquatic ecosystems – see Table 5. These concentrations are based on national and international literature and practical experience and expertise.

However, ammonium (NH_4-N) is also a nitrogen source available for plant and algal growth, and should also be considered. Therefore, if one look at nitrogen availability, then it is better to work with the total inorganic nitrogen (TIN) concentration available, *i.e.* the nitrate plus ammonium concentrations – see Table 6.

The phosphate concentrations used for this assessment and planning review is very strict (therefore there is a general non-compliance to phosphate throughout the country) and probably only applicable to dams (reservoirs). However, most of the 275 sites used in the report are in rivers, therefore a new set of ranges is proposed that is applicable for phosphate concentrations in streams and rivers (Table 5). These concentrations are more practical and still strict enough to limit eutrophication.

Table 5: Proposed Generic nutrient ranges

Variable	Units	Ideal	Acceptable	Tolerable	Unacceptable
NO_3 (NO_3-N)					
Current:	*mg/ℓ*	*6*	*10*	*20*	*>20*
Proposed:	mg/ℓ	0.50	1.50	2.50	>2.50
PO_4-P					
Current (dams):	*mg/ℓ*	*0.005*	*0.015*	*0.025*	*>0.025*
Proposed - Rivers:	mg/ℓ	0.025	0.075	0.125	>0.125

Table 6: Additional nitrogen ranges to consider

Variable	Units	Ideal	Acceptable	Tolerable	Unacceptable
NH_4 (NH_4-N)					
Current:	*mg/ℓ*	-	-	-	-
Proposed:	mg/ℓ	0.05	0.15	0.25	>0.25
DIN*					
Current:	*mg/ℓ*	-	-	-	-
Proposed:	mg/ℓ	0.70	1.75	3.0	>3.0

* DIN = Dissolved inorganic nitrogen
(NO3-N + NH4-N) = TIN (Total inorganic nitrogen)

While the above concentrations are proposed for rivers the management of nutrients still requires an integrated approach that should consider the impacts of these rivers on dams. Investigations into the response of dams need to be undertaken in a catchment context before RWQOs for nutrients are set for rivers.

12.5 Salinisation of the Country's Water Resources

The water quality in South Africa's aquatic ecosystems is declining primarily because of salinisation and eutrophication. Anthropogenic increases in salinity and electrical conductivity in surface waters are largely due to agriculture, mining, urbanisation and industrial activities.

Changing salinity in freshwater systems can have detrimental impacts on biodiversity. Salinisation can also lead to changes in the physical environment that will affect ecosystem processes, for example, higher TDS concentrations in the rivers evidently decrease the turbidity of the water that will have a direct influence on the primary productivity of aquatic ecosystems.

To prevent or minimise salinisation impacts, it is important to set maximum salinity targets. It is also important to identify taxa or other indicators of salinity impacts so that biomonitoring can identify impacts before they become severe or irreversible.

There are two main anthropogenic sources of salinity, point and nonpoint source discharges from mines (acid mine drainage), and irrigation return flows from large-scale irrigation schemes. The salinity of South Africa's water resources is being threatened by acid mine drainage. Coal mining activities are expanding in the Olifants, Upper and Middle Vaal catchments. The

Waterberg will be further developed in the future. The eastern, western and central gold mining basins are decanting or in the process of filling. The decant volumes that are expected in the future are large and of poor quality. The impact of the water quality will be large if this excess water is not managed properly.

The most viable long-term solution for acid mine drainage related salinity is desalination of contaminated water. The success of the eMalahleni mine water treatment works demonstrated that it is a viable solution if implemented at a regional scale. Controlled release schemes offers a short-term solution to managing river salinity but in the long term salts would accumulate in a system if the residence time is sufficiently long.

Currently river dilution is most commonly used to mitigate the impacts of saline irrigation return flows. This is inefficient use of scarce water supplies and will become more difficult as water becomes limiting in highly developed catchments. The collection or evaporation of saline return flows are used in Israel and in the Colorado River. This offers an on-site solution but it is not common practice in South Africa. It is recommended that the Department also collaborate with the Department of Agriculture and Agricultural Research Council to pilot test evaporation ponds as a means of capturing saline return flows.

12.6 Re-use of Wastewater

The direct and in-direct re-use of domestic waste water is receiving much greater attention in South Africa. Treated domestic waste water can be used directly for potable water supply. The Windhoek water reclamation works is an example of direct re-use. Indirect re-use generally entails blending treated waste water by discharging it to a dam or river and abstracting it elsewhere for treatment to domestic standards. The middle Vaal River is an example of indirect re-use from a river and the Garden Route Dam at George is an example of in-lake blending before abstraction. Other common options include the irrigation of sports fields and gardens in urban centers, irrigation of crops not eaten raw, and aquifer recharge. The Department's requirement that large urban centers consider re-use of wastewater before any new supply schemes are developed is having the desired effect and should be continued.

The key driver for the implementation of water re-use is increased utilization of a limited water resource. However in terms of water quality, protection of receiving water bodies may restrict the discharge of treated wastewater back to streams and aquifers, thus encouraging the use of reclaimed water.

Re-use of water would have positive benefits, specifically on the water resource, *viz*:

- Protection of aquatic ecosystems by not having to abstract more water from a water source, and
- Avoiding degradation of water resources by not discharging wastewater.

Water re-use projects may, however, still have an environmental footprint and energy usage depending on the water reclamation technologies used. In the South African context, re-use of mine wastewater results primarily in a brine and sludge waste stream with some useful byproducts such as gypsum. The re-use of domestic wastewater results in a saline waste stream which contains recalcitrant organic compounds. These waste streams have to be managed appropriately and responsibly within the environmental regulatory framework, to ensure that they do not negate the benefits of the water re-use.

Water re-use must therefore be evaluated in the context of other water supply and water augmentation options with consideration of water quality, environmental impacts, carbon footprint, ecological footprint and energy usage.

12.7 Inadequate Protection of Surface Water Resources

A higher hazard for the water resource needs to be taken into consideration by Department of Agriculture (DoA) during the regulation of pesticide application. It is suspected that aerial application of pesticides pose a higher hazard compared to ground application. This needs to be confirmed in a more intensive study together with Department of Environmental Affairs (DEA) (air sampling) and DoA (application patterns).

Awareness campaigns on safe and responsible use of pesticides for farmers, pesticide applicators and community members should be recommended to DoA.

Existing toxicity tests (within the NTMP) do not show any response to the pesticide/ trace metal contamination in the water and do not reflect the predicted effect of water quality guidelines. It is suggested that the toxicity tests be expanded to include endocrine disrupting activity and other chronic toxicity tests in order to understand the effect of these pesticides on the aquatic ecosystem.

12.7.1 Endocrine Disrupting Compounds

Endocrine disrupting compounds (EDCs) are chemicals that interfere with the structure and function of hormone-receptor complexes. They cause endocrine disruptive effects at very low levels. Impacts include testicular and prostatic cancer, decline in male fertility, and impacts on aquatic organisms. The Water Research Commission (WRC) has launced a research programme to develop an understanding of the situation in South Africa. It is recommended that the Department collaborates with the WRC to make an informed decision whether a baseline monitoring programme for EDCs should be implemented in high risk areas. A similar approach was followed in the development of the National Microbial Monitoring Programme (NMMP).

12.8 Enforcing Appropriate Land Use

Existing urban infrastructure is not adequate to accommodate increasing urbanization. Unfortunately this has resulted in severe impacts on water quality, unsanitary conditions in settlements, open waste sites and degradation of agricultural land and natural vegetation. Coastal areas are particularly vulnerable and impacted because of their complex ecosystems and many demands placed on them.

Protection of riparian vegetation and wetlands losses can be used to improve runoff and ultimately water quality in our rivers. There is a need for DWA, provincial and local authorities to integrate water quality planning and management in the development of land use plans, particularly to consider high impact land use activities.

12.9 Diffuse Pollution

Internationally it has become recognised that diffuse sources of pollution (also known as non-point sources of pollution) plays a major role in the degradation of water quality, specifically with respect to salinity, eutrophication (nutrient enrichment), sediments, pathogens, persistent organic pollutants (POPs) and some heavy metals. It is now accepted that it is not feasible to properly manage water quality without addressing the contribution from diffuse sources. Consequently, attention is increasingly being devoted to the quantification of diffuse water source pollution and to identify means to control it cost-effectively at source.

In South Africa the major water user is agriculture and as a consequence diffuse pollution from the sector has a large impact on surface and ground water quality. The agricultural use of fertilizers and pesticides impacts water quality due to rainfall runoff and leachate into the soils and water table. Typically the diffuse water quality impacts from agriculture results in increased salinity, eutrophication and POPs.

Coal and gold mines (operational, closed and abandoned mining operations), are the most significant sources of diffuse contamination in terms of surface and groundwater in South Africa. Typical diffuse pollutants from the mines include sulphates, acid mine drainage, salinity, metals (including aluminium, iron and manganese), and toxic and radioactive substances such as uranium from goldmines. Many of these pollutants contribute to the three types of non-point pollution caused by mining *i.e.* surface water, groundwater and atmospheric pollution. Typical sources of diffuse mine pollution are waste rock dumps, slimes dams and open cast mines.

Uranium pollution of surface and groundwater in the Wonderfonteinspruit catchment and potential health risk to humans in the area and downstream users such as Potchefstroom (Boskop Dam) are also further identified concerns.

The risk of the uncontrolled releases (decanting) of acid mine drainage (AMD) to the environment and rising levels of groundwater to infrastructure are diffuse pollution risks facing our country's water resources.

Runoff from urban areas and large industries also contribute to diffuse water pollution of both surface and groundwater.

Specific plans and strategies are required to manage diffuse sources of pollution, specifically from the agricultural sector as the increase in nutrients and agrochemicals cannot continue to increase in water resources unabated, as well as acid mine drainage which currently poses a serious threat to the country's water resources.

12.10 Sewage Treatment Work Discharges

A key contributor to the deterioration in the water quality of South Africa's water resources and the marked increase in nutrients and microbiological contaminants with associated health risks are as a result of untreated or partially treated domestic wastewater discharges from sewage treatment works. This situation will continue unless plans or a management strategy is developed to address the current *status quo*. Serious efforts must be made to finance or support the improvement of wastewater treatment works at local government level.

12.10.1 Green Drop Report – Key findings

Recent investigations and audits of South African municipal wastewater treatment plants confirmed that the situation with regard to waste water treatment and compliance must be addressed as a matter of urgency. The municipal waste water services business is generally considered to be far from acceptable, when compared to the required national standards and international best practice. Only 53% (449 out of 852) of municipal waste water treatment works (WWTW) were assessed for the first Green Drop Certification programme. In other words 403 systems (47%) failed to submit any data to DWA. The Department should expand its waste water regulatory initiative to obtain more information on these systems not assessed during the certification programme. Only 32 (out 449 assessed) *i.e.* 7.1% achieved the Green Drop Status by scoring 90% and above in terms of the seven critical performance areas (DWA, 2009a).

Two hundred and two (203) of the WWTWs, out of the 449 (45%) assessed, scored between 50 and 89%. In this case there is room for improvement in some of the critical performance areas. However, there remains concern over the 55% (of systems) that scored between 0% and 49%, meaning that drastic improvement is required. Thus, in total 76%, *i.e*. 649/852 waste water treatment works in South Africa are dysfunctional and pose a serious pollution threat to our water resources and should urgently be addressed by DWA and local governments.

A "turn-around intervention" is not only dependant on the replacement/ refurbishment of existing infrastructure and expansion of infrastructure. The strategic decrease of the risk factor is a reachable target which will have significant benefits to the environmental health of the receiving water bodies.

12.10.2 Efficient Enforcement

One of the greatest challenges to water quality management is effective and efficient enforcement. In light of the current situation regarding non-compliant wastewater discharges specifically that of wastewater treatment works DWA needs to refocus efforts on enforcement. A management strategy should be developed to address the issue.

12.11 Technology

Many effective technologies and approaches are available to improve water quality. Appropriate technologies can be used to treat wastewater if funding is available to communities to implement needed technology and infrastructure. A tremendously cost-effective approach to improving water quality is through pollution prevention. In cases where contaminants result from domestic, industrial, or agricultural activities, wastewater must be treated. When water quality and watersheds are adversely impacted by poor water quality, strategies to remediate pollution and restore watershed functions are important.

Technologies and infrastructure to prevent, treat, and restore water quality must be employed in every region of the world by (UNEP, 2010):

- connecting communities, governments, and businesses to effective water quality technologies and approaches;
- developing new technologies when needed to meet the particular environmental or resource conditions in a particular location;
- providing financing to implement needed technologies and infrastructure projects; and
- providing technical and logistical support to help communities and governments implement technology and infrastructure projects to improve water quality.

12.12 Water Quality Modelling

Water quality modelling tools are used locally and internationally to assist with water quality management.

In South Africa there have been several studies that DWA have funded to assess the current status of water quality modelling tools, the gaps in data as well as the needs of the country for these tools.

Many of these models are propriety international models that need to be customized for our conditions or are commercially available at high prices (purchase and license prices). Despite these studies there is a still a lack of competent water quality modellers and limited models used for water quality management. Coupled to this is the lack of confidence in the modelled outcomes due to the shortage of data (many variables not monitored and not frequently enough) that these models require.

There is an urgent need for the continued support of local water quality models and skills development through tertiary institutions.

12.13 Consequences of failure

The decisions made in the next decade will determine the path we take in addressing the South African water quality challenge. Disturbing scenarios of the future are certainly possible if we fail to address water pollution now. Increased industrial and sewage waste will continue to strain our surface water resources.

A greater proportion of people will be effected by preventable waterborne diseases if the problem of safe sanitation and clean drinking water remains unsolved. Industries and farms will spend more and more money to find and treat water that is clean enough to use. However, taking bold steps internationally, nationally, and locally to protect water quality will mean a much different future. Water resources can again become the centerpieces of cities and villages, the cultural and social gathering places, and residents will once again turn toward the rivers and streams that gave them life (UNEP, 2010). Drastic actions and interventions are however necessary sooner rather than later to achieve this future.

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APPENDIX A:

National water quality monitoring sites assessed as part of planning level review of water quality

Monitoring Points Assessed for Planning level review of Water Quality
A2H006 PIENAARSRIVIER 90 JR AT KLIPDRIFT ON PIENAARSRIVIER
A2H010Q01 MALONEY'S EYE AT STEENEKOPPIE
A2H013 SCHEERPOORT 477 JQ MAGALIES RIVER AT SCHEERPOORT
A2H019Q01 ROODEKOPJES DAM ON CROCODILE RIVER: DOWN STREAM WE
A2H021Q01 PIENAARS RIVER AT BUFFELSPOORT
A2H027Q01 PIENAARS RIVER AT BAVIAANSPOORT
A2H059 VAALKOP 192 JQ AT ATLANTA ON KROKODILRIVIER
A2H061Q01 APIES RIVER AT RONDAVEL
A2H111Q01 VAALKOP DAM ON ELANDS RIVER: DOWN STREAM WEIR
A2H132 HAAKDOORNDRIFT 373 KQ @ PAUL HUGO DAM ON KROKODILRIVI
A3H040Q01 MARICO RIVER AT MOOIPLAATS/TZWASA WEIR ABSTRACTIO
A3R003 KROMELLENBOOG DAM AT KROMELLENBOOG 104 JP NEAR DAM WA
A3R004 MOLATEDI DAM AT EERSTEPOORT 136 KP ON MARICORIVIER NE
A4H013Q01 MOKOLO RIVER AT MOORDDRIFT/VUGHT
A4H014 ZANDPAN 63 LQ AT SAMEVLOEIDAM ON MOKOLO
A5H006Q01 AT BOTSWANA STERKLOOP ON LIMPOPO RIVER
A5H008Q01 GA-SELEKA VILLAGE BOSSCHE DIESCH 53 LQ R572 BRIDGE ON LEPHALALA RIVER
A7H008Q01 DOWN STREAM OF BEIT BRIDGE ON LIMPOPO RIVER
A8H009Q01 LUPHEPHE DAM ON LUPHEPHE RIVER: DOWN STREAM WEIR
A9H001Q01 LUVUVHU RIVER AT WELTEVREDEN/SCHUYNSHOOG
A9H011Q01 LUVUVHU RIVER AT PAFURI/KRUGER NATIONAL PARK
A9H012Q01 AT MHINGAS ON LUVUVHU RIVER
A9H013 AT MUTALE BEND KRUGER NATIONAL PARK ON MUTALE
B1H005Q01 OLIFANTS RIVER AT WOLVEKRANS
B1H010Q01 WITBANK DAM ON OLIFANTS RIVER: DOWN STREAM WEIR
B1H015Q01 MIDDELBURG DAM ON LIT. OLIFANTS RIV: DOWN STREAM
B2H016 @ WATERVAL ON WILGERIVIER
B3H001Q01 OLIFANTS RIVER AT LOSKOP NORTH
B3H021Q01 ELANDS RIVER AT SCHERP ARABIE
B4H003Q01 STEELPOORT RIVER AT BUFFELSKLOOF
B4H011Q01 STEELPOORT RIVER AT ALVERTON
B6H001Q01 BLYDE RIVER AT WILLEMSOORD
B6H004Q01 BLYDE RIVER AT CHESTER
B7H007Q01 AT OXFORD ON OLIFANTS RIVER
B7H015Q01 OLIFANTS RIVER AT MAMBA/KRUGER NATIONAL PARK
B7H017Q01 OLIFANTS RIVER AT BALULE REST CAMP/KRUGER NAT PAR
B7H019Q01 GA-SELATI RIVER AT LOOLE/FOSKOR
B8H008Q01 AT LETABA RANCH ON GROOT LETABA
B8H018Q01 GREAT LETABA RIVER AT ENGELHARDT DAM/KRUGER NAT P
B8H028Q01 GREAT LETABA RIVER AT MAHLANGENE/KRUGER NAT PARK
B8H033 TABAAN STATE LAND ON KLEIN-LETABA

Monitoring Points Assessed for Planning level review of Water Quality
B9H002 AT SILVERVIS DAM/KRUGER NAT PARK ON SHINGWIDZI
C1H002 STERKFONTEIN DELANGESDRIFT ON KLIPRIVIER
C1H007Q01 VAAL RIVER AT GOEDGELUK/BLOUKOP
C1H008Q01 ELANDSLAAGTE ON WATERVALRIVIER
C1H012Q01 VAAL RIVER AT NOOITGEDACHT/GLADDEDRIFT
C1H017 VILLIERS 492 AT FLOOD SECTION ON VAALRIVIER
C1H019Q01 GROOTDRAAI DAM ON VAAL RIVER: DOWN STREAM WEIR
C1R002Q01 GROOTDRAAI DAM - GROOTDRAAI DAM ON VAALRIVIER: NEA
C2H001Q01 MOOI RIVER AT WITRAND
C2H004Q01 SUIKERBOSRANT RIVER AT VEREENIGING WEIR (RW S2)
C2H005Q01 RIETSPRUIT AT KAALPLAATS (RW RV2)
C2H007 PILGRIMS ESTATE 272 AT ORKNEY ON VAALRIVIER
C2H011 GERHARDMINNEBRON EYE AT GERHARDMINNEBRON
C2H018Q01 VAAL RIVER AT DE VAAL/SCHOEMANSDRIFT
C2H061 PALMIETFONTEIN 250 - AT KLIPPLAATDRIFT ON VAALRIVIER
C2H065Q01 LEEUDORING SPRUIT AT KLIPSPRUIT
C2H066Q01 AT VLIEGEKRAAL ON MAKWASSIESPRUIT
C2H067Q01 AT LEEGTE ON SANDSPRUIT
C2H069Q01 MOOIRIVIERLOOP (RIVER) AT BLAAUWBANK
C2H073Q01 @ GOEDGENOEG 150M U/S ORKNEY BRIDGE ON SKOONSPRUIT
C2H085Q01 MOOI RIVER AT HOOGEKRAAL/KROMDRAAI
C2H122Q01 VAAL DAM ON VAAL RIVER: DOWN STREAM WEIR
C2H131Q01 RW C-S1 COLLIERY POINT ON SUIKERBOSRANT RIVER
C2H139Q01 KOEKEMOER SPRUIT AT BUFFELSFONTEIN
C2H140Q01 VAAL RIVER AT WOODLANDS/GOOSE BAY CANYON
C2H141Q01 KLIP RIVER AT WITKOP (NEW BRIDGE)
C2H260Q01 AT KROMDRAAI LOW WATER BRIDGE ON VAALRIVIER
C2R005Q01 KLIPDRIFT 395 IQ - KLIPDRIF DAM ON LOOPSPRUIT NEAR
C2R008Q01 LTS24 VAAL BARRAGE ON VAAL RIVER NEAR BARR WAL
C3H003Q01 AT TAUNG ON HARTSRIVIER
C3H007 ESPAGSDRIF SEODING 25 BRIDGE AT THE WEIR ON HARTS RIV
C3H016Q01 AT DELPORTSHOOP LLOYDS WEIR ON HARTSRIVIER
C4H004Q01 FAZANTKRAAL AT NOOITGEDACHT ON VETRIVIER
C4H016 MOND VAN DOORNRIVIER 38 - @ BLOUDRIF ON SANDRIVIER
C4H017Q01 SAND RIVER AT DORINGRIVIER/BLOUDRIF
C4R002Q01 CORANNAKRAAL 87 - ERFENIS DAM ON VETRIVIER NEAR DA
C5H003Q01 AT LIKATLONG / SANNASPOS ON MODDERRIVIER
C5H012Q01 RIET RIVER AT KROMDRAAI/RIETWATER
C5H030Q01 @ RIETRIVIER SETT. JACOBSDAL ON ORANGE-RIET CANAL
C5H039Q01 KRUGERSDRIFT DAM ON MODDER RIVER: DOWN STREAM WEI
C5H048Q01 AT ZOUTPANSDRIFT ON RIETRIVIER

Monitoring Points Assessed for Planning level review of Water Quality
C5H053Q01 CYPRESS 89 - AT GLEN ON MODDERRIVIER
C6H002Q01 BOTHAVILLE GROOTDRAAI 408 - @ RIVER BANK ON VALSRI
C6H003Q01 BOTHAVILLE MOOIFONTEIN 624 - @ RIVER BANK ON VALSR
C6H007Q01 KROONSTAD - @ R721 ROAD BRIDGE ON VALSRIVIER (OLD
C7H003Q01 AT DANKBAAR MISPAH ON HEUNINGSPRUIT
C7H006Q01 RENOSTER RIVER AT ARRIESRUST
C8H001Q01 WILGE RIVER AT FRANKFORT
C8H009Q01 AT TIJGER HOEK ON TIERKLOOF RIVER
C8H010Q01 FRASER SPRUIT 94 HARRISMITH ON OUBERGSPRUIT
C8H026Q01 AT FREDERIKSDAL ON LIEBENBERGSVLEI RIVER
C8H027Q01 AT BALLINGTOMP ON WILGE RIVER
C8H028Q01 WILGE RIVER AT BAVARIA (FLOOD SECTION)
C8H032Q01 AT STERKFONTEINDAM ON NUWEJAAR SPRUIT
C9H008 NAZARETH FARM STUDAM 1KM DOWNSTREAM OF VAALHARTS DAM
C9H009Q01 VAAL RIVER AT DE HOOP
C9H024Q01 SMIDTS DRIFT OUTSPAN 23 SCHMIDTSDRIFT @ WEIR ON VA
C9R003Q01 ST CLAIR 148 - EGMONT DAM ON WITSPRUIT @ DAM WALL
D1H001Q01 WONDERBOOM/STORMB. SPRUIT AT DIEPKLOOF/BURGERSDOR
D1H003Q01 ORANGE RIVER AT ALIWAL NORTH
D1H006Q01 KORNET SPRUIT AT MAGHALEEN
D1H009Q01 ORANGE RIVER AT ORANJEDRAAI
D1H011Q01 KRAAI RIVER AT ROODEWAL
D2H012 CALEDONSPOORT 190 THE POPLARS 199 AT THE POPULARS ON
D2H035Q01 CALEDONRIVER AT FICKSBURG/FICKSBURG BRIDGE
D2H036Q01 CALEDONRIVER AT KOMMISSIEDRIFT
D2H037Q01 CALEDON RIVER AT WILGEDRAAI/HOBHOUSE
D2R004Q01 WELBEDACHT 285 - WELBEDACHT DAM ON CALEDONRIVIER:
D3H008Q01 AT MARKSDRIFT ON ORANGE RIVER
D3H012Q01 ORANGE RIVER AT DOOREN KUILEN (DOWN STREAM D3R003
D3H013 ROODEPOORT ON ORANJERIVIER
D3H015Q01 SEEKOEI RIVER AT DE EERSTE POORT
D4R003Q01 DISANENG DAM ON MOLOPO RIVER: NEAR DAM WALL
D4R004Q01 MOLOPO (RATSHIDI) - MODIMOLA DAM ON MOLOPORIVIER:
D7H005Q01 ORANGE RIVER AT UPINGTON
D7H008Q01 ORANGE RIVER AT BOEGOEBERG RESERVE/ZEEKOEBAART
D8H003Q01 AT VIOOLSDRIFT ON ORANGE
D8H008Q01 ORANGE RIVER AT PELLA MISSION
E1H011Q01 CLANWILLIAM DAM ON OLIFANTS RIVER: DOWN STREAM WE
E1H013 MIDDELPOS 553 AT CITRUSDAL ON OLIFANTSRIVIER
E1R001 KROMME VALLEY 113 BULSHOEK DAM ON OLIFANTSRIVIER: NEA
E2H002Q01 AT ELANDS DRIFT ASPOORT ON DORINGRIVIER

Monitoring Points Assessed for Planning level review of Water Quality
E2H003Q01 AT MELKBOOM ON DORINGRIVIER
E2H016 OLIFANTS RIVER AT LUTZVILLE
G1H008 NIEUWKLOOF 198 - ON KLEIN BERGRIVIER
G1H013Q01 AT DRIEHEUVELS ON BERGRIVIER
G1H020Q01 AT DAL JOSAFAT NOORDER PAARL ON BERGRIVIER
G1H023Q01 AT JANTJIESFONTEIN ON BERGRIVIER
G1H031Q01 AT MISVERSTAND DIE BRUG ON BERGRIVIER
G1H036Q01 AT VLEESBANK HERMON BRIDGE ON BERGRIVIER
G2H012Q01 DIEP RIVER AT MALMESBURY
G2H015Q01 AT FAURE ON EERSTERIVIER
G2H042 ADDERLEY 155 - ON DIEPRIVIER
G4H006Q01 KLEIN RIVER AT CAN Q5-8/WAGENBOOMSDRIFT
G4H007Q01 PALMIET RIVER AT FARM 562-WELGEMOED/KLEINMOND
G5H008Q01 SOUT RIVER AT KYKOEDY
G5R001Q01 AT DE HOOP NATURE RESERVE JETTY ON DE HOOPVLEI SOU
H1H003Q01 BREE RIVER AT CERES COMMONAGE
H1H015Q01 BREE RIVER AT DIE NEKKIES (ONDER BRANDVLEI)
H2H010Q01 HEX RIVER AT WORCESTER/DRIE RIVIERE (BRIDGE)
H3H011Q01 KOGMANSKLOOF RIVER AT GOUDMYN
H4H017Q01 BREE RIVER AT LA CHASSEUR
H4H020Q01 NUY RIVER AT DOORNRIVIER
H5H004Q01 BREE RIVER AT WOLVENDRIFT/SECUNDA
H5H005Q01 BREE RIVER AT WAGENBOOMSHEUVEL/DREW
H6H009Q01 RIVIERSONDEREND AT REENEN
H7H006Q01 AT SWELLENDAM ON BREE RIVER
H8H001Q01 DUIWENHOKS RIVER AT DASSJES KLIP
H9H005Q01 AT FARM 216 SWQ 4A-11 ON GOUKOU
J1H018Q01 TOUWS RIVER AT OKKERSKRAAL
J1H019Q01 AT BUFFELSFONTEIN VAN WYKSDORP ON GROOTRIVIER
J1H028Q01 FLORISKRAAL DAM ON BUFFELS RIVER: DOWN STREAM WEI
J2H010Q01 GAMKA RIVER AT HUISRIVIER
J3H011Q01 OLIFANTS RIVER AT WARM WATER
J4H002Q01 GOURITS RIVER AT ZEEKOEDRIFT/DIE POORT
K1H004Q01 AT BRANDWACHT ON BRANDWAGRIVIER
K1H005Q01 MOORDKUIL RIVER AT BANFF
K2H002Q01 AT WOLVEDANS ON GROOT-BRAKRIVIER
K3H001Q01 KAAIMANS RIVER AT UPPER BARBIERS KRAAL
K3H003Q01 MAALGATE RIVER AT KNOETZE KAMA/BUFFELSDRIFT
K4H001Q01 HOEKRAAL RIVER AT EASTBROOK
K4R002Q01 SWART VLEI AT RONDE VALLEY/HOOGEKRAAL
K5H002Q01 KNYSNA RIVER AT MILWOOD FOREST RESERVE/LAER STREE

Monitoring Points Assessed for Planning level review of Water Quality
K7H001Q01 BLOUKRANS RIVER AT LOTTERING FOREST RES/BLAAUW KR
K8H005Q01 AT GEELHOUTBOOM ON TSITSIKAMA
K8H006Q01 AT ROOIWAL ON GROOTRIVIER
K9H003Q01 IMPOFU/ELANDSJAGT DAM ON KROM RIVER: DOWN STREAM
L3R001Q01 BEERVLEI DAM ON GROOT RIVER: NEAR DAM WALL
L7H006Q01 GROOT RIVER AT GROOTRIVIERSPOORT (UP/S KOUGA CONF
L7H007Q01 GROOT RIVER AT SANDPOORT 170
L8H005Q01 KOUGA RIVER AT STUURMANSKRAAL
L8R001Q01 TWEE RIVIEREN 37 - KOUGA (PAUL SAUER) DAM ON KOUGA
L9H004Q01 GAMTOOS RIVER AT BUFFELSHOEK (RAIL BRIDGE)
M1H012Q01 SWARTKOPS RIVER AT UITENHAGE/NIVENS BRIDGE
N4H003Q01 SUNDAYS RIV AT ADDO DRIFT EAST/ADDO BRIDGE
P1H003Q01 BOESMANS RIVER AT DONKER HOEK/ALICEDALE
P3H001Q01 KARIEGA RIVER AT SMITHFIELD/LOWER WATERFORD
P4H001Q01 KOWIE RIVER AT BATHURST/WOLFSCRAG
Q1H001Q01 AT KATKOP ON GROOT-VISRIVIER
Q1H012Q01 TEEBUS RIVER AT JAN BLAAUWS KOP/BEACONSFIELD
Q1H022Q01 GRASSRIDGE DAM ON GREAT BRAK RIV: RIVER OUTLET-RI
Q2H002Q01 AT ZOUTSPANS DRIFT ZOUTPAN ON GROOT-VISRIVIER
Q3H005Q01 AT RIETFONTYN WAAIKRAAL ON GROOT-VISRIVIER
Q4H013Q01 TARKA RIVER AT BRIDGE FARM/TARKA BRIDGE (NEW WEIR
Q6H003Q01 AT BOTMANSGAT DE KLERKDAL ON BAVIAANSRIVIER
Q7H003Q01 AT LEEUWE DRIFT ON GROOT-VISRIVIER
Q7H005Q01 AT SOUT VLEIJ SHELDON ON KLEIN-VISRIVIER
Q8H008Q01 LITTLE FISH RIVER -DOORN KRAAL
Q9H002Q01 KOONAP RIVER AT ADELAIDE
Q9H012Q01 AT BRANDT LEGTE PIGGOT'S BRIDGE ON GROOT-VISRIVIER
Q9H018Q01 AT MATOMELA'S RESERVE OUTSPAN ON GROOT-VISRIVIER
Q9H029Q01 KAT RIVER AT FORT BEAUFORT
R1H015Q01 FARM 7 ABOUT 220M U/S OF HOWARD SHAW BRIDGE ON KEI
R2H027 POTSDAM NDANTSANE AT MHLABATI NEEDS CAMP ON BUFFALO R
S1R001Q01 XONXA DAM ON WHITE KEI RIVER: NEAR DAM WALL
S3H006Q01 KLAAS SMITS RIVER AT WELTEVREDEN/QUEENSTOWN
S3H013 AT HOT FIRE HIGH CLERE ON SWART - KEIRIVIER
S5H002Q01 AT WYK MADUMA TSOMO ON TSOMO
S7H001Q01 GCUWA RIVER AT BUTTERWORTH
S7H004Q01 AT AREA 8 SPRINGS B ON GROOT-KEIRIVIER
T1H001Q01 XUKA RIVER (1) AT THE BRIDGE ON R61
T1H010 CLARKEBURY ON MGWALI RIVER
T1H013 @ GXWALI BOMVU ON MBASHE
T1H014 @ RUNE ON MBASHE

Monitoring Points Assessed for Planning level review of Water Quality
T1H015 @ RARA 34 COLLYWOBBLES ON MBASHE
T3H004Q01 MZIMNTLANA RIVER AT SLANGFONTEIN/KOKSTAD
T3H005Q01 TINA RIVER ON N2 BRIDGE TO MT FRERE
T3H006Q01 TSITSA RIVER AT N2 BRIDGE TO QUMBU
T3H007 MZIMVUBU RIVER ON N2 BRIDGE KU-MAKHALA TO MT AYLIFF
T3H008Q01 MZIMVUBU RIVER AT KROMDRAAI/INUNGI
T4H001Q01 MTAMVUNA RIVER AT GUNDRIFT/MTAMVUNA
T5H002Q01 AT NOOITGEDACHT BISI ON BISI
T5H003Q01 POLELA RIVER AT COXHILL/HIMEVILLE
T5H004Q01 AT FP 1609030/THE BANKS ON MZIMKHULU
T5H007Q01 AT BEZWENI/ISLAND VIEW ON MZIMKHULU
T7H001Q01 MNGAZI RIVER AT MGWENYANA 22/NMGAZI
U1H005Q01 MKOMAZI RIVER AT LOT 931821/CAMDEN
U2H006Q01 KARKLOOF RIVER AT SHAFTON
U2H014Q01 ALBERT FALLS DAM ON MGENI RIVER: DOWN STREAM WEIR
U2H041Q01 MSUNDUZE RIVER AT HAMPSTEAD PARK/MOTO-X (DARV)
U2H043Q01 MGENI RIVER AT INANDA/NAGLE DAM OUTFLOW (NARO)
U2H048Q01 MIDMAR DAM ON MGENI RIVER: DOWN STREAM WEIR
U2H055Q01 AT INANDA LOCATION EGUGWINI ON MGENI
U3H005Q01 HAZELMERE DAM ON MDLOTI RIVER: D/ S WEIR (HMRO)
U4H002Q01 MVOTI RIVER AT MISTLEY
U6H003Q01 AT UMLAAS ROAD ON MLAZI
U6H004Q01 MLAZI RIVER AT FARM 10936/SHONGWENI DAM INFLOW (V
U7H008Q01 NUNGWANA DAM ON NUNGWANA RIVER: DOWN STREAM WEIR
U8H001Q01 FAFA RIVER AT COWICK/NEVER DESPAIR
U8H003Q01 MPAMBANYONI RIVER AT UMBELI BELLI
V1H001Q01 TUGELA RIVER AT TUGELA DRIFT/COLENSO
V1H010Q01 LITTLE TUGELA RIVER AT WINTERTON
V1H038Q01 KLIP RIVER AT LADYSMITH TOWNLANDS/ARMY CAMP
V2H008Q01 MOOI RIVER AT KEATE'S DRIFT
V3H002Q01 AT SCHURVEPOORT ON BUFFELSRIVIER
V3H010Q01 @ TAYSIDE ON BUFFELSRIVIER
V5H002Q01 AT MANDINI ON TUGELA RIVER
V6H002Q01 AT TUGELA FERRY ON TUGELA
V6H004 KLEIN FONTEIN 1262 GT ON SUNDAYS RIVER
V7H012Q01 LITTLE BOESMANS RIVER AT ESTCOURT
VS1 VAAL RIVER ORIGIN AT N17 BRIDGE (GDDC01)
VS2 VAAL RIVER AT R29/N2 BRIDGE AT CAMDEN (GDDC10)
VS2-3 BLESBOK SPRUIT AT R39 BRIDGE RIETVLEY (GDDC12)
VS2-4 LEEUSPRUIT AT R39 WELBEDACHT BRIDGE (GDDC19)
VS3 VAAL RIVER ON N11 BRIDGE TO AMERSFORT

Monitoring Points Assessed for Planning level review of Water Quality
W1H009Q01 MHLATUZE RIVER AT RIVERVIEW 11459
W1H032Q01 UMHLATUZE VALLEY PUMP STATION (SUGAR FACTORY)
W2H005Q01 AT OVERVLOED/ULUNDI ON WIT-MFOLOZI
W2H006Q01 AT RESERVE NO 12 ON SWART - MFOLOZI
W2H028Q01 AT EKUHLENGENI ON SWART - MFOLOZI
W2H032Q01 UMFOLOZI RIVER AT STATE LAND/MONZI
W3H015Q01 HLUHLUWE RIVER AT VALSBAAI/ST LUCIA INFLOW
W3H032Q01 MKUZE RIV AT OVERWIN - D/S MONDI IRR & VORSTER (M
W4H004Q01 AT WELGELEGEN PIVAANSBAD ON BIVANE
W4H006Q01 PHONGOLO RIVER AT M'HLATI
W4H009Q01 PHONGOLO RIVER AT NDUME GAME RESERVE
W4H013Q01 PONGOLAPOORT DAM ON PHONGOLO RIVER: DOWN STREAM W
W5H022Q01 AT ZANDBANK ON ASSEGAAIRIVIER
W5H024Q01 MPULUZI RIVER AT DUMBARTON
W5H025Q01 USUTU RIVER AT STAFFORD
W5H026Q01 NGWEMPISI RIVER AT MERRIEKLOOF
X1H001Q01 KOMATI RIVER AT HOOGGENOEG
X1H003Q01 AT TONGA ON KOMATI RIVER
X1H014Q01 MLUMATI RIVER AT LOMATI
X1H018Q01 KOMATI RIVER AT GEMSBOKHOEK
X1H049Q01 @ SCHOEMANSDAL DRIEKOPPIES DAM DOWNSTREAM WEIR
X2H013Q01 CROCODILE RIVER AT MONTROSE
X2H016Q01 AT TEN BOSCH KRUGER NATIONAL PARK ON CROCODILE RIV
X2H022Q01 KAAP RIVER AT DOLTON
X2H032Q01 CROCODILE RIVER AT WELTEVREDE
X2H036Q01 @ KOMATIPOORT KRUGER NATIONAL PARK ON KOMATI RIVER
X2H046Q01 CROCODILE RIVER AT RIVERSIDE/KRUGER NATIONAL PARK
X3H006Q01 SABIE RIVER AT PERRY'S FARM
X3H008Q01 SAND RIVER AT EXETER
X3H015Q01 SABIE RIVER AT LOWER SABIE REST CAMP/KRUGER NAT PARK

APPENDIX B:

Summary of Trends at monitoring sites assessed as part of the planning level review of water quality

Monitoring Point	pH	EC	Phosphate	Ammonia (NH3-N)	Sulphate	Chloride
A2H006 PIENAARSRIVIER 90 JR AT KLIPDRIFT ON PIENAARSRIVIER	J	-	J	J	-	L
A2H010Q01 MALONEY'S EYE AT STEENEKOPPIE	J	L	L	-	-	J
A2H012 KALKHEUWEL 493 JQ ON KROKODILRIVIER	J	J	L	J	J	L
A2H013 SCHEERPOORT 477 JQ MAGALIES RIVER AT SCHEERPOORT	J	L	-	-	-	L
A2H019Q01 ROODEKOPJES DAM ON CROCODILE RIVER: DOWN STREAM WE	-	L	L	L	J	L
A2H021Q01 PIENAARS RIVER AT BUFFELSPOORT	-	L	L	-	L	L
A2H027Q01 PIENAARS RIVER AT BAVIAANSPOORT	J	L	L	L	L	L
A2H059 VAALKOP 192 JQ AT ATLANTA ON KROKODILRIVIER	J	L	L	L	L	L
A2H061Q01 APIES RIVER AT RONDAVEL	J	L	L	L	-	L
A2H111Q01 VAALKOP DAM ON ELANDS RIVER: DOWN STREAM WEIR	-	L	-	-	L	L
A2H132 HAAKDOORNDRIFT 373 KQ @ PAUL HUGO DAM ON KROKODILRIVI	-	L	L	L	-	L
A3H040Q01 MARICO RIVER AT MOOIPLAATS/TZWASA WEIR ABSTRACTIO	-	L	J	L	L	L
A3R003 KROMELLENBOOG DAM AT KROMELLENBOOG 104 JP NEAR DAM WA	J	L	L	L	-	L
A3R004 MOLATEDI DAM AT EERSTEPOORT 136 KP ON MARICORIVIER NE	L	L	J	L	L	L
A4H013Q01 MOKOLO RIVER AT MOORDDRIFT/VUGHT	L	L	L	L	L	L
A4H014 ZANDPAN 63 LQ AT SAMEVLOEIDAM ON MOKOLO						□
A5H006Q01 AT BOTSWANA STERKLOOP ON LIMPOPO RIVER	J	-	J	J	L	L
A5H008Q01 GA-SELEKA VILLAGE BOSSCHE DIESCH 53 LQ R572 BRIDGE ON LEPHALALA RIVER		L	L	-	L	L
A7H008Q01 DOWN STREAM OF BEIT BRIDGE ON LIMPOPO RIVER	J	J	J	J	J	J
A8H009Q01 LUPHEPHE DAM ON LUPHEPHE RIVER: DOWN STREAM WEIR	-	J	J	-	J	L
A9H001Q01 LUVUVHU RIVER AT WELTEVREDEN/SCHUYNSHOOG	J	L	-	L	J	L
A9H011Q01 LUVUVHU RIVER AT PAFURI/KRUGER NATIONAL PARK	J	-	J	L	J	J
A9H012Q01 AT MHINGAS ON LUVUVHU RIVER	J	L	J	L	J	L
A9H013 AT MUTALE BEND KRUGER NATIONAL PARK ON MUTALE	L	J	J	L	J	J
B1H005Q01 OLIFANTS RIVER AT WOLVEKRANS	J	J	L	L	-	J
B1H010Q01 WITBANK DAM ON OLIFANTS RIVER: DOWN STREAM WEIR	J	J	L	-	J	J
B1H015Q01 MIDDELBURG DAM ON LIT. OLIFANTS RIV: DOWN STREAM	J	L	L	L	L	L
B2H016 @ WATERVAL ON WILGERIVIER	-	L	-	-	L	L
B3H001Q01 OLIFANTS RIVER AT LOSKOP NORTH	J	L	-	J	L	L

Monitoring Point	pH	EC	Phosphate	Ammonia (NH3-N)	Sulphate	Chloride
B3H021Q01 ELANDS RIVER AT SCHERP ARABIE	-	L	J	J	L	L
B4H003Q01 STEELPOORT RIVER AT BUFFELSKLOOF	J	J	-	J	-	L
B4H011Q01 STEELPOORT RIVER AT ALVERTON	J	J	-	J	J	L
B6H001Q01 BLYDE RIVER AT WILLEMSOORD	J	J	-	J	L	L
B6H004Q01 BLYDE RIVER AT CHESTER	J	-	-	-	L	L
B7H007Q01 AT OXFORD ON OLIFANTS RIVER	J	L	J	L	L	L
B7H015Q01 OLIFANTS RIVER AT MAMBA/KRUGER NATIONAL PARK	J	J	-	L	-	J
B7H017Q01 OLIFANTS RIVER AT BALULE REST CAMP/KRUGER NAT PAR	-	L	-	L	J	L
B7H019Q01 GA-SELATI RIVER AT LOOLE/FOSKOR	J	J	L	L	L	L
B8H008Q01 AT LETABA RANCH ON GROOT LETABA	J	L	J	L	L	L
B8H018Q01 GREAT LETABA RIVER AT ENGELHARDT DAM/KRUGER NAT P	J	J	J	L	L	J
B8H028Q01 GREAT LETABA RIVER AT MAHLANGENE/KRUGER NAT PARK	J	L	L	L	-	L
B8H033 TABAAN STATE LAND ON KLEIN-LETABA	J	L	J	L	J	L
B9H002 AT SILVERVIS DAM/KRUGER NAT PARK ON SHINGWIDZI	J	J	J	L	J	J
C1H002 STERKFONTEIN DELANGESDRIFT ON KLIPRIVIER	-	L	L	L	L	L
C1H007Q01 VAAL RIVER AT GOEDGELUK/BLOUKOP		L	L	L	-	L
C1H008Q01 ELANDSLAAGTE ON WATERVALRIVIER	J	J	L	L	J	J
C1H012Q01 VAAL RIVER AT NOOITGEDACHT/GLADDEDRIFT	-	J	-	-	-	L
C1H017 VILLIERS 492 AT FLOOD SECTION ON VAALRIVIER	J	J	J	L	L	L
C1H019Q01 GROOTDRAAI DAM ON VAAL RIVER: DOWN STREAM WEIR	J	-	J	L	-	L
C1R002Q01 GROOTDRAAI DAM - GROOTDRAAI DAM ON VAALRIVIER: NEA	L	L	-	L	L	L
C2H001Q01 MOOI RIVER AT WITRAND	-	L	L	L	-	L
C2H004Q01 SUIKERBOSRANT RIVER AT VEREENIGING WEIR (RW S2)	J	J	L	L	J	J
C2H005Q01 RIETSPRUIT AT KAALPLAATS (RW RV2)	J	J	L	L	J	J
C2H007 PILGRIMS ESTATE 272 AT ORKNEY ON VAALRIVIER	-	L	L	-	-	L
C2H011 GERHARDMINNEBRON EYE AT GERHARDMINNEBRON	J	L	-	-	L	L
C2H018Q01 VAAL RIVER AT DE VAAL/SCHOEMANSDRIFT	J	-	L	-	J	L
C2H061 PALMIETFONTEIN 250 - AT KLIPPLAATDRIFT ON VAALRIVIER	J	L	-	-	-	L
C2H065Q01 LEEUDORING SPRUIT AT KLIPSPRUIT	J	J	L	L	-	L
C2H066Q01 AT VLIEGEKRAAL ON MAKWASSIESPRUIT	-	L	-	L	L	L

Monitoring Point	pH	EC	Phosphate	Ammonia (NH3-N)	Sulphate	Chloride
C2H067Q01 AT LEEGTE ON SANDSPRUIT		-	J	J	J	L
C2H069Q01 MOOIRIVIERLOOP (RIVER) AT BLAAUWBANK	-	L	L	L	L	L
C2H073Q01 @ GOEDGENOEG 150M U/S ORKNEY BRIDGE ON SKOONSPRUIT	J	-	-	-	-	L
C2H085Q01 MOOI RIVER AT HOOGEKRAAL/KROMDRAAI	-	L	L	L	L	L
C2H122Q01 VAAL DAM ON VAAL RIVER: DOWN STREAM WEIR	J	J	L	L	-	J
C2H131Q01 RW C-S1 COLLIERY POINT ON SUIKERBOSRANT RIVER	J	L	J	L	J	J
C2H139Q01 KOEKEMOER SPRUIT AT BUFFELSFONTEIN	-	L	L	L	L	L
C2H140Q01 VAAL RIVER AT WOODLANDS/GOOSE BAY CANYON	J	J	L	-	J	L
C2H141Q01 KLIP RIVER AT WITKOP (NEW BRIDGE)	J	-	J	J	-	J
C2H260Q01 AT KROMDRAAI LOW WATER BRIDGE ON VAALRIVIER	J	L	L	L	-	L
C2R005Q01 KLIPDRIFT 395 IQ - KLIPDRIF DAM ON LOOPSPRUIT NEAR	J	L	-	-	L	L
C2R008Q01 LTS24 VAAL BARRAGE ON VAAL RIVER NEAR BARR WAL	J	J	J	L	J	-
C3H003Q01 AT TAUNG ON HARTSRIVIER	J	J	-	-	-	J
C3H007 ESPAGSDRIF SEODING 25 BRIDGE AT THE WEIR ON HARTS RIV	L	J	L	L	-	L
C3H016Q01 AT DELPORTSHOOP LLOYDS WEIR ON HARTSRIVIER	-	L	-	-	L	L
C4H004Q01 FAZANTKRAAL AT NOOITGEDACHT ON VETRIVIER	J	J	L	L	J	L
C4H016 MOND VAN DOORNRIVIER 38 - @ BLOUDRIF ON SANDRIVIER	J	L	-	J	L	L
C4H017Q01 SAND RIVER AT DORINGRIVIER/BLOUDRIF	J	L	L	-	L	L
C4R002Q01 CORANNAKRAAL 87 - ERFENIS DAM ON VETRIVIER NEAR DA		J	L	-	-	L
C5H003Q01 AT LIKATLONG / SANNASPOS ON MODDERRIVIER	J	J	J	J	-	L
C5H012Q01 RIET RIVER AT KROMDRAAI/RIETWATER	-	L	-	L	L	L
C5H030Q01 @ RIETRIVIER SETT. JACOBSDAL ON ORANGE-RIET CANAL	J	-	-	-	-	J
C5H039Q01 KRUGERSDRIFT DAM ON MODDER RIVER: DOWN STREAM WEI	J	-	L	L	-	L
C5H048Q01 AT ZOUTPANSDRIFT ON RIETRIVIER	J	J	-	-	J	L
C5H053Q01 CYPRESS 89 - AT GLEN ON MODDERRIVIER	J	L	L	-	-	L
C6H002Q01 BOTHAVILLE GROOTDRAAI 408 - @ RIVER BANK ON VALSRI	-	L	L	-	L	L
C6H003Q01 BOTHAVILLE MOOIFONTEIN 624 - @ RIVER BANK ON VALSR	J	-	L	-	-	L
C6H007Q01 KROONSTAD - @ R721 ROAD BRIDGE ON VALSRIVIER (OLD	J	J	J	-	-	L
C7H003Q01 AT DANKBAAR MISPAH ON HEUNINGSPRUIT	J	J	L	-	J	J
C7H006Q01 RENOSTER RIVER AT ARRIESRUST	J	J	-	-	-	J

Monitoring Point	pH	EC	Phosphate	Ammonia (NH3-N)	Sulphate	Chloride
C8H001Q01 WILGE RIVER AT FRANKFORT	J	J	L	L	-	J
C8H009Q01 AT TIJGER HOEK ON TIERKLOOF RIVER	J	L	J	J	-	L
C8H010Q01 FRASER SPRUIT 94 HARRISMITH ON OUBERGSPRUIT	J	J	J	-	-	L
C8H026Q01 AT FREDERIKSDAL ON LIEBENBERGSVLEI RIVER	J	J	J	-	J	J
C8H027Q01 AT BALLINGTOMP ON WILGE RIVER	-	J	J	-	-	L
C8H028Q01 WILGE RIVER AT BAVARIA (FLOOD SECTION)	J	-	-	-	-	L
C8H032Q01 AT STERKFONTEINDAM ON NUWEJAAR SPRUIT		L	-	L	-	L
C9H008 NAZARETH FARM STUDAM 1KM DOWNSTREAM OF VAALHARTS DAM	J	L	L	-	L	L
C9H009Q01 VAAL RIVER AT DE HOOP	L	J	-	L	-	L
C9H024Q01 SMIDTS DRIFT OUTSPAN 23 SCHMIDTSDRIFT @ WEIR ON VA	L	-	-	L	-	L
C9R003Q01 ST CLAIR 148 - EGMONT DAM ON WITSPRUIT @ DAM WALL	-	L	L	L	J	L
D1H001Q01 WONDERBOOM/STORMB. SPRUIT AT DIEPKLOOF/BURGERSDOR	J	L	L	L	-	J
D1H003Q01 ORANGE RIVER AT ALIWAL NORTH	J	J	L	-	-	L
D1H006Q01 KORNET SPRUIT AT MAGHALEEN	J	-	J	-	-	L
D1H009Q01 ORANGE RIVER AT ORANJEDRAAI	J	J	J	-	-	J
D1H011Q01 KRAAI RIVER AT ROODEWAL	J	J	J	L	J	L
D2H012 CALEDONSPOORT 190 THE POPLARS 199 AT THE POPULARS ON	J	L	J	-	-	L
D2H035Q01 CALEDONRIVER AT FICKSBURG/FICKSBURG BRIDGE	J	-	J	-	-	L
D2H036Q01 CALEDONRIVER AT KOMMISSIEDRIFT	J	L	J	-	L	L
D2H037Q01 CALEDON RIVER AT WILGEDRAAI/HOBHOUSE	J	L	J	L	L	L
D2R004Q01 WELBEDACHT 285 - WELBEDACHT DAM ON CALEDONRIVIER:	J	L	-	-	L	L
D3H008Q01 AT MARKSDRIFT ON ORANGE RIVER	J	L	J	L	-	L
D3H012Q01 ORANGE RIVER AT DOOREN KUILEN (DOWN STREAM D3R003	J	L	-	L	-	L
D3H013 ROODEPOORT ON ORANJERIVIER	J	L	-	L	-	L
D3H015Q01 SEEKOEI RIVER AT DE EERSTE POORT	J	L	L	-	L	L
D4R003Q01 DISANENG DAM ON MOLOPO RIVER: NEAR DAM WALL	-	L	L	L	L	L
D4R004Q01 MOLOPO (RATSHIDI) - MODIMOLA DAM ON MOLOPORIVIER:	L	L	L	L	L	L
D7H005Q01 ORANGE RIVER AT UPINGTON	J	J	L	J	-	L
D7H008Q01 ORANGE RIVER AT BOEGOEBERG RESERVE/ZEEKOEBAART	J	L	J	L	-	L

Monitoring Point	pH	EC	Phosphate	Ammonia (NH3-N)	Sulphate	Chloride
D8H003Q01 AT VIOOLSDRIFT ON ORANGE	J	L	J	L	-	L
D8H008Q01 ORANGE RIVER AT PELLA MISSION	J	L	J	L	-	L
E1H011Q01 CLANWILLIAM DAM ON OLIFANTS RIVER: DOWN STREAM WE	L	J	J	L	L	J
E1H013 MIDDELPOS 553 AT CITRUSDAL ON OLIFANTSRIVIER	-	L		L	L	L
E1R001 KROMME VALLEY 113 BULSHOEK DAM ON OLIFANTSRIVIER: NEA	L	J	L	L	J	J
E2H002Q01 AT ELANDS DRIFT ASPOORT ON DORINGRIVIER	-	J	L	L		J
E2H003Q01 AT MELKBOOM ON DORINGRIVIER	-	J	L	L	J	J
E2H016 OLIFANTS RIVER AT LUTZVILLE	J	J	J	L	J	J
G1H008 NIEUWKLOOF 198 - ON KLEIN BERGRIVIER	-	L	-	L	J	L
G1H013Q01 AT DRIEHEUVELS ON BERGRIVIER	-	L	-	L	-	L
G1H020Q01 AT DAL JOSAFAT NOORDER PAARL ON BERGRIVIER	L	L	-		J	L
G1H023Q01 AT JANTJIESFONTEIN ON BERGRIVIER	L	L		L	L	L
G1H031Q01 AT MISVERSTAND DIE BRUG ON BERGRIVIER	-	L	J	L	-	L
G1H036Q01 AT VLEESBANK HERMON BRIDGE ON BERGRIVIER	-	L	J	L	J	L
G2H012Q01 DIEP RIVER AT MALMESBURY	-	L	L	L	L	L
G2H015Q01 AT FAURE ON EERSTERIVIER	J	J	J	L	J	J
G2H042 ADDERLEY 155 - ON DIEPRIVIER		J	J	J	J	J
G4H006Q01 KLEIN RIVER AT CAN Q5-8/WAGENBOOMSDRIFT	-	J	J		L	L
G4H007Q01 PALMIET RIVER AT FARM 562-WELGEMOED/KLEINMOND	J	L	L	L	J	L
G5H008Q01 SOUT RIVER AT KYKOEDY	L	J	L	L	J	J
G5R001Q01 AT DE HOOP NATURE RESERVE JETTY ON DE HOOPVLEI SOU	L	J	J	J	J	J
H1H003Q01 BREE RIVER AT CERES COMMONAGE	-	L	L	J	L	L
H1H015Q01 BREE RIVER AT DIE NEKKIES (ONDER BRANDVLEI)	L	L	L	L	L	L
H2H010Q01 HEX RIVER AT WORCESTER/DRIE RIVIERE (BRIDGE)	-	J	J	L	L	J
H3H011Q01 KOGMANSKLOOF RIVER AT GOUDMYN	J	L	-	J	J	L
H4H017Q01 BREE RIVER AT LA CHASSEUR	-	L	L	L	L	L
H4H020Q01 NUY RIVER AT DOORNRIVIER	-	J	L	L	J	J
H5H004Q01 BREE RIVER AT WOLVENDRIFT/SECUNDA	-	L	J	L	L	L
H5H005Q01 BREE RIVER AT WAGENBOOMSHEUVEL/DREW	-	L	L	L	J	L

Monitoring Point	pH	EC	Phosphate	Ammonia (NH3-N)	Sulphate	Chloride
H6H009Q01 RIVIERSONDEREND AT REENEN	L	L		L	L	L
H7H006Q01 AT SWELLENDAM ON BREE RIVER	L	L		L	L	L
H8H001Q01 DUIWENHOKS RIVER AT DASSJES KLIP	L	L	J	L	L	L
H9H005Q01 AT FARM 216 SWQ 4A-11 ON GOUKOU	L			L		L
J1H018Q01 TOUWS RIVER AT OKKERSKRAAL	J	L	J		L	L
J1H019Q01 AT BUFFELSFONTEIN VAN WYKSDORP ON GROOTRIVIER	J	J	J	L	J	J
J1H028Q01 FLORISKRAAL DAM ON BUFFELS RIVER: DOWN STREAM WEI	J	J	-	J	J	J
J2H010Q01 GAMKA RIVER AT HUISRIVIER	J	J	J	L	J	J
J3H011Q01 OLIFANTS RIVER AT WARM WATER	J	J		L	J	J
J4H002Q01 GOURITS RIVER AT ZEEKOEDRIFT/DIE POORT	J			L	L	L
K1H004Q01 AT BRANDWACHT ON BRANDWAGRIVIER	-	L		L		L
K1H005Q01 MOORDKUIL RIVER AT BANFF	L	L		L		L
K2H002Q01 AT WOLVEDANS ON GROOT-BRAKRIVIER	-	J	-	L	J	J
K3H001Q01 KAAIMANS RIVER AT UPPER BARBIERS KRAAL	L	J			J	J
K3H003Q01 MAALGATE RIVER AT KNOETZE KAMA/BUFFELSDRIFT	L	L		L		L
K4H001Q01 HOEKRAAL RIVER AT EASTBROOK	L	L		L	L	L
K4R002Q01 SWART VLEI AT RONDE VALLEY/HOOGEKRAAL	-	L	J	L	J	J
K5H002Q01 KNYSNA RIVER AT MILWOOD FOREST RESERVE/LAER STREE	L	L	L	L	J	L
K7H001Q01 BLOUKRANS RIVER AT LOTTERING FOREST RES/BLAAUW KR	L	L	-	L	J	L
K8H005Q01 AT GEELHOUTBOOM ON TSITSIKAMA	L	J	L	L	L	L
K8H006Q01 AT ROOIWAL ON GROOTRIVIER	L	L	L	L	L	L
K9H003Q01 IMPOFU/ELANDSJAGT DAM ON KROM RIVER: DOWN STREAM	J	J	-	L	J	J
L3R001Q01 BEERVLEI DAM ON GROOT RIVER: NEAR DAM WALL	-	J	L	J		J
L7H006Q01 GROOT RIVER AT GROOTRIVIERSPOORT (UP/S KOUGA CONF	J	J	J	-	J	J
L7H007Q01 GROOT RIVER AT SANDPOORT 170	J		J		J	J
L8H005Q01 KOUGA RIVER AT STUURMANSKRAAL	-	L		L	L	L
L8R001Q01 TWEE RIVIEREN 37 - KOUGA (PAUL SAUER) DAM ON KOUGA	L		L	L	L	L
L9H004Q01 GAMTOOS RIVER AT BUFFELSHOEK (RAIL BRIDGE)		L	J	L	L	L

Monitoring Point	pH	EC	Phosphate	Ammonia (NH3-N)	Sulphate	Chloride
M1H012Q01 SWARTKOPS RIVER AT UITENHAGE/NIVENS BRIDGE	L	J	L	L	J	J
N4H003Q01 SUNDAYS RIV AT ADDO DRIFT EAST/ADDO BRIDGE	L	L	J	L	L	J
P1H003Q01 BOESMANS RIVER AT DONKER HOEK/ALICEDALE	-	□	□	□	□	L
P3H001Q01 KARIEGA RIVER AT SMITHFIELD/LOWER WATERFORD	J	L	J	L	J	J
P4H001Q01 KOWIE RIVER AT BATHURST/WOLFSCRAG	J					J
Q1H001Q01 AT KATKOP ON GROOT-VISRIVIER		J	L	L	J	J
Q1H012Q01 TEEBUS RIVER AT JAN BLAAUWS KOP/BEACONSFIELD	J	J		L	J	L
Q1H022Q01 GRASSRIDGE DAM ON GREAT BRAK RIV: RIVER OUTLET-RI	-	J	J	J	-	L
Q2H002Q01 AT ZOUTSPANS DRIFT ZOUTPAN ON GROOT-VISRIVIER	J	J	J	L	J	L
Q3H005Q01 AT RIETFONTYN WAAIKRAAL ON GROOT-VISRIVIER	-	J	J	J	J	J
Q4H013Q01 TARKA RIVER AT BRIDGE FARM/TARKA BRIDGE (NEW WEIR	J	J	J	L	J	J
Q6H003Q01 AT BOTMANSGAT DE KLERKDAL ON BAVIAANSRIVIER	J	J	-	-	J	J
Q7H003Q01 AT LEEUWE DRIFT ON GROOT-VISRIVIER	J	J	J	L	J	J
Q7H005Q01 AT SOUT VLEIJ SHELDON ON KLEIN-VISRIVIER	-	J	J	L	J	J
Q8H008Q01 LITTLE FISH RIVER -DOORN KRAAL	J	J	J	L	J	J
Q9H002Q01 KOONAP RIVER AT ADELAIDE	J	J	J	L	J	J
Q9H012Q01 AT BRANDT LEGTE PIGGOT'S BRIDGE ON GROOT-VISRIVIER	J	J	J	-	J	J
Q9H018Q01 AT MATOMELA'S RESERVE OUTSPAN ON GROOT-VISRIVIER	-	J	J	L	J	J
Q9H029Q01 KAT RIVER AT FORT BEAUFORT	J	J	J	J	J	J
R1H015Q01 FARM 7 ABOUT 220M U/S OF HOWARD SHAW BRIDGE ON KEI	J	J	J	J	L	L
R2H027 POTSDAM NDANTSANE AT MHLABATI NEEDS CAMP ON BUFFALO R	J	L	L		J	L
S1R001Q01 XONXA DAM ON WHITE KEI RIVER: NEAR DAM WALL	J	J				J
S3H006Q01 KLAAS SMITS RIVER AT WELTEVREDEN/QUEENSTOWN	J	L	J	J	L	L
S3H013 AT HOT FIRE HIGH CLERE ON SWART - KEIRIVIER	L	L	J	L	L	J
S5H002Q01 AT WYK MADUMA TSOMO ON TSOMO	J	J	J	L	L	L
S7H001Q01 GCUWA RIVER AT BUTTERWORTH	J	J	J	L	□	J
S7H004Q01 AT AREA 8 SPRINGS B ON GROOT-KEIRIVIER	J	J	J	L	J	J
T1H001Q01 XUKA RIVER (1) AT THE BRIDGE ON R61	J	J	L	L	L	L
T1H010 CLARKEBURY ON MGWALI RIVER	L			L	J	J

Monitoring Point	pH	EC	Phosphate	Ammonia (NH3-N)	Sulphate	Chloride
T1H013 @ GXWALI BOMVU ON MBASHE	L	L	L	J	J	J
T1H014 @ RUNE ON MBASHE		L	L	L	L	L
T1H015 @ RARA 34 COLLYWOBBLES ON MBASHE		L	J	L	J	L
T3H004Q01 MZIMNTLANA RIVER AT SLANGFONTEIN/KOKSTAD	J	L	J	L	J	L
T3H005Q01 TINA RIVER ON N2 BRIDGE TO MT FRERE	J	J	L	L	J	L
T3H006Q01 TSITSA RIVER AT N2 BRIDGE TO QUMBU	J	J	J	L	J	L
T3H007 MZIMVUBU RIVER ON N2 BRIDGE KU-MAKHALA TO MT AYLIFF	J	J	L	L	J	L
T3H008Q01 MZIMVUBU RIVER AT KROMDRAAI/INUNGI	J	J	J	L	J	J
T4H001Q01 MTAMVUNA RIVER AT GUNDRIFT/MTAMVUNA	J	L	-	-	-	L
T5H002Q01 AT NOOITGEDACHT BISI ON BISI	J	J	-	-	J	L
T5H003Q01 POLELA RIVER AT COXHILL/HIMEVILLE	J	J	-	-	J	J
T5H004Q01 AT FP 1609030/THE BANKS ON MZIMKHULU	J	-	-	-	-	J
T5H007Q01 AT BEZWENI/ISLAND VIEW ON MZIMKHULU	J	L	L	L	L	L
T7H001Q01 MNGAZI RIVER AT MGWENYANA 22/NMGAZI	J	J	-	L	-	J
U1H005Q01 MKOMAZI RIVER AT LOT 931821/CAMDEN	-	-	J	-	-	J
U2H006Q01 KARKLOOF RIVER AT SHAFTON	L	L	-	-	J	L
U2H014Q01 ALBERT FALLS DAM ON MGENI RIVER: DOWN STREAM WEIR	L	L	L	L	J	L
U2H041Q01 MSUNDUZE RIVER AT HAMPSTEAD PARK/MOTO-X (DARV)	-	L	J	L	-	L
U2H043Q01 MGENI RIVER AT INANDA/NAGLE DAM OUTFLOW (NARO)	-					L
U2H048Q01 MIDMAR DAM ON MGENI RIVER: DOWN STREAM WEIR	L	L	L	L	J	J
U2H055Q01 AT INANDA LOCATION EGUGWINI ON MGENI	J	L	J	L	-	L
U3H005Q01 HAZELMERE DAM ON MDLOTI RIVER: D/ S WEIR (HMRO)	L	L	J	L	L	J
U4H002Q01 MVOTI RIVER AT MISTLEY	J	-	L	-	J	L
U6H003Q01 AT UMLAAS ROAD ON MLAZI	J	L	-	-	-	L
U6H004Q01 MLAZI RIVER AT FARM 10936/SHONGWENI DAM INFLOW (V	L	L	J	L	L	L
U7H008Q01 NUNGWANA DAM ON NUNGWANA RIVER: DOWN STREAM WEIR	L	L	J	-	J	L
U8H001Q01 FAFA RIVER AT COWICK/NEVER DESPAIR	J	J	J	L	J	L
U8H003Q01 MPAMBANYONI RIVER AT UMBELI BELLI	J	J	J	L	-	J
V1H001Q01 TUGELA RIVER AT TUGELA DRIFT/COLENSO	J	L	J	L	-	L

Monitoring Point	pH	EC	Phosphate	Ammonia (NH3-N)	Sulphate	Chloride
V1H010Q01 LITTLE TUGELA RIVER AT WINTERTON	-	L	L	L	L	J
V1H038Q01 KLIP RIVER AT LADYSMITH TOWNLANDS/ARMY CAMP	J	L		L	J	L
V2H008Q01 MOOI RIVER AT KEATE'S DRIFT	J	L	L	L	J	L
V3H002Q01 AT SCHURVEPOORT ON BUFFELSRIVIER	J	J	L	L	L	L
V3H010Q01 @ TAYSIDE ON BUFFELSRIVIER	J	J	J	L	J	J
V5H002Q01 AT MANDINI ON TUGELA RIVER	J	L	-	L	L	L
V6H002Q01 AT TUGELA FERRY ON TUGELA	J	L	-	-	L	L
V6H004 KLEIN FONTEIN 1262 GT ON SUNDAYS RIVER		J	L	L	J	L
V7H012Q01 LITTLE BOESMANS RIVER AT ESTCOURT	J	L	L	L	J	L
VS1 VAAL RIVER ORIGIN AT N17 BRIDGE (GDDC01)	-		-	L	-	J
VS2 VAAL RIVER AT R29/N2 BRIDGE AT CAMDEN (GDDC10)	-		J	-	-	J
VS2-3 BLESBOK SPRUIT AT R39 BRIDGE RIETVLEY (GDDC12)	-		L	L	J	L
VS2-4 LEEUSPRUIT AT R39 WELBEDACHT BRIDGE (GDDC19)	J		L	L	J	J
VS3 VAAL RIVER ON N11 BRIDGE TO AMERSFORT	L		L	L	L	L
W1H009Q01 MHLATUZE RIVER AT RIVERVIEW 11459	J	J	J	L	J	J
W1H032Q01 UMHLATUZE VALLEY PUMP STATION (SUGAR FACTORY)	J	J	L	L	J	J
W2H005Q01 AT OVERVLOED/ULUNDI ON WIT-MFOLOZI	J	L	J	L	J	L
W2H006Q01 AT RESERVE NO 12 ON SWART - MFOLOZI	J	L	L	L	J	L
W2H028Q01 AT EKUHLENGENI ON SWART - MFOLOZI	J	L	L	L		L
W2H032Q01 UMFOLOZI RIVER AT STATE LAND/MONZI	L	L	J	L	J	L
W3H015Q01 HLUHLUWE RIVER AT VALSBAAI/ST LUCIA INFLOW	L	J	J	L	J	J
W3H032Q01 MKUZE RIV AT OVERWIN - D/S MONDI IRR & VORSTER (M	L	L		L		L
W4H004Q01 AT WELGELEGEN PIVAANSBAD ON BIVANE	J	L	L	L	J	L
W4H006Q01 PHONGOLO RIVER AT M'HLATI	J	J	L	J	J	J
W4H009Q01 PHONGOLO RIVER AT NDUME GAME RESERVE	-					L
W4H013Q01 PONGOLAPOORT DAM ON PHONGOLO RIVER: DOWN STREAM W	J	L	J	L	J	L
W5H022Q01 AT ZANDBANK ON ASSEGAAIRIVIER		L	L	L	L	L
W5H024Q01 MPULUZI RIVER AT DUMBARTON	-	L	J	L	J	L
W5H025Q01 USUTU RIVER AT STAFFORD	-	L	J	L	J	L

Monitoring Point	pH	EC	Phosphate	Ammonia (NH3-N)	Sulphate	Chloride
W5H026Q01 NGWEMPISI RIVER AT MERRIEKLOOF	J	-	J	-	J	L
X1H001Q01 KOMATI RIVER AT HOOGGENOEG	J	J	L	L	-	L
X1H003Q01 AT TONGA ON KOMATI RIVER	J	L	J	-	-	L
X1H014Q01 MLUMATI RIVER AT LOMATI	J	L	-	-	-	L
X1H018Q01 KOMATI RIVER AT GEMSBOKHOEK	J	J	L	L	L	L
X1H049Q01 @ SCHOEMANSDAL DRIEKOPPIES DAM DOWNSTREAM WEIR	J	J	-	-	J	L
X2H013Q01 CROCODILE RIVER AT MONTROSE	J	L	L	J	-	L
X2H016Q01 AT TEN BOSCH KRUGER NATIONAL PARK ON CROCODILE RIV	J	L	-	J	L	L
X2H022Q01 KAAP RIVER AT DOLTON	J	L	J	-	L	L
X2H032Q01 CROCODILE RIVER AT WELTEVREDE	-	L	L	L	L	L
X2H036Q01 @ KOMATIPOORT KRUGER NATIONAL PARK ON KOMATI RIVER	-	L	-	-	L	L
X2H046Q01 CROCODILE RIVER AT RIVERSIDE/KRUGER NATIONAL PARK	J	L	J	J	L	L
X3H006Q01 SABIE RIVER AT PERRY'S FARM	-	L	J	J	-	L
X3H008Q01 SAND RIVER AT EXETER	L	L	L	L	L	L
X3H015Q01 SABIE RIVER AT LOWER SABIE REST CAMP/KRUGER NAT P	J	-	L	L	-	L

Legend	
-	water quality stable
L	water quality deteriorating (concentrations are increasing)
J	water quality improving (concentrations are decreasing)
blank	insufficient data available to determine trends

APPENDIX C:

List of stakeholder workshop attendees

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APPENDIX D:

National Water Quality Status Map

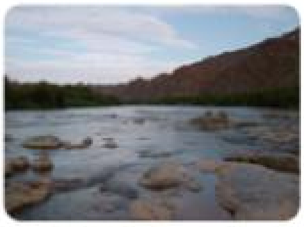

Water Resource Planning Systems Series

Water Quality Planning


SUB-SERIES NO. WQP 2.0

RESOURCE DIRECTED MANAGEMENT OF WATER QUALITY


PLANNING LEVEL REVIEW OF WATER QUALITY IN SOUTH AFRICA




March 2011

Final

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Department:
Water Affairs
REPUBLIC OF SOUTH AFRICA

DEPARTMENT OF WATER AFFAIRS

Water Resource Planning Systems

Water Quality Planning

SUB-SERIES NO. WQP 2.0

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PLANNING LEVEL REVIEW OF WATER QUALITY IN SOUTH AFRICA

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ABBREVIATIONS

ARC	Agricultural Research Council
AMD	Acid Mine Drainage
COD	Chemical Oxygen Demand
DoA	Department of Agriculture
DIN	Dissolved Inorganic Nitrogen
DEA	Department of Environmental Affairs
DWA	Department of Water Affairs
DWAF	Department of Water Affairs and Forestry
EA	Environmental Agency
EDCs	Endocrine Disrupting Compounds
IWWMPs	Integrated Water and Waste Management Plans
NEMP	National Eutrophication Monitoring Programme
NGOs	Non-governmental Organisations
NMMP	National Microbiological Monitoring Programme
NTMP	National Toxicity Monitoring Programme
NWA	National Water Act
POPs	Persistent Organic Pollutants
RDMs	Resource Directed Measures
RHP	River Health Programme
RQOs	Resource Quality Objectives
RQS	Resource Quality Services
RWQOs	Resource Water Quality Objectives
SAWQGs	South African Water Quality Guidelines
TDS	Total Dissolved Salts
TIN	Total Inorganic Nitrogen
TWQR	Target Water Quality Range
UNEP	United Nations Environmental Programme
WDCS	Waste Discharge Charge System
WMA	Water Management Area
WMS	Water Management System
WQM	Water Quality Management
WQP	Water Quality Planning
WRC	Water Research Commission
WRCS	Water Resource Classification System
WWTWs	Wastewater Treatment Works

Executive Summary

South Africa is a water stressed country (<1 700 m^3 per person annually) and will probably be facing water scarcity (<1 000 m^3/p/a) by 2025 (GEO-2000, 1999). Increased stresses on the world's water are affecting quality, quantity and availability. Therefore the need to protect and not pollute valuable freshwater resources cannot be over emphasized. Rising demand for increasingly scarce water resources is leading to growing concerns about future access to water.

The availability of water and its physical, chemical, and biological composition affect the ability of aquatic environments to sustain healthy ecosystems; as water quality and quantity are eroded, organisms suffer and ecosystem services may be lost. Moreover, an abundant supply of clean, usable water is a basic requirement for many of the fundamental uses of water on which humans depend (UNEP-GEMS, 2006).

Rivers are the most important freshwater resource for man. Social, economic and political development has, in the past, been largely related to the availability and distribution of freshwater contained in riverine systems (Chapman, 1996). Deteriorating water quality not only affects aquatic ecosystems but also impacts economic growth, community health and empowerment.

Freshwater is a complex ecological system that has a number of dimensions. Surface water, groundwater, quantity and quality are all linked in a continuous cycle – the hydrological cycle – of rainfall, runoff from the land, infiltration into the ground, and evaporation from the surface back to the atmosphere. Each component may influence the other components and each must therefore be managed with regard to its inter-relationships with the others (DWAF, 2004a).

Water as a system also interacts with other systems. Human activities such as land use, waste disposal and air pollution can have major impacts on the quantity and quality of water available for human use, while the abstraction and storage of water and the discharge of waste into water resources can impact on the quality of the water resource. These interactions must also be addressed in the management of water resources.

Taking an even broader view, water must also be managed in the full understanding of its importance for social and economic development (DWAF, 2004a). Water resource management at the catchment or regional level thus occurs within a highly integrated environment, where water quality, quantity and the aquatic ecosystem are all interlinked and interdependent.

The Department recognises that, just as a quantity of water can be "used", so can water quality. For water to be regarded as "fit for use" for a number of different users in the same catchment, the water quality needs to satisfy the most demanding of those users. Water quality planning of South Africa's water resources is thus taking place to ensure that the water quality in South African water resources enables an equitable and sustainable balance to be achieved between its use by society and its protection as a critical component of a natural system so that the quality of life of all South Africans is improved and sustained in the long term. A specific objective of the Water Quality Planning function within DWA is to provide effective management solutions and policy guidance to address the current water quality challenges within the context of integrated water resource management.

In support of this objective the Department has identified the need to establish a national review on water quality status and trends that measure, assess and report on the current state and appropriate temporal trends of selected groups of water quality indicators in South African surface water resources. This is aimed at supporting strategic management decisions in the context of sustainable fitness for use of those water resources and for the protection of the integrity of aquatic ecosystems. This report is intended to provide that perspective on the water quality state of the surface water resources of South Africa and in doing so provide the water quality planning strategic interventions to be adopted to address the key challenges and threats facing water quality and fitness for use of the country's water resources.

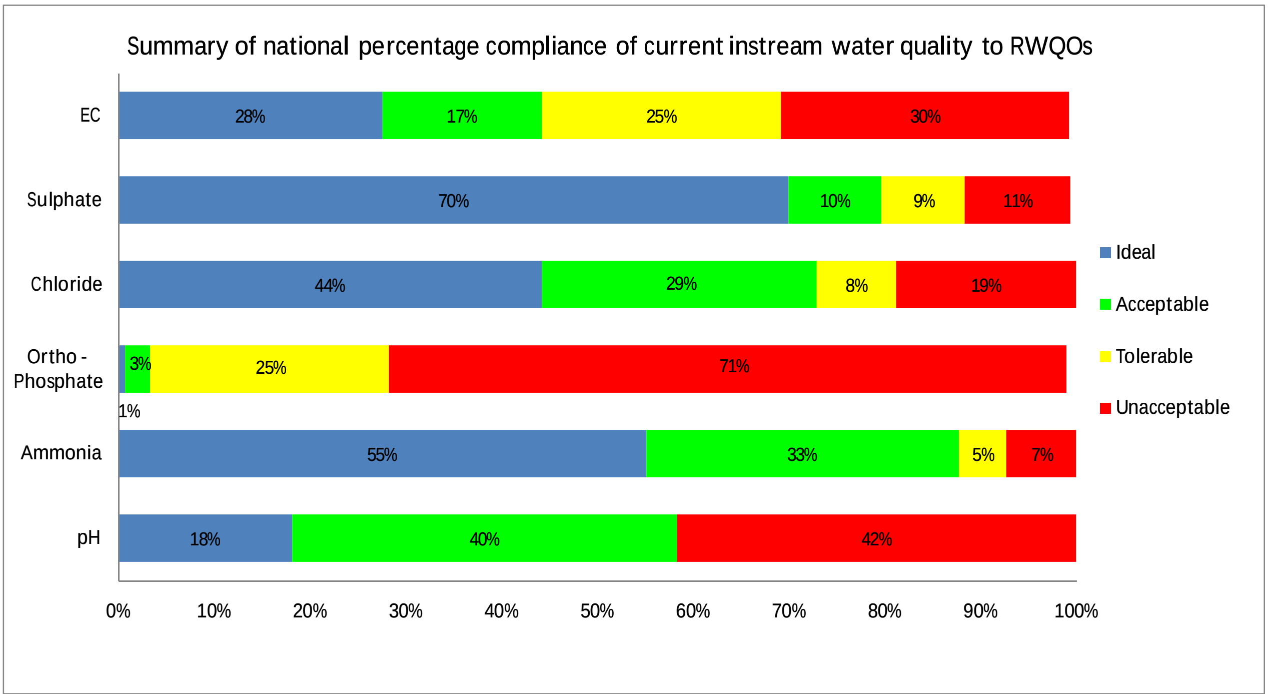
The current perspective reported on is based on the Department's routine National Chemical Monitoring (priority) Programme of the country's water resources for the period 2006 to 2008 at 276 selected surface water quality monitoring sites (3 years). A major focus of the National Chemical Monitoring Programme is on regional and national-scale assessments of water quality status and trends in streams and rivers. The nineteen water management areas (WMAs) which form the major river basins of South Africa serve as the basis for the water quality perspective assessment. The primary goals of this report are to characterize the state of surface-water quality (river chemistry); determine temporal trends at those sites that have been consistently monitored for a decade (January 1999 to February 2008); and build an understanding of how natural features and human activities have affected the water quality of our water resources. Analysis and reporting have focused on the understanding of water quality status and dominant issues at the WMA scale. The current in stream water quality was compared to a generic set of Resource Water Quality Objectives (RWQOs) for all users throughout all WMAs and reflected as ideal, acceptable, tolerable and unacceptable in terms of an indication of compliance.

This report concentrates on the chemical quality of the nation's water resources. It does not deal with the biological or microbiological status of the surface water resources as this information is not readily available on a national scale. A snapshot of some areas is however given in the context of a WMA. Groundwater quality is also not addressed in this report. A perspective is provided in terms of the National Groundwater Strategy, however to a very limited extent.

The results of the water quality review show that the levels of nutrients in the country's water resources are the water quality problem of most concern. Only 29% of the monitoring sites showed compliance to the prescribed RWQOs (≤ 0.025mg/l) for phosphate. There is currently 71% of non-compliance at a national scale. The current state is a threat to the aquatic ecosystem health of our water resources and to domestic water supply.

Salinisation is another major water issue identified at a national scale. This situation is linked to elevated levels of sulphate, sodium and chloride which pose a risk to industrial water supply and aquatic health. Salinity compliance indicates that 30% of the monitoring sites have unacceptably high levels (>85 mS/m) of salts, and 25% within the tolerable range (50 mS/m to 85 mS/m).

With regard to the levels of ammonia, 55% of the sites assessed show a compliance to the ideal RWQO of < 0.015mg/l. As aquatic ecosystems are extremely sensitive to levels of ammonia, this reflects a fairly good situation of the aquatic health of water resources. 7% of the sites assessed show unacceptably high levels (>0.073 mg/l) of ammonia. Only 48 of the (17%) monitoring points assessed at a national scale met all the RWQOs for all water quality variables.



The summary of the water quality status per WMA in terms of RWQO compliance is provided in Table E1, and the identified water quality issues that are of concern within the WMAs are listed in Table E2. These concerns were identified by a combination of the water quality data analyzed as well as consultation with regional water quality managers.

Regional consultation with stakeholders indicated that microbiological quality of the water resources is also deteriorating. Sufficient data is still required to understand the extent of the problem. Further issues identified through consultation were that of siltation/sedimentation in many catchments as well as the presence of heavy metals and perceptions of Persistent Organic Pesticides (POPs). However there is no data available for total suspended solids, heavy metals or POPs on a national scale to reflect this concern.

Major problem areas and pollution sources, include untreated or poorly treated wastewater treatment works discharges, run-off from un-serviced areas, agricultural run-off, industrial wastewater discharges and mining impacts.

Based on the planning level review of water quality obtained here at a national scale and per WMA a range of strategic water quality interventions are provided as the Department's focus areas over the short, medium and long term planning horizon. The implementation of these actions will require a co-ordinated and integrated approach in order to achieve the objectives of resource directed water quality management.

Based on the proposed strategic plan, the intention is to, provide effective guidance on how water quality considerations should be integrated into water resource management in general, thereby "making water resource management water quality friendly".

Table E1: Summary of water quality compliance to RWQOs per WMA for monitoring sites assessed

WMA	Electrical Conductivity (EC)	Sulphate (SO_4)	Chloride (Cl)	Ortho-phosphate (PO_4-P)	Ammonia (NH_3-N)	pH
1 - Limpopo	33% / 17% / 50%	17% / 83%	50% / 50%	17% / 50% / 33%	100%	17% / 66% / 17%
2 - Luvuvhu and Letaba	12% / 44% / 44%	100%	22% / 33% / 45%	44% / 56%	11% / 89%	11% / 56% / 33%
3 - Crocodile (West) and Marico	15% / 62% / 15% / 8%	23% / 77%	15% / 46% / 39%	69% / 23% / 8%	15% / 8% / 62% / 15%	54% / 46%
4 - Olifants	43% / 36% / 7% / 14%	43% / 7% / 50%	14% / 14% / 21% / 50%	36% / 64%	64% / 36%	57% / 36% / 7%
5 - Inkomati	7% / 29% / 14% / 50%	7% / 93%	29% / 71%	43% / 57%	14% / 86%	29% / 50% / 21%
6 - Usustu to Mhlatuze	19% / 25% / 25% / 31%	7% / 7% / 86%	19% / 6% / 19% / 56%	50% / 50%	6% / 38% / 56%	31% / 31% / 38%
7 - Thukela	10% / 40% / 50%	10% / 90%	100%	80% / 20%	10% / 30% / 60%	20% / 60% / 20%
8 - Upper Vaal	22% / 34% / 16% / 28%	6% / 22% / 9% / 63%	6% / 34% / 60%	91% / 9%	15% / 9% / 38% / 38%	53% / 31% / 16%
9 - Middle Vaal	50% / 24% / 13% / 13%	13% / 31% / 6% / 50%	19% / 19% / 38% / 24%	100%	19% / 12% / 25% / 44%	50% / 44% / 6%
10 - Lower Vaal	78% / 22%	44% / 44% / 12%	11% / 33% / 56%	56% / 44%	34% / 44% / 22%	78% / 22%
11 - Mvoti to Mzimkulu	16% / 16% / 68%	100%	5% / 26% / 68%	32% / 36% / 21% / 11%	5% / 5% / 32% / 58%	16% / 42% / 42%
12 - Mzimvubu to Keiskamma	11% / 20% / 16% / 53%	5% / 95%	5% / 11% / 16% / 68%	95% / 5%	37% / 63%	16% / 79% / 5%
13 - Upper Orange	16% / 32% / 32% / 20%	5% / 5% / 90%	5% / 32% / 63%	84% / 16%	16% / 16% / 68%	53% / 47%
14 - Lower Orange	29% / 29% / 43%	100%	71% / 29%	43% / 57%	14% / 14% / 14% / 57%	43% / 57%
15 - Fish to Tsitsikamma	61% / 18% / 14% / 7%	11% / 18% / 25% / 46%	54% / 7% / 25% / 14%	82% / 18%	4% / 7% / 46% / 43%	57% / 29% / 14%
16 - Gouritz	64% / 18% / 18%	35% / 6% / 18% / 41%	64% / 12% / 12% / 12%	94% / 6%	6% / 6% / 24% / 64%	47% / 29% / 24%
17 - Olifants Doorn	17% / 17% / 66%	17% / 83%	17% / 33% / 50%	33% / 67%	100%	50% / 17% / 33%
18 - Breede	72% / 14% / 14%	36% / 21% / 43%	72% / 21% / 7%	86% / 14%	7% / 7% / 29% / 57%	57% / 14% / 29%
19 - Berg	34% / 22% / 22% / 22%	33% / 67%	44% / 44% / 12%	100%	22% / 78%	11% / 22% / 67%
Ideal range limit	30mS/m	80 mg/l	40 mg/l	0.005 mg/l	0.015 mg/l	≥6.5 - ≤8.0
Acceptable range limit	50 mS/m	165 mg/l	120 mg/l	0.015 mg/l	0.044 mg/l	>8.0 - ≤8.4
Tolerable range limit	85 mS/m	250 mg/l	175 mg/l	0.025 mg/l	0.073 mg/l	No range limit set
Unacceptable limit	> 85 mS/m	> 250 mg/l	> 175 mg/l	> 0.025 mg/l	> 0.073 mg/l	<6.5 and > 8.4

Table E2: Summary of water quality issues identified and WMAs within which they are cause for concern

Water Quality Issue	Driver	Effect	WMAs associated with WQ issue
Eutrophication	Waste water treatment works Intensive agriculture fertilizer use Dense urban sprawl un-serviced sewage	Algal growth, smell, toxic algae, water treatment extra costs, taste and odour, irrigation clogging, aesthetics, recreational water users.	All WMA's except the Gouritz WMA (16).
Microbial contamination	Waste water treatment works Informal dense settlements; Vandalism of sewage reticulation system & pumping infrastructure Sewage spills into receiving streams	Recreational users (human health risks), washing and bathing; Poor bacterial water quality Impacts on downstream users Low dissolved oxygen and ecosystem impacts; Water-borne diseases.	All WMAs except for Usutu to Mhlatuze(6); Thukela (7); Upper Orange (13); Lower Orange (14) and Fish to Tsitsikamma (15).
Salinisation	Mines (operational and abandoned) Waste water treatment works Agricultural runoff	Water treatment costs, soil salinity and irrigation system clogging.	All WMAs except for Mvoti to Umzimkulu (11).
Toxicants	Pesticides (subtropical fruits, nuts) industry, DDT for malaria control	Fish kills, human health impacts, bioaccumulation in fish, crocodile deaths.	Luvuvhu and Letaba (2), Crocodile (West) and Marico (3); Olifants (4); Inkomati (5); Upper Vaal (8)
Altered flow regime	Dams and weirs Inter-basin transfers	Turbidity (erosion), algal growth, water temperature increase, dissolved oxygen changes, taste and odour changes, changes in environmental flows. Seasonal flow changes, ecological water requirement changes, impact of recreational water users	Luvuvhu and Letaba (2), Olifants (4); Inkomati (5); Middle Vaal (9); Lower Vaal (10); Upper Orange (13); Lower Orange (14)
Acid mine drainage	Mines (operational and abandoned), Controlled releases	Mobilisation of metals, Fish and crocodile kills, bioaccumulation, low pH, elevated sulphur and iron, elevated salts and dissolved metals.	Olifants (4); Inkomati (5); Usutu to Mhlatuze(6); Upper Vaal (8)
Metal contamination	Mines (operational and abandoned) Uncertain in some instances	Mobilisation of metals, fish and crocodile kills, bioaccumulation. Potentially harmful for human health and for the aquatic environment.	Olifants (4); Inkomati (5); Lower Orange (14)

Water Quality Issue	Driver	Effect	WMAs associated with WQ issue
Suspended solids (turbidity, sedimentation)	Land degradation and over grazing; soil erosion; mining Informal dense settlements, subsistence agriculture	High suspended solids during high flows; silting up of rivers, weirs and dams; loss of habitat, increased water treatment costs, irrigation clogging.	Limpopo (1), Luvuvhu and Letaba (2); Crocodile (West) and Marico (3); Olifants (4); Inkomati (5); Usutu to Mhlatuze(6), Thukela (7); Upper Vaal (8;)Mvoti to Umzimkulu (11); Mzimvubu to Keiskamma (12); Upper Orange (13)
Radioactivity	Discarded mine dumps	Bioaccumulation fish, aquatic organisms, soils, humans. Carcinogenic effects.	Upper Vaal 98); Middle Vaal (9)
Urban rivers	Poor quality stormwater runoff and dry weather flow from dense settlements	Poor bacterial water quality, human health risks, and impacts on ecosystems (low DO).	Upper Vaal (8); Fish to Tsitsikamma (15); Gouritz (16); Berg (19)
Agro-chemicals	Pesticide & herbicide residues Endocrine disrupting chemicals	Interference with hormone systems of organisms and ecosystem impacts.	Fish to Tsitsikamma (15); Olifants-Doorn (17); Breede (18); Berg (19)

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1. Introduction

Water is an indispensable natural resource, fundamental to life, the environment, food production, hygiene and sanitation, industry and power generation.

In South Africa it is recognised as a crucial element in the battle against poverty, the cornerstone of prosperity, and a limiting factor to growth. South Africa is situated in a subtropical region of the world where rainfall is unreliable, unevenly distributed, and prone to erratic, unpredictable extremes in the form of droughts and floods. On average only 9% of the rainfall reaches the river systems. Being mostly semi-arid, water is scarce compared to most other countries. Wise utilisation of this resource in a sustainable manner is, therefore, essential for the future of the country.

Groundwater resources are not easily exploitable due to the predominantly hard rock nature of the South African geology. Only about 20 percent of groundwater occurs in major aquifer systems that could be utilised on a large scale. Already the freshwater resources of the country are under stress.

Dams have been build in most of the country's major rivers to provide water for the increasing population; in some areas over 50% of the wetlands have been converted for other land-use purposes; industrial and domestic effluents are polluting the ground- and surface waters, and changes in habitat have affected the biotic diversity of freshwater ecosystems. Good management and sustainable utilisation depend on reliable information.

South Africa's water resources belong collectively to the nation. Since water is a national asset, a significant responsibility is placed on government in their capacity as the trustee of the nation's water resources. The responsibility rests specifically with the Department of Water Affairs ("the Department") acting on behalf of the Minister of Water and Environmental Affairs. However, their responsibility extends to ensuring that water shared with countries beyond our borders is also managed considerately (DWAF, 2006a).

The current political imperative for socio-economic development necessitates that the balance between the use of water resources and their protection gives preference to, from an overall national perspective, their use for socio-economic development, especially for poverty eradication and redress of past inequities. However, under no circumstances should water resources be exploited to the extent that they are "unacceptably degraded" and unable to provide adequate water quality on a sustainable basis.

It is acknowledged that the quality of life of all South Africans is inextricably linked, directly and indirectly, with maintaining the integrity of aquatic ecosystems since these provide many of the goods and services upon which society depends (particularly good quality water). Accordingly, strict protection of selected aquatic ecosystems will occur when this is considered necessary to sustain the biodiversity and general integrity of those ecosystems.

This philosophy will be implemented primarily through "Resource Directed Measures". These measures relate to the management class, the Reserve and associated Resource Quality Objectives (RQOs). These will comprise some of the most important instruments that will ultimately enable improvement of quality of life through effective water resource management (DWA, 2010a).

1.1 Water Quality

"Water quality" is a term used to express the suitability of water to sustain various uses or processes. Any particular use will have certain requirements for the physical, chemical or biological characteristics of water; for example limits on the concentrations of toxic substances for drinking water use, or restrictions on temperature and pH ranges for water supporting invertebrate communities. Consequently, water quality can be defined by a range of variables which limit water use by comparing the physical and chemical characteristics of a water sample with water quality guidelines or standards. Although many uses have some common requirements for certain variables, each use will have its own demands and influences on water quality (UNEP/WHO, 1996).

Water quality is neither a static condition of a system, nor can it be defined by the measurement of only one parameter. Rather, it is variable in both time and space and requires routine monitoring to detect spatial patterns and changes over time.

The composition of surface and groundwater is dependent on natural factors (geological, topographical, meteorological, hydrological and biological) in the drainage basin and varies with seasonal differences in runoff volumes, weather conditions and water levels. Large natural variations in water quality may, therefore, be observed even where only a single water resource is involved. Human intervention also has significant effects on water quality. Some of these effects are the result of hydrological changes, such as the building of dams, draining of wetlands and diversion of flow. More obvious are the polluting activities, such as the discharge of untreated or partially treated domestic, industrial, urban and other wastewaters into the water resource (whether intentional or accidental) and the spreading of chemicals on agricultural land in the drainage basin. A single influence (e.g. faecal pollution, eutrophication or diffuse pollution) may give rise to a number of water quality problems, just as a problem may have a number of contributing influences.

1.2 Integrated Water Quality Management in South Africa

To give effect to the interrelated objectives of sustainability and equity an approach to managing the water quality of water resources has been adopted that includes measures to protect water resources by setting objectives for the desired condition of resources, and putting measures in place to control water use to limit impacts to acceptable levels (DWAF, 2004a).

The Department's approach to integrated water quality management in South Africa comprises two complementary strategies *viz*. resource directed measures and source directed controls.

Resource-Directed Measures are measures that focus on the quality of the water resource itself. Resource quality reflects the overall health or condition of the water resource, and is a measure of its ecological status. Resource quality includes water quantity and water quality, the character and condition of in-stream and riparian habitats, and the characteristics, condition and distribution of the aquatic biota. Resource Quality Objectives (RQOs) and specifically Resource Water Quality Objectives (RQWOs) will be defined for each significant resource to describe its quality at the desired level of protection.

Specific actions in terms of resource directed measures that require attention at national level in respect of water quality management include the following (DWAF, 2004a):

- Formulation of objectives for managing sources of pollution and associated single source interventions.
- Benchmarking water resource quality.
- Identification of emerging threats to the water resource and prioritisation for action.
- Establishing priorities in relation to, for instance, remediation of water resources and degraded land as a focus for regulation using source-directed controls.

Source-Directed Controls are measures that contribute to defining the limits and constraints that must be imposed on the use of water resources to achieve the desired level of protection. They are primarily designed to control water use activities at the source of impact, through tools such as standards and the situation-specific conditions that are included in water use authorisations. Source-directed controls are the essential link between the protection of water resources and the regulation of their use.

Source directed controls may be categorised as follows (DWAF, 2004a):

- Best management practice measures that relate to measures and standards that apply nationally with respect to water use.
- Special measures related to source-related requirements dictated by and/or derived from catchment management strategies and/or plans.
- Site-specific measures related to measures arising from the process of authorising water use. They take account, among other considerations, of general authorisations specified at national or regional levels, and considerations that are specific to the water use being considered in a particular location.

Integrated water quality management can be viewed as a component of integrated water resource management. The latter is, in turn, a component of integrated environmental management, as mandated by the National Environmental Management Act (Act 107 of 1998).

Integrated water quality management (WQM) is a catchment-focused, iterative yet systematic process that should be implemented in a cyclical process aimed at continual improvement (fundamental to the principle of adaptive management). The measures range from individual (local) source and resource management initiatives (short-term) through re-consideration of the catchment management strategy (medium-term) to re-consideration of the resource directed measures and vision (long-term). Integrated WQM involves the integration of the following (DWAF, 2006a):

At pollution source scale:

- Resource directed measures with source directed controls relating to water quality management, and

At local scale:

- The achievement of resource quality objectives, and resource water quality objectives in particular,

- Water services development plans, as required by the Water Services Act (Act No. 108 of 1997),
- Integrated development plans, as required by the Municipal Systems Act (Act No 32 of 2000); and

At regional scale:

- The water quality component of catchment management strategies,
- The achievement of the water quality management goal within the catchment,
- The achievement of the catchment vision, and

At national scale:

- The National Water Resource Strategy (DWAF, 2004 a),
- Nationally consistent approaches to resource directed measures and associated source directed controls,
- The achievement of national water quality management goals.

Water quality management is the process of administering and controlling the physical, chemical, toxicological, biological (including microbiological) and aesthetic properties of the water in water resources that determine sustained healthy functioning of aquatic ecosystems, and fitness for use.

Resource directed management of water quality focuses specifically on how water quality in water resources should be managed, particularly in respect of use and protection.

The vision of the Department's Resource Directed Management of Water Quality Policy is to ensure that the water quality in South African water resources enables an equitable and sustainable balance to be achieved between its use by society and its protection as a critical component of a natural system so that the quality of life of all South Africans is improved and sustained in the long term.

1.3 Water Quality Planning

Quantity and quality water requirements of different users will not always be compatible, and the activities of one user may restrict the activities of another, either by requiring water of a quality outside the range required by the other user or by lowering quality during use of the water (e.g. discharges). Efforts to improve or maintain a certain water quality often compromise between the quality and quantity requirements of different users. The Department recognises that, just as a quantity of water can be "used", so can water quality. For water to be regarded as "fit for use" for a number of different users in the same catchment, the water quality needs to satisfy the most demanding of those users. The achievement of this desired resource water quality requires a combination of planning guidance and management actions.

The Water Quality Planning function of the Department aims to provide policy guidance specifically on how water quality in water resources should be managed, particularly in respect of use and protection. It does not concern itself with the detailed management of those activities that cause impacts on water quality. However, it does address "source management" (or "source directed controls") to the extent that such management should be driven directly by the requirements of the water resource (DWAF, 2006a).

Water quality planning is directed at addressing the following key issues facing water resource management:

- Balancing the degree to which water, and water quality, is used (e.g. for socio-economic development) with the degree of protection of water resources as natural systems (for current and future generations) requires both political and scientific considerations.
- The nature of the imbalance between the requirement for and supply of water, and water quality, is such that equitable allocation of these resources is not possible without management intervention.
- Resource directed management of water quality requires certain specialist skills, while decision-making is often complex and may have to be based on uncertain or incomplete data and information.
- Consistent nationwide application of legislation relating to management of water quality is essential.

1.4 Why the need for a Water Quality Planning Level review of the state of South Africa's surface water resources?

In support of the Department's Water Quality Planning objective to provide effective management solutions and policy guidance to address the current water quality management challenges facing South Africa, the need has been identified to undertake a national review on the water quality status of available groups of surface water quality indicators. The findings are aimed at supporting strategic management decisions in the context of sustainable fitness for use of those water resources and the integrity of aquatic ecosystems.

This analysis of water quality data in a regional (WMA) and national context is aimed at obtaining information for understanding point and nonpoint sources, natural features, and human activities affecting surface water resources and ecosystems. Improved understanding can help prioritize actions for water resources protection and remediation, reduce monitoring costs, and evaluate strategies for reducing concentrations of contaminants, such as nutrients in rivers. In addition, findings in individual WMAs and catchments can be placed within the context of the larger river systems and impoundments. This is critical because local decisions related to land-use planning and development, or other human actions, in individual catchments can contribute to the cumulative or overall impact on the quality of the water resource.

Because water resources, aquatic communities and ecosystems are interconnected across great distances, successful solutions and actions depend on local, catchment, WMA and national involvement.

Other specific applications of the water quality planning level review of the state of the country's surface water resources will help:

- Identify the water resources that are heavily polluted and impaired;
- Implement resource water quality objectives (RWQOs) by identifying water resources of good quality that need to be maintained and impaired water resources that need to be restored;
- Identify priority catchments and WMAs where good water quality must be maintained and others that need management interventions to limit pollution and specific source control measures;

- Evaluate the effectiveness of activities undertaken to manage the impacts on water quality of water resources; and
- Prioritize management actions that must be implemented.

2. Overview of South Africa's Water Resources

Due to the poor spatial distribution of rainfall, the natural availability of water across the country is also highly uneven. Most of the rain falls in the marginal zone along the eastern and southern coastlines. This situation is compounded by the strong seasonality of rainfall, as well as high within-season variability, over virtually the entire country. Consequently surface runoff is also highly variable. As a result, stream flow in South African rivers is at relatively low levels for most of the time. The sporadic high flows that do occur limit the proportion of stream flow that can be relied upon to be available for use.

Surface runoff is the main water source in South Africa. The average total mean annual runoff of South Africa under natural (undeveloped) conditions is estimated at a little over 49 000 million m^3/a, which includes about 4 800 million m^3/a and 700 million m^3/a of water originating from Lesotho and Swaziland respectively, which naturally drains into South Africa. Some highly variable rivers can have up to 10 consecutive years of less than average flow.

In addition about 10 000 million m^3per annum is available as renewable groundwater in South Africa (Utilisable Groundwater Exploitation Potential) (DWA, 2010b). However groundwater, while also extensively utilised, particularly in the rural and more arid areas, is limited due to the geology of the country, much of which is hard rock. Large porous aquifers occur only in a few areas (DWAF, 2004a).

Total available surface water in South Africa in year 2000 was about 12 800 million m^3 per annum (DWA, 2010c).

The mean annual run-off in South Africa is not directly proportional to the mean annual rainfall. It reduces far more sharply than a reduction in rainfall due to high evaporation losses. South Africa's water supply situation may worsen if unfavourable climatic changes should arise from global warming.

To compound the situation, most urban and industrial development, as well as some dense rural settlements, has been established in locations remote from large watercourses. As a result, in several river basins the requirement for water already far exceeds its natural availability, and widely-spread and often large-scale transfers of water across catchments have, therefore, already been implemented.

To facilitate the management of water resources, the country has been divided into 19 catchment-based water management areas.

2.1 Major River systems

The great escarpment separates South African rivers into two groups, *viz*. the plateau rivers and those of the marginal areas. The eastern marginal area, covering 13% of the country, accounts for 43% of the total run-off. This is derived from several short steep rivers which rise on the slopes and flow directly into the Indian Ocean. The longer east-flowing rivers in the north, such as the Limpopo, the Komati, the Crocodile and the Olifants rise on the interior plateau and have broken through the escarpment (Sancold, 1994).

Most of the plateau is drained by the large Orange River System which flows westwards to the

Atlantic Ocean. Although its catchment area comprises 48% of South Africa, it contributes only 22% of the total mean annual runoff because the rainfall reduces towards the west where evaporation is high. Its major tributaries are the Caledon and Vaal rivers. Downstream of its confluence with the Vaal, there is almost no addition to its runoff over a distance of 1200 km. No water is known to have reached this reach of river from the large Molopo-Nossob system situated to the northwest for millennia. In the south-western Cape the major rivers are the Gamtoos, Gouritz, Breede, Berg and Olifants progressing westwards from the year round rainfall area to the winter rainfall area.

Only one quarter of South Africa has perennial rivers. These are mainly in the southern and south western Cape and on the eastern marginal slopes. With no inland lakes and permanent snows to stabilize flow, these rivers flow irregularly and they are often seasonal. Rivers that flow only periodically are found in a further quarter of the country. Over the entire western interior, rivers are episodic and flow only after infrequent storms (Sancold, 1994).

2.2 Dams

Water resources are highly developed over most of the country as South Africa depends mainly on surface water resources for most of its urban, industrial and irrigation requirements. Storage is necessary to be able to make best use of runoff.

About 320 major dams, each with a full supply capacity exceeding 1 million m^3, have a total capacity of more than 32 400 million m^3, equivalent to 66 per cent of the total mean annual runoff (DWAF, 2004 a). The major dams command virtually all the run-off from the interior plateau. The undeveloped resources are mainly along the coast. However it is accepted that natural processes occurring in rivers, wetlands and estuaries require a share in the water resources of the country.

2.3 Types of water quality of South Africa's water resources

As South Africa is water deficient, wastewater has to be purified and returned to water resources. With the growing industrialization, urbanization, irrigation and the use of agrochemicals, the quality of receiving waters is deteriorating by increased return flows. Poor water quality is becoming more critical than reduced availability in some areas, particularly in the interior of the country.

To meet the country's growing water requirements, water resources are highly developed in large parts of the country. As a result of the many control structures (dams and weirs), the abstraction of water and return flows to rivers, as well as the impacts of land use, the flow regime in many rivers has also been significantly altered. This has significantly changed the quality of water and the integrity of aquatic life in many rivers.

South Africa's surface and groundwater resources show pronounced regional differences and changes in water quality. The changes in those areas where water quality has deteriorated significantly are due to anthropogenic activities.

Exceptions are the ambient salinity levels of certain rivers of the eastern (e.g. Great Fish and Sundays rivers) and western Cape (e.g. lower Berg River) where natural salinisation is of geological origin.

2.4 Drivers of water quality in South Africa's

The quality of water resources in many areas of South Africa is driven by man-made causes. However in some instances the quality related problems are inherent in the geological characteristics of the area.

Currently much of the water quality of the country's water resources is influenced by wastewater discharges and land-based activities. Major impacting sources include agricultural drainage and wash-off (irrigation return flows, fertilisers, pesticides and runoff from feedlots), urban wash-off and effluent return flows (bacteriological contamination, salts and nutrients), industries (chemical substances), mining (acids and salts) and areas with insufficient sanitation services (microbial contamination).

The quality of groundwater is influenced by mining activities, leachate from landfills, human settlements and intrusion of sea water.

2.5 Inter-basin Transfers

Due to the spatial imbalances in the availability of and requirements for water in the country, inter-catchment transfer of water is a necessary reality in South Africa. Inter-basin water transfer schemes have been implemented throughout the country to augment the supply of freshwater. A total of 26 major inter-basin water transfers have been completed to date.

The transfer of water between water management areas amounts to about 3 000 million m^3/a (DWA, 2010c).

Some of these transfers are from upper to lower water management areas through releases along rivers, as in the Vaal and Orange rivers, while others are affected through inter-catchment water transfers. It has become evident that more water will have to be transferred in future. In comparison, the total surface water yield in the year 2000 amounted to about 12 800 million m^3 (DWA, 2010c).

The physical transfer of water within or between catchments has physical, chemical, hydrological and biological implications for the recipient catchment. Inter-basin transfers cause a disruption of the river continuum downstream of the transfer in the following ways:

- Water quality: sediments, nutrients, turbidity, salinity, alkalinity, temperature effects and toxic chemicals; and
- Land implications: erosion, sedimentation, salinity, alkalinity, waterlogging, changes in land use patterns, changes in mineral and nutrient contents of soils, and any other hydrogeological factors.

In particular some water quality implications for inter-basin transfer schemes in South Africa include the transfer of more salinity which has been rising dramatically in recent years for example in the Vaal and Orange River Systems. A further key concern is the threat to the water quality in the Grootdraai Dam. Inadequate management of the impacts from the defunct and abandoned coal mines in the upstream catchment could potentially affect the water quality of the Grootdraai Dam and thus the water transferred to existing power stations in the Olifants and Inkomati catchments.

2.6 Groundwater quality

Groundwater occurs widely and, geographically, and a significant portion of South Africa's population depends on it for their domestic water needs. The groundwater quality management policy for South Africa is aimed at providing an adequate level of protection to groundwater resources and securing the supply of water of acceptable quality in an integrated and sustainable manner (DWAF, 2000). The value and vulnerability of groundwater represents a strategic component of water resources of South Africa. Security of groundwater supplies is thus essential and protection of groundwater has become a national priority. The major reason for poor management of groundwater has been a lack of a structured approach to management and a lack of knowledge and information about groundwater (DWA, 2010b). Management is often focused on the long-term sustainability of the resource in terms of quantity or yield. However water quality is often neglected in many areas where groundwater is the sole source of water supply.

Groundwater has a natural dissolved mineral content that includes ions such as chloride, sodium, iron, etc. Natural groundwater quality depends on factors such as aquifer material and groundwater residence times. The natural level of groundwater electrical conductivity in South Africa is indicated in Figure 1 (DWAF, 2010b). In some parts of South Africa the natural mineral content (highly saline or brackish) of groundwater renders it unsuitable to consume. Monitoring is the key to understanding natural groundwater quality variations.

Groundwater pollution and over-abstraction are serious problems in certain parts of South Africa. Poor and deteriorating groundwater quality is widespread and can be attributed to diverse sources in various sectors such as mining, industrial activities, effluent from municipal wastewater treatment works, storm water runoff from urban and especially informal settlements (where adequate sanitation facilities are often lacking), return flows from irrigated areas, effluent discharge from industries, etc.(DWA, 2010b)

Measurements and/or observations (i.e. groundwater monitoring systems) are inadequate when used to define the status of, and trends in, groundwater quality and in determining its "fitness to use". Pollution and over-abstraction are dealt with in existing legislation and strategies, but implementation of such strategies is hampered by a lack of capacity and coordination between different governmental departments and between the different levels of water resource management. The localized nature of groundwater means that it is generally more effectively managed at the local or catchment level rather than at the national level (DWA, 2010b).

The strategy of the Department is to address areas where serious pollution or over-abstraction threatens the integrity and reputation of groundwater resources. Groundwater monitoring is to be improved at all levels. Hydrogeological support to locally based catchment and municipal managers involved in water resource management needs to be improved. Inter-governmental co-operation has to be enhanced to facilitate decision-making (DWA, 2010b).

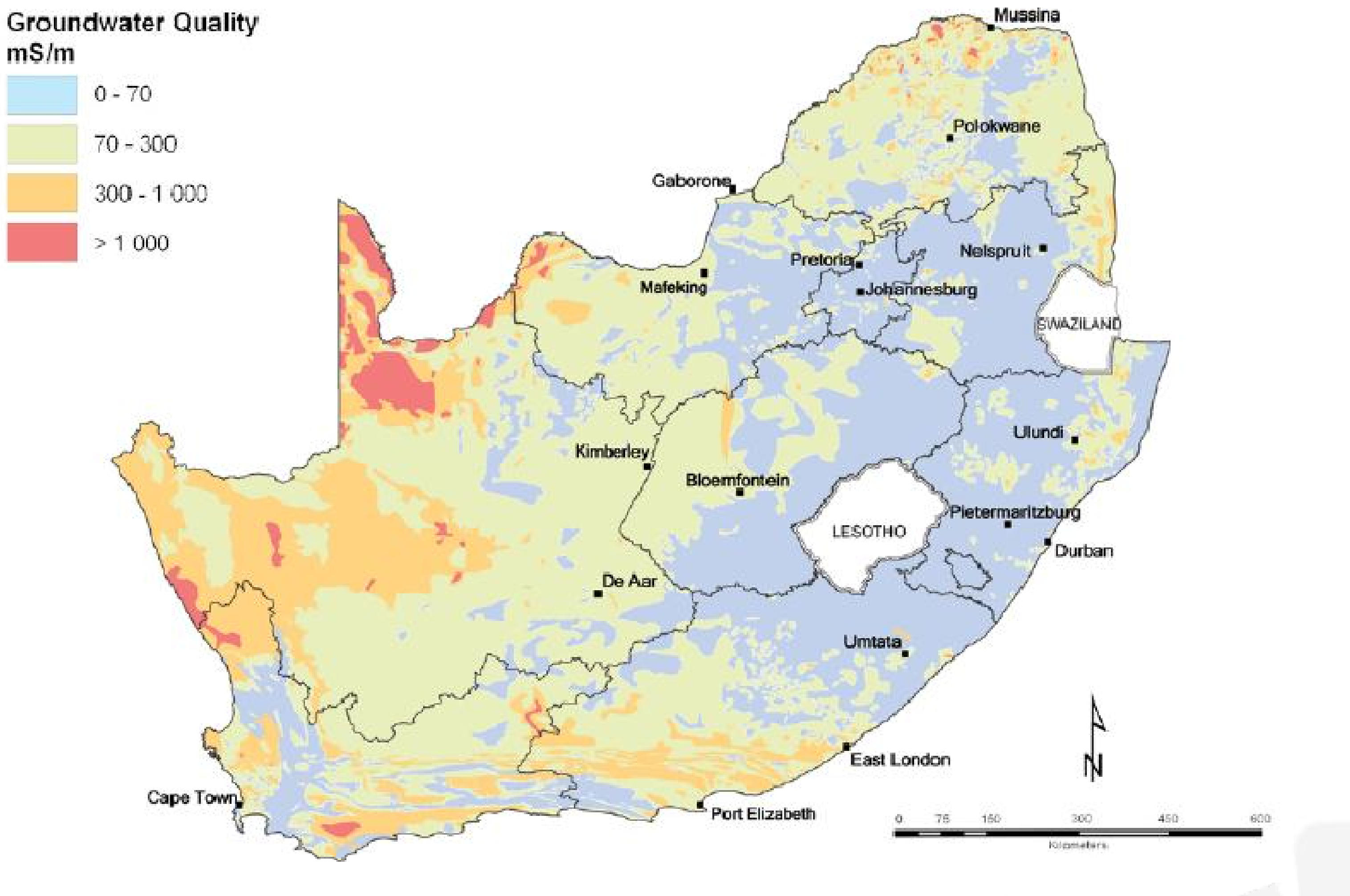


Figure 1: Electrical conductivity map of groundwater in South Africa (DWA, 2010b)

2.7 River Health Programme

As a means to serve as a source of information regarding the overall ecological status of river ecosystems in South Africa, the Department of Water Affairs (DWA) initiated the River Health Programme (RHP) in 1994. The RHP primarily makes use of in-stream and riparian biological communities (e.g. fish, invertebrates, vegetation) to characterize the response of the aquatic environment to multiple disturbances. The rationale is that the integrity or health of the biota inhabiting the river ecosystems provides a direct and integrated measure of the health of the river as a whole.

The objectives of the RHP are to:

- Measure, assess and report on the ecological state of aquatic ecosystems;
- Detect and report on spatial and temporal trends in the ecological state of aquatic ecosystems;
- Identify and report on emerging problems regarding aquatic ecosystems; and
- Ensure that all reports provide scientifically and managerially relevant information for national aquatic ecosystem management.

The National Water Act (Act no. 36 of 1998) acknowledges the importance of protecting aquatic ecosystems in maintaining the full suite of goods and services that people rely on for their livelihoods, and requires that a national aquatic ecosystem health monitoring system be established. To date, the implementation of the RHP has largely been driven by provincial implementation teams consisting of amongst others, DWA Regional Offices, provincial departments of the environment, conservation agencies, universities and municipalities. Implementation in the provinces has largely been voluntary and is influenced by various factors such as the enthusiasm of provincial champions and provincial task teams, buy-in from their respective organisations, as well as the availability of financial and human resources. This makes the RHP very vulnerable and affects its long-term sustainability (www.csir.co.za/rhp/).

To date a number of the state of the rivers reports have been compiled for many of the South African River Systems through the RHP and a Rivers Database has been set up for the collation of biomonitoring data.

3. Resource Directed Water Quality Management

Resource Directed Management of water quality pertains specifically to management of the use and protection of the water quality component of inland water resources, including rivers, dams, groundwater, estuaries and wetlands.

Although the water quality component is specifically considered, it must be managed holistically, within the general framework of "resource directed measures", with water quantity (flows) and the habitat and biota components that comprise the overall water resource quality (see Text Box 1) . Resource directed management of water quality also focuses on how the management of anthropogenic activities that modify the water quality in water resources should be influenced.

The Department envisions in the application of resource directed management of water quality an equitable and sustainable balance between the use and protection of water quality in water resources to the benefit of all South Africans. To achieve this, the Department's planning function has developed policy direction describing how water quality considerations should be integrated into water resource management. This has included the development of the associated strategy and management instruments to support detailed implementation (see Text Box 2)(DWAF, 2006a).

Text Box 1: Resource Quality
Resource quality does not mean water quality alone. It refers to all aspects of the water resource including water quantity, water quality, character and condition of in-stream and riparian habitats, and the characteristics, condition and distribution of the aquatic biota.

3.1 Allocatable Water Quality and Stress

The Department recognises that, just as a quantity of water can be "used", so can water quality. For water to be regarded as "fit for use" for a number of different users in the same catchment, the water quality needs to satisfy the most demanding of those users. Typically this will be quantified in terms of individual water quality attributes. This is the basis for the concept of "allocatable water quality" which can be defined from two points of view.

First, it can be regarded as that water quality, if any, that remains allocatable (available) to uses other than the strategic national priority uses (the Reserve, etc,) (see Text Box 3) and current lawful uses (all contributing to current equitable access). It can also be more formally regarded as the maximum worsening change in any water quality attribute away from its present value that maintains it within a pre-determined range reflecting the desired future state (typically defined by a resource quality objective).

3.2 Resource Quality Objectives and Reserve

Setting resource quality objectives for a chosen management unit of a water resource, is a technical process of integration of water quality, water quantity and ecosystem integrity, the results of which will further inform the stakeholder engagement process. These objectives can include a wide variety of characteristics of the resource, some of which refers explicitly to water quality.

Text Box 2: Resource Directed Management of Water Quality – Management Instruments (DWAF 2006a)

Resource Directed Management of Water Quality Instruments developed to support implementation

Report number	Report title
1.4	Volume 1: *Policy Document Series*
1.4.1	Volume 1.1: Summary Policy: Resource Directed Management of Water Quality
1.4.2	Volume 1.2: Policy: Resource Directed Management of Water Quality
1.5	Volume 2: *Strategy Document Series*
1.5.1	Volume 2.1: Summary Strategy: Resource Directed Management of Water Quality
1.5.2	Volume 2.2: Strategy: Resource Directed Management of Water Quality
1.5.3	Volume 3*: Institutional Arrangements*
1.6	*1st Edition Management Instruments Series (Prototype Protocol)*
1.6.1	Appendix B: Project Document. Conceptual Review for water licence application from a Resource Directed Management of Water Quality (RDMWQ) perspective
1.6.2	**Guidelines on Catchment Visioning for the Resource Directed Management of Water Quality
1.6.3.1	**Guideline for determining Resource Water Quality Objectives (RWQOs), water quality stress and allocatable water quality
1.6.3.2	**Guideline on the conversion of the South African Water Quality Guidelines to fitness-for-use categories
1.6.3.3	**Guideline for converting Resource Water Quality Objectives (RWQOs) to individual end-of-pipe standards
1.6.3.4	Appendix D: Project Document. ACWUA Decision-making support system for Resource Directed Management of Water Quality (RDMWQ)
1.6.4	**Decision-support instrument for the Assessment of Considerations for Water Use Applications (ACWUA)
1.6.5	**Guideline on pro-forma licence conditions for the Resource Directed Management of Water Quality
1.7	Volume 4: *2nd Edition Management Instruments Series*
1.7.1	Volume 4.1: Guideline for Catchment Visioning for the Resource Directed Management of Water Quality
1.7.2	Volume 4.2: Guideline for determining Resource Water Quality Objectives (RWQOs), Allocatable Water Quality and Stress of the Water Resource
1.7.2.1	Volume 4.2.1: Users' Guide. Resource Water Quality Objectives (RWQOs) Model (Version 4.0)
1.7.3	Volume 4.3: Guideline on Monitoring and Auditing for Resource Directed Management of Water Quality
1.7.4	Appendix A: Project Document: Philosophy of Sustainable Development
1.7.5	Appendix C: Project Document: Guidelines for Setting Licence Conditions for Resource Directed Management of Water Quality (RDMWQ)
1.7.6	Introduction

** These reports are earlier versions that have been improved upon in the second edition and thus are not available for publication.

Text Box 3: The Reserve

The Reserve is the quantity and quality of water required to satisfy the basic human needs and to protect aquatic ecosystems, in order to secure ecologically sustainable development and use of the relevant water resource. The Reserve is the only water right specified as inviolable in the law. Water for basic human needs has the highest allocation priority in the country. The basic human needs Reserve includes water for drinking, food preparation and personal hygiene. In terms of water quality the intention of the basic human needs Reserve is to secure the quality requirements for basic human needs with minimal treatment.

The intention of the ecological Reserve is to secure sufficient water of an appropriate quality to maintain aquatic ecosystems in such a form that they can continuously provide the desired set of socio-economic goods and services to society.

The Department has used lower confidence standard approaches and instruments in the absence of a classification system to determine preliminary classes of water resources nationwide, based on water quality. This will be used to identify potential priority water resources exhibiting water quality stress. Preliminary resource quality objectives relating to water quality and resource water quality objectives (RWQOs) will then be set for these priority resources using more accurate (higher confidence) approaches. This provides an initial impetus to the implementation of resource directed management of water quality in accordance with the intentions of the NWA (Act No. 36 of 1998) (DWAF, 2006a).

Some impacts on water quality, particularly those relating to conservative water quality variables, will have increasingly cumulative effects towards the most downstream reaches of surface water resources.

Accordingly, the setting of resource quality objectives or resource water quality objectives for a particular catchment must take cognisance of that catchment's water quality issues (current and future) and those of upstream and particularly downstream catchments as well as those linked through inter-basin transfers. All water quality-related objectives in such catchments must be mutually compatible.

3.3 Source Directed Controls

The control and management of sources of pollution is guided by environmental legislation as well as the management classes set for identified water resources.

The precautionary approach is always applicable and will be balanced against socio-economic necessities. Preventing pollution in the first place will always be encouraged while pursuing the best practicable environmental option. Should some water quality degradation be inevitable, waste minimisation will be encouraged. The precautionary approach will be applied to point sources of pollution by enforcing uniform national minimum requirements or standards.

The degree to which they may be enforced or relaxed will depend on the degree of water quality stress (DWAF, 2006a and 2006b).

3.4 Monitoring

Sound water quality monitoring is essential for adaptive management. Monitoring of (a) overall national water quality status and trends, (b) compliance with resource quality objectives, (c) compliance with water use licence conditions, including monitoring of affected water resources, and (d) remediation efforts is crucial to sound management.

Water quality monitoring is most commonly related to adaptive water quality management, which aims to control the physical, chemical and biological characteristics of water resources.

By gathering sufficient data through monitoring, the spatial and/or temporal variations in water quality can be assessed. The quality of water may be described in terms of the chemical concentration and state (dissolved or particulate) of some or all of the organic and inorganic material present in the water, together with certain physical characteristics of the water (UNEP/WHO, 1996).

The quality of the aquatic environment is a broader issue which can be described in terms of:

- water quality,
- the composition and state of the biological life present in the water body,
- the nature of the particulate matter present, and
- the physical description of the water body (hydrology, dimensions, nature of lake bottom or river bed, etc.).

Water quality (the physico-chemical characteristics of the water) therefore forms a component in the assessment of the health aquatic environment, together with biological life, particulate matter and the physical condition of the water body.

Artificial and/or natural changes in the water quality of freshwaters can produce diverse biological effects ranging from the severe (such as a total fish kill) to the subtle (for example changes in enzyme levels or sub-cellular components of organisms) (UNEP/WHO, 1996).

Water quality is thus a driver that indicates that the ecosystem, and its associated organisms, is under stress or that the ecosystem has become unbalanced. As a result there could be possible implications for the intended uses of the water and even possible risks to human health

Chemical monitoring together with biological monitoring is therefore required to understand the total health of the aquatic ecosystem.

4. Resource Water Quality Objectives

Resource Water Quality Objectives (RWQOs) is a mechanism through which the balance between sustainable and optimal water use and protection of the water resource can be achieved. RWQOs are the water quality components of the Resource Quality Objectives (RQOs) which are defined by the National Water Act as "clear goals relating to the quality of the relevant water resources" (DWAF, 2006a).

RWQOs are descriptive or quantitative, spatial or temporal, and ultimately allows realisation of the catchment vision by giving effect to the water quality component of the gazetted (RQOs). RWQOs are typically set at a finer resolution than RQOs to provide greater detail upon which to base the management of water quality. The catchment vision is a collective statement from all stakeholders of their future aspirations of the relationship between the stakeholders (in particular their quality of life) and the water resources in the catchment. The RWQOs form part of the strategy to attain that vision. The levels at which RWQOs are set require that they are practical and cost-effective as possible.

The policy of the Department of Water Affairs (DWAF, 2005a) regarding RWQOs is that they should:

- Ultimately allow realisation of the catchment vision;
- Give effect to the water quality component of gazetted RQOs;
- Express more detailed stakeholder needs than those accounted for by the RQOs (where necessary);
- May equal these gazetted RQOs, but may be set at a finer spatial/or temporal resolution; and
- Dictate the tolerable level of impact collectively produced by upstream users.

The Department recognises the importance of a strong technical basis for defining RWQOs, and a heavy reliance on a catchment/situation assessment.

RWQOs provide the basis for determining the allocatable water quality and water quality stress.

RWQOs include three elements: the designated users of the water resource (e.g. recreational, aquatic ecosystem, industrial use, domestic etc), the criteria/numeric or descriptive in-stream goals defined to protect the water resource, and the alignment to the catchment vision and class of the water resource (see Text Box 4).

4.1 Balancing the needs of downstream water users with upstream water use and development

In setting of RWQOs, the Department strives to achieve a balance between protecting the water resource for the downstream users and allowing use and development of the water resource upstream of the river reach selected for the RWQOs. For the downstream water users, the focus is on protecting the water quality in order to ensure a healthy functional aquatic ecosystem, while also meeting the water quality requirements of the other recognised water user groups (domestic, agricultural, industrial, recreation and aquatic ecosystems) downstream of the RWQOs point. However, the selected RWQO might also restrict the type and extent of water use upstream of the point. Water uses refer to those described in Section 21 of the NWA (DWAF, 2006a).

It must also be borne in mind that in terms of DWA policy the RQOs (and related RWQOs) will be used as the basis for the setting of waste discharge standards (Section 26[h] of the NWA) and waste discharges charges in each catchment. Thus the setting of RQOs and RWQOs become central to balancing the needs of the upstream "impactors" with downstream user requirements.

4.2 Fitness for use

Fitness for use is a scientific judgement, involving objective evaluation of available evidence, of how suitable the quality of the water is for its intended use. Water quality can therefore only be expressed in terms of fitness for use. Water quality assessment to determine fitness for use is based on resource water quality objectives (RWQOs) that have been set for the water resource.

In South Africa, the South African Water Quality Guidelines (SAWQGs) have been developed as discrete values that depict the change from one category of fitness for use to another (DWAF, 1996). The SAWQGs recognises only one management category, namely the Target Water Quality Range (TWQR). Above this value / range, the categories describe an ever increasing negative impact with respect to the use of the water. Thus, for any resource it is necessary to determine whether or not the effect is acceptable to the user (DWAF, 2006c).

The water quality guidelines describe the "fitness for use" of a water resource, while the water quality objectives define "what management action is required" for a water resource. The fitness for use of water is a judgement as to how suitable the quality of water is for its intended use. The following fitness for use categories are linked to the SAWQGs:

- Ideal – the use of water is not affected in any way; 100% fit for use by all users at all times; desirable water quality (TWQR);
- Acceptable – slight to moderate problems encountered on a few occasions or for short periods of time;
- Tolerable – moderate to severe problems are encountered; usually for a limited period only; and
- Unacceptable – water cannot be used for its intended use under normal circumstances at any time (DWAF, 2006c).

The descriptions are related to an associated effect of a particular water quality variable for a water user category. The South African Water Quality Guidelines also serve as a common basis for the development of RWQOs for water resources.

The Department strives to maintain a balance between the need to protect and the need to use the country's water resources. The TWQR is a management objective that is used to specify the ideal concentration range and / or water quality requirements for a particular constituent. This is the range of concentrations or levels within which no measurable adverse effects are expected on the health of the user, and should therefore ensure their protection (DWAF, 2006c).

The TWQR has been used to define the Ideal category, while the upper limit of where negative effects are seen has been defined as the tolerable category. Assuming that a linear distribution in the data was used to derive the TWQRs (DWAF, 1996), the acceptable category was interpolated to be the average of the Ideal category (*i.e*. TWQR) and the tolerable level. The unacceptable category is regarded as any concentration / level above the upper limit (*i.e.* Tolerable) (DWAF, 2006c).

The assessment of the water resource to rate its current water quality status in terms of fitness for use and associated water quality range usually supports or links to water quality management related targets and goals, a management action or objective that is required. This can range from no action (ideal) to immediate intervention (unacceptable).

Text Box 4: National Water Resource Classification System

Classification system

Resource Directed Measures, together with Source Directed Controls are the key strategic approaches designed under the National Water Act (NWA) (Act 36 of 1998) to achieve equity, sustainability and efficiency in Integrated Water Resources Management in South Africa. These measures comprise the classification system, the Reserve and Resource Quality Objectives. Together they are intended to ensure comprehensive protection of all water resources.

The Water Resource Classification System (WRCS), which is required by the NWA, is a set of guidelines and procedures for determining the desired characteristics of a water resource, and is represented by a Management Class (MC). The Management Class outlines those attributes that the custodian [Department: Water Affairs (DWA)] and society require of different water resources. The WRCS is a consultative process to classify water resources (Classification Process) to help facilitate a balance between protection and use of the nation's water resources. The outcome of the Classification Process will be the Minister or her delegated authority setting the MC and Resource Quality Objectives (RQOs) for every significant water resource (river, estuary, wetland and aquifer) which will be binding on all authorities or institutions when exercising any power, or performing any duty under the NWA. Only three management classes are acceptable, Class I: Minimally Used, or Class II: Moderately Used, or Class III: Heavily Used. The management classes essentially describe the desired condition of the resource, and conversely, the degree to which it can be utilised. In other words, the MC of a resource sets the boundaries for the volume, distribution and quality of the Reserve and RQOs, and thus the potential allocable portion of a water resource for off-stream use.

The Classification Process is not carried out in isolation, but is integrated within the overall planning for water resource protection, development and use. A key component of classification is therefore the ongoing process of evaluating options with stakeholders in which the economic, social and ecological trade-offs will be clarified and decided upon (DWAF 2006c).

5. Objectives of this report

The main objective of the report is to provide a critical planning level review of the state of water quality of South Africa's surface waters. In doing so, national water quality planning interventions, strategy guidance and management actions have been identified. The review also provides an assessment of the fitness of use of water resources and their sustainability in terms of maintaining aquatic ecosystem integrity.

The report concentrates on the water quality state of the nation's surface water resources in terms of chemical quality. The report deals with surface water resources (including outlet quality of dams) only and does not include a review of groundwater, estuaries or dams. It also does not deal with the biological or microbiological status in detail (a summary is given in Text Box 5) of the surfaces water resources, as this information is not readily available on a national scale.

The objectives of the report are:

- To provide a critical review of the water quality status of the country's surface water resources;
- To provide information on the major factors and aspects that are impacting on the water quality status of our surface water resources;
- To identify strategic issues and key challenges that need to be addressed and important information gaps regarding water quality considerations and aspects, and
- To provide recommendations for future actions regarding water quality planning and management.

The results of this review is also aimed at informing the review of policy objectives including, the resource directed quality management policy and the associated implementation strategy and instruments.

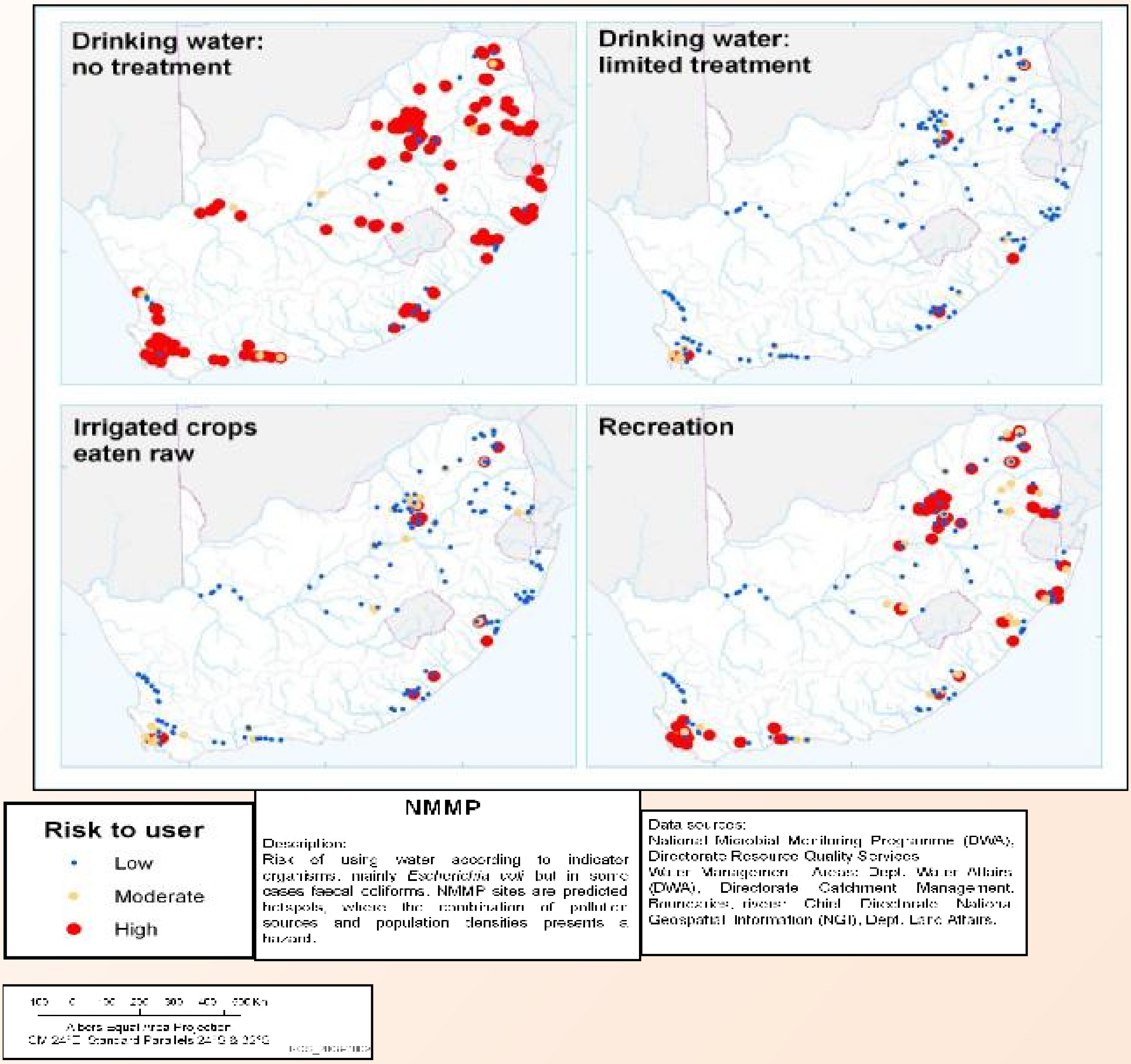
The degree to which individual catchment visions are being realised through catchment management strategies and the degree to which these are influencing achievement of national water quality goals will also be reviewed through this process.

Text Box 5: Microbiological Status of water resources of South Africa at selected hotspot areas

Microbiological Status

In terms of microbiological status, the Department of Water Affairs monitors feacal pollution through the National Microbial Monitoring Programme (NMMP). The NMMP provides information on the status and trends of the extent of faecal pollution in surface water resources especially in selected high risk settlement areas. Water related diseases include cholera, typhoid fever, viral gastroenteritis, dysentery, shigellosis etc.

The programme identified 163 high-risk or "hotspot" areas across the country for the 2007/2008 hydrological period and the number was increased to 182 for the 2008/2009 hydrological cycle. *Escherichia coli* (*E. coli*) was used as a bacterial indicator for faecal pollution in all the hotspots. There is a high risk associated with the use of water directly from the river for drinking purposes with no treatment as indicated in the figure below for most of the hotspot sites. Limited or domestic treatment of water will result in a low risk level for healthy individuals. The data also revealed that there will be no risk associated with eating raw crops (*i.e.* tomatoes etc.) that have been irrigated with the water abstracted from the hotspot areas. Around 40% of the sites are not good spots for recreational activities, *i.e.* partial or full contact (DWA, Resource Quality Services, Annual National State of Water Resources Report 2008/2009- *in publication*).



6. Water Management Areas

To facilitate the management of water resources, the country has been divided into 19 catchment-based water management areas (Figure 2).

The boundaries of the water management areas lie mostly along the divides between surface water catchments. Pronounced differences are evident among the water management areas with respect to water availability and water requirements, which are attributable to the large spatial variations in climate, the level and nature of economic development and population characteristics. Similarly, there are large differences within water management areas with respect to hydro-meteorological conditions and economic activity which cannot be adequately represented or managed without further spatial differentiation.

WMAs were therefore divided into sub-areas to enable improved representation of the water resources situation in the country and to facilitate the applicability and better use of information for strategic management purposes. Delineation of the sub-areas was based on practical considerations such as the size and location of sub-catchments, the homogeneity of natural characteristics, the location of pertinent water infrastructure such as dams, and economic development. It is foreseen that the catchment management agencies may later introduce smaller or alternative subdivisions (DWAF, 2004a).

For the current status assessment water quality was reviewed at a WMA scale so as to identify local perspectives that the national scale review cannot provide.

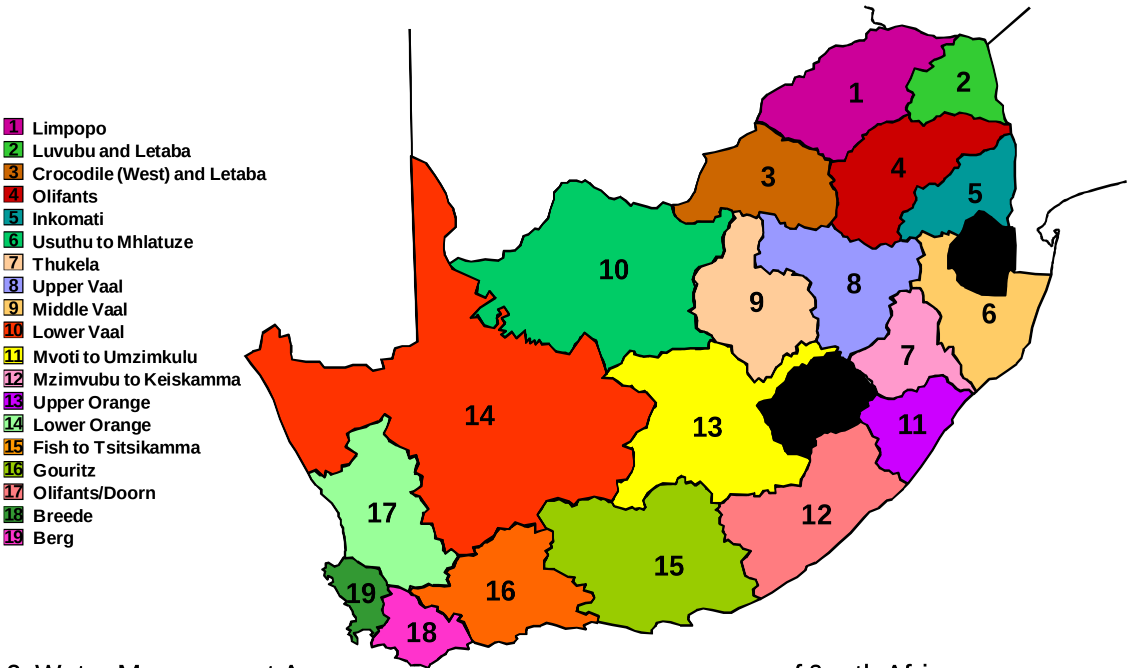


Figure 2: Water Management Areas of South Africa

7. Methodology

The water quality state of the country's surface water resources is provided here at planning review level. The current state is represented in terms of the key water quality variables considered indicative for reporting of water quality. Six parameters have been selected to provide an indication of the fitness for use of water resources by the designated user groups.

In-stream water quality of surface water resources was assessed using chemical monitoring data at a range of monitoring sites throughout the country (in each of the 19 WMAs) which was compared to a generic set of conservative level RWQOs to determine compliance for the selected water quality variables.

7.1 Collection of Data

The data was extracted from the WMS (Water Management System) on 15 February 2010 with a stipulated date range of 1st January 1999 to 31st December 2008. The monitoring sites selected were from the National Chemical Monitoring (Priority) Programme. This programme has a spatial resolution covering South Africa with approximately 330 sites that are situated predominantly on rivers and for which surface water quality samples are taken to analyse the levels of specific inorganic and physico-chemical attributes. The sites that had at minimum 25 samples taken over the period 01 January 2006 to 31 December 2008 were selected for the current state assessment. This resulted in 276 monitoring sites being assessed (Appendix A). An assessment of trends was done at the sites where a 10 year data range was available from 1st January 1999 to 31st December 2008.

7.2 Collection of Samples

These sites are sampled predominantly by the Hydrometry staff from the various DWA Regional Offices during their routine visits to flow gauging structures. It is at these flow gauging structures where most of the water quality sites are also located. The sampling frequency varies from twice to once a month, with some samples being taken less frequently when the sites are in very remote locations. Selected sites are sampled by private individuals or institutions where it is not possible or feasible for the DWA Regional Offices to assist. The water quality samples are immediately preserved with $HgCl_2$ to prevent uptake of any of the components (especially nutrients) by biological processes and the samples are then sent to the laboratories at Resource Quality Services (RQS) of DWA.

There the samples are logged at Sample Reception, and sent to the appropriate laboratory where they are analysed and the results entered onto the WMS via the Laboratory Information Management System (LIMS).

The results are subjected to the following quality control procedures:

- Metered Electrical Conductivity (EC) values are compared with calculated EC values;
- A cation/anion balance is conducted;
- Proficiency testing between laboratories using a common sample is conducted;
- Certified Reference Materials are used to check and calibrate the instruments;
- Calibration of the older instruments was forced to occur at a specified frequency; and

- In-run control standards are utilized during routine analysis (e.g. every tenth analysis is performed on a standard solution).

7.3 Identification of Key Water Quality Variables

Due to the scale and extent of the assessment it was considered necessary to select indicator water quality variables to represent the water quality status of the country's water resources.

While the 17 physico-chemical water quality variables of the National Chemical Monitoring (Priority) Programme were analysed only six are depicted on the water quality maps for reporting for planning purposes. These six variables were selected as they serve as suitable indicators of the general water quality status within the present data constraints, in that they provide insight into the salinity and eutrophication status, mining related impacts and variability of the country's water resources. The perspective provided by these variables gives a critical review and "the worst scenario water quality map." In addition, the other eleven water quality variables do not show much variance with regard to compliance to the RWQO limits (generally compliant) and thus do not provide any critical perspective of water quality.

The variables include Electrical Conductivity (EC), Orthophosphate (PO_4-P), Ammonia (NH_3-N), Chloride (Cl^-), Sulphate (SO_4^{2-}) and pH as they are representative of the water quality issues prevalent in the country and for which data is available. While it is accepted that there are a range of other variables that could be included (e.g. Total suspended solids, total phosphate, *E. coli* counts, metals, etc.) the reality is that there is insufficient data available for these on WMS to support a national scale water quality assessment of this nature.

The selection of the variables was based on the following reasoning:

- Electrical Conductivity (EC) (mS/m): to provide an indication of salinisation of water resources (increase in salinisation of the country's water resources);
- Orthophosphate (PO_4-P) (mg/l): as an indicator of the nutrient levels in water resources (eutrophication is becoming a threat). Nitrate (NO_3+NO_2-N) (mg/l) was assessed but showed a 97% compliance to ideal RWQO due to the fact that the upper limit is set at 6 mg/l based on the most sensitive user.
- Sulphate (SO_4^{2-}) (mg/l): as an indicator of mining impacts (a major issue in many catchment areas);
- Chloride (Cl^-) (mg/l): as an indicator of agricultural impacts, sewage effluent discharges and industrial impacts;
- Ammonia (NH_3-N) (mg/l): as an indicator of toxicity; and
- pH (pH units): as a indicator for mining impacts as well as natural variability nationally.

7.4 Water Quality Data Analysis

The water quality status (fitness for use) of the surface water resources in the 19 WMAs is presented as hexagons at the selected monitoring points on the map of each WMA.

Each piece of the hexagon represents the compliance of the water quality variable along the river with a generic set of RWQOs applicable to all the rivers across the entire country.

The 95th percentile values were used to assess EC, sulphate, chloride, ammonia compliance, while the 50th percentile values were used to assess phosphate compliance, and 5th and 95th percentile values to assess pH compliance.

7.5 Assessment of water quality (RWQO Compliance)

A generic set of RWQOs for the country's surface water resources was used to assess compliance and determine the current water quality status. While it is known that water resources vary considerably and different management RWQOs are in place in many catchment areas, it was necessary to provide a generic set of assessment RWQOs which would provide a consistent indication of fitness for use of water resources anywhere in the country. The RWQOs used for the compliance assessment (Table 1) were derived using the Resource Water Quality Objectives (RWQOs) Model (Version 4.0) (DWAF, 2006d) which uses as its basis the South African Water Quality Guidelines (DWAF, 1996), Quality of Domestic Water Supplies: Assessment Guide, Volume 1 (WRC, 1998) and Methods for determining the Water Quality Component of the Reserve (DWAF, 2008a) and are based on the strictest water user criteria (thus represent fairly conservative limits).

7.6 Water Quality Trends

Where data is available, the water quality trends of the above six variables for the period 1999 to 2008 were determined by calculating the R^2 of the straight line of the time series graphs. The trends were determined per water quality monitoring point per WMA. The trend per water quality variable is depicted as a face on the map within the hexagon (Section 9). An improving trend is indicated by smiley face, a deteriorating trend by a frowny face and no trend by a dash (-).

Table 1: Generic Resource Water Quality Objectives at a National Level

Variable	Units	Bound	Ideal	Sensitive user	Acceptable	Sensitive user	Tolerable	Sensitive user
Alkalinity ($CaCO_3$)	mg/l	Upper	**20**	AAq	**97.5**	AAq	**175**	AAq
***Ammonia (NH_3-N)**	mg/l	Upper	**0.015**	Ecological	**0.044**	Ecological	**0.073**	Ecological
Calcium (Ca)	mg/l	Upper	**10**	Dom	**80**	BHN	**80**	BHN
***Chloride (Cl)**	mg/l	Upper	**40**	In2	**120**	In2	**175**	In2
***EC**	mS/m	Upper	**30**	In2	**50**	In2	**85**	Ecological
Fluoride (F)	mg/l	Upper	**0.7**	Dom	**1**	Dom	**1.5**	Dom
Magnesium (Mg)	mg/l	Upper	**70**	Dom	**100**	Dom	**100**	Dom
NO_3 (NO_3-N)	mg/l	Upper	**6**	AIr	**10**	AIr	**20**	AIr
***pH**	units	Upper	**≤ 8**	In2	**<8.4**	In2		
		Lower	**≥6.5**	AIr AAq In2	**>8.0**	AIr AAq In2		
Potassium (K)	mg/l	Upper	**25**	Dom	**50**	Dom	**100**	Dom
***PO_4-P**	mg/l	Upper	**0.005**	Ecological	**0.015**	Ecological	**0.025**	Ecological
SAR	mmol/l	Upper	**2**	AIr	**8**	AIr	**15**	AIr
Sodium (Na)	mg/l	Upper	**70**	AIr	**92.5**	AIr	**115**	AIr
***SO_4**	mg/l	Upper	**80**	In2	**165**	In2	**250**	In2
TDS	mg/l	Upper	**200**	In2	**350**	In2	**800**	In2
Si	mg/l	Upper	**10**	In2	**25**	In2	**40**	In2

Basic Human Needs	BHN	Agriculture - Aquaculture	AAq
Domestic use	Dom	Industrial - Category 2	In2
Agriculture - Irrigation	AIr		

*Selected water quality variables used for the water quality status planning review

8. Current Water Quality Status of South Africa's Surface Water Resources

8.1 National Water Quality Status

The water quality of South African surface water resources was assessed based on the fitness for use generic RWQOs that have been set for the country (refer to Table 1). Only 48 of the 276 (17%) monitoring points assessed at a national scale complied with the RWQOs for all water quality variables.

This implies that approximately 83% of water resources have some implication for the fitness for use for one or other user group. The water quality variables assessed included electrical conductivity (EC), Sulphate (SO4), Chloride (Cl-), Orthophosphate (PO4-P), Ammonia (NH3-N) and pH. The summary results of the assessment are reflected in Figure 3 below. A national water quality status map (2006 to 2008) (A2 size) is available in Appendix D as a fold out at the back of this report.

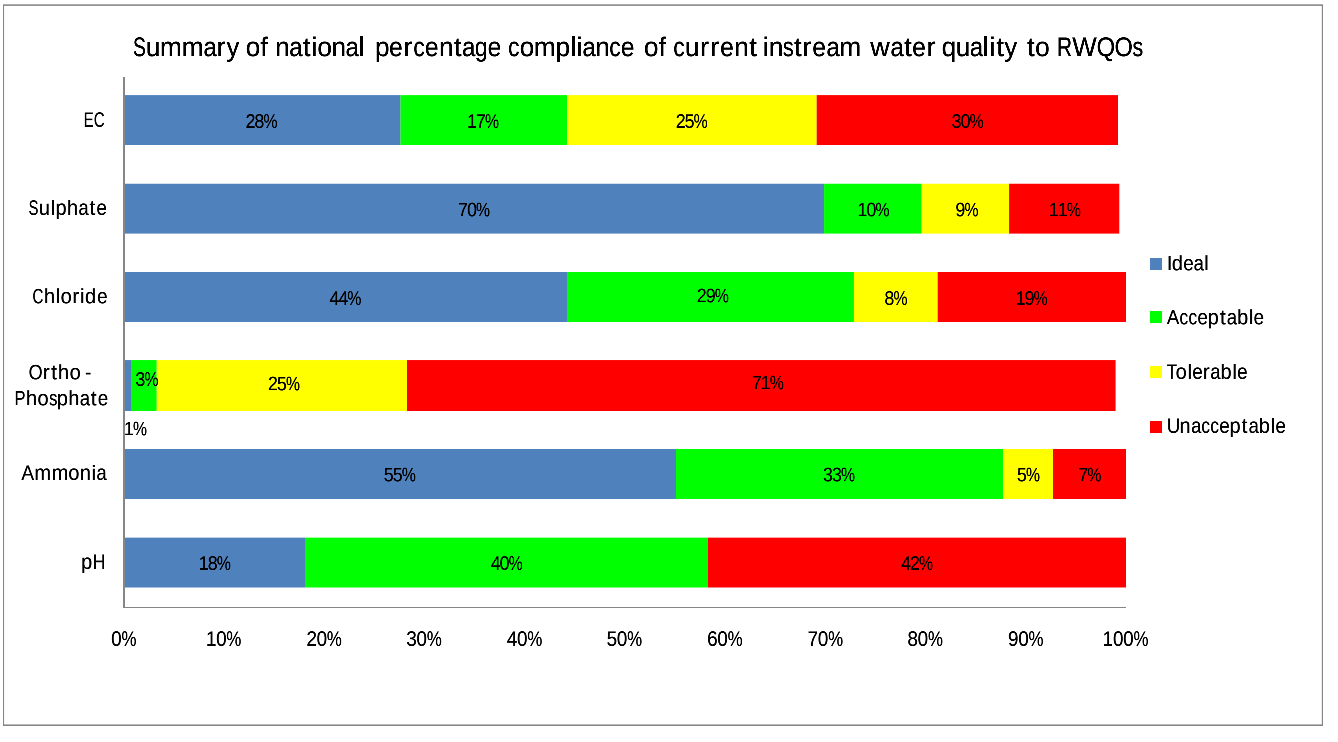


Figure 3: Summary of the national percentage compliance of in stream water quality with RWQOs at the 276 selected monitoring sites (2006 to 2008)

8.2 Results

8.2.1 Salinity

EC is proportional to the TDS concentration of water and thus is an estimate of TDS concentration. TDS is generally used as an aggregate indicator of the presence of a broad array of chemical contaminants. The primary sources of TDS in receiving water resources are agricultural runoff, point source water pollution from industrial and domestic wastewater and leaching of soil contamination. Salinisation is another major water quality issue identified at a national scale.

EC compliance indicates that 30% of the monitoring sites have unacceptably high levels (>85 mS/m) of salts, and 25% within the tolerable range (>50 to ≤ 85 mS/m). Figure 4 presents the compliance rating of monitoring sites for EC.

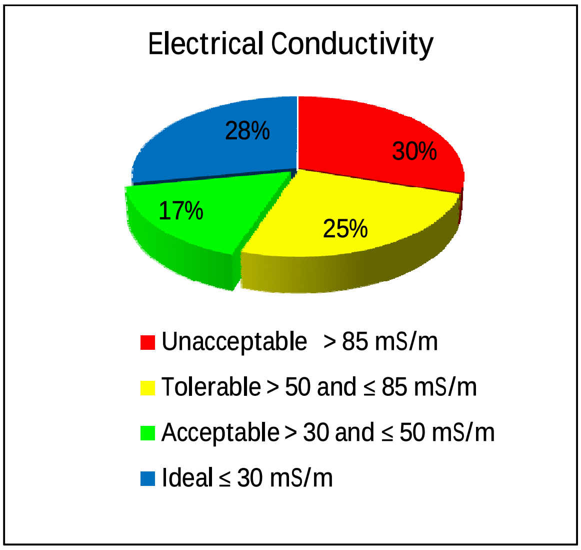


Figure 4: Percentage compliance of water quality with the EC RWQO set at monitoring points assessed

Results of the compliance assessment of sulphate and chloride with their respective set RWQOs indicate that neither poses a significant national scale threat to water users. Compliance indicates that 11% of monitoring sites show unacceptably high levels of sulphate and 19% unacceptably high levels of chloride (Figure 5 and Figure 6).

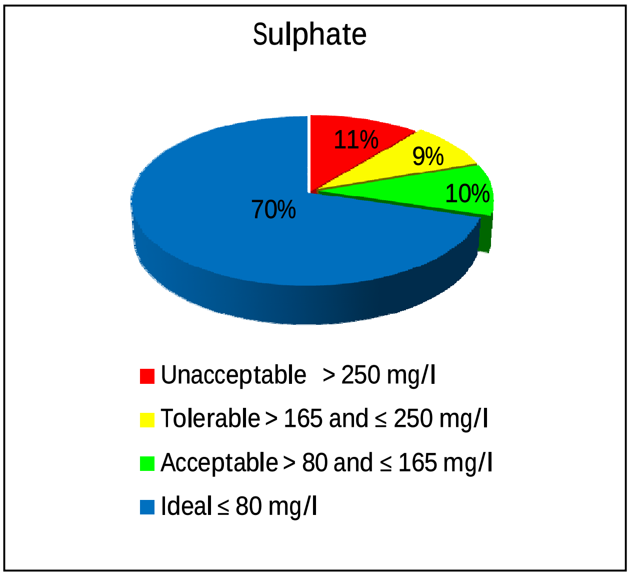


Figure 5: Percentage compliance of water quality with the sulphate RWQO set at monitoring points assessed

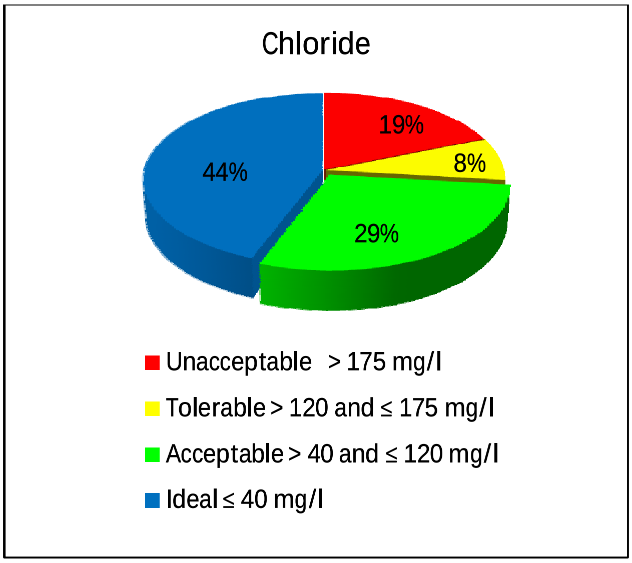


Figure 6: Percentage compliance of water quality with the chloride RWQO set at monitoring points assessed

8.2.2 Nutrients

Results show that the levels of nutrients in the country's water resources are the most concerning water quality problem. Only 29% of the monitoring sites showed compliance to the prescribed RWQO ranges (≤0.025mg/l) for phosphate (see Figure 7). There is currently a 71% non-compliance at a national scale. The current status and the resulting eutrophication is a threat to the aquatic ecosystem health of our water resources and to domestic water supply (see Text Box 7 and Text Box 8).

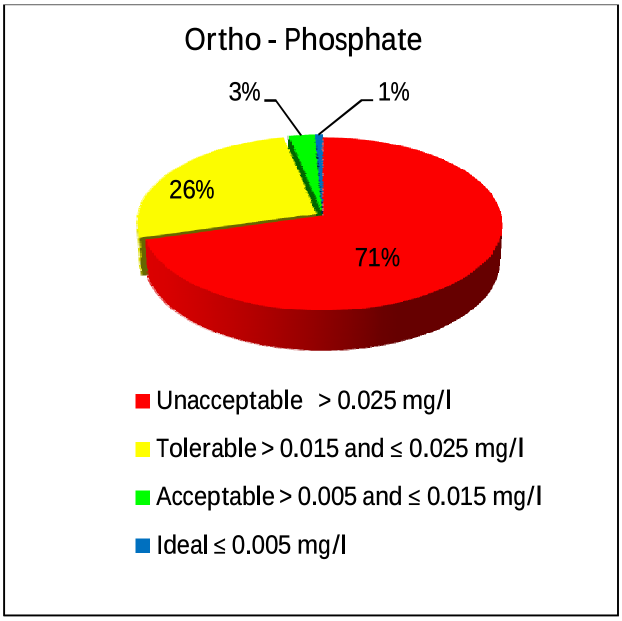


Figure 7: Percentage compliance of water quality with ortho-phosphate RWQO set at monitoring points assessed

Nitrate was not selected as a variable as part of this planning level review of surface water quality used as nitrate indicated a 100% compliance to the RWQO limits. This is due to the lenient RWQO of 6 mg/l defined for the ideal level. The current status indicates that nitrate concentrations pose no threat to domestic water supply. However the implications for aquatic health still need to be determined.

With regard to the levels of ammonia, 55% of the sites assessed show a compliance to the ideal RWQO of ≤ 0.015mg/l. This reflects a fairly good situation of the aquatic health of water resources. Only 7% of the sites assessed show unacceptably high levels (>0.073 mg/l) of ammonia (Figure 8).

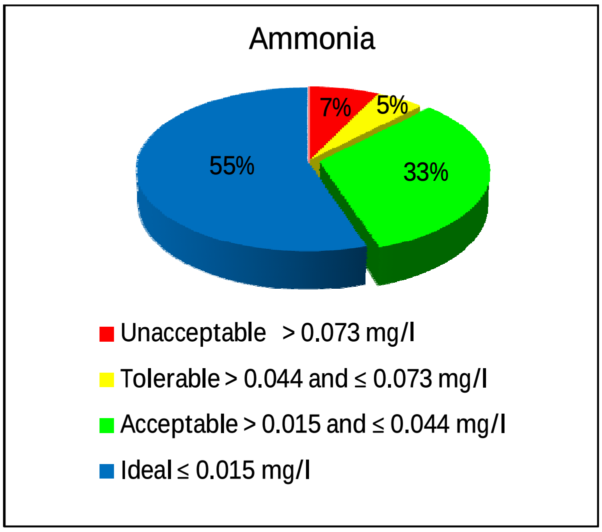


Figure 8: Percentage compliance of water quality with the ammonia RWQO set at monitoring points assessed

8.2.3 pH

In terms of the pH of the country's water resources, 42% of the monitoring sites are non-compliant in terms of the RWQO. Of these sites 86% exceed the upper limit of 8.4 pH units. Four sites displayed low pH (<5) which is due natural characteristics of the system. All these sites are located on water resources in the Gouritz WMA in the K primary drainage region, which are influenced by natural humic acid concentrations during low flows.

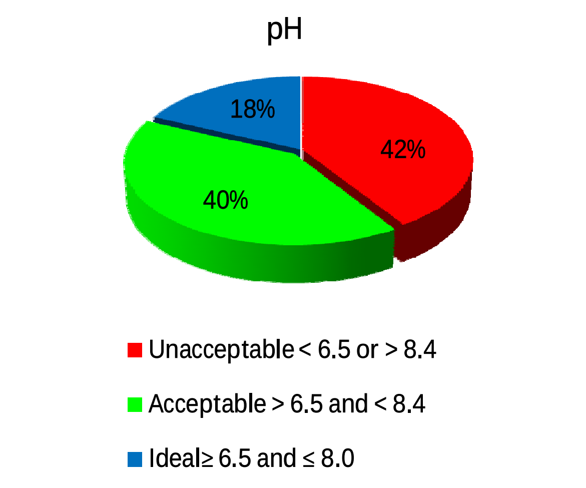


Figure 9: Percentage compliance of water quality with the pH RWQO set at monitoring points assessed

8.2.4 Water Quality Trends

Water quality trends where they could be determined are summarized in Table 2 and detailed in Appendix B, and are depicted on the water quality status maps in Section 9 and Appendix D. The results reflect that for the monitoring points assessed 69% show a deteriorating chloride trend, the highest for the six variables assessed, followed by ammonia at 63% of the points and then EC at 51% of the points.

Phosphate in terms of the current status assessment is at an unacceptable quality range at 71% of the monitoring points assessed however 37% of the points indicate an improvement, with 20% being stable and 35% deteriorating. The pH of water resources shows the highest improving trend (at 58% of points).

8.2.5 General Remarks

Overall current state water quality at a national scale appears to be at an acceptable level, with the only major threat to fitness for use being phosphate concentrations (indicative of possible eutrophication). Eutrophication is a looming threat, and the country's water resources are considered to be a high risk from elevated nutrient levels.

The status assessment has identified that high salinity concentrations is currently a problem and 51% of the sites have a deteriorating trend.

A summary of the water quality issues and concerns and possible consequences per WMA is presented in Section 9.

Text Box 6: Percentiles

Did you know?

A percentile is the value of a variable below which a certain percent of observations fall. So the 95th percentile is the value (or score) below which 95 percent of the observations are found. The term percentile is often used in descriptive statistics.
Analysis of water quality data is very often reported on in terms of percentiles (usually 5th, 50th, 75th and 95th percentile values). The percentile value is used to describe the main features of the water quality data set quantitatively (descriptive statistic)
For example:
A 95th percentile value for ortho-phosphate of 1.0 mg/l implies that 95% of the data set of phosphate values are below 1.0 mg/l.

Table 2: Summary of National Water Quality Trends per variable at the monitoring points assessed

Trend		Water Quality Variable					
		Electrical Conductivity	Sulphate	Chloride	Ortho-phosphate	Ammonia	pH
Improving	J	37%	38%	30%	37%	11%	58%
Deteriorating	L	51%	30%	69%	35%	63%	16%
Stable	-	8%	26%	0.4%	20%	22%	22%

Where: % indicates the number of water quality monitoring sites that have either improved, deteriorated or remained stable over the assessment period.

Text Box 7: Eutrophication and its effects

"Eutrophication" is an ecological term that is used to describe the process by which a water body becomes enriched with plant nutrients such as phosphorus and nitrogen. This results in a range of undesirable changes, including over-production of algae and aquatic plants (rooted and free floating macrophytes), and the deterioration of water quality and other symptomatic changes which may interfere with water uses. This process is reversible through the management of nutrient sources.

The trophic status of a water body describes the degree of enrichment with plant nutrients. Oligotrophic means the presence of low levels of nutrients and no water quality problems; Mesotrophic means intermediate levels of nutrients, with emerging signs of water quality problems; Eutrophic means high levels of nutrients and an increased frequency of water quality problems; and Hypertrophic means excessive levels where plant production is governed by physical factors. Water quality problems are almost continuous.

The link between aquatic plant growth, nutrients and human activities (eutrophication) was first noted in the early part of this century. However, it was not until after the 1960s that a clear scientific understanding of eutrophication was developed. Phosphorus is recognised as the fundamental cause of eutrophication because clear correlations have been observed between algal growth and phosphorus concentrations in lakes and reservoirs, and phosphorus availability determines the influence of the other nutrients. Nitrogen plays a secondary role, but can become important at a high level of eutrophication. In this case nitrogen-fixing cyanobacteria can cause a much more significant nuisance than other types of algae.

Water quality problems associated with excessive eutrophication are numerous and may be either long- or short-term. The problems include, amongst others:

- Increased occurrence and intensity of nuisance algal blooms;
- An increasing dominance by cyanobacteria and occurrence of toxic cyanobacteria;
- Increased occurrence of floating and rooted aquatic macrophytes;
- Increased occurrence of taste and odour problems in final drinking water;
- Increased occurrence of deoxygenation in reservoir bottom waters with associated chemical effects (hydrogen sulphide and elevated levels of heavy metals);
- Increased fish and invertebrate mortality;
- Changes of ecological community structure and loss of biodiversity;
- Increased water treatment costs due to the need for filter cleaning and toxin removal in water treatment works (WTW);
- Increased interference in recreation activities (boating, fishing, swimming);
- Increased occurrence of human health problems (gastroenteritis, skin complaints);
- Loss of property values;
- Interference with irrigation and livestock agriculture (e.g. clogging of irrigation nozzles and livestock mortality);
- Undesirable aesthetic conditions (e.g. turbidity, foam, discolouration, odours).

Summarised from Walmsley, R.D. (2000). Perspectives on Eutrophication of Surface Waters: Policy/research needs in South Africa. WRC Report No KV129/00. Water Research Commission.

A typical cyanobacterial bloom – dense algae scum

Water hyacinth – Inanda Dam

Algal bloom – Krugersdrift Dam

Text Box 8: Eutrophication status of water resources of South Africa at selected impoundments

Eutrophication Status

The National Eutrophication Monitoring Programme (NEMP) of the Department provides information on the trend and status of nutrient enrichment in the country's reservoirs and lakes. The 2008-2009 report entails information or data from 78 priority reservoirs. The 2007-2008 hydrological report took into account sites from the inlet and outlet of the reservoirs to constitute the reported 106 NEMP sites. The 2008-2009 report (refer to figure below) indicates that the dams in the Crocodile-West and Marico, Upper Vaal, Middle Vaal, Lower Vaal and Berg WMAs are hypertrophic and show symptoms of serious eutrophication (e.g. the Erfenis, Allemanskraal and Koppies Dams). Other WMAs are not that affected e.g. the Levuvhu-Letaba WMA.

There is a need to focus more on methods that can be implemented through policies to reduce nutrient enrichment in our water resources. In the 1980s, the Department of Water Affairs issued a special phosphorus standard (1 mg P/ℓ) on effluent discharged into sensitive catchments in an attempt to reduce nutrient enrichment in surface water resources. A stricter approach of phosphorus standard in Wastewater Treatment Works (WWTWs) and other related industries need to be enforced. A number of initiatives funded by different stakeholders including the Department have been put in place to develop in-lake eutrophication or nutrient enrichment management.

Harties Metsi-a Me Project (Hartebeespoort Dam) is an over-arching project that looks at a wide variety of short-term and long-term methods to control the eutrophication status of the Hartbeespoort Dam. Tshwane Metropolitan Council funded the acquisition and installation of six (6) Solar-Bee's pump stations at Rietvlei dam (11 July 2008). Solar-Bee, a solar powered aeration pump system, is a step towards finding solutions to in-lake eutrophication. The Water Research Council (WRC) is funding/has funded a number of eutrophication management studies in which the Department is supporting in various ways (DWA, Resource Quality Services, Annual National State of Water Resources Report 2008/2009 - *in publication*).

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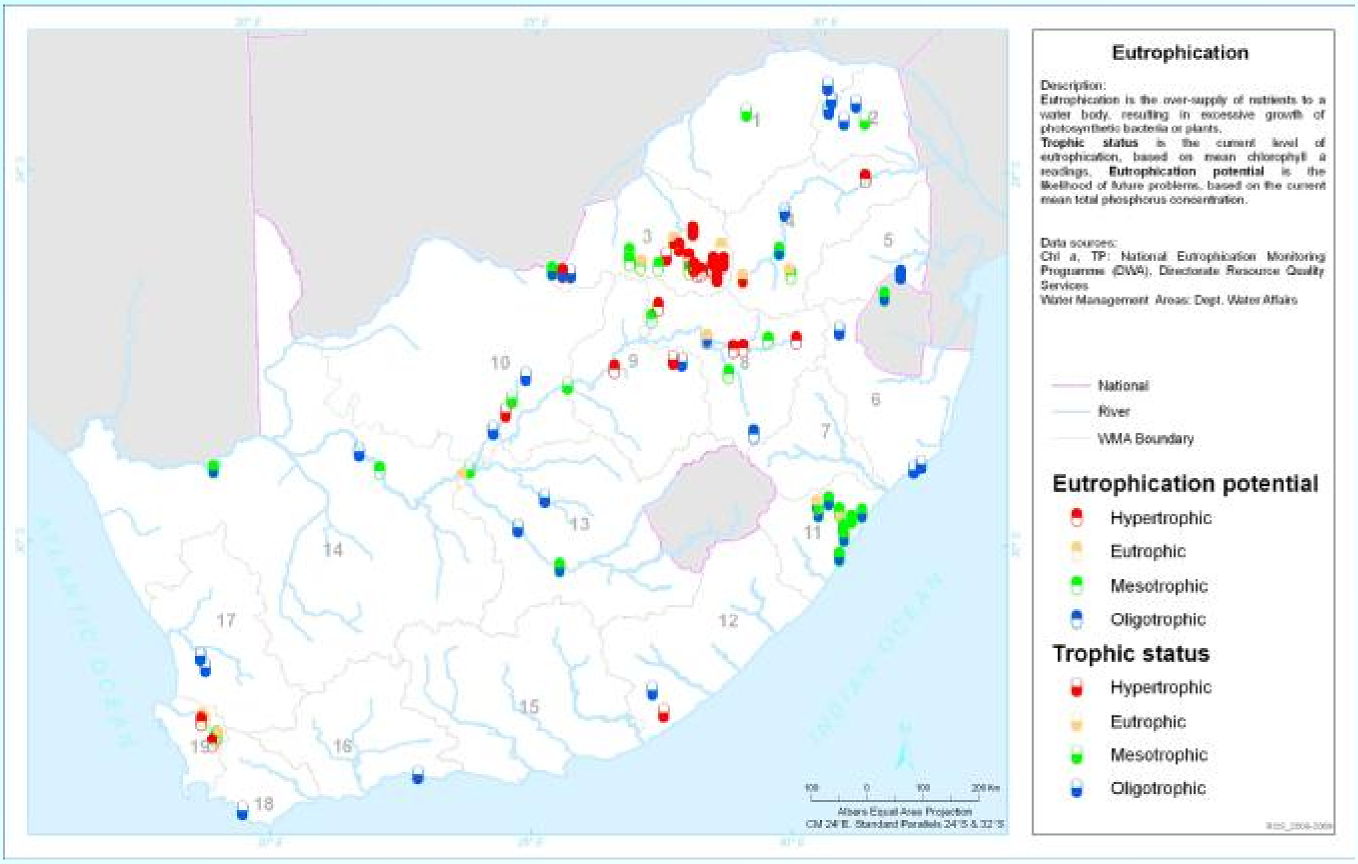

9. Water Quality Status per Water Management Area

In the following sections the water quality status per WMA is described in detail. The current water quality status is presented, as well as trends observed from 1999 to 2008. In addition the water quality issues of concern and important WMA related considerations are described.

A summary of the water quality issues and associated drivers and water quality status in terms of fitness for use are described below in Table 3 and Table 4 respectively. The water quality issues were identified and confirmed through four regional stakeholder workshops held in Cape Town, Bloemfontein, Pretoria and Durban. Regional DWA personnel from all offices and identified stakeholders from each province attended the workshops and made contributions to the water quality status assessment of surface water resources to support the planning level review (see Appendix C for list of participants). The water quality results of the status assessment were discussed and fitness for use confirmed. Associated sources of impact and related consequences were also documented.

Table 3: Summary of water quality issues identified within each of the WMAs

WMA	Water Quality Issue	Driver	Effect
WMA 1: Limpopo	Eutrophication (Nutrient enrichment)	Waste water treatment works, Intensive agriculture fertilizer use and dense urban sprawl un-serviced sewage.	Algal growth, smell, toxic algae, water treatment extra costs, taste and odour, irrigation clogging, aesthetics, recreational water users.
	Microbial contamination	Waste water treatment works, Informal dense settlements.	Recreational users (human health), washing and bathing.
	Turbidity	Informal dense settlements, subsistence agriculture, Mining and agriculture.	Water treatment costs, irrigation clogging.
	Salinisation	Mines (operational and abandoned), Waste water treatment works and agricultural runoff	Water treatment costs, soil salinity, irrigation system clogging.

WMA	Water Quality Issue	Driver	Effect
WMA 2: Luvuvhu and Letaba	Eutrophication (Nutrient enrichment)	Wastewater treatment works, Intensive agriculture fertilizer use, and dense urban sprawl un-serviced sewage.	Algal growth, smell, toxic algae, taste and odour, irrigation clogging, aesthetics, recreational water users.
	Microbial contamination	Wastewater treatment works and Informal dense settlements.	Recreational users (human health), washing and bathing.
	Turbidity	Informal dense settlements Urbanisation, forestry, mining, agriculture,	Dam and weir sedimentation, irrigation clogging.
	Salinisation	Wastewater treatment works, agricultural (intensive irrigation) and mines (operational and abandoned).	Increased water treatment costs, soil salinity and irrigation system clogging.
	Toxicants*	Pesticides (subtropical fruits, nuts) industry and DDT for malaria control.	Fish kills, human health impacts, bioaccumulation of pollutants in fish and crocodiles and crocodile deaths.
	Altered flow regime	Dams and weirs, Inter-basin transfers.	Increased turbidity (erosion), algal growth, water temperature increase, dissolved oxygen changes, taste and odour changes, impact on recreational water users, fish kills, and habitat reduction due to changed environmental flows.

*see Text Box 9 for more information on Toxicants

WMA	Water Quality Issue	Driver	Effect
WMA 3: Crocodile West and Marico	Eutrophication (Nutrient enrichment)	Wastewater treatment works, Intensive agriculture fertilizer use, and dense urban sprawl un-serviced sewage.	Algal growth, smell, toxic algae, water treatment extra costs, taste and odour, irrigation clogging, impact on aesthetics and recreational water users.
	Microbial contamination	Wastewater treatment works, Informal dense settlements.	Impact on recreational users (human health), washing and bathing.
	Turbidity	Informal dense settlements, Urbanisation, mining, agriculture, and point source discharges.	Dam sedimentation, increase in water treatment costs and irrigation clogging.
	Salinisation	Wastewater treatment works agricultural (intensive irrigation) and mines (operational and abandoned).	Increased water treatment costs, soil salinity and irrigation system clogging.
	Toxicants*	Pesticides industry	Fish kills, bioaccumulation of pollutants in fish and crocodiles.

WMA	Water Quality Issue	Driver	Effect
WMA 4: Olifants	Eutrophication (Nutrient enrichment)	Wastewater treatment works, Intensive agriculture fertilizer use and dense urban sprawl un-serviced sewage.	Algal growth, smell, toxic algae, increased water treatment costs, taste and odour problems, increased irrigation clogging, impact on aesthetics and recreational water users.
	Microbial contamination	Wastewater treatment works and informal dense settlements.	Impact on recreational users (human health), washing and bathing.
	Turbidity	Informal dense settlements, urbanisation, mining, agriculture and point source discharges.	Dam sedimentation, increased water treatment costs and irrigation clogging.
	Salinisation	Mines (operational and abandoned), wastewater treatment works and agricultural (intensive irrigation).	Increased water treatment costs, soil salinity and irrigation system clogging.
	Toxicants*	Pesticides (subtropical fruits, nuts) industry	Fish kills, bioaccumulation of pollutants in fish and crocodiles and crocodile deaths.
	Altered flow regime	Dams and weirs	Turbidity (erosion), algal growth, water temperature increase, dissolved oxygen changes, taste and odour changes, impact on recreational water users, fish kills and changes in environmental flows.
	Acid mine drainage	Mines (operational and abandoned) and controlled releases .	Mobilisation of metals, fish and crocodile deaths, bioaccumulation of pollutants in fish and crocodiles.
	Metal contamination	Mines (operational and abandoned)	Mobilisation of metals, fish kills, bioaccumulation and crocodile deaths in Loskop Dam.

*see Text Box 9 for more information on Toxicants

WMA	Water Quality Issue	Driver	Effect
WMA 5: Inkomati	Eutrophication (Nutrient enrichment)	Wastewater treatment works, Intensive agriculture fertilizer use and dense urban sprawl un-serviced sewage.	Algal growth, smell, toxic algae, increased water treatment costs, taste and odour changes, irrigation clogging, impact on aesthetics and recreational water users.
	Microbial contamination	Wastewater treatment works and informal dense settlements.	Impact on recreational users (human health), washing and bathing and potential for water borne diseases.
	Turbidity	Informal dense settlements, urbanisation, forestry, mining, agriculture and point source discharges.	Dam sedimentation, increased water treatment costs and irrigation clogging.
	Salinisation	Wastewater treatment works, agricultural (intensive irrigation) and mines (operational and abandoned).	Increased water treatment costs, soil salinity and irrigation system clogging.
	Toxicants*	Pesticides (subtropical fruits, nuts) industry	Fish kills, bioaccumulation of pollutants in fish and crocodiles and crocodile deaths.
	Altered flow regime	Dams and weirs Inter-basin transfers	Turbidity (erosion), algal growth, water temperature increase, dissolved oxygen changes, taste and odour changes, impact on recreational water users, fish kills, habitat reduction due to altered flows.
	Acid mine drainage	Mines (operational and abandoned) and controlled releases.	Mobilisation of metals, fish and crocodile deaths, bioaccumulation of pollutants in fish and crocodiles.
	Metal contamination	Mines (operational and abandoned)	Mobilisation of metals, fish kills, bioaccumulation of pollutants into fish and the food chain (crocodiles and birds).

*see Text Box 9 for more information on Toxicants

WMA	Water Quality Issue	Driver	Effect
WMA 6: Usutu to Mhlathuze	Eutrophication (Nutrient enrichment)	Irrigation runoff rich in nutrients, and treated wastewater return flows.	Eutrophication problems in upper reaches of Pongolapoort Dam, animal deaths due to toxic algae and eutrophication of Klipfontein Dam (Upper Mfolozi).
	Microbial contamination	Faecal pollution in rural catchments. Poor sanitation. Wastewater treatment works Informal dense settlements.	Water borne disease Outbreaks of cholera and diarrhoea High health risk to infants, elderly and immuno-compromised individuals
	Salinisation	High salinity in irrigation return flows	Increased salts in downstream rivers and dams (Pongolapoort Dam, middle & lower Mhlathuze, lower Mkuze/Hluhluwe)
	Acid mine drainage	Coal mining activities in headwaters of Pongola, Mfolozi & Mkuze rivers	Low pH, elevated sulphur and iron. Elevated salts and dissolved metals.
	Suspended sediment loads	Land-degradation and over-grazing	High suspended solid loads during high flows and silting up of rivers.

WMA	Water Quality Issue	Driver	Effect
WMA 7: Thukela	Eutrophication (Nutrient enrichment)	Poor wastewater treatment works (Green Drop Report, 2009), intensive agriculture fertilizer use, informal settlements, high rural population density (56/km^2). Poor sanitation.	Algal blooms, toxic cyanobacteria (health risk), increased water treatment costs, taste and odour problems, impacts on aesthetics and recreational water users, etc.
	Salinisation (especially Buffalo River)	Coal mines (operational and abandoned) – AMD, Industries from New Castle and Dundee area, wastewater treatment works and agriculture (irrigation).	Increased water treatment costs, soil salinity, drip irrigation system clogging.
	Suspended sediment loads	Soil erosion, severe overgrazing (e.g. subsistence agric area, Mweni valley, etc.)	Siltation of rivers, weirs, and dams and loss of habitat.
	Paper pollution (air, water and land)	Sappi Paper Mill at Mandini (toxic POP dioxine, high BOD, DOC, etc.)	Environmental health, reduction in biodiversity and fish kills.

WMA	Water Quality Issue	Driver	Effect
WMA 8: Upper Vaal	Eutrophication (Nutrient enrichment)	Wastewater treatment works, intensive agriculture fertilizer use and dense urban sprawl un-serviced sewage.	Algal growth, smell, toxic algae, taste and odour, greater treatment costs, irrigation clogging, fish kills, impact on aesthetics and recreational water users.
	Microbial contamination	Wastewater treatment works and informal dense settlements.	Impact on recreational users (human health), washing and bathing.
	Salinisation	Mines (new, operational and abandoned), wastewater treatment works agricultural (intensive irrigation) and atmospheric deposition.	Increased water treatment costs, soil salinity, irrigation system clogging and increased vulnerability to the water that is transferred.
	Turbidity	Informal dense settlements, urbanisation, mining and agriculture.	Dam and weir sedimentation, irrigation clogging and habitat loss.
	Toxicants*	Wastewater treatment works, intensive agriculture fertilizer use and dense urban sprawl un-serviced sewage.	Fish kills, bioaccumulation of pollutants into fish and the food chain (crocodiles and birds).
	Acid mine drainage	Mines (operational and abandoned) and controlled releases.	Low pH, elevated sulphur and iron, elevated salts and dissolved metals.

*see Text Box 9 for more information on Toxicants

WMA	Water Quality Issue	Driver	Effect
WMA 9: Middle Vaal	Eutrophication (Nutrient enrichment)	Poor wastewater treatment works (see Green Drop Report, 2009), dense urban sprawl un-serviced sewage – informal settlements and intensive agriculture fertilizer use.	Algal blooms (increasing), toxic cyanobacteria (health risk), increased water treatment costs, taste and odour problems, undesirable aesthetics condition and impeding of recreational water use, etc.
	Microbial contamination	Wastewater treatment works and dense informal settlements.	Impact on recreational users (human health), health risk to drink raw water, washing and bathing.
	Salinisation	Gold mines (operational and abandoned) – especially KOSH area (~150 Mℓ/d, EC 500 mS/m), wastewater treatment works and agriculture (irrigation).	Soil salinisation, lower crop yield, drip irrigation system clogging and increased water treatment costs.
	Altered flow regime and less flow in river (River Regulation))	Dams and weirs	Seasonal flow changes, ecological water requirement changes, turbidity (erosion), algal growth, smell, water temperature increase, fish kills and changes in environmental flows.
	Radioactivity	Discarded mine dumps	Bioaccumulation of pollutants into fish and the food chain (crocodiles and birds), aquatic organisms, soils and humans. Carcinogenic effects.

WMA	Water Quality Issue	Driver	Effect
WMA 10: Lower Vaal	Salinisation (Vaal, and Harts rivers)	Agriculture (intensive irrigation – Vaalharts scheme) return flows (82% water requirements) and wastewater treatment works.	Degrade soil (79 - 280 t salts/ha), salt-induced water stress reduce the crop yield, impact on sustainability of agriculture and increased water treatment costs.
	Eutrophication (Spitskop Dam - eutrophic)	Intensive agriculture fertilizer use, nutrients from Upper and Lower Vaal WMA, wastewater treatment works and dense urban sprawl un-serviced sewage.	Toxic cyano-bacterial blooms, increased water treatment costs, taste and odour problems, irrigation clogging, impacts on aesthetics, limit recreational water use, etc.
	Microbial contamination	Wastewater treatment works and informal dense settlements.	Impact on recreational users (human health), washing and bathing.
	Altered flow regime and less flow in river (River Regulation)	Dams and weirs	Seasonal flow changes, ecological water requirement changes, turbidity (erosion), algal growth, smell impact on recreational water users, fish kills and habitat reduction due to altered flows temperature increase.

WMA	Water Quality Issue	Driver	Effect
WMA 11: Mvoti to Umzimkulu	Eutrophication (Nutrient enrichment)	Poor wastewater treatment works (e.g. Msunduzi local municipality), agriculture fertilizer use, feedlots, dairies, piggeries and dense informal settlements.	Toxic cyanobacterial blooms – health risk, bad tasting water, macrophytic growth – e.g. hyacinths in lower Umgeni and increased water treatment costs.
	Microbial contamination	wastewater treatment works, dense informal settlements – (Umhlanga River mouth, Msunduze River, Umzinto area, Phosphorus and *E. coli* are increasing in Midmar)	Health risk for recreational users, drinking raw water, washing and bathing.
	Sediments (Suspended solids – Turbidity)	Soil erosion (especially Mdloti catchment), due to settlement patterns, overgrazing, poor agricultural activities and sand mining.	Siltation of dams, e.g. Hazelmere (20 % reduction capacity)
	Paper Mill pollution	Effluent from sugar and paper mills	Impact on environmental health, lower biodiversity.

WMA	Water Quality Issue	Driver	Effect
WMA 12: Mzimvubu to Keiskamma	Eutrophication (Nutrient enrichment)	Poorly treated wastewater, urban runoff and failing sewage infrastructure.	Eutrophication of Laing and Bridledrift Dam . Poor microbial water quality.
	Microbial pollution (point and diffuse sources)	Untreated or partially treated wastewater enter river systems, poor maintenance of wastewater infrastructure, inadequate design of sanitation systems (Mthatha, Tsolo, Ugie, Maclear, East London etc.).	Health risks to local residents and water users and outbreaks of water-borne diseases such as cholera.
	Salinisation	Semi-closed loop system in Buffalo River system.	Increase in salinity only alleviated during floods.
	Suspended sediment loads	Degradation and overgrazing of communal lands	High sediment loads during flood events Silting up of structure.
	Leaching from solid waste sites	Unlicensed and/or poorly designed solid waste sites in rural towns	Organic loads to streams and rivers Heavy metals.

WMA	Water Quality Issue	Driver	Effect
WMA 13: Upper Orange	Eutrophication (especially Modder River)	Wastewater treatment works, dense urban sprawl un-serviced sewage and intensive agriculture fertilizer use.	Algal blooms, toxic cyanobacteria, increased water treatment costs, taste and odour, impeding of recreational water use, etc.
	Salinisation (especially Riet and Modder; lesser extent Caledon and Orange)	Agricultural (intensive irrigation – return flows), wastewater treatment works.	Degradation of soil, salt-induced water stress reduces the crop yield, impact on sustainability of agriculture and increase in water treatment costs.
	Sediment (Turbidity) (especially Orange & Caledon rivers)	Erosion – naturally high, enhanced by poor farming methods and sand mining.	Siltation of Dams (e.g. Welbedacht –86 % storage capacity).
	Inter-basin transfers (Orange River)	Growing population and an expanding economy; Vaal River, Gauteng, Great-Fish, Eastern Cape.	Less flow in river, seasonal flow changes and ecological water requirement changes.
	Reduced stream flow (especially Orange River)	Dams and weirs, domestic and agricultural use.	Altered flow regime, homogenized the flow, blockage of fish migration, impact on recreational water users, fish kills and habitat reduction due to altered flows.

WMA	Water Quality Issue	Driver	Effect
WMA 14: Lower Orange	Eutrophication (Nutrient enrichment)	Intensive agriculture fertilizer use and wastewater treatment works.	Algal blooms, toxic cyanobacteria (health risk), irrigation clogging, impact on aesthetics and recreational water users, etc.
	Salinisation	Agricultural intensive irrigation – return flows, high evaporation, wastewater treatment works and reduced flow.	Soil salinisation – lower productivity and irrigation system clogging.
	Less sediment (lower turbidity in Orange River)	Sedimentation in impoundments, lower flow.	Increased under water light climate – stimulate algal growth.
	Reduced stream flow (e.g. Orange 60 % at Upington, over the past 70 years)	River diversions (primarily for irrigation), inter basin transfers and evapo-transpiration.	Increases the susceptibility of the river to pollution; reduces its capacity to attenuate and degrade wastes; Concentration of pollutants and increased salinity and Reduced dilution effects.
	Metal contamination (Aluminium, Cadmium, Copper and Lead)	Uncertain, Mines (operational and abandoned)	Potentially harmful for human health and for the aquatic environment.

WMA	Water Quality Issue	Driver	Effect
WMA 15: Fish to Tsitsikamma	Salinisation	Fish and Sundays rivers naturally saline. Flat topography, low MAR, high evaporation, underlying mudstones, saline groundwater and resulting saline base flows.	Affects on fruit growing industries, negative impacts on crop yields, corrosion of appliances and domestic water supply.
	Urban rivers	Poor quality stormwater runoff and dry weather flow from dense settlements.	Poor bacterial water quality. Human health risks and impacts on ecosystems (low DO).
	Compliance to effluent standards	Poor operations at wastewater treatment works result in poor quality effluent discharges.	Poor microbiological quality downstream of discharge points. Eutrophication problems in rivers and dams.
	Industrial impacts	Industrial impacts in Uitenhage/Port Elizabeth area	Heavy metal pollution and ecosystem impacts.
	Agrochemicals	Pesticide and herbicide use in intensive irrigation agriculture residues, Persistent Organic Pollutants[#](POPs) and Endocrine Disrupting Chemical (EDCs).	Hormonal imbalances, bioaccumulation of pollutants in fish, aquatic organisms, soils, humans and up and the food chain. Carcinogenic effects.

[#]see Text Box 10 for more on Persistent Organic Pollutants (POPs)

WMA	Water Quality Issue	Driver	Effect
WMA 16: Gouritz	Salinisation	Natural geology High evaporation	Water unsuitable for irrigation agriculture. Corrosion of appliances and equipment. Alteration of the taste of domestic water.
	Urban impacts on water quality	Densely populated urban areas on coast, urban runoff, treated wastewater not meeting standards and runoff from informal settlements.	Poor bacterial water quality. Impacts on downstream users. Human health risks. Low dissolved oxygen & ecosystem impacts.
	Microbial and organics contamination	Vandalism of sewage reticulation system and pumping infrastructure. Sewage spills into receiving streams Oudtshoorn for example.	Poor bacterial water quality. Impacts on downstream users. Human health risks and low dissolved oxygen & ecosystem impacts.
	Wood processing waste	Disposal of wood processing waste in the coastal catchment. Some saw mill operators are without permits.	Leachate with high organic acids and COD. Low dissolved oxygen and ecosystem impacts.

WMA	Water Quality Issue	Driver	Effect
WMA 17: Olifants/Doorn	Nutrient enrichment in upper Olifants	Agricultural return flows, effluent from fruit and wine industries high in nutrients and high P concentrations in effluent discharges.	Algal growth potential in Clanwilliam and Bulshoek dams. Stimulation of growth of filamentous algae in canals. Interference with canal structures and irrigation equipment.
	Microbial contamination in the upper Olifants	Poor quality effluents from Citrusdal and Clanwilliam.	Negative impacts on export fruit industry (Eurepgap certification). Endangers household use of irrigation canal water.
	Salinisation of middle and lower Olifants	Intensive irrigation agriculture (LORWUA). Irrigation return flows to Olifants River.	Increase in salinity. Water unusable for downstream users, Tastes, corrosion, etc.
	Agro-chemicals	Pesticide and herbicide residues and endocrine disrupting chemicals.	Hormonal imbalances Bioaccumulation of pollutants into fish, aquatic organisms, soils, humans and up and the food chain. Carcinogenic effects.

WMA	Water Quality Issue	Driver	Effect
WMA 18: Breede	Nutrient enrichment of Breede	Leaching of fertilisers and wastewater high in nutrients.	Algal blooms in some reaches of Breede. Excessive growth of filamentous algae in river and canals.
	Microbial contamination	Discharge of inadequately treated wastewater, irrigation with untreated winery and industrial effluents and diffuse pollution from high density settlements.	Affect export fruit industry. Human health impacts. Recreation impacts .
	Salinisation of Breede River	Natural geology and soils. Irrigation return flows, leaching of salts from new lands and salinisation of Riviersonderend.	River water unusable for irrigation users downstream of Zanddrift canal. Corrosion of appliances and equipment. Possible inefficient water use.
	Agrochemicals	Pesticide residues found in Hex River. Probably present in rest of basin.	Hormonal imbalances. Bioaccumulation of pollutants into fish, aquatic organisms, soils, humans and up and the food chain. Carcinogenic effects.

WMA	Water Quality Issue	Driver	Effect
WMA 19: Berg:	Nutrient enrichment	Wastewater discharges, fertiliser wash off, winery effluents and informal settlements.	Nuisance algal blooms in lower Berg and Voëlvlei Dam. Filamentous algae in shallow rivers and increased water treatments costs.
	Microbial contamination	Runoff from informal and high density settlements. Inadequate wastewater treatment.	Human health impacts. Impacts of fruit export industry. Ecosystem impacts.
	Salinisation of middle and lower Berg	Natural geology, irrigation return flows and agricultural practices.	Increased salinity in middle and lower Berg River. Water less suitable for irrigation users and impacts on industrial and domestic users.
	Urban rivers	Urban rivers conduits for treated wastewater. Toxic spills and high COD.	Eutrophication problems, excessive growth of aquatic weeds and ecosystem impacts.
	Agrochemicals and EDCs	Residues of pesticides and herbicides, endocrine disrupting chemicals and persistent organic pesticides (POPs).	Hormonal imbalances. Bioaccumulation of pollutants in fish, aquatic organisms, soils, humans and up and the food chain. Carcinogenic effects.
	Change in state of Voëlvlei Dam	Low water levels in drought of 2004/5 changed state from clear to turbid reservoir.	Increased frequency of algal blooms. Increased water treatment costs.

Table 4: Summary of water quality compliance with RWQOs per WMA for monitoring sites assessed

WMA	Electrical Conductivity (EC)	Sulphate (SO_4)	Chloride (Cl)	Ortho-phosphate (PO_4-P)	Ammonia (NH_3-N)	pH
1 - Limpopo	33% 17% 50%	17% 83%	50% 50%	17% 50% 33%	100%	17% 66% 17%
2 - Luvuvhu and Letaba	12% 44% 44%	100%	22% 33% 45%	44% 56%	11% 89%	11% 56% 33%
3 - Crocodile (West) and Marico	15% 62% 15% 8%	23% 77%	15% 46% 39%	69% 23% 8%	15% 8% 62% 15%	54% 46%
4 - Olifants	43% 36% 7% 14%	43% 7% 50%	14% 14% 21% 50%	36% 64%	64% 36%	57% 36% 7%
5 - Inkomati	7% 29% 14% 50%	7% 93%	29% 71%	43% 57%	14% 86%	29% 50% 21%
6 - Usustu to Mhlatuze	19% 25% 25% 31%	7% 7% 86%	19% 6% 19% 56%	50% 50%	6% 38% 56%	31% 31% 38%
7 - Thukela	10% 40% 50%	10% 90%	100%	80% 20%	10% 30% 60%	20% 60% 20%
8 - Upper Vaal	22% 34% 16% 28%	6% 22% 9% 63%	6% 34% 60%	91% 9%	15% 9% 38% 38%	53% 31% 16%
9 - Middle Vaal	50% 24% 13% 13%	13% 31% 6% 50%	19% 19% 38% 24%	100%	19% 12% 25% 44%	50% 44% 6%
10 - Lower Vaal	78% 22%	44% 44% 12%	11% 33% 56%	56% 44%	34% 44% 22%	78% 22%
11 - Mvoti to Mzimkulu	16% 16% 68%	100%	5% 26% 68%	32% 36% 21% 11%	5% 5% 32% 58%	16% 42% 42%
12 - Mzimvubu to Keiskamma	11% 20% 16% 53%	5% 95%	5% 11% 16% 68%	95% 5%	37% 63%	16% 79% 5%
13 - Upper Orange	16% 32% 32% 20%	5% 5% 90%	5% 32% 63%	84% 16%	16% 16% 68%	53% 47%
14 - Lower Orange	29% 29% 43%	100%	71% 29%	43% 57%	14% 14% 14% 57%	43% 57%
15 - Fish to Tsitsikamma	61% 18% 14% 7%	11% 18% 25% 46%	54% 7% 25% 14%	82% 18%	4% 7% 46% 43%	57% 29% 14%
16 - Gouritz	64% 18% 18%	35% 6% 18% 41%	64% 12% 12% 12%	94% 6%	6% 6% 24% 64%	47% 29% 24%
17 - Olifants Doorn	17% 17% 66%	17% 83%	17% 33% 50%	33% 67%	100%	50% 17% 33%
18 - Breede	72% 14% 14%	36% 21% 43%	72% 21% 7%	86% 14%	7% 7% 29% 57%	57% 14% 29%
19 - Berg	34% 22% 22% 22%	33% 67%	44% 44% 12%	100%	22% 78%	11% 22% 67%
Ideal range limit	30mS/m	80 mg/l	40 mg/l	0.005 mg/l	0.015 mg/l	≥6.5 - ≤8.0
Acceptable range limit	50 mS/m	165 mg/l	120 mg/l	0.015 mg/l	0.044 mg/l	>8.0 - ≤8.4
Tolerable range limit	85 mS/m	250 mg/l	175 mg/l	0.025 mg/l	0.073 mg/l	No range limit set
Unacceptable limit	> 85 mS/m	> 250 mg/l	> 175 mg/l	> 0.025 mg/l	> 0.073 mg/l	<6.5 and > 8.4

Text Box 9: Toxicants

Did you know? TOXICANTS

Exposures to toxic chemicals can occur through contaminated food and water, skin absorption, inhalation, or transmission from mother to child across the placenta, and in breast milk. It is quite evident that the impacts of toxicants on people and animals warrant concern and attention. Monitoring the degree to which toxicity and individual toxicants exist in water resources is one important component of establishing the extent to which these substances are a problem in South Africa.
Inorganic toxicants (like heavy metals) and organic toxicants (like many pesticides, petroleum products, pharmaceuticals, etc.) can enter water resources and have devastating impacts on ecosystem integrity. The following summarises the critical ecological issues:

- Besides occasional immediate and highly visible impacts of accidental spills (like fish kills), many toxicants have more subtle, though no less serious, long-term impacts on aquatic biota.
- Some impacts, like endocrine disruption, manifest at extremely low concentrations of toxicants.
- The nature of many long-term impacts makes them difficult to detect and quantify.
- Some toxicants are highly resistant to degradation in the environment and may persist for decades.
- Some organic toxicants degrade rapidly in the environment, or are metabolised, to other chemicals that may also be toxic.
- Many organic toxicants and some heavy metals (like mercury) have an affinity for animal tissue (*e.g.* in fish) and sediments in water resources. They can gradually accumulate in these media to levels many thousands of times the original background levels.
- Contaminated animals can be eaten by other animals up the food chain (including humans).
- Contaminated sediments can be scoured during floods, mobilising trapped toxicants and increasing the risks of exposure downstream.
- Some toxicants, like the persistent organic pollutants (POPs) (see Text Box 10) addressed in the Stockholm Convention (2001), are highly volatile. They can be transported vast distances through the atmosphere away from their original sources. POPs have even been found in the Arctic, Antarctic and remote Pacific islands [UNEP, 2002].

The complexity and the potential severity of the problems evident in the above further emphasizes the necessity for programmes like the NTMP. However, the NTMP should be seen as only one of a suite of approaches that South Africa should adopt. These should include better characterisation of sources of toxic substances and associated risks and formulation of focused policy and legislation. These should focus on minimising risks to humans and ecosystems without unnecessarily compromising much needed socio-economic development.

Examples of potential sources of various toxicants in natural waters

Toxicant	Typical sources
Heavy metals	Mining industry, chemical industry, tanning
Inorganics	Mining industry
Pesticides	Pesticide manufacture and formulation; Agriculture
Petroleum products	Petroleum industry
Petrochemicals	Petrochemical industry
Surfactants	Household aqueous waste, industrial laundering and other cleansing operations
Pharmaceuticals	Pharmaceutical industry, agriculture, hospitals

Examples of toxicants are given for each class.

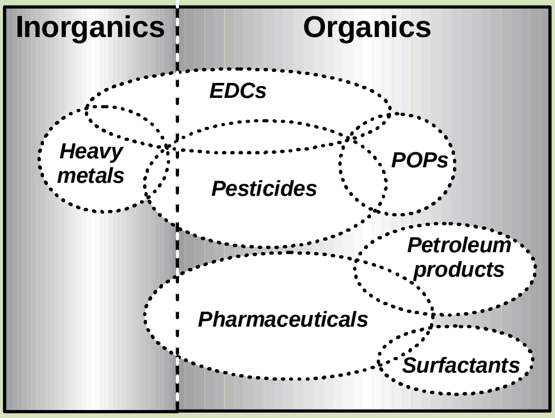

Illustration of some of the overlaps between some classes of toxicants (EDCs = Endocrine Disrupting Compounds, POPs = Persistent Organic Pollutants).

Text Box 10: Persistent Organic Pollutants

Persistent organic pollutants (POPs) are organic compounds that are resistant to environmental degradation through chemical, biological, and photolytic processes. Because of this, they have been observed to persist in the environment, to be capable of long-range transport, bioaccumulate in human and animal tissue, biomagnify in food chains, and to have potential significant impacts on human health and the environment.

Many POPs are currently or were in the past used as pesticides. Others are used in industrial processes and in the production of a range of goods such as solvents, polyvinyl chloride, and pharmaceuticals. Though there are a few natural sources of POPs, most POPs are created by humans in industrial processes, either intentionally or as by products.

In May 1995, the United Nations Environment Programme Governing Council (GC) decided to begin investigating POPs, initially beginning with a short list of the following twelve POPs, known as the 'dirty dozen': aldrin, chlordane, DDT, dieldrin, endrin, heptachlor, hexachlorobenzene, mirex, polychlorinated biphenyls, polychlorinated dibenzo-p-dioxins, polychlorinated dibenzofurans, and toxaphene. Since then, this list has generally been accepted to include such substances as carcinogenic polycyclic aromatic hydrocarbons (PAHs) and certain brominated flame-retardants, as well as some organometallic compounds such as tributyltin (TBT).

POPs released to the environment have been shown to travel vast distances from their original source. Due to their chemical properties, many POPs are semi-volatile and insoluble. The indirect routes include attachment to particulate matter, and through the food chain. The chemicals' semi-volatility allows them to travel long distances through the atmosphere before being deposited. POP exposure can cause death and illnesses including disruption of the endocrine, reproductive, and immune systems; neurobehavioral disorders; and cancers possibly including breast cancer. Exposure to POPs can take place through diet, environmental exposure, or accidents.

South Africa is a signatory of the Stockholm Convention on Persistent Organic Pollutants which is an international environmental treaty that aims to eliminate or restrict the production and use of POPs. Co-signatories agree to outlaw nine of the dirty dozen chemicals, limit the use of DDT to malaria control, and curtail inadvertent production of dioxins and furans. Parties to the convention have agreed to a process by which persistent toxic compounds can be reviewed and added to the convention, if they meet certain criteria for persistence and transboundary threat.

DDT is still used in South Africa for malaria control in the Limpopo and Inkomati WMA's and studies have shown elevated levels of DDT in fish and humans. These WMA's are subject to ongoing research by the University of Pretoria and Cape Town University.

9.1 WATER MANAGEMENT AREA 1: LIMPOPO

Background

The Limpopo (WMA) is the northern most water management area in the country and represents part of the South African portion of the Limpopo Basin which is also shared by Botswana, Zimbabwe and Mozambique. The WMA borders on Botswana and Zimbabwe, where the Limpopo River forms the entire length of the international boundary before flowing into Mozambique. The region is semi-arid and the mean annual rainfall ranges from 300 mm to 700 mm. Economic activity is mainly centred around game, livestock and irrigation farming, together with increasing mining operations. Approximately 760 rural communities are scattered throughout the water management area, with little local economic activity to support these population concentrations (DWAF, 2004 b).

The main catchments are the Matlabas, Mokolo, Lephalala, Mogalakwena, Sand, Nzhelele and Nwanedi.

Due to the aridity and flatness of the terrain few sites are available for the construction of major dams and the surface water potential has largely been developed. Relatively favourable formations for groundwater are found in the area and groundwater is therefore used extensively. However, over exploitation occurs in certain areas. Several inter-water management area transfers exist, all of which bringing water into the WMA.

The Mokolo River Catchment covers 8 387 km^2, stretching from the Waterberg Mountains through the upper reaches of the Sand River to its confluence with the Limpopo River. A number of tributaries are present in the catchment, e.g. the Tambotie River, Poer-se-Loop and the Rietspruit. The largest water user, particularly in the upper catchment, is agriculture, with crops such as tobacco, maize, sunflower, vegetables and fruit predominating. Approximately 87% of the present water use in the catchment is therefore taken up by agricultural activities along the Mokolo River, with the remaining 13% being committed to industry, mining, power generation and domestic water supply. The sub-catchment has very unreliable supplies of water and there seems to be little opportunity for expansion of the irrigated areas without the importation of additional water supplies (Midgley *et al*., 1999). There are only two mining concerns in this sub-catchment (Ashton *et al*., 2001), with large water users in this mining/industry sector including the Matimba Power Station and Kumba Resources' Grootgeluk coal mine, both situated outside Lephalale. Matimba is the world's largest dry cooling power station and Grootgeluk the largest coal mine in the country.

All of the towns and settlements in the sub-catchment rely on water supplied from the water supply impoundments, from run-of-river abstraction points and, occasionally (in the lower reaches) from local boreholes. A few informal settlements have sprung up around the periphery of the minor towns in the sub-catchment.

These settlements lack access to basic services such as clean water supplies and suitable sanitation systems. In addition, the large numbers of subsistence farmers in the north-eastern portion of the sub-catchment have to rely on boreholes and hand-dug wells for water supply (Ashton *et al*., 2001). The Mokolo Dam was built in the 1970s primarily to serve the power station, and now also supplies the coal mine, downstream farmers and Lephalale.

The land-use is agriculture, with private and provincial nature reserves as well as coal mining.

Water Quality Status

The current surface water quality of the Mokolo River is generally good upstream of the Mokolo Dam with all variables either acceptable or ideal with the exception of tolerable phosphates. Groundwater quality in much of the Mokolo area is generally poor due to the coal and gas fields and cannot be used for domestic use, although surface water quality is generally good (DWAF, 2004 a).

The current surface water quality of the Mokolo River downstream of the Mokolo Dam is either acceptable or ideal with the exception of phosphates which are unacceptable. Flows are variable, with reductions in low and moderate flows and unseasonal releases from Mokolo Dam still having an impact.

The current surface water quality of the Lephalala River is either acceptable or ideal with the exception of pH, phosphates and sulphates which are unacceptable. The land use of the Lephalala River is mainly agriculture. Witpoort is a small town with the waste water treatment not operating efficiently.

The new planned Mokolo pipeline coming from the Crocodile (West) will potentially result in water quality changes in the Mokolo catchment due to the poor water quality originating in the Crocodile River. The water quality of the Crocodile (West) catchment is impacted by high nutrient and salinity due to numerous wastewater discharges and flow regulation in the catchment.

WMA 1: WATER QUALITY STATUS MAP

There is no current water quality monitoring point on Mokgalakwena River. The drivers of water quality in this catchment are the towns of Nylstroom, Dimune, Nylsvlei, Mokupane and Naboomspruit all of which have the challenges of waste water treatment works (WWTWs).

Furthermore there are large platinum mines in the upper catchment with nitrate problems from blasting as well as season turbidity levels from runoff from mining activities. Glen Alpine Dam is used for commercial agriculture of potatoes and tomatoes.

There is no current water quality monitoring point on the Sand River. There are coal mines in the catchment that have potential for acid mine drainage and sulphate contamination. There are many areas of sand mining. The water quality is impacted by effluent from three WWTWs in the area. There is also intensive agricultural activities which contribute to the nutrient levels in the river.Nzhelele catchment is dominated by agriculture (citrus) both up and downstream of the Nzhelele Dam. The sewage treatment works discharges do not meet appropriate discharge standards. There is some forestry around Louis Trichardt and associated industries (timber, etc.).

Nwandezi River land usage is game farming, some agriculture and use of pesticides. The Limpopo River's water quality is driven by the seasonal flows from Botswana, intensive irrigated agriculture and mining activities. The water quality of the Limpopo River deteriorates downstream to tolerable salinity and nutrients due to accumulated irrigation runoff and coal mining impacts.

There have been recorded cholera outbreaks in the Limpopo River that originated from Zimbabwe, around Messina area. The Beit Bridge town's infrastructure completely collapsed and this has further impacted downstream abstraction boreholes for Messina town.

The rapid and uncontrolled growth of informal settlements in the upper Mokolo River (around Vaalwater and Alma) may in future impact on surface and groundwater quality in this area. The water quality trend in the Mokolo River indicates a deterioration of variables downstream due to urbanisation, agricultural runoff and mining activities. The Lepalale River has a deteriorating water quality trend due to agricultural runoff and mining activities in the catchment. The water quality trend of the Limpopo River improves downstream.

9.2 WATER MANAGEMENT AREA 2: LUVUVHU AND LETABA

Background

The Luvuvhu and Letaba WMA lies entirely within the Limpopo Province and borders on Zimbabwe and Mozambique. It forms part of the Limpopo basin, which is shared by South Africa, Botswana, Zimbabwe and Mozambique. While the Luvuvhu River is a direct tributary of the Limpopo River, the Shingwedzi and Letaba rivers flow into the Olifants River, which is a tributary of the Limpopo. A unique feature of the WMA is the Kruger National Park along its eastern boundary, which occupies approximately 35% of the area and through which all the main rivers flow into Mozambique. Due to the topography, rainfall varies from well over 1000 mm/a to less than 300 mm/a. Economic activity is characterised by irrigation, afforestation, tourism and informal farming. Over 90% of the area's population of about 1.5 million live in rural communities (DWAF, 2004 c).

The main urban areas are Tzaneen and Nkowakowa in the Groot Letaba River catchment, Giyani in the Klein Letaba River catchment, and Thohoyandou in the Luvuvhu River catchment. The rural population is scattered throughout the WMA. The mean annual temperature ranges from about 18 °C in the mountainous areas to more than 28 °C in the northern and eastern parts of the WMA with an average of about 25,5 °C for the WMA as a whole. Maximum temperatures are experienced in January and minimum temperatures occur on average in July.

The Letaba River catchment is highly regulated particularly in the upper catchments where most of the runoff is generated. Surface water mainly originates in the mountainous areas and is regulated by several dams in the upper (Magoebaskloof and Ebaneezer dams) and middle reaches of the river. The Letaba River is further regulated by a series of irrigation weirs that limit the flows of water into the Kruger National Park. There are further regulatory weirs and dams with the Kruger National Park (Mingerhout Engelhardt dams).

Intensive irrigation farming is practised in the upper parts of the Klein Letaba River catchment (upstream and downstream of the Middle Letaba Dam), the Groot Letaba (downstream of the Tzaneen Dam) and Letsitele rivers, as well as in the upper Luvuvhu River catchment. Vegetables (including the largest tomato production area in the country), citrus and a variety of sub-tropical fruits such as bananas, mangoes, avocados and nuts are grown. Large areas of the upper catchments have been planted with commercial forests in the high rainfall parts of the Drakensberg escarpment and on the Soutpansberg.

Groundwater is utilised extensively and limited potential remains for further development. Significant over exploitation of groundwater occurs in parts of the WMA particularly near Albasini Dam and in the vicinity of Thohoyandou. Water transfers occur from this WMA to both neighbouring WMAs to supply amongst other Polokwane with drinking water and some inter catchment transfers within the WMA also take place (DWAF, 2004 c).

Water Quality Status

Groot Letaba River

Typically the water quality issues in the Letaba study area are driven by diffuse pollution, such:

- Afforestation: upper catchment (turbidity, fertilizers)
- Agricultural runoff from intensive cultivated lands – banana and citrus (fertilizers, salts, nutrients, pesticides)
- Villages close to rivers (microbiological, litter, turbidity)
- Animal grazing and watering (microbiological, turbidity)

The point sources of pollution in the Letaba River are limited to effluents from wastewater treatment works from Tzaneen and Giyani and are consequently not a major contributor to the water quality in the Letaba catchment. The current water quality down the Letaba River indicates ideal values of ammonia, sulphates and nitrates. Acceptable pH values occur. There are tolerable salt values (electrical conductivity and TDS) which are as a result of afforestation and runoff from the intensive agriculture. The unacceptable phosphate values that occur all the way into the KNP are as a result of the use of fertilizers for the intensive agriculture and a lesser extent due to waste water treatment plant effluents. Elevated levels of Chlorophyll-a and algal growth are recorded along the length of the Letaba River as a result of the high nutrients, river regulation and high lowveld temperatures.

There are records of acute and chronic toxicity relate to the use of pesticides and herbicides in the Letaba River. The Letsitele River, a tributary of the Letaba River is unregulated, with a small dam on the Thabina tributary. The water quality at this site is influenced by upstream stream flow reduction (forestry) and a township, with no formal sanitation system. In the lower catchment the main land-use is irrigation agriculture, namely citrus plantations (mangos and bananas) and afforestation. Water quality impacts are expected to relate to salinisation, the release of pesticides / herbicides into the environment and elevated nutrient levels

Klein Letaba River is in a moderately modified to modified state mostly due to dense settlements and

WMA 2 WATER QUALITY STATUS MAP

agriculture above the Middle Letaba Dam and upper Klein Letaba River. The primary land-use is dense rural / urban settlements (limited subsistence agriculture, with livestock), with a very dry landscape. Water quality impacts may relate to sewage effluent leading to eutrophication. The current water quality down the Klein Letaba River indicates ideal values of ammonia, sulphates and nitrates. There are tolerable salt values (electrical conductivity and TDS) which are as a result of afforestation and runoff from the intensive agriculture. The unacceptable phosphate values are as a result of a number of WWTWs and waste disposal sites leading to eutrophication. The unacceptable pH values are due to releases from Mid Letaba Dam.

The Molototsi River's main land-use is rural informal settlements e.g. Ka-Dzumeri (limited subsistence and cultivated agriculture, with livestock). The landscape is dry and when the river flows it carries a high sediment load due to the informal settlements and cultivated agriculture that takes place into the flood plain of the river.

The water quality trends in the Letaba River indicate that the TDS values are increasing due to land use practices such as increased subsistence agriculture and afforestation. This results in a continuous sediment movement down the length of the river into the KNP. The increased pH trend is due to algal blooms in the highly regulated river raising the pH. The raised trend in phosphate and nitrogen values upstream of the KNP is a result of the continued intensive irrigated agriculture on the banks of the Groot Letaba.

Luvuvhu River

The water quality status of the Luvuvhu River is driven by intensive agriculture of sub-tropical fruits and afforestation in the upper catchment, the urban sprawl of Thohoyandou in the middle catchment and the KNP in the lower end of the catchment. The unacceptable phosphate values that occur all the way into the KNP are as a result of the use of fertilizers for the intensive agriculture, a lesser extent due to waste water treatment plant effluent from Thohoyandou and the lack of formal treatment for the dense urban sprawl outside the KNP.

The water quality trends in the middle to lower Luvuvhu River indicate a deterioration of the phosphates, nitrates and ammonia levels. This deterioration in water quality is a result of the intense agriculture and domestic wastes associates with Thohoyandou and the un-serviced intense dense settlements upstream of the KNP. The Luvuvhu River is subject to ongoing research into the human health and fish impacts associated to the use of DDT for malaria control in the catchment.

The Shindwezi River

The majority of the catchment of the Shindwezi River's catchment falls within the KNP. Outside the land use is mainly subsistence agriculture and informal urban settlements. The unacceptable pH, phosphates and EC values are due to runoff from these land use practises that take place into the flood plain of the river. There is an improved water quality trend in the river.

Water quality issues and concerns

Regulation and water shortages

The water shortages experienced in the Letaba Catchment area have led to intense competition for the available water resources between different sectors. A substantial portion of the population does not have access to the basic level of service and planned extensions to irrigation have consequently been put on hold. The Kruger National Park (KNP) is located at the lower end of the catchment, is internationally renowned as a conservation resource, and is responsible for significant tourism and contribution to South Africa's GDP. In order to sustain the flow of the Letaba River in the KNP and ultimately aquatic biota, riparian vegetation and terrestrial animal life, water has to be released from the series of dams and weirs starting at the headwaters of the catchment. Furthermore, there is an international obligation to release water to Mozambique at the eastern boundary of the KNP.

The most ecologically modified sections in the Groot Letaba River are those between Tzaneen Dam and the is due to the reduction in flow due to upstream impoundments (Tzaneen and Ebeneezer Dams), large weirs (Junction, Yamorna, Prieska and Jasi) as well as direct abstraction for irrigation. The water quality problems are associated with intensive irrigated agriculture (fertilizer, salts and pesticide runoff).

More than 20 major in-stream dams and weirs have been constructed in the Groot Letaba catchment, which has resulted in this catchment being highly regulated. The existing limited water resources in the Letaba Catchment have been severely overexploited at the expense of the environment in order to meet the commercial (irrigation, afforestation and industry) and rapidly increasing domestic water demands. The dense afforestation that takes place in the upper catchment and the intensive irrigated agriculture, of mainly sub tropical fruits, on the banks of the Groot Letaba outside the KNP, are the major water users in the study area. The in stream dams are used for the supply of irrigation water for this intensive irrigated agriculture.

International obligations

The rivers that leave South Africa and flow into Mozambique are subjected to an international agreement between the two countries. The National Water Act (Act 36 of 1998) make reference to international obligations being as important as basic human needs and the ecological Reserve with regards to water allocations. The rivers that are subject to this agreement are the Letaba/Olifants, Komati and Shindwezi.

Pesticides

The intensive irrigated agriculture in the Letaba and Luvuvhu River has resulted in the use of a wide range of pesticides over the past decades. Most of these pesticides are categorised as Persistent Organic Pesticides (POPs). South Africa is a signature of the Stockholm Convention on POPs (see Text Box 9).

DDT is an approved malaria control in the Luvuvhu catchment and there are records of DDT bioaccumulation in the fish and humans in this catchment. There is evidence of human health impacts on this catchment as a result of the use of these pesticides and this is the subject to ongoing studies by the Universities of Pretoria and Cape Town's medical fatalities.

9.3 WATER MANAGEMENT AREA 3: CROCODILE (WEST) AND MARICO

Background

The Crocodile West and Marico WMA's have boundary on Botswana in the north-west. It includes two major river systems the Crocodile West and Marico, which give rise to the Limpopo River at their confluence. The climate is generally semi-arid, with the mean annual rainfall ranging from 400 mm to 800 mm. Average temperatures range between 15 and 30°C.

The water resources of the Crocodile West and Marico WMA support major economic activities of the WMA and a population of approximately 5.0 million people. It is the second most populous WMA in the country with the largest proportionate contribution to the national economy, generating almost a third of the country's Gross Domestic Product. The WMA is highly altered by catchment development, with economic activity dominated by urban areas and industrial complexes of northern Johannesburg, Midrand and Tshwane and with platinum mining north-east of Rustenburg. Extensive irrigation activities occur along the major rivers, with game and livestock farming occurring in other parts of the WMA.

The two major rivers in the Crocodile (West) – Marico WMA, the Crocodile (West) River and the Groot Marico River form the south-western part of the Limpopo River basin (Drainage Region A), which eventually drains into the Indian Ocean in Mozambique. The WMA also includes the headwaters of the Molopo River, which is a tributary of the Orange River, draining westwards to the Atlantic Ocean. The WMA includes the tertiary drainage regions A10, A21 to A24, A31, A32 and quaternary drainage region D41A. The WMA covers a total catchment area of 47 565 km^2.

Development and utilisation of surface water occurring naturally in the water management area has reached its full potential. Large dolomitic groundwater aquifers occur along the southern part of the area. The aquifers are utilised extensively for urban and irrigation purposes. Localised over-exploitation of groundwater occurs in the Molopo area. Some aquifers also underlie the border with Botswana and are shared with that country. A substantial portion of the water used in the WMA is transferred from the Vaal River and further afield. Small transfers out of the WMA are to Gabarone in Botswana and to Modimolle in the Limpopo WMA.

Increasing quantities of effluent return flow from urban and industrial areas offer considerable potential for re-use, but the effluent is at the same time a major cause of pollution in some rivers. Population and economic growth, centred on the Johannesburg - Pretoria metropolitan complex and mining developments, are expected to continue strongly in this area. Little change is foreseen in population and economic development in rural areas (DWAF, 2004 d).

Water Quality Status

Crocodile Catchment

Water quality is a driver of the status of rivers in the catchment. The river is highly impacted in terms of water quality while some sub-catchments, such as the Upper Elands displaying a good to fair condition in terms of water quality.

Water quality issues are mainly related to nutrient status and salinity impacts due to wastewater discharges and flow regulation in the catchment. Microbial water quality issues are also known to be a problem in the upper catchment but there is insufficient monitoring data to confirm this.

The water quality of the Upper Crocodile River is impacted by urbanisation and large volumes of wastewater discharges (WWTWs and industrial). Water quality in the rivers is relatively poor with high levels of nutrients and salt concentrations. There is a general non-compliance to phosphate RWQO throughout the WMA.

The water quality of the Magalies River is relatively good with localised impacts from land based activities. The dams in the system impact on the water quality in the rivers.

Water quality of the Elands River catchment is good in the upper reaches. However the middle and lower reaches are of a fair quality with mining activities in the catchment impacting on the river. Water quality has also deteriorated as a result of erosion and high sediment loads. The Hex River shows elevated concentrations of salts and nutrients as well as toxicants. There are impacts from agricultural (intensive irrigation) activities in the catchment.

The water quality of the Apies Pienaars catchment is of poor quality with certain areas being impacted by nutrients and salinisation. There are thirteen point source discharges into the system from industries and wastewater treatment works. The water quality of the upper catchments is deteriorating even further in certain areas. pH is high but salts are stable. Sources of pollution are mainly from urban return flows, WWTWs and land based activities.

The Lower Crocodile River is deteriorating in terms of water quality. Salts and nutrients are high. There are also increased levels of toxicants in the middle reaches of the river. Urbanisations, industrial diffuse sources and high agricultural return flows are the major impacting activities.

WMA 3 WATER QUALITY STATUS MAP

Eutrophication due to increasing nutrient concentrations is posing as the major threat to the Crocodile River system and needs to receive attention. The phosphate RWQO is in the unacceptable range at all the monitoring sites. Salinity impacts need to be managed.

Marico Catchment

The water quality of the Upper Marico River is relatively good with localised impacts from land based activities. The tributaries are impacted to some extent by slate mining activities and agricultural impacts. Turbidity and erosion are the main water quality issues. The Marico Bosveld Dam impacts on the water quality in the river.

Water quality of the Klein Marico River catchment is good in the upper reaches. However the middle and lower reaches are of a fair water quality with urbanisation and the dams in the catchment impacting on water quality. Water quality has also deteriorated as a result of erosion and sedimentation. The Klein Marico River shows elevated concentrations of nutrients. There are impacts from agricultural activities in the catchment.

The water quality of the middle and lower Marico River is of fair to poor quality with certain areas being impacted by nutrients, erosion and salinisation. The impoundments impact on the river water quality downstream due to flows being managed by demands for irrigation purposes. There are also increased levels of toxicants in the middle reaches of the river.

The Lower Marico River is deteriorating in terms of water quality. Nutrients are high. High agricultural return flows are the major impacting activity.

Water quality issues and concerns

Wastewater Discharges

The biggest impactors on water quality in the area are the large scale water and land users. The sprawling urban areas in the south-east of the catchment, with their undersized water systems and large waste problems contribute to poor water quality downstream. This is evident through the eutrophication problems being experienced in both dams. The discharges from WWTWs are also a major contributing factor and local authorities struggle to comply to discharge standards. The effluents from wastewater treatment works are a major contributor to the water quality in the Crocodile catchment. Other contributors to the poor water quality include industries and old abandoned mines.

Agricultural Run-off

Fertilizers and pesticides from agricultural activities are also having a negative impact on water resources in the WMA, which is also a contributing factor to the increase in nutrient levels that are observed. However the exact extent of this impact has not been quantified yet.

Use of Return flows

The Vaal River System is directly linked to the Crocodile River West System through the Rand Water potable water distribution network. The discharges from Tshwane and northern suburbs of Johannesburg contribute large volumes of water to the Crocodile River West catchment. The planning scenarios developed for the Crocodile River West and Marico River catchments show that there are projected short falls where a future Coal to Liquid (CTL) plant and coal fired power station at Lephalale are included in the water requirement projections. There is the option available of using some of this excess wastewater from the Vaal River System to support the Crocodile River West catchment.

Water Transfers

The water resources that naturally occur in the Crocodile catchment have already been fully developed and most of the tributaries as well as the main stem of the Crocodile (West) River are highly regulated. Treated wastewater return flows from the Upper Vaal WMA play an important role as the water is used in the Crocodile West catchment area (makes up approximately 27% of available water - 356 million m^3/annum). The quantities of return flows are increasing and while serving as potential source of water for future development in the catchment, the cascading effect of the return flows and the associated water quality have to be monitored and its impact determined.

There is an elaborate network of inter-basin water transfers into and out of the Crocodile (West) and Marico WMA. The Marico River is also used for an international transfer to Botswana downstream of Tswasa Weir in the Madikwe Game Reserve. Furthermore there is the planned transfer of water out of the Crocodile River to the Mokolo catchment (Lephalale) for the water requirements of the Madupi Power Station. There are also plans to transfer treated waste water from the Klip River catchment in the Vaal River System into the Crocodile River system to meet the increasing water demand in the Crocodile (west) and Mokolo catchment. The date of this transfer system has not been finalised as yet.

9.4 WATER MANAGEMENT AREA 4: OLIFANTS

Background

The Olifants River originates at Trichardt to the east of Johannesburg and initially flows northwards before gently curving in a generally eastward direction through the Kruger National Park and into Mozambique, where it joins the Limpopo River before discharging into the Indian Ocean. The Olifants water management area corresponds with the South African portion of the Olifants River catchment (excluding the Letaba River catchment). It falls within three provinces, *viz*. a small part to the west within Gauteng, with the southern part mainly in Mpumalanga and the northern part in Limpopo Province. The main tributaries are the Wilge, Elands and Ga-Selati rivers on the left bank and the Steelpoort, Blyde, Klaserie and Timbavati rivers on the right bank.

Distinct differences in climate occur; from cool Highveld in the south to subtropical, east of the escarpment. Mean annual rainfall is in the range of 500 mm to 800 mm over most of the WMA.

The main economic activity is related to coal, platinum, vanadium, chrome, copper and phosphate mining. The coal mining is located in the upper reaches of the catchment around Witbank, Middelburg and Delmas. There are large thermal coal fired power stations associated with the coal mining. The platinum, chrome and vanadium mines are located in the Steelpoort and middle areas of water management area while the copper and phosphate mining occurs in the lower Olifants around Phalaborwa. There are also large steel foundries located in Middelburg and Witbank.

Extensive irrigation occurs in the vicinity of the Loskop Dam, along the lower reaches of the Olifants River, near the confluence of the Blyde and Olifants rivers, as well as in the Steelpoort valley and upper Selati catchment. Much of the central and north western areas of the water management area are largely undeveloped, with scattered rural villages where the people are mainly dependent on income from migrant workers in the Gauteng area, Witbank, Middelburg and Phalaborwa are the largest urban centres. Land use in the water management area is characterised by rain-fed cultivation in the southern and north-western parts, with grain and cotton as main products. While most of the water management area remains under natural vegetation for livestock and game farming as well as conservation, severe overgrazing is prevalent in many areas. Afforestation is found in some of the higher rainfall areas, with notable plantations in the upper Blyde River valley.

With the Olifants River flowing through the Kruger National Park, which is located at the downstream extremity of the water management area, the provision of water to meet ecological requirements is one of the controlling factors in the management of water resources throughout the water management area (NWRS).

Most surface runoff originates from the higher rainfall southern and mountainous areas. There are 9 major dams constructed in the Olifants River and the major tributaries which regulate the flow in the river system.

Large quantities of groundwater are abstracted for irrigation in the north-west of the water management area, as well as for rural water supplies throughout most of the area. Potential for increased groundwater utilisation has been identified on the Nebo Plateau north-east of Groblersdal. Substantial amounts of water are transferred into the water management area as cooling water for power generation, while smaller transfers are made to neighbouring water management areas.

Water Quality Status

The water quality data covering the period 2006 to 2008 was analysed statistically and compared to Resource Water Quality Objectives (RWQO) to determine the water quality variables of concern in the different parts of the catchment. Trends were also analysed for over the period 1999 to 2008.

The analysis results highlight the following:-

- The salinity related impacts due to mining, power generation and industries in the upper areas of the WMA are highlighted with EC and sulphate concentrations at unacceptable levels.
- The unacceptable EC concentrations in the lower reaches of the Elands River are due to irrigation return flows and concentration due to evaporation of water from the low flows.
- The pH in places marginally exceeds the 8.4 upper limit. There are however localised acid conditions in sub-catchments associated with acid mine drainage. The acid mine drainage generally emanates from defunct coal mines.
- The trophic status in the dams is mesotrophic. However in the upper reaches of the Loskop Dam, eutrophic conditions have been observed. These have resulted in blooms of blue-green algae. The eutrophic conditions in the upper reaches of Loskop Dam are due to high nutrient inputs from the WWTWs discharging below Witbank Dam.
- There are unacceptable phosphate concentrations in the Selati and in the lower Olifants below the Selati confluence. These are associated with sewage return flows and effluents from the mining and industrial activities around Phalaborwa. .

WMA 4 WATER QUALITY STATUS MAP

- There is limited heavy metal concentration information in the catchment. The available data however shows unacceptably high levels in parts of the catchment. In fact high aluminium concentrations have been cited as a possible cause of the fish deaths in Loskop Dam.
- The intensive agricultural activities in the Elands and Moses River catchments could contribute pesticides and herbicides to the local river systems. These are not currently monitored.

Water quality issues and concerns

Coal mining – threats of decants

The coal mining in the upper areas of the Olifants WMA is extensive and is still growing.

A number of the mines are reaching the end of their economic lives and the mine workings will start filling up to ultimately decant. This water will be polluted and the volumes will be large enough to impact significantly on the regional water quality. The major mining houses are aware of this problem and plans are being developed to treat the excess mine water. Mine water reclamation schemes have already been constructed which are supplying water for potable use to the local municipalities. These schemes have to be developed and coordinated to address the future decants. The reclamation of the excess mine water has been earmarked as the future source of water to meet the growing water requirements in the upper areas of the Olifants WMA (see Text Box 11).

Seeps and Spills from Mine and industrial water management systems

The mine water management systems are required to comply with Regulation 704 of the National Water Act of 1998 and to meet best practice. Although not strictly applicable to industries, Regulation 704 serves as a good guide for industrial systems. The new mines and industries are being designed to achieve compliance with the Regulation. However the majority of the mines and industries are old with legacy issues which require upgrades of the water management systems. The excess water in these systems has been managed using the controlled release scheme which started in 1996. However with the growth in the volumes of excess water, there is insufficient assimilative capacity available in the system for the controlled release scheme to deal with the excess water. Urgent attention is required to upgrade the water management system to achieve compliance with Regulation 704.

Defunct mines

There are a number of defunct mines in the WMA. Some of these mines are abandoned (ownerless) and are decanting into the river system. A strategy needs to be developed and implemented to deal with the water discharging from the defunct mines.

Nutrients and Performance of WWTWs

The majority of the wastewater treatment works associated with the local municipalities are producing an effluent which does not meet their license requirements. The works are discharging water which contains high organic, nutrient and microbiological loads to the river systems. The organics result in reduction in dissolved oxygen concentrations and anaerobic conditions which detrimentally impacts on the health of the aquatic system. The high nutrient concentrations lead to eutrophic conditions in the river systems and dams. The trophic status of the upper reaches of Loskop Dam which receives effluent from the major treatment works of the Emalahleni and Steve Tshwete Local Municipalities has been classified as eutrophic with periodic outbreaks of the toxic blue green algae. Not only do the wastewater treatment works have to be operated and maintained correctly but the license conditions should be reviewed to implement more stringent discharge standards regarding nutrients in particular phosphorus.

Agricultural Run-off

Agricultural runoff has the potential to contribute nutrients and toxic organic chemicals associated with herbicides and pesticides to the water resource. The potential certainly exists in the Olifants WMA for contributions of these pollutants to the river system from agricultural areas. The water quality monitoring network has not allowed for the quantification of the contribution of organic pollutants from agriculture, in particular the intensive irrigation areas to the river system.

Text Box 11: Mine water Re-use

Mine Water Re-use
The threat of acid mine drainage (AMD) to the environment will not be solved in the short to medium term, and is likely to persist for centuries to come (as has been seen in Wales where the Roman's mined). It is also not solved by a single intervention, but will require the integrated implementation of a range of measures. Such measures include active water treatment (as demonstrated by the Emalahleni and Optimum treatment plants), passive water treatment systems, controlled placement of acid-generating mine waste, and prevention of water ingress into mine voids and of AMD loss from mine voids.
One of the options for mine water is to make in into a resource rather than a waste product. The Emalahleni Water Reclamation Plant in Mpumalanga, which treats 25ML/day of acid mine water generated by coal mining to a drinking water standard is the first example of large scale project. These initiatives provide benefits, not only to the potential users of the treated water, but also the receiving aquatic environment. There is an estimated 62ML/day post-closure decant from coal mines in the Highveld Coalfield and around 50ML/day of AMD discharging into the Olifants River Catchment, reducing the quality of water for irrigation and municipalities, as well as damaging freshwater ecosystems. The same principle of mine water treatment is being also being used in the newly constructed Optimum Colliery water treatment works.

There is still a tremendous need for further technical research and innovation in the treatment of AMD, to enable cost-effective treatment of the range of AMD waters present in South Africa. Many treatment processes give rise to new large waste streams (such as brines or gypsum), and there needs to be ongoing effort to develop near zero waste processes. Near zero waste processes have a further benefit in that they allow for the recycling of a large portion of treatment chemicals. This recycling not only has the benefit to generate income through the recovery of saleable by-products, thereby reducing operational costs of treatment, but also allows for the reuse of chemicals such as lime and limestone. These chemicals are likely to be in short supply soon, as they are used increasingly in AMD and other forms of remediation. When the value of treated water and by-products exceeds the cost of treatment, it is feasible to create enterprises that will provide economic benefits while dealing with the environmental problems (Source: Manders, P; Godfrey, L and Hobbs, P (2009) Acid Mine Drainage in South Africa Briefing Note 2009/02)
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9.5 WATER MANAGEMENT AREA 5: INKOMATI

Background

The Inkomati WMA is situated in the Mpumalanga Province, in the north-eastern part of South Africa and borders on Mozambique and Swaziland. All rivers from this area flow through Mozambique to the Indian ocean. The population in the WMA is estimated at 1 462 000 people, of which 64% is estimated to be urban and semi-urban. The WMA covers an area of 28 757 km^2. Important urban centres are Nelspruit, White River, Komatipoort, Carolina, Badplaas, Barberton, Sabie, Bushbuckridge, Kanyamazane and Matsulu. The WMA borders with Mozambique on the east and Swaziland on the south east, the Olifants WMA to the northern and western part, and to the south it borders on the Usuthu to Mhlatuze and Upper Vaal WMAs.

The mean annual runoff (MAR) from the entire WMA is estimated at 3 022 million m^3/annum (DWAF, 2003a). This excludes the MAR from Swaziland (517 million m^3/annum), which is not part of the WMA, although it is part of the catchment. Annual rainfall varies from close to 1 500mm in the mountainous areas to 400mm in the lower lying areas. The famous eco-tourism haven, the Kruger National Park occupies almost 35% of the WMA.

The water resources of the Inkomati WMA are an important asset to the country and its people, supporting major economic activities and eco-tourism. The main rivers in the WMA include the Sabie, Crocodile and Komati rivers which form the three major catchment areas. The Komati River first flows into Swaziland and re-enters South Africa before flowing into Mozambique to form the Inkomati River in Mozambique. The WMA comprises the primary drainage region X within the water management drainage regions of South Africa.

Economic activity in the WMA is mainly centred on irrigation and afforestation, with related industries and commerce, and a strong eco-tourism industry. There is an emergence of increased coal mining in upper parts of the catchment. The Kruger National Park is a key feature of the WMA. The Sabie River which flows through the park is ecologically one of the most important rivers in South Africa.

Dams have been constructed on all the main rivers or their tributaries, and surface water resources in the WMA are generally well regulated. An important feature is the joint management by South Africa and Swaziland of part of the water resources of the Komati Basin Water Authority (KOBWA). Because of the well-watered nature of most of the area, groundwater utilisation is relatively small. Most of the present yield from the Komati River west of Swaziland is transferred to the Olifants WMA for power generation (DWAF, 2003a). The Vygeboom and Nooitgedacht dams are used to supply this water.

The Inkomati River is subject to an international cooperative agreement with Mozambique which obligates South Africa to have a minimum of 2m^3/s supplied to Mozambique.

Water Quality Status

The water quality of the WMA is varied and will be discussed per catchment.

Sabie

The upper catchment of the Sabie River is densely commercially afforested. The land use of the middle reaches is a mixture in sub-tropical fruits and dense informal settlements. The lower reach is with the KNP. The upstream water usage has resulted in a winter cessation of flow in the Sabie River within the KNP for the first times on record in the past two decades.

The water quality in the Sabie River indicates unacceptable levels of phosphates throughout the catchment. This is due to return flows from waste water treatment works, the large surface area dense settlements in Bushbuckridge that are mainly un-serviced and runoff from the intensive fertilised cultivation of subtropical fruits.

The water quality trends in the Sabie River indicate increasing nutrient and turbidity levels. The turbidity trend is due to over grazing, the removal of vegetation for firewood from the slopes of the river in the Bushbuckridge area. The increasing nutrient levels are due to the use of fertilizers for the growth of sub-tropical fruits and sewage waste (both formal and un-serviced).

Crocodile

The upper Crocodile River catchment has intensive afforestation and agriculture of sub-tropical fruits and nuts. The flow of the Crocodile River is regulated by the Kwena Dam in the upper catchment.

The current water quality status of the Crocodile River deteriorates downstream with unacceptable values of salts (EC), turbidity, pH and phosphates occurring from below the Kaap River confluence. The major drivers of the phosphate deterioration are a combination of waste water effluent (Nelspruit, Kanyamazane, Matsulu, Hectorspruit, Malelane and Komatipoort) and runoff from fertilisers used for the intensively irrigated sugar cane and subtropical fruits. The increased salt values are from diffuse returns from the intensive agriculture and the gold mining activities in the Kaap and Queens rivers. The increased pH values are due to algal growth, due to nutrients, causing pH values to be become more basic.

In the Elands River there is a recorded increasing trend in salts and chloride associated with the pulp and paper mill in the catchment. There are some recorded industrial pollution incidents around Nelspruit which have resulted

WMA 5 WATER QUALITY STATUS MAP

in high manganese levels in the river, sediments and bioaccumulation into fish. There are also recorded cyanide and arsenic pollution incidents in the Kaap and Queens rivers associated with the gold mining operations.

The water quality trend in the Crocodile catchment indicates and increasing trend upstream of the Kaap River confluence of turbidity and nutrients (phosphates and nitrogen) due to increased urbanisation (treated and untreated waste water returns to the river).

The water quality trend below the Kaap River confluence indicates increased turbidity and sulphate values. The increased turbidity is due to runoff from dense settlements in Matsulu, agricultural runoff and mining. The increased sulphate values are due to the mining activities in the Kaap and Queens rivers.

Komati

The Komati River upstream of Swaziland is regulated by the Eskom transfers out of the catchment via the Nooitgedacht and Vygeboom dams. Water quality problems relate to changes in river discharges caused by the transfers from the Nooitgedacht Dam by Eskom. Only surface warm water spills from Nooitgedacht Dam. Despite this there are no difference in water quality between the Nooitgedacht Dam and Vygeboom Dam.The current water quality status indicates unacceptable phosphate values which originate from sewage effluent generated, from Badplaas and Teespruit and in the lower reach of the river due to cattle watering, subsistence agriculture into the flood plain of the river as well as and un-serviced dense urban communities.

Water quality problems in the Komati before it enters Swaziland indicates increased phosphates and ammonia due to returns flows of both treated and untreated waste water, catchment slopes being highly degraded due to over grazing, the removal of vegetation for firewood and many villages on the slopes of the river. Typical water quality variables of concern are microbiological, nutrients and turbidity.

The Komati River below Swaziland's flow is controlled by releases from the Maguga and Driekoppies Dams as well as many in-stream irrigation weirs. Water quality problems associated with coal and sand mining on the banks of the river, runoff from burgeoning urban population, intensive irrigated sugar cane, many diversion weirs that result in the majority of the river being dammed up from below Tonga to the confluence of the Crocodile River. Many weirs will result in temperature increases in the lower reaches and diurnal dissolved oxygen fluctuations. Typical water quality problems are unacceptable nutrient enrichment (phosphates, nitrates, nitrites, ammonia), aquatic algae, higher salinity values (electrical conductivity), increased temperatures, dissolved oxygen, possible toxicity (due to pesticide usage), microbiological contamination an tolerable values of EC and turbidities. The increased nutrient, salt and turbidity values are due to a combination of this system being highly regulated by many irrigation weirs, high ambient temperatures and runoff from intensive sugar cane culture and subtropical fruit farming (fertilizers and salts).

Water quality issues and concerns

Currently the major stresses facing the WMA are the high water demands by Eskom, irrigation, afforestation and industry and rapidly increasing domestic water demands. The water shortages experienced in the area have led to intense competition for the available water resources among user sectors. In addition, a substantial portion of the population in the WMA does not have access to basic level of services.

Furthermore the large number of dams in the study area not only changes the flow regime but also impacts the water quality. Impacts include increased turbidity (erosion), algal growth, smell, toxic algae, water temperature increase, dissolved oxygen changes, taste and odour, fish kills, and changes to environmental flows.

9.6 WATER MANAGEMENT AREA 6: USUTU TO MHLATHUZE

Background

The Usutu to Mhlathuze WMA is situated in the northern KwaZulu-Natal province, but also occupies the south-eastern corner of the Mpumalanga province, covering a catchment area of 56 231 km^2. The primary drainage region is W, which consists of the W11, W12 and W13 secondary drainage catchments. Climate conditions across the WMA vary significantly. The mean annual temperature ranges between 12 and 14 °C in the west to 20 and 22 °C at the coast, with an average annual temperature for the whole WMA of 16 to 18 °C. The mean annual rainfall ranges between 1 500 mm and 600 mm per annum and the evaporation ranges from 1600mm to 1800 mm in the west to 1800 mm to 2000 mm at the coast.

The Usutu to Mhlathuze WMA borders on Mozambique and Swaziland and two of its major rivers, the Usutu and the Pongola are shared with these countries. Other major rivers within the WMA include the Mhlatuze, Mfolozi and Mkuze rivers.

Large quantities of water are transferred to the Upper Vaal and Olifants WMA, by the Heyshope, Morgenstond Dam and Westoe dams. The natural inflow into the Goedertrouw Dam is supplemented by transfers from the Thukela River. The Usutu to Mhlathuze WMA is one of the smaller contributors to the South African economy, contributing only 1.94% to the Gross Domestic Product of the country. The WMA partakes in the industrial, agricultural and transportation economic sectors. Land use in the WMA, from a water resources perspective, is dominated by irrigation and afforestation. A large portion of the WMA is tribal land which is typically used for stock farming. There are old mining areas in the vicinity of Vryheid. The Richards Bay area is a fast growing industrial hub with a number of industrial complexes.

In the Usutu to Mhlathuze WMA, diffuse waste from rural settlements pollutes the water and is responsible for Cholera outbreaks. Industrial effluent within the WMA does pose a pollution threat to the ground and surface water and the marine environment.

The total population of the Usutu to Mhlathuze WMA is approximately 2.3 million people, of which 80% is in KwaZulu-Natal and the remaining 20% in Mpumalanga province. The majority of the population in the WMA live in rural areas, whereas 18% of the population are classified as urban. The WMA includes the world famous St Lucia estuary (see Text Box 13).

Water Quality Status

Water quality in the headwaters of the Usutu River and its tributaries (W5H024Q01, W5H025Q01 and W5H026) is in an “ideal” category except phosphates which is in a “tolerable” category. This good water quality is the reason for transferring water into the Vaal and Olifants WMA’s to be used as cooling water in coal fired power stations. In the Assegaai River downstream of Piet Retief (W5H002Q01), water quality is “ideal” except for phosphate and ammonia which is in an “unacceptable” category probably due to effluent discharges from the Piet Retief WWTW.

Water quality in the headwaters of the Pongola River and its main tributary, the Bivaan River (W4H004Q01), is “ideal”. However, downstream of the Pongola irrigation scheme at W4H008Q01, the salinity has increased to a “tolerable” category with elevated phosphates concentrations and pH values (“unacceptable” categories) and ammonia concentrations (“acceptable” category) due to irrigation return flows. There is still sufficient dilution available in Pongolapoort Dam to ensure that salinity in the dam is in an “acceptable” category but trends show that Pongolapoort Dam may change to a “tolerable” category if long-term salinity trends continue. By the time the Pongola River joins the Usutu River near W4H009Q01, salinity has again increased to a “tolerable” category largely due to the natural geology (saline groundwater) of the region.

Water quality in the Mkuze River at W3H032Q01 is high in salinity, phosphates and pH which are all in an “unacceptable” category. This is due to intensive irrigation agriculture and return flows in the middle reaches and acid mine drainage problems in the upper reaches of the river. Water quality in the Hluhluwe River at W3H015Q01 is also in an “unacceptable” category due to elevated salinity, phosphates and pH values. Intensive irrigation agriculture and irrigation return flows are the cause of this situation. The lack of fresh water from the these two rivers have contributed to occurrences of hyper-saline conditions in Lake St. Lucia with severe detrimental impacts on the aquatic ecosystem of the lake.

Water quality in the upper reaches of the Black Mfolozi River is also affected by acid mine drainage problems, and salinity and sulphate concentrations are in an “acceptable” category at W2H028Q01. Further downstream at W2H006Q01 the situation is largely unchanged for salinity but pH has changed from an “ideal” to “acceptable” category and phosphates to an “unacceptable” category. Water quality in the middle reaches of the White Umfolozi is similar to those in the Black Umfolozi with salinity in an “acceptable” category and pH in an “unacceptable” category. However, in the lower reaches at W2H032Q01, after the confluence of the two rivers, salinity, phosphates and pH are in “unacceptable” categories, largely due to intensive

WMA 6 WATER QUALITY STATUS MAP

irrigation and reduced flows in the lower reaches. Water quality in the Mhlatuze at W1H009Q01 and W1H032Q01 is in a "tolerable" category for salinity due to intensive irrigation and return flows in the area, pH is in an "acceptable" category and phosphates in an "unacceptable" category.

The elevated phosphate concentrations are probably the result of fertilizer wash off in the middle to lower reaches of the river. Trend analysis indicate increasing trends in salinity in the Black Mfolozi, lower Umfolozi and Mkuze rivers.

Water quality issues and concerns

Impacts of coal mining activities

Acid mine drainage from abandoned and operational coal mines in the Vryheid and Paulpietersburg areas have impacted on the headwaters of the Pongola River, Mkuze River and Umfolozi River. This has resulted in problems with low pH streams and elevated iron, TDS and sulphate concentrations in rivers draining those areas. The buffer capacity of the bigger rivers have to date ensured that the low pH problems remained localised but this does not mitigate the elevated salt concentrations.

Nutrient enrichment

Concerns have been expressed about the impacts of nutrient enrichment downstream of WWTW discharges and irrigation schemes. Incidents of toxic algal blooms and game fatalities have been reported in the upper reaches of the Pongolapoort Dam. Excessive growth of filamentous algae has occurred in the Assegaai River downstream of Piet Retief which impacted on the habitats of aquatic organisms. Concerns have also been expressed about algal blooms in the Klipfontein Dam near the town of Vryheid (Upper Umfolozi River).

Irrigation return flows

The practice of returning irrigation seepage water to the river has lead to increases in salinity downstream of large irrigation schemes. Such increases have been observed in the Pongola River downstream of the Pongola irrigating scheme, in the Mkuze River, Hluhluwe River, lower Mfolozi River, and the middle and lower Mhlathuze rivers. The increase in salinity reduces the fitness for use for downstream users and in the case of Lake St. Lucia, contributes to an increase in the incidence of hyper-saline conditions in the lake.

Suspended sediment loads

Poor management of communal lands and over grazing in the upper reaches of the Black and White Mfolozi rivers have increased suspended sediment loads in the Mfolozi River. This, along with reduced flows, can lead to silting problems in the river channel, equipment problems for irrigation farmers, and negative impacts on aquatic organisms and the estuary ecosystem.

Water borne diseases

Outbreaks of cholera and diarrhoeal diseases have been reported in the rural areas of the WMA. These have been attributed to poor sanitation, use of bush toilets, and taking untreated water directly from rivers for domestic purposes. Infants, the elderly and immuno-compromised people are vulnerable to such diseases.

Aquatic weeds

Concerns have been expressed about infestations of aquatic weeds such as water hyacinth and water lettuce in rivers in the WMA. These affect access to open water, increased evaporation and oxygen exchange at the water surface.

Transportation and pollution risks

There is no registered hazardous waste site in the WMA. Concerns have been expressed about the transport of hazardous industrial wastes on the N2 to Durban and the risk of accidents and pollution into water courses. Such incidents have occurred in the past.

Text Box 12: Sea Outfall pipelines

MANAGEMENT OF SEA OUTFALL PIPELINES

The Department's policy for the disposal of land-derived water containing waste to the marine environment of South Africa is in line with international trends and national objectives of efficient and effective management of the nation's resources, priority is thus given to a resource water quality management approach. Previously the focus was on 'end-of-pipe' pollution control with little attention to the receiving environment, whereas this new approach focuses on the capacity of the receiving marine resource to assimilate waste and hence ensure water that is fit for use by all its other intended users.

In recent years, the discharge of land-derived water containing waste to the marine environment has been receiving increasing attention in many parts of the world due to the environmental sensitivity of the oceans and the cumulative impact of these discharges on the marine environment. In South Africa there are more than forty discharges of water containing waste formalized through authorisations issued in terms the Water Act, 1956 (Act 54 of 1956) and the National Water Act, 1998, (Act 36 of 1998).

These discharges vary widely from surf zone and estuarine discharges of municipal sewage or industrial wastewater to discharges through well designed offshore marine outfalls fitted with hydraulically efficient diffusers operating in water depths of more than 20 metre.

The DWA operational policy provides basic principles and ground rules as the framework within which disposal practices of land-derived water containing waste could be evaluated when marine disposal is a possible alternative. It also provides a management framework within which such disposal needs to be conducted.

Text Box 13: Estuaries

Did you know….

In the southern African context the following is a generally accepted definition of an estuary. "It is a partially enclosed, coastal body of water which is either permanently or periodically open to the sea and within which, there is a measurable variation of salinity due to the mixture of sea water with fresh water derived from land drainage". Such water bodies are therefore linked to a river, stream or other freshwater input at one and to the sea at the other. The absence of a recognizable source of freshwater, would exclude any such systems from inclusion in this definition although they may display many of the typical estuarine characteristics (e.g. Langebaan Lagoon).

Estuaries are dynamic systems and virtually any physical or chemical feature associated with them is subject to rapid and sometimes extreme changes. The mouths of South African estuaries unless pinned by some rocky feature tend to meander under the influence of currents, wind and wave action and sediment movement.

Estuaries are well known for their high productivity, high carrying capacity and ability to support, apart from the resident species, a variety of migratory fish, birds and invertebrates. The maximization of this capacity depends on a variety of interacting attributes or features several of which reflect the significance of processes in the catchment and the need for a holistic approach for successful estuarine management.

Biodiversity in estuarine systems is enhanced by a number of factors such as, the size of the system, the habitat diversity, the presence of intertidal areas whether salt marsh, mangrove, sand or mud flats and by the presence of an axial salinity gradient, i.e. a gradient from full seawater at the mouth to freshwater or significantly reduced salinities at the head of the estuary. (source: http://www.nmmu.ac.za/cerm)

9.7 WATER MANAGEMENT AREA 7: THUKELA

Background

The Thukela water management area (WMA) covers primary drainage region V. The Thukela River originates in the Drakensberg Mountain Range along the border between Lesotho and the KwaZulu-Natal Province of South Africa. The river meanders through central KwaZulu-Natal and discharges into the Indian Ocean. The Little Thukela, Klip, Bloukrans, Bushmans, Sundays, Mooi and Buffalo rivers are the major tributaries of the Thukela.

The Thukela River catchment experiences a wide variety of weather conditions ranging from generally wet and cold in the Drakensberg Mountains, to dry and hot in the Thukela Valley from Colenso down towards the coast, and hot and humid and reasonably well watered at the coast.

The average rainfall ranges from about 1 500 mm per annum in the mountains to about 650 mm per annum in the central parts of the catchment. Annual runoff varies from 600 mm in the Drakensberg to as little as 50 mm in the dry bushveld areas with an estimated natural Mean Annual Runoff (MAR) of 3 799 Mm^3/a at the river mouth. Rainfall is however erratic and years of prolonged drought in the central and lower catchment alternate with very wet periods. The reliable yield (2000) of the Thukela WMA is 776 Mm^3/a.

The wetlands and sponges in the upper and middle Drakensberg are at present not under major threat of destruction due to their remoteness and the fact that this is a protected area. These resources need to be preserved as far as possible due to their critical role in supplying base flows in all the rivers (DWAF, 2004e). The Thukela estuary also needs to be preserved.

The resources of the Thukela River are predominantly used to support requirements for water in other parts of the country, with large transfers of water to all three neighbouring WMAs – see below. Eight major dams in WMA with a combined firm yield of 950 Mm^3/a. include: Woodstock, Spioenkop, Zaaihoek, Driel Barrage, Kilburn, Ntshingwayo, (formerly Chelmsford Dam), Craigie Burn and Wagendrift Dams.

Many people in the WMA are dependent on agriculture for their livelihood. Agriculture is most productive in the Dundee and Escourt districts. Subsistence farming is practised on communal land, which covers much of the WMA.

Water Quality Status

The water quality in the Thukela River at Colenso (V1H001) and at Mandini (V5H002), the Little Thukela at Winterton (V1H010), and Klip River at Ladysmith (V1H038) was generally good with low nitrate (<0.60 mg/ℓ) ammonia (<0.015 mg/ℓ) and acceptable salts (<350 mg/ℓ) concentrations. Although the phosphates were relatively high, the concentrations were generally <0.050 mg/ℓ.

The Little Boesmans River at Estcourt (V7H012) show signs of nutrient enrichment (eutrophication) with relatively high nitrate (1.94 mg/ℓ), ammonia (0.018 mg/ℓ) and unacceptable high phosphate concentration (0.182 mg/ℓ). The sources of these nutrients are agricultural and industrial waste.

The water quality at the upstream point in the Buffels River at Schurvepoort (V3H002) was good, but with relative high phosphate concentrations (0.056 mg/ℓ). However, at the downstream point (V3H010 at Tayside) the quality was poor with high salts (396 mg/ℓ), high ammonia (0.06 mg/ℓ), high nitrate (5.74 mg/ℓ), unacceptable high pH (8.62) and phosphate concentration (0.139 mg/ℓ). The high salts and nutrients (especially ammonia) indicate organic pollution, probably sewage pollution.

The water quality in the Sundays River at Kleinfontein (V6H004) was very good with low salts (87 mg/ℓ), low nutrients concentrations (ammonia, 0.004; nitrate, 0.168; and phosphate, 0.024 mg/ℓ) and ideal pH (7.8).

The Mooi River at Keate's drift (V2H008) shows high dissolved salts (366 mg/ℓ), high pH (8.49) and high phosphates (0.044 mg/ℓ), thus poor quality.

Water quality issues and concerns

Impacts of the mining activities

The upper Buffalo River is the most severely impacted on (water quality) of all the Thukela River's tributaries. Acid mine drainage from numerous old coal mines and industrial pollution from the Newcastle area and the Ngagane River area, requires special intervention. Water quality in the Buffalo River all the way down to its confluence with the Thukela has been described by the Regional Office as being very poor (DWAF, 2004e).

The natural drainage from geological formations but especially from coal mine workings also contains appreciable amounts of nitrates and phosphate. There are two dormant and six closed coal mines that are located in the Sundays River Key Area. There is evidence of salt deposition in the Upper Sundays River at gauging point V6H004 with sulphate concentrations reaching 214 mg/ℓ (compared with 18 mg/ℓ further upstream at V6H006).

WMA 7 WATER QUALITY STATUS MAP

Industry

The most significant water quality impact on the Thukela River is caused by the Sappi Paper Mill at Mandini, which requires sufficient river flows to dilute its effluent releases. Also, fibres from this industrial process could be affecting the biota downstream to the river mouth. Releases from the Spioenkop Dam have been made in the past to dilute Sappi's effluent, but if the surplus in the Thukela WMA is to be allocated then this practice must cease or Sappi must apply for a water use licence for the use of this water.

Agriculture

Soils of the Drakensberg Mountain Range are relatively shallow. Pressure from human activities outside of the protected areas, particularly in the subsistence agriculture areas, is resulting in soil erosion with the consequent loss of habitat and siltation of dams in the upper catchment.

In the Bushmans River below Escourt, water quality problems are experienced due to the leaching of fertilisers and agro-chemicals from the soil and the discharge of industrial waste from the various factories in the town. This pollution impacts on the Weenen Nature Reserve and irrigators in the Weenen area. Agro-chemicals from intensive farming activities also threaten the quality of the water resource in the Mooi River.

Severe overgrazing and soil erosion problems are being experienced in the Driefontein Block and Matiwaneskop areas to the north-west and north of Ladysmith. Soils in the Drakensberg Mountain Range are relatively shallow and highly dispersive. Pressure from human activities is resulting in soil erosion with the consequent loss of habitat and siltation of dams in the upper catchment. This has long-term consequences for the Thukela-Vaal Transfer Scheme. These lower Drakensberg areas and specifically the Mweni Valley are the most affected. Intervention and mitigation measures are required to deal with this.

The naturally good water quality in the Little Thukela Key Area is threatened by large concentrations of tourism activities (e.g. Champagne Valley), agro-chemicals and fertilisers as a diffuse source of pollution. These problems need to be better understood before they can be adequately addressed (DWAF, 2004e).

Rural settlements

The high rural population density in many of the tribal / communal areas (about 56 people/km^2) contributes to the occasional high P concentrations observed in the Sundays River (up to 0.450 mg/ℓ) and Wasbankspruit (1.320 mg/ℓ).

Large rural settlements and poor sanitation facilities along the Lower Thukela River could cause water quality problems during low-flow conditions. The water quality problems are currently mitigated by the reasonably large volumes of water that flow down this lower section of the Thukela River from the well-watered tributary sub-catchments upstream.

Eutrophication

Poor performing waste water treatment works (WWTW) are a major source of nutrient enrichment of aquatic systems. The Newcastle Local Municipality (Charlestown, Kilbarchan, Madadeni, Newcastle, and Osizweni) WWTW performance was less satisfactory and has scored on average only 41% in Green Drop evaluation. Equally poor performances (average 34%) were recorded in the uThukela District Municipality (Escourt, Wembezi, Colenso, Ezakheni, Ladysmith, Bergville and Winterton).

Limited information is available on algae in the WMA. However, the water quality indicator is occasionally outside the acceptable levels for recreational use at some locations due to toxic cyanobacteria having been found. Microbial contamination may also limit use, but insufficient valid data precludes meaningful comment on this at a catchment scale.

Cyanobacteria or 'blue-green algae' are natural inhabitants of many inland waters, estuaries and the sea. In still waters, such as lakes, ponds, canals, and reservoirs, they may multiply sufficiently in summer months to discolour the water so that it appears green, blue-green, or greenish brown. The toxic variants of these algae pose a health hazard to humans and livestock (DEAT, 2006).

Urbanisation

The effluent from the industrial area and untreated sewerage from the Ezakheni complex outside of Ladysmith has resulted in very poor quality water flowing down the Klip River into the Thukela River.

The water quality in the Mooi River was generally good, but the ammonium concentration in Mearns Dam is increasing drastically (150% past 3 years), which is a matter of concern for eutrophication status. High ammonia usually indicates a high organic load to the system (DWAF, 2008b).

Water Transfers

There are a number of large dams in the Thukela WMA, some of which make up the Thukela-Vaal Transfer Scheme. The largest of these is Woodstock Dam, from which water is released to the Driel Barrage near Bergville. Water is then pumped into a canal that conveys this water to the Kilburn Dam, from which it is pumped over the escarpment from the Kilburn Dam into the Driekloof Dam (at the upper end of the Sterkfontein Dam). Spioenkop Dam supplies the downstream requirements of Ladysmith and irrigated agriculture. In future the dam could be used to supplement flows in the lower Thukela to ensure that the water requirements of the Fairbreeze Mine, the Sappi mill at Mandini and the ecology are met. Other significant infrastructure is Zaaihoek Dam on the Slang River with its related pump station and pipeline.

This scheme was constructed primarily to transfer water to the Eastern Vaal sub-system. Some water is also released to local users. The estimated impact of these transfers on the available yield in the Thukela WMA is 541 Mm^3/a.

The implementation of the Reserve will have an impact on the water reconciliation and the availability of water for transfer out of the WMA. Potential for further development of surface water resources exists (DWAF, 2004e). The need for increased and additional transfers in future have been identified and investigated in detail although no decision on this has as yet been made (DWAF, 2004e).

9.8 WATER MANAGEMENT AREA 8: UPPER VAAL

Background

The Upper Vaal WMA is centrally located in the country covers a catchment area of 55 562 km^2. It includes parts of Gauteng, Mpumulanga, Free State and North-West Provinces and consists of the C1, C2 and C8 secondary drainage catchments. The Drakensberg mountains forms the eastern and boundary, while the Maluti Mountains are found to the south and the Witwatersrand in the north. The average temperature for the WMA is 15˚C with mean annual rainfall ranging between 600m and 800mm per year and evaporation between 1300mm and 1700mm per year.

The Vaal River is the major river in the WMA contributing 46% of the surface flow in the WMA. It is fed by a number of tributaries of which the most significant are the Wilge River, Liebensbergvlei River, Klip, Waterval River, Suikerbos, Mooi River and Klip (Gauteng). From a water resources point of view the most important tributaries are the Wilge and Liebenbergsvlei (Lesotho Highlands Water Project). Important wetlands occur along the Klip River and there are several vlei areas throughout the WMA. The surface water resources occurring in the WMA have been well developed and the system is highly regulated (DWAF 2004f).

There are several large dams that have been developed *viz.* Grootdraai Dam, Vaal Dam and Sterkfontein Dam. Large quantities of water are transferred into the WMA to augment local water resources. The Upper Vaal WMA is an economically important region of South Africa, contributing nearly 20% to its Gross Domestic Product. The WMA displays a well diversified economy and a strong industrial and financial base. Land use in the WMA is characterised by expansive urban, mining and industrial areas in the northern and western parts between the Grootdraai Dam and Mooi River catchments. This urbanised area is situated mainly in the province of Gauteng and extends beyond the WMA boundary. Other development in the WMA relates to dry land agriculture. The WMA includes several large towns located around the mining, industrial and agricultural development areas.

Water Quality Status

The water quality of the Vaal River in the Upper Vaal WMA can be divided into the area upstream of the Grootdraai Dam, Grootdraai Dam to Vaal Dam and Vaal Dam to the Mooi River confluence.

The water quality in the Vaal River in the upstream catchment to Grootdraai Dam is good and suitable for use for domestic and industrial supply. The TDS ranges from 150 mg/L to 200 mg/L which falls well within the requirements for domestic use. The water quality of the Grootdraai Dam water is currently suitable for use by Eskom and Sasol. However there is poor quality water in the Leeuspruit, Witpuntspruit and Blesbokspruit tributaries of the Vaal River due to mining impacts (acid mine drainage). The Leeuspruit also has eutrophication issues due to the discharges from the wastewater treatment plants. The water quality in the Grootdraai Dam is under threat in the long term unless the mine water is managed, in particular the closure situation.

The water quality in the Vaal River and its tributaries from Grootdraai Dam to Vaal Dam is suitable for supply as potable and industrial water and for irrigation. The TDS concentrations are about 140 mg/L. The only reach of the Vaal River where the TDS concentrations and eutrophication issues could affect water supply is from the confluence of the Waterval River to Villiers at the upper end of the Vaal Dam. In this reach the TDS concentration exceeds 450 mg/L during the dry season. The reasons are the contribution of saline and high nutrient water from the Waterval catchment.

The water quality of the Vaal River between Vaal Dam to the Mooi River confluence is highly impacted on by the discharges from the wastewater treatment works, mines and industries. Specific catchments are of concern in terms of their contributions to the deteriorating water quality of the Vaal River include the Suikerbosrand, Rietspruit,Klip River (Gauteng) and Mooi River

Dilution releases from Vaal Dam are used to maintain the TDS concentrations in this reach of the Vaal River at a suitable concentration. Currently the TDS concentration is maintained at 600 mg/L in the Vaal Barrage. This ensures that the salinity in the middle reaches of the Vaal River meets the Class 1 water requirements *i.e* less than 1000 mg/L. The trophic status of the water in this reach of the Vaal River (to Bloemhof Dam) is categorized as hypertrophic.

Water quality issues and concerns

Impacts of the mining activities and mine closure

The management of mining activities in the WMA is crucial to the management of water quality both in the short term to alleviate the current salt loads being released and long term to manage the impacts of mine closure and mine decants. While the complex dynamics of this situation is accepted in terms of maintaining base flows in the system, permitting active mining, and promoting wider socio-economic imperatives, a major intervention in terms of current mining development practices is required if the situation in the Vaal Barrage (and towards the Middle Vaal River) is to be alleviated. Of further concern is the final decant points within the system once all the mines within this area close and pumping ceases. This is unknown at this stage but will

WMA 8 WATER QUALITY STATUS MAP

have future ramifications for all surrounding catchments. Closure plans need to be developed by the mines. The water quality of the Grootdraai Dam is currently acceptable. However, there are a number of operational and defunct coal mines in the catchment which need to be managed pro-actively. Estimates of the of water volumes decanting from the mines post closure is 48 million m^3/a. The post closure plans need to be finalized and implementation of the plans need to be managed.

Management of wastewater treatment works discharges

The lack of compliance of wastewater discharges from the many smaller wastewater treatment plants in the WMA to discharge standards is deeply concerning. There is a general non-compliance to the phosphate RWQO throughout the WMA. This situation appears to be continuing unabated, and until such time as this matter is addressed by all the role players at the appropriate levels, water quality management goals will not be achieved. The Vaal Barrage water quality cannot be maintained or improved if this aspect is not prioritised by the local authorities of the smaller towns. The Department needs to develop an intervention strategy as this is a problem throughout the Vaal River System and in other WMA's. The poor water quality is impacting on downstream treatment costs for drinking water.

Urbanisation

The issue of urbanisation is linked to the above concern related wastewater treatment works to some degree, however it also related to the uncontrolled development and urban sprawl that is being experienced in many of the urbanised centres of the Vaal Barrage and Mooi River catchment areas. Lack of, poor and improper planning is leading to large quantities of pollutants entering stormwater return flows which are draining to various tributaries that report to the Vaal River. This issue requires integrated planning approaches that need to be taken up with the appropriate structures if the situation is meant to improve.

The loss of wetlands due to urbanisation and increased discharges of poor water quality is a cause of concern in the Upper Vaal WMA. The WMA had a high concentration of wetlands which play a significant role in maintaining water quality in the rivers (especially the tributaries).

Water Transfers

The water quality in the Grootdraai Dam and Vaal Dam are dependent on the water quality of the water transferred into the Vaal River System. Large quantities of water are transferred from the Lesotho Highlands Project. The water quality in the Wilge River and Vaal Dam is strongly dependent on the water quality of the transfer water. The water quality of the transfer water is currently good, however, any deterioration in quality will impact on the water quality in the Vaal River System. The recent water quality history shows that the water quality in Heyshope Dam is deteriorating, impacting on the water quality of Grootdraai Dam. An increase in the illegal abstraction of water being transferred is impacting on water availability and reducing dilution capacity especially in the Wilge River catchment.

Vaal Barrage

The salinity in the Vaal Barrage and the middle reaches of the Vaal River is currently being managed by dilution releases from Vaal Dam to maintain a TDS concentration of 600 mg/ℓ in the water leaving the Vaal Barrage. The dilution releases of water from Vaal Dam are in effect another water demand on the system and thus play a role in the date of the next Vaal River System transfer scheme. The Vaal Dam releases also influenced the extent to which excess water builds up in Bloemhof Dam. The volume of the Vaal Dam dilution releases depends on the salinity loads and volumes discharged. Thus the management strategy for the saline mine and industrial discharges play an important role in the date of the next Vaal River System augmentation scheme.

Text Box 14: Use of excess water from the Upper Vaal WMA

Strategies for the use of excess water from the Upper Vaal WMA

The recent Integrated Water Quality Management Strategy study of the Department for the Vaal River System (DWAF, 2009a) considered some options for the use of excess water in the system.

The water requirements of Rand Water are expected to grow in the future which implies that the return flow volumes from the wastewater treatment works will also grow. The point source discharges to the Vaal River are currently 492 million m3/year from the domestic wastewater treatment works and 91 million m3/year from the mines. A major portion of the point source discharges is into the Vaal Barrage and Mooi River catchments. This discharge water together with the water released from Vaal Dam is currently used to meet the irrigation and domestic water requirements of the downstream Middle and Lower Vaal River reaches.

Application of the Water Resource Planning Model (WRPM) in investigating future reconciliation and water quality management scenarios for the Vaal River System showed that excess water would start accumulating in Bloemhof Dam from 2015. This scenario is based on a continuation of the current practice of releasing sufficient water from Vaal Dam to meet the downstream resource water quality objectives. This excess water is available to meet the water requirements of the water users along the Lower Orange River or the water could be used directly at the source of discharges by further treating the effluent for direct re-use.

The Vaal River System is also directly linked to the Crocodile River West System through the Rand Water potable water distribution network. The discharges from Tshwane and northern suburbs of Johannesburg contribute large volumes of water to the Crocodile River West catchment. The planning scenarios developed for the Crocodile River West and Marico River catchments show that there are projected short falls where a future potential Coal to Liquid (CTL) plant and coal fired power station at Lephalale are included in the water requirement projections. The possibility of using some of this excess water in the Vaal River System to support the Crocodile River West catchment is also a possibility.

Text Box 15: Re-use of Wastewater

RE-USE OF WASTEWATER

In order to extend the use of SA's limited water resource, DWA is strongly promoting water re-use as one of the options to prevent or minimise water shortfalls in the interim periods before major augmentation schemes can, or have to be implemented. The DWA gives prominence to water re-use in management strategies, like its Water for Growth and Development Strategy. The re-use of treated domestic sewage is being investigated in the Western Cape, KwaZulu-Natal and the Eastern Cape.

There are various types of re-use options that have evolved both nationally and internationally, namely planned or unplanned, potable or non-potable and direct or indirect re-use. Unplanned indirect use has been an integral part of the water supply system in inland areas where the treated effluent of upstream towns is returned to the rivers to become part of the water available to downstream towns or irrigation areas. Planned direct use is where effluent is directly treated to particular standards to be directly put back into a water supply system for use.

The concept of water re-use is thus not new. In fact 14 % of the water use in South Africa is already provided from the use of return flows. What is now being investigated is intensifying of water re-use as a source of water. Water re-use is not seen as the only solution to supplementing water resources but rather one of several options. It is technically possible to implement water re-use much quicker than for instance a large dam development.

Water re-use is also environmentally friendly as it will in fact improve the quality of water in rivers, natural resources will be protected because less water will be taken from rivers and the building of expensive dams will be avoided, or at least postponed.

9.9 WATER MANAGEMENT AREA 9: MIDDLE VAAL

Background

The Middle Vaal WMA is situated in the central part of South Africa, in the Free State and North West Provinces. It is situated between the Rietspruit and Bloemhof Dam and also borders on the Crocodile (West) and Marico as well as the Upper Orange WMA. The Vaal River is the only main river in the WMA. It flows in a westerly direction from the Upper Vaal WMA, to be joined by the Koekemoer-spruit, Skoonspruit, Rhenoster, Vals and Vet rivers as main tributaries from the Middle Vaal WMA, before flowing into the Lower Vaal WMA and then into the Orange River.

Climate over the WMA is temperate with frost occurring in winter, and is generally semi-arid. The mean annual temperature ranges between 18 °C in the west to 14 °C in the east, with an average of about 16 °C for the catchment as a whole. Mean annual rainfall ranges from 700 mm in the south-east to 400 mm in the west. The potential evaporation, which can be as high as 1 900 mm per year is well in excess of the rainfall.

Vegetation is mainly grassland, with sparse bushveld in patches. The topography is relatively flat with no distinct features. Hilly terrain occurs to the south-east. The geology is varied, which also gave rise to different soil types. A large dolomitic formation occurs from Orkney and extends towards the northern part of the WMA (DWAF, 2003b; 2004g).

Present land use in the WMA is characterised by extensive dry land cultivation, particularly in the central parts. Irrigation is practised downstream of dams along the main tributaries as well as at locations along the Vaal River. The remainder of the WMA is natural grassland used for livestock farming.

There are several dams that have been developed *viz*. Bloemhof Dam on the Vaal River, Allemanskraal Dam on the Sand River, Erfenis Dam on the Vet River, and Koppies Dam in the Renoster River.

The WMA includes several large towns located around the mining, industrial and agricultural development areas. The largest urban areas are the North West Goldfields (KOSH, Klerksdorp-Orkney-Stilfontein-Hartbeesfontein area) and the Free State Goldfields (Welkom, Virginia, etc). The MidVaal Water Company (Stilfontein) is the main supplier of bulk water to urban areas in the North West Goldfields and Sedibeng Water (Bothaville) is the main supplier of bulk water in the Free State Goldfields.

The economy in the WMA is mainly based on mining and agriculture as primary production sectors. Numerous inactive mines are found in the north and west of the WMA, many of which were small diamond claims. The Middle Vaal WMA is relatively sparsely populated, with just over 3% of the national population, which is somewhat less than the proportionate contribution to the economy (DWAF, 2003b).

Water Quality Status

The water quality of the Vaal River in the Middle Vaal WMA was generally poor due to high dissolved salts and high nutrients, e.g. the Vaal River at Orkney (C2H007) was characterised by unacceptable high EC (90 mS/m; ~630 mg TDS/ℓ), phosphate concentration (0.224 mg/ℓ) and pH (9.11).

The water quality in the Renoster River (C7H006) and Sandspruit (C2H067) was fair in terms of salts (331 & 373 mg/ℓ), but poor in terms of nutrients, 0.080 and 0.118 mg PO_4-P/ℓ respectively.

Koekemoerspruit (C2H139) and Skoonspruit (C2H073) are hotspot areas with unacceptable high salts concentrations, 1 760 and 987 mg/ℓ respectively. The salt load evidently originates from the mining activities and the high nutrients draining from the KOSH urban area.

Another problem area is the Sand River at Bloudrift (C4H016) with unacceptable high salts (2 415 mg/ℓ) from the Welkom-Virginia gold mines and very high nutrients (nitrate, 1.05; P, 0.50 mg/ℓ), evidently from poorly treated sewage effluent.

The water quality in the Vals River at Kroonstad (C6H007) was fair with ideal ammonia, sulphate and nitrate concentrations, acceptable pH (8.39), and salts (316 mg/ℓ), but with unacceptable high phosphate concentration (0.080 mg/ℓ). However, the Vals River at Bothaville (C6H002) was in a poor state with high salts concentration (837 mg/ℓ), probably originating mainly from seepage water and return flows from irrigation, unacceptable high pH (8.69) and phosphate concentration (0.90 mg/ℓ).

The water quality in Erfenis Dam (C4R002) was generally good except for the very high phosphate concentrations (0.126 mg/ℓ) that indicate a serious potential for algal productivity. However, the water quality in the lower section of the Vet River (C4H004) was poor with high salts (666 mg/ℓ) and high nutrients concentrations (phosphate, 0.088 mg/ℓ).

All the parameters in Heuningspruit at Dankbaar Mispah (C7H003) were ideal, except for the unacceptable P concentrations (0.194 mg/ℓ) that results in a poor quality.

WMA 9 WATER QUALITY STATUS MAP

Water quality issues and concerns

Impacts of the mining activities and mine closure

The economy of the Middle Vaal WMA is dominated by the mining sector, with a contribution of 45.6 % to GGP, particularly gold mining. However, discharges from mines impact significantly on both the hydrology and water quality of the Middle Vaal system. The impacts from the gold mining activities on groundwater have been recognised as early as 1960 when localised dewatering became an issue at Stilfontein Gold Mine. Only more recently have the impacts on the quality of the groundwater and the interaction with the Vaal River becomes a concern. The largest volumes are abstracted at Stilfontein Gold Mine's Margaret Shaft. Although Stilfontein's underground operations has ceased for more than ten years, pumping at Margaret shaft continues for the safety of the downstream mines. The volume of water abstracted daily is estimated at 32 Mℓ/d. The water is utilized by a number of users and any excess is discharged to the Koekemoer Spruit. Groundwater is also abstracted from other operating shafts in the KOSH mining area for safety and the water is utilized as process water Due to the large quantities of water present in the mined Witwatersrand rocks, a large quantity of water (120 -150 Mℓ/d) is pumped to the surface for accessibility each day. This groundwater however has average conductivities of 500 mS/m (~3 500 mg/ℓ) and cannot be used for drinking or irrigation purposes (DWAF, 2004g).

Water quality in the Vaal River is of serious concern because of high salinity and nutrient content, which mainly results from urban and industrial return flows as well as mining activities in the Upper Vaal WMA. The closure of mines may have further water quality impacts.

Management of wastewater treatment works discharges

A large proportion of the sewage emanating from SA urban areas is not treated properly prior to discharge, because the sewer systems are incomplete, or sewage treatment plants are overloaded (Oberholster & Ashton, 2008; Green Drop, 2009a).Matjhabeng Local Municipality (Welkom, Odendaalsrus, Virginia, Hennenman, Allanridge and Ventersburg) with 11 sewage purification plants and the Moqhaka municipality (Kroonstad, Maokeng, Steynsrus and Viljoenskroon) have failed to present information to DWA for the Green Drop certification and are classified with zero Green Drop scores. These local municipalities have been implicated for polluting the local rivers and lakes with poorly treated sewage and occasionally raw sewage spills.

Municipal wastewater treatment plants, not complying with effluent standards and informal, unsewered human settlements along the river banks or in the close vicinity of the Vaal River, pose a threat to regional water quality, especially eutrophication (nutrient enrichment) and human health. There is a general non-compliance to phosphate RWQO throughout the WMA.

Sewage wastewater, by its nature, is teeming with microbes. Therefore, from a social perspective, the discharge of sewage effluent into the natural environment can have negative impacts on human health, primarily from bacteriological and other forms of pathogens that survive the biological treatment process and inadequate disinfection of the effluent.

However, municipal wastewater effluent is also one of the impacts that is most easy to mitigate because they are easily identified, measured, and susceptible to control by policies and regulation.

Eutrophication

The Vaal River, in the Middle Vaal WMA, experience regular algal blooms and has been classified as hypertrophic (nutrient over-enriched), which causes several problems to man and the environment. Eutrophication effects and problems are profound in the Vaal River and have become a matter of major concern to all water users. The impacts of eutrophication are ecological, social and economical. Infestations of alien vegetation are also found along the Vaal River (DWAF, 2009d).

Erfenis, Koppies and Allemanskraal Dams are classified as oligotrophic, however, toxic cyanobacterial incidents have been recorded. Bloemhof Dam is eutrophic and experience cyanobacterial blooms usually dominated by *Microcystis* spp. and *Oscillatoria* sp. (Van Ginkel, 2004).

Cyanobacterial blooms (frequency and intensity) in the Vaal River are increasing. As cyanobacterial blooms become more common, the likelihood grows that people will be exposed to increased doses of toxins and the risk of animal die-offs grows as well (DWAF, 2009d).

Urbanisation

Over 75 % of the population in the WMA are classified as living in urban areas, and about 25 % as rural. Most of the population are concentrated in the main urban and mining centres of Klerksdorp, Orkney and Stilfontein in the Middle Vaal sub-area; Welkom and Virginia in the Sand-Vet sub-area, as well as Kroonstad (which is not a mining town) in the Rhenoster-Vals sub-area. South Africa's freshwater resources are under increasing stress from a growing population and an expanding economy.

Water Transfers and availability

Substantial transfers take place from the Upper Vaal to the Middle Vaal (790 Mm^3/a). However, there are no large control structures with respect to the regulation of flow in the Vaal River within the Middle Vaal WMA, and both the quantity and quality of water in the Vaal River are largely influenced by management practices in the Upper Vaal WMA. There are existing weirs on the Vaal River at Orkney and Balkfontein. Water from tributaries as well as from groundwater in the water management area is fully utilised, mainly for irrigation and for towns remote from the Vaal River (DWAF, 2003b).

Text Box 16: Acid Mine Drainage

Acid Mine Drainage

The South African mining sector is one of the critical pillars and drivers of the South African economy. South Africa is globally recognised as being a leading supplier of a variety of minerals and mineral products. Not only are gold, diamond, coal and platinum production responsible for the largest contribution to the national economy but in general the mining of these commodities is a potential sources of water pollution.

The chemical composition of the product mined also determines the chemical composition of the waste produced and the contribution to pollution. Typical pollutants from the mines include sulphates, acidity, salinity and metals (including aluminium, iron and manganese). These pollutants may contribute to pollution (both point and diffuse) of the surface water, groundwater and atmosphere.

Mining activities are also associated with environmental contamination such as acid mine drainage (AMD). AMD is highly acidic water, usually containing high concentrations of metals, sulphides, and salts as a consequence of mining activity. The major sources of AMD include drainage from underground mine shafts, runoff and discharge from open pits and mine waste dumps, tailings and ore stockpiles, which make up nearly 88% of all waste produced in South Africa. Drainage from abandoned underground mine shafts into surface water systems (decant) may occur as the mine shafts fill with water. Although the chemistry of AMD generation is straightforward, the final product is a function of the geology of the mining region, presence of micro-organisms, temperature and also of the availability of water and oxygen. These factors are regionally variable making the prediction, prevention, containment and treatment of AMD site specific. The major contributors of AMD are from the gold and coal mining industry.

The Witwatersrand gold mining industry has been active for 120 years and the post-closure decant of AMD poses an enormous threat (currently and in the future). This threat will worsen if remedial activities are delayed or not implemented. For example, acid mine water started to decant from defunct flooded underground mine workings near Krugersdorp on the West Rand in August 2002, leading to polluted surface water. Randfontein and the Wonderfonteinspruit are also problematic. These cases have received substantial media attention, which has been critical of the efforts so far to address the problems. In the absence of remediation, there is likely to be substantially more decant in future, with potentially severe implications for aquatic systems, leading to increased water treatment costs as well as making this water not suitable for downstream users.

AMD from coal mining is problematic in the Highveld Coalfield in Mpumalanga, and has been reflected by media attention on the consequences of severe pollution seen in the Loskop Dam and the Olifants River Catchment.

(Sources: (1) Manders, P; Godfrey, L and Hobbs, P (2009) Acid Mine Drainage in South Africa Briefing Note 2009/02.
(2) Pulles, W., Heath, R., Howard, M. (1996). A manual to assess and manage the impact of gold mining operations on the surface water environment. WRC Report No. 647/1/96.

9.10 WATER MANAGEMENT AREA 10: LOWER VAAL

Background

The Lower Vaal WMA (between the Bloemhof Dam and Orange River) is one of five WMAs in the Orange River Basin. The Vaal River is the only major river in the WMA. It flows across the south-eastern corner of the WMA, connecting it to the Middle Vaal and Lower Orange water management areas. The Harts River is the only significant tributary to the Vaal River from the Lower Vaal water management area.

Climatic conditions are fairly uniform from east to west across the area. The mean annual temperature ranges between 18.3 ºC in the east to 17.4 ºC in the west. Maximum temperatures are experienced in January and minimum temperatures usually occur in July. Frost occurs throughout the study area in winter, typically mid-May to late August.

Rainfall is strongly seasonal with most rain occurring in the summer period (October to April). The peak rainfall months are December and January. Rainfall occurs generally as convective thunderstorms and is sometimes accompanied by hail. The mean annual precipitation (MAP) for the Lower Vaal WMA is low at only 100 mm.

The land use in the Lower Vaal WMA is primary livestock farming, with some dry land cultivation in the northeast. Intensive irrigation is practiced at Vaalharts as well as locations along the Vaal River. Water use in the water management area is dominated by irrigation, which represent 80% of the local requirements for water (643 Mm^3/a). Development of surface water naturally occurring in the water management area has reached its potential and all the water is being fully utilised, thus limited growth in the water requirements is projected.

Diamond bearing intrusions occur near Kimberley (the most important urban area) and alluvial diamonds are found near Bloemhof. Iron ore and other minerals are found in the south-eastern parts of the WMA. Diamond mining in and around the lower Vaal River is a major concern (habitat destruction and increased turbidity).

The economy in the water management area is mainly based on mining and agriculture as primary production sectors. The economy of the Lower Vaal WMA is relatively small and contributes less than 2 % of the GDP of South Africa. The WMA is relatively sparsely populated, with just over 3% of the national population.

The main storage dams are: Bloemhof Dam on the Vaal River. The dam wall and outlet works are located within the Lower Vaal WMA immediately where the river enters the WMA from the Middle Vaal WMA. Most of the reservoir basin falls in the Middle Vaal WMA. The yield from the dam, however, is available in the Lower Vaal WMA, mainly for irrigation purposes. Vaalharts Weir is a main diversion weir on the Vaal River while the Douglas Weir falls just inside the WMA, immediately upstream of the confluence of the Vaal River with the Orange River. Wentzel, Taung and Spitskop dams on the Harts River.

Barberspan is an off-channel pan in the upper reaches of the Harts River, known for its rich bird life. It has been declared a Ramsar wetland, but currently under threat because of poor water quality.

Water Quality Status

The Vaal River at Vaalharts weir (C9H008) displays high salts (479 mg/ℓ) and unacceptable high phosphate concentrations (0.117 mg/ℓ). The high nutrients stimulate algal and water hyacinths growth (DWAF, 2009a).

The water quality in the Harts River was extremely poor; 5/7 parameters were in the unacceptable range. The TDS concentration in the Harts at Delportshoop, Lloyds weir (C3H016) was unacceptable at 1 322 mg/ℓ and shows an increasing trend. The Harts River contributes significant amounts of salts to the lower Vaal River.

The water quality in the Vaal River at Schmidtsdrift (C9H024) was unacceptable because of the high salts (EC, 117 mS/m; ~820 mg TDS/ℓ) and high nutrients, especially high ammonia (0.147 mg/ℓ).

Water quality issues and concerns

Irrigation and salinisation

Irrigation use about 82 % of the total water requirements in the WMA. Over 85 % of the requirements for irrigation are in the Harts sub-area, mainly at the Vaalharts irrigation scheme, with the balance being along the Vaal River. The Vaalharts irrigation scheme serves the purpose of beneficially utilising lower quality water discharged from the Upper Vaal water management area and thus prevents the accumulation of salinity in the lower reaches of the Lower Vaal WMA.

Water in the Harts River downstream of the Vaalharts irrigation scheme is of exceptional high salinity as a result of saline leachate from the irrigation fields, and needs to be carefully managed through blending with fresher water.

Because of salinisation problems experienced at the Vaalharts irrigation scheme an efficient subsurface drainage system was installed, resulting in large quantities of irrigation effluent being returned to the river and which could potentially be re-used downstream. The resultant balance at the downstream end of the water management area is reflected as a surplus for the Lower Vaal water management area, and not as a transfer to the Lower Orange water management area (DWAF, 2003c).

WMA 10 WATER QUALITY STATUS MAP

Water quality in the lower reaches of the Vaal River is also impacted upon by irrigation return flows from the Harts River as well as from the Riet/Modder River further downstream, necessitating further blending with low salinity water from the Orange River at the Douglas.

In arid and semi-arid regions irrigation tends to degrade soil and water quality through salt accumulation with devastating effects on some crops. A recent study in the Lower Vaal WMA showed that the addition of salts to the soils as a result of farming practices varied between 79 t/ha and 280 t/ha, with irrigation water being the major contributor of salt. Soils had been irrigated for periods of between 17 to 53 years. However, predictions showed that if the current practices are sustained for the next 50 years the osmotic potential of 6 soils will decline to below the threshold of -100 kPa for maize. In two of these soils the threshold of -280 kPa for wheat will also be exceeded. Hence salt-induced water stress could reduce the yield of maize and even wheat significantly in future if appropriate precautionary measures are not introduced (Van Rensburg *et al.*, 2008).High dissolved salts concentrations in the Vaal River could be the tipping factor that may shift the algal composition in favour of undesirable highly toxic cyanobacterium species (notably *Cylindrospermopsis sp.*) that was already observed in the lower part of the Vaal River and Orange River (Van Ginkel, 2004).

Eutrophication and Algal blooms

Spitskop Dam is classified as an eutrophic system and toxic cyanobacterial blooms have been recorded. The occurrence of cyanobacterial species, *Cylindrospermopsis sp.*, is a major concern because of the potent toxin produced by these algae and the difficulty to remove it from the water during water treatment process.

During 2000 the first major cyanobacterial outbreak in the Orange River downstream of the confluence of the Vaal and the Orange River was recorded. The findings of a study during this event indicated that the problem species (*Cylindrospermopsis sp.*) originated in the Spitskop Dam. During high flows the cyanobacterial species were transported downstream causing problems for all the treatment works that was designed to handle high turbidity in the supply waters and not cyanobacterial or algal blooms (Van Ginkel, 2004).

Water Transfers

The bulk of the surface water found in the water management area is in the Vaal River, most of which is transferred along the river from the Upper Vaal water management area and via the Middle Vaal water management area, to the Lower Vaal water management area. Water is also transferred into the water management area at Douglas Weir, from the Upper Orange water management area, for water quality management purposes.

The only direct international obligation affecting the water resources of the Vaal River System is in the Lower Vaal WMA, in particular the Molopo River catchment.

The transfer of water between water management areas and arrangements with neighbouring countries resort under national control. The following reservations are made in the National Water Resource Strategy with respect to water transfers in to and out of the Lower Vaal water management area: Currently 500 Mm^3/a is transferred from the Middle Vaal water management area to the Lower Vaal water management area. As an upper scenario this may increase to about 555 Mm^3/a during the period of projection – Reserved in the Middle Vaal WMA.

A reservation applies to the transfer of 18 Mm^3/a from the Upper Orange WMA to the Douglas Weir in the Lower Vaal WMA – Reserved in the Upper Orange WMA. The Lower Vaal WMA also forms part of the Vaal River System which extends over several water management areas. As water resource management in the Vaal River System impacts to some degree on water quantity and quality in all the inter-linked water management areas, management of water resources in the Vaal River System is to be controlled at a national level (DWAF, 2003c).

9.11 WATER MANAGEMENT AREA 11: MVOTI TO UMZIMKULU

Background

The Mvoti to Umzimkulu WMA encompasses the entire Southern KwaZulu-Natal Province, bounded by the Thukela River Catchment to the North, the Drakensberg Mountains to the west, the Transkei Region of the Eastern Cape Province to the south and the sea in the east - covers primary drainage region U and tertiary drainage regions T40, T51 and T52.

The main river systems in this WMA flow from west to east discharging to the sea and are as follows: The Mvoti River which rises in the Greytown area and passes through Stanger. The Mgeni River which rises above Pietermaritzburg and passes through Durban. The Illovo and Mlazi rivers, both rising in the Richmond area and discharging south of Durban. The Mkomazi River, rising in the Drakensberg along the Lesotho Border and discharging at the town of Umkomaas. The Mzimkulu River also rising in the Southern Drakensberg above Underberg and discharging to the sea at the town of Port Shepstone (DWAF, 2003 d).

Climatic conditions vary significantly from west (Drakensberg mountain range) to east (Indian Ocean) across the WMA. The mean annual temperature ranges between 12 ºC in the west to 20 ºC at the coast with an average annual temperature for the whole WMA of 17 ºC. Mean annual precipitation ranges from in excess of 1 500 mm in the west to between 800 mm and 1 000 mm in the central area to over 1 000 mm at the coast. The WMA incorporates a total catchment area of over 27 000 km^2 and a MAR of 4 798 Mm^3. However, the total available water is 644 Mm^3/a and total water requirements is 776 Mm^3/a, thus a deficit 240 Mm^3/a. Especially the Mvoti Key Area is highly stressed with water requirements far in excess of the available resource and the Mkomazi Key Area is experiencing serious deficits due to the high demands placed on the undeveloped resource. As a result, no new water allocations are possible.

Mvoti to Umzimkulu WMA makes the fourth largest contribution of 10.7 % to the GDP of the national economy. The manufacturing sector is well developed and the most important sector in terms of contribution to GGP (28.4 %). This WMA includes the Durban-Pinetown Metropolitan Area (DWAF, 2003 d).

Water Quality Status

The water quality in the Umgeni River at (i) Midmar Dam (U2H048) was good with low salts (EC, 9.1 mS/m; ~65 mg TDS/ℓ) and acceptable nutrient concentrations; (ii) Fair in Albert Falls Dam (U2H014), due to high pH (8.6) and ammonia (0.053 mg/ℓ) concentration; (iii) Good at Nagle Dam (U2H043) with all parameters in the ideal and acceptable range and (iv) poor in Inanda Dam (U2H055) because of relative high P concentration (0.057 mg/ℓ). All above 4 dams have earlier been classified as Oligotrophic (low productivity), based on their low mean annual chlorophyll-*a* concentrations (Van Ginkel, 2004). However, toxic cyanobacterial incidents have been reported in 3 of the dams, *i.e.* Albert Falls, Nagle, and Inanda. Recent dense water hyacinths in Inanda dam indicate eutrophic conditions.

The water quality in the Umsunduze River at Hampstead park (U2H041) was very poor with high salts (EC, 52.4 mS/m; TDS, ~367 mg/ℓ) and unacceptable high nutrients (phosphate, 0.197 mg/ℓ). The high ammonia concentration (0.18 mg/ℓ) indicates sewage pollution.

The water quality was good (6/7 parameters in the ideal range) in: (i) Mvoti River at Mistley (U4H002), (ii) Karkloof River at Shafton (U2H006), (iii) Mkomazi River at Camden (U1H005), (iv) Fafa River at Cowick (U8H001), (v) Polela River at Coxhill (T5H003), (vi) Mzimkulu River, upper reach at the Banks (T5H004) and (vii) downstream at Bezweni (T5H007), (viii) Bisi River at Nooitgedacht (T5H002), and (ix) uMtamvuna River at Gundrift (T4H001).

Only the phosphate concentrations at these sites were relatively high (ranged between 0.017 – 0.043 mg/ℓ), but are considered to be largely natural. In these rivers, concentrations >0.050 mg/ℓ, would be considered as unacceptable.

The water quality in Hazelmere Dam on Mdloti River (U3H005) and Nungwana Dam on Nungwana River (U7H008) were good with all the parameters in the ideal or acceptable range. However, toxic cyanobacterial incidents have been reported in Hazelmere Dam.

The water quality in the uMlazi River at Umlaas road (U6H003) was fair, but poor at Shongweni Dam inflow (U6H004) with high EC value (51.5 mS/m; TDS ~360 mg/ℓ), and unacceptable pH value (8.54) and phosphates concentration (0.047 mg/ℓ).

The ecological importance and sensitivity of the Mkomzana and Mkomazi rivers are considered to be high to very high. Ecological sensitivity refers to the ability of the ecosystem to tolerate disturbances and to recover from certain impacts. Therefore, the more sensitive the system is, the lower its tolerance will be to various forms of alteration and disturbance..

WMA 11 WATER QUALITY STATUS MAP

Monitoring sites and data constraints identified were: Several sites don't have nitrate concentrations; no data points were in estuaries, whilst estuaries are generally a big concern. Towns, dense population, and developments (thus potential pollution sources) occurred in a narrow strip along the coast but no monitoring sites are located here, therefore no indication of urban pollution and environmental impact. A site downstream of dams does not necessarily indicate the conditions within the dam.

Water quality issues and concerns

Management of wastewater treatment works discharges

The pollution levels are unacceptable in the middle and lower Msunduze River. The high faecal coli contamination in the river poses a threat to human health. The health problems experienced annually by canoe paddlers during the Dusi marathon are well known. Due to the high faecal coliform counts in the Msunduze River, it is evident that raw sewage and diffuse urban runoff is entering the river system. The waste water quality management performance of the Msunduzi Local Municipality, as a whole, is not satisfactory with an average Green Drop score of 43 %. The source is largely the spills from the water borne systems and runoff from the informal urban areas rather than the underperforming Darvill Works. This raw sewage puts downstream users at risk. The fact that many rural communities are directly reliant on raw water from the rivers and streams emphasizes the importance of improving this situation. The previous cholera epidemic in northern KZN bears grim testimony to this (DWAF, 2008b).

The eThekwini Municipality (Durban) currently have a licence to discharge treated sewage at a rate up to 30 Mℓ/day into the Umhlanga River. Due to potential impacts on recreational activities at the Umhlanga River mouth the eThekwini Municipality have investigated alternative options of disposing of this waste. However, recently 12 waste water treatment works in the Ethekwini Metro (Durban) received the Green drop status (2009a). Faecal pollution in the Umzinto area, affecting the Mzimayi River has resulted in high *E. coli* counts, algae and bad tasting water in the EJ Smith Dam.

The cause of this is the inadequately serviced areas and sewer infrastructure in dire need of maintenance (DWAF, 2004h). Poor performing WWTWs (Green Drop score <50 %) in the Ugu Distric Municipality (South Coast Key area) are: Umzinto, Pennington, Eden Wilds, Gamalakhe, Melville, Mbango, Munster, Murchison Hospital, Ramsgate, RedDessert, SouthBroom, Harding, and KwaBonwa.

The South Coast Key Area as a whole also suffers from seasonal load variations to local small treatment plants along the coastal strip. This is due to the seasonality of the tourism industry. The consequence of this is sewage effluent that does not meet the minimum standard.

KwaDukuza (Stanger) has limited faecal and small industry pollution. The Potential Health Risk Index (*E. coli* index), derived from the national DWA Pollution Health Risk Index, shows the catchment to have a low-moderate pollution health risk, with the lower Mvoti catchment being the most impacted and classified as eutrophic. The phosphate and *E. coli* concentrations are also increasing in Midmar Dam (DWAF, 2008b).

The water quality problems in the Mkomazi catchment are due to faecal contamination from over-loaded sewers, poor services in the dense informal settlement around Mzinto and excessive seasonal loads on the small sewage plants during holiday periods. Sewage discharges from Verulam have resulted in the eutrophication of the Mdloti River and poor quality water. District Municipalities, DWAF and affected operators need to develop a strategy for dealing with this problem (DWAF, 2004h).

Agriculture

Erosion problems are prevalent in the upper Mdloti catchment due to settlement patterns, overgrazing, poor agricultural activities and sand mining operations upstream of Hazelmere Dam. This has resulted in rapid sedimentation of Hazelmere Dam, which has lost more than 20 % of its original storage capacity. Hazelmere Dam is one of the most turbid systems (mean, 47.3 NTU) in the study area (DWAF, 2008b). The large-scale irrigation in the Mvoti catchment has not as yet resulted in a noticeable deterioration in water quality. Steep over-utilised subsistence agriculture is present in the moderately populated areas in the Valley of a Thousand Hills, with moderate to high erosion and limited faecal contamination.

Eutrophication

Toxic cyanobacterial blooms were recorded in Albert Falls, Nagle and Inanda Dam, which is a sign of eutrophication (Van Ginkel, 2004; DWAF, 2008b). As cyanobacterial blooms become more common in the aquatic ecosystem, the likelihood grows that people will be exposed to increased doses of toxins and the risk of animal die-offs grows as well.

Water hyacinths have also become a problem in the lower Umgeni River (DWAF, 2008b). An integrated approach to control aquatic weeds comprising biological control and herbicide spraying was undertaken. A major concern was development of large amounts of water lettuce in the Albert Falls system which required periodic introduction of biological control and herbicide application.

Data does show deterioration in the water quality in the Midmar Resource Unit. The increase in the nutrient concentrations, in particular phosphorus, is significant.

The decline in water quality could be ascribed to poor sewage effluents and agriculture, in particular dairies, piggeries and maize production, impacting moderately on river health through excessive nutrient input into rivers. However the increased pollution from the growing Mphophomeni settlement and future expansion in urban areas around Midmar Dam requires management (DWAF, 2008b).

Effluent return flows downstream of Hazelmere Dam and sewage discharges from Verulam have resulted in the eutrophication of the Mdloti River and poor quality water.

Industry

The only current significant water quality problem in the Mvoti catchment area is effluent from the sugar and paper mill situated near the mouth of the catchment. The effluents have at times had a pollution impact on the estuary. There are also potential groundwater pollution in Durban South from the large industrial activities.

The main water uses in the Mkomazi River catchment are large industry (SAPPI-SAICCOR situated at the mouth of the catchment) and the irrigation sector. There are also discharges of effluent by SAPPI into the Mkomazi River.

Water quality problems in the WMA can best be addressed through co-operative governance between the Regional Office and local authorities. Local authorities must accept responsibility for the quality of effluent arising from state-owned infrastructure in their jurisdiction (DWAF, 2004h).

9.12 WATER MANAGEMENT AREA 12: MZIMVUBU TO KEISKAMMA

Background

The Mzimvubu to Keiskamma Water Management Area is bounded in the east by the Mvoti to Mzimkulu WMA, in the north west by the Upper Orange WMA, in the west by the Fish-Tsitsikamma WMA and in the north by Lesotho. Although the area shares an international boundary with Lesotho, there are no shared watercourses between them.

The Mzimvubu River (the largest undeveloped river in South Africa) flows through deep gorges across the coastal plain before discharging into the Indian Ocean at Port St Johns. The Amatola coastal catchments features the main rivers of the Buffalo, Keiskamma and Nahoon that drain in a south-easterly direction into the Indian Ocean along the coastline either side of East London, while the Great Kei catchment drains the northern slopes of the Amatola mountain range and the southern slopes of the Stormberg / Drakensberg range with the Great Kei River exiting into the Indian Ocean at Kei Mouth north of East London.

The climate and temperature variations are closely related to elevation and proximity to the coast. The study area experiences a mild, temperate climate along the coast to more extreme conditions inland with most rainfall occurring during the summer months. Annual rainfall ranges from between 600 mm to 800 mm in the upper areas of Matatiele and Maluti to between 1000 mm and 1500 mm in the coastal regions of the Mbashe key area.

The total population of the Mzimvubu to Keiskamma WMA in 1995 was estimated at 3.45 million. The majority of the population of the area is situated in rural areas where their incomes are directly linked to the agricultural sector, which is mainly subsistence. Other main economic activities include tourism and commercial forestry activities, as well as manufacturing - vehicle manufacturing being the dominant industry in the Buffalo City Municipal Area.

The only area expected to experience significant growth in the future is the Buffalo City Municipal area where employment opportunities will attract people from the smaller urban centres and rural areas. The levels of education and training in the rural areas are low and approximately 49% of the people are unemployed.

The Mzimvubu to Mbashe area is one of the areas with the highest mean annual runoff in the country. Small hydro-electric developments exist in the water management area, and inter-basin water transfer occurs between the Kei and the Mbashe catchments. Future large waterwork schemes that will be required within the next eight to ten years include an additional water supply for Queenstown (possibly from Xonxa Dam) and an additional water supply for the Buffalo City Municipality.

Water Quality Status

Water quality in the Mzimvubu River and its major tributaries is good and salinity in the Mzintlava River (T3H004Q01), Mzimvubu River (T3H008Q01 and T3H007Q01), Tina River (T3H005Q01) and Tsitsa River (T3H006Q01) was mostly in an “ideal” category although some of the TDS concentrations were categorised as “acceptable”. Phosphate concentrations were all classified as “unacceptable” which may be a reflection of some manmade activities in the catchment. pH values were slightly elevated and were regarded as “acceptable”.

Similarly, water quality recorded at monitoring points in the Mngazi River and the Mbashe River were “ideal” in terms of salinity, ammonia, nitrate and sulphate, “acceptable” in terms of pH values, and “unacceptable” in terms of phosphates.

Water quality in the Kei River varied between “acceptable” and “unacceptable”. Salinity in the south flowing tributaries of the Kei River, the White Kei at Xonxa Dam (S1R001Q01) and the Tsomo River (S5H002Q01) were in an “acceptable” category for salinity, “ideal” for ammonia, sulphate and nitrate, and “acceptable” for pH. However, the rivers originating in the western part of the Kei River catchment were quite saline with salinities varying between “unacceptable” in the Klaas Smits River near Queenstown (S3H006Q01) and “tolerable” in the Kei River at S3H013Q01. The high salinities are due to the geology of that part of the catchment, some agricultural impacts (irrigation return flows), and impacts from Queenstown on phosphates and ammonia concentrations. In the lower Kei River, the salinity is in a “tolerable” category, phosphates and pH in an “unacceptable” category.

On the Buffalo River at R2H027, upstream of Bridledrift Dam, the conductivity was in a “tolerable” category, and the other constituents in an “ideal” to “acceptable” category. This is probably the most impacted river in the WMA and water quality is affected by urban and industrial return flows, WWTW discharges, and aging infrastructure in King Williamstown and Mdantsane. Reservoirs such as Laing Dam and Bridledrift Dam show signs of severe eutrophication.

Salinity in the Keiskamma River at R1H015Q01 is in a “tolerable” category, pH in an “acceptable” class and

WMA 12 WATER QUALITY STATUS MAP

phosphates in an "unacceptable" category. The other constituents are in "ideal" categories.

Water quality issues and concerns

Nutrient enrichment in the Buffalo River

Laing Dam and Bridledrift Dam in the Buffalo River and Nahoon Dam in the Nahoon River show symptoms of nutrient enrichment and eutrophication. Nuisance algal blooms affect water treatment from these reservoirs. The causes of nutrient enrichment are treated wastewater rich in nutrients being discharged into the catchments of these reservoirs, urban runoff rich in organic material, and failing sewer infrastructure resulting in sewage leaking into the dams or into the catchment of the dams.

Localised microbiological pollution

The aging sewerage infrastructure and sanitation systems that have not kept pace with the rate of expansion of many of the rural towns (Umtata, Butterworth, Ugie, Maclear, etc.) and East London have resulted in untreated or partially treated wastewater entering the river systems. Poor maintenance and vandalism of the wastewater infrastructure has also contributed to this problem. This has resulted in health risks to local residents and downstream water users and outbreaks of water-borne diseases such as cholera and severe diarrhea.

Suspended sediment loads

Degradation and overgrazing of communal lands have resulted in high sediment loads during flood events. This has lead to silting up of structures and smothering of aquatic habitats, and inhibition of rooted aquatic plants.

Salinisation in the Buffalo River

Salinity problems in the Buffalo River are related to the discharge of treated industrial (e.g. textile factories) wastewater into the Buffalo River upstream of Laing Dam. Water is abstracted from Laing Dam, treated for domestic water supply, and supplied to domestic and industrial users in King Williams town, upstream of Laing dam. This creates a semi-closed system leading to a gradual increase in salts which is only reduced when a major flood event flushes the saline water downstream.

Salinity problems in the Kei River are largely due to geological sources (Karoo mudstones) and to a lesser degree, manmade activities such as irrigation return flows.

Leaching from solid waste sites

Concerns have been raised about leaching of wastewater high in organics from poorly designed solid waste sites in rural towns and villages. The concern related to increased organic loads and the impacts on dissolved oxygen concentrations as well as heavy metal pollution. This was not regarded as a significant problem at a WMA scale.

9.13 WATER MANAGEMENT AREA 13: UPPER ORANGE

Background

The Orange-Senqu River catchment spans four Southern African countries (Botswana, Lesotho, Namibia and South Africa) and is one of the largest river basins in Southern Africa. About 60% of the almost 1 000 000 km^2 area of the Orange River catchment lies in South Africa. The remainder falls within Namibia (25%), Botswana (13%), and Lesotho (2%). It originates as the Senqu River in the Maluti Mountains in the highlands of Lesotho, from where it drains westward to cut through the dry Richtersveld Mountains (Augrabies Falls), before it discharges into the Atlantic Ocean at Alexander Bay, stretching over 2300 km. Co-operation amongst the Orange River Basin countries is facilitated through the Orange-Senqu River Commission (ORASECOM), with membership by the basin countries.

The Upper Orange WMA stretches from its origin in Lesotho to its confluence with the Vaal River at Douglas. Major rivers include the Modder, Riet, Kraai, Caledon and Orange. The average temperature for the WMA is 15°C with mean annual rainfall ranging between 600 mm and 800 mm per year and evaporation between 1 300 mm and 1 700 mm per year. In Lesotho, which is the source of most of the water in the Upper Orange WMA, rainfall varies between 600 mm per year to about 1 500 mm per year (DWAF, 2003e).

The main storage dams in the Orange River are Gariep and Vanderkloof. Welbedacht Dam in the Caledon River, Rustfontein, Mockes, and Krugersdrift Dams in the Modder River with the Tierpoort and Kalkfontein Dams in the Riet River.

Land use in the WMA is mainly under natural vegetation with livestock farming (sheep, cattle and some game) as main economic activity. Extensive areas under dry land cultivation, mostly for the production of grains, are found in the north-eastern parts of the WMA. Ficksburg is famous for the cherry orchards in the region. Large areas under irrigation for the growing of grain and fodder crops have been developed along the main rivers, mostly downstream of irrigation dams.

Bloemfontein, Botshabelo and Thaba ‘Nchu represent the main urban, and industrial development, in the WMA. Two large hydropower stations were constructed at Gariep and Vanderkloof Dams. Mining activities have significantly declined and currently mainly relate to salt works and small diamond mining operations. Approximately 5% of the GDP of South Africa originates from the Upper Orange WMA (DWAF, 2003e).

Water Quality Status

The water quality and quantity in the uppermost reaches of the Orange River, above Gariep Dam, is still in a quite natural state. The water is moderately soft, relatively low in salt concentrations. For example, at Aliwal North (D1H003) the TDS was low at 215 mg/ℓ, with ideal concentrations of ammonia, sulphate and nitrate. The relatively high phosphate concentrations (0.020 – 0.040 mg/ℓ) in the upper Orange River are considered to be largely natural (DWAF, 2009b).

The general water quality in Kornetspruit (D1H006) and Kraai River (D1H011) was good. Due to the good ecological present state of the Kraai River and because of the good quality of water with little impacts, this site was recommended as a global baseline monitoring site (DWAF, 2009c).

The water quality in the Caledon River is highly variable but generally in a fair condition, however, clear signs of eutrophication because of the high phosphate concentrations are noticeable.

The high salt concentration (832 mg/ℓ), phosphate (0.062 mg/ℓ), and pH (8.6) were unacceptable in the Seekoei River (D3H015), however high natural background concentrations are present. The stream flow in the river has decreased dramatically and indicates over-extraction of the water (DWAF, 2009b).

The water quality in the Modder River was poor, especially because of high dissolved salts and unacceptable nutrients (Nitrate & Phosphate) concentrations and very high pH values. However, the trends (C5H003) show decreasing values.

The pollution levels are unacceptably high in the Stormbergspruit at Burgersdorp (D3H015). The high nutrients (Nitrate & Phosphate) and faecal coliforms contamination indicate that poorly treated sewage is entering the system.

The general water quality of the Riet River at Jacobsdal (C5H030) was good, except for the high pH (8.47), but it shows a decreasing trend. However, the water quality in the lower end of the Riet River at Zoutpansdrift (C5H048, before confluence with the Vaal River) is unacceptable primarily because of very high salt concentrations (TDS, 1 396 mg/ℓ). Water quality in the Lower Riet River is of concern, and also impacts on water quality in the Lower Vaal River and at the Douglas Weir.

WMA 13 WATER QUALITY STATUS MAP

Water quality issues and concerns

Soil erosion

The most severe ecological problem in the upper reaches of the Orange River is the high degree of soil erosion experienced in Lesotho. Approximately 2% of top-soil is lost in the country each year, with adverse effects on habitats as well as agricultural productivity, and negative impacts on water resources. The natural vulnerability is intensified by the impact of unsuitable agricultural practices and overgrazing. As a result of the cultivation of areas not suitable for agriculture, wind erosion, mostly during winter when fields lie bare, adds to the soil losses caused by the summer rains (Earle *et al*., 2005). The Caledon River is characterized by extreme seasonal fluctuations in turbidity and with a mean value of 400 NTU is probably the most turbid river in South Africa. Due to siltation, the storage capacity of the Welbedacht Dam (in Caledon River) reduced rapidly from the original 115 Mm^3 to approximately 16 Mm^3, *i.e.* by 86%, during the twenty years since completion (DWAF, 2009b).

Wetland degradation

The wetlands in the Lesotho Highlands are of great importance for the environmental integrity of the Orange's upper reaches. They accumulate run-off from the surrounding mountain slopes and regulate the release of water into the river systems. Through their filtering system they contribute to the maintenance of the required water quality and quantity in streams and springs. In addition to their important role for the river systems they are unique habitats, which represent a large part of the country's biodiversity.

In recent decades the wetlands in Lesotho have seriously degraded and more wetlands are under threat. The most common causes for wetland destruction are overgrazing, the building of roads and the encroachment of settlements. Efforts to curb erosion thus far have had limited success (Earle *et al.*, 2005).

Management of wastewater treatment works discharges

The persistent discharge of treated sewage is one of the most obvious sources of degradation of urban freshwater ecosystems. Major pollution sources in the Modder River are sewage effluent from Mangaung local municipality (Bloemfontein-Botshabelo-Thaba Nchu) and return flows from irrigation along river.

Pollution levels (nutrients and faecal contamination) in the Caledon River at Ficksburg and Maseru is a matter of concern. The pollution in the Stormbergspruit at Burgersdorp (D1H001) is also associated with poor sewage effluent (DWAF, 2009b).

The Sterkspruit was polluted with sewage effluent indicated by high *E. coli* counts, high DOC concentration, and high nutrient (N & P) concentrations (DWAF, 2009b).

Eutrophication

Limited information is available on the trophic status of the water bodies in the Upper Orange WMA. The trophic statuses of dams are as follow: Gariep and Vanderkloof Dams – Oligotrophic; Welbedacht Dam – Mesotrophic and Krugersdrift dam – serious potential for algal productivity. However, cyanobacterial blooms have been observed in Gariep, Vanderkloof, Rustfontein, and Krugersdrift Dam (Van Ginkel, 2004; DWAF, 2009b).

Agriculture and urbanisation

Irrigation return flows has a major impact on salinity in the lower Riet River and water is transferred to the Riet River from Vanderkloof Dam, partly for blending and water quality management purposes. A natural pan below Krugersdrift Dam also adds salinity to the Modder River.

General trends in the Upper Orange WMA are the continued concentration of economic development and population in the Bloemfontein region, and a decline in rural population. In addition, water has been allocated for 12 000 ha new irrigation development for poverty relief to be sourced from the Upper Orange WMA, which will result in an approximate balance situation once implemented (DWAF, 2003e).

Water Transfers

The Upper Orange WMA is a major source of water, and of pivotal importance for several other WMAs which receive large quantities of water either directly or indirectly from the Upper Orange WMA through inter-basin transfers or via the Orange River. The Orange is a recipient basin for three inter-basin transfers schemes (IBTs); a donor basin for three IBTs; with four intra-basin transfers also in existence. Through a number of dams and transfer schemes, water is moved in and out of the Orange River.

The Lesotho Highlands Water Project has resulted in large volumes (770 Mm^3/a) of low salinity water being diverted from the Orange River into the Vaal River catchment. This has lead to an increase in salt levels in the Gariep and Vanderkloof dams. The implementation of the new Polihali Dam (second phase of the LHWP) in Lesotho will influence (reduce) the flow of water into the dams, which in turn will have a negative influence on water quality and availability in the lower reaches of the Orange River.

Flow regulation

The construction of the Gariep and Vanderkloof Dams in the Orange River made a great contribution towards the establishment and maintenance of irrigated crops throughout large sections of the Orange River, however, with a negative impact on the environment. The controlled releases of water from the dams have also homogenized the flow regimes, chiefly through modification of the magnitude and timing of ecologically critical high and low flows. It also has greatly dampened the seasonal and inter-annual stream flow variability of the Orange River, thereby altering natural dynamics in ecologically important flows and to blockage of fish migrations (DWAF, 2009b).

Climate change

Results from a recent study on the impacts of climate change in the Orange-Senqu River basin (Knoesen *et al.*, 2009), confirm the widely accepted notion that climate change will cause increases in temperature and evaporation in the future. However, rainfall in the future is projected to generally increase over the Orange-Senqu basin, with consequential amplified increases in stream flow and the occurrence of flooding, especially for shorter return periods. The upper reaches of the basin in the east could be particularly affected since this area has the highest historical rainfall already. Rainfall and stream flows are predicted to become more variable in the future (Knoesen *et al.*, 2009).

9.14 WATER MANAGEMENT AREA 14: LOWER ORANGE

Background

The Lower Orange WMA refers to the stretch of Orange River between the Orange-Vaal confluence and Alexander Bay where the river meets the Atlantic Ocean, approximately 1 200 km. The Orange River, which forms a green strip in an otherwise arid but beautiful landscape, also forms the border between South Africa and Namibia over about 550 km to the west of the 20 degree longitude.

The Vaal River, the main tributary to the Orange River, has its confluence with the Orange River about 13 km west of Douglas. Other tributaries are the Ongers and Hartebeest rivers from the south, and the Molopo River (an endoreic tributary) and Fish River (Namibia) from the north. There are a number of highly intermittent water courses along the coast which drain directly to the ocean.

The Lower Orange WMA is the largest, but also the driest and most sparsely populated WMA in South Africa. The area experiences the lowest mean annual rainfall in the country, which ranges between 20 mm at the coast and 400 mm on the eastern boundary, yet one of the highest users of water. Potential evaporation can be as high as 3 000 mm per year and in general is several times more than the rainfall (DWAF, 2003f).

Minerals and water from the Orange River were the key elements for economic development in the region, and still remain so. Irrigation is by far the dominant water use sector in the Lower Orange WMA, representing 94% of the total requirements for water (1 082 Mm^3/a). The exotic tree, *Prosopis* species has invaded large areas of the riparian vegetation in the Lower Orange WMA.

The importance of the agriculture sector is attributable to the climate which is particularly suitable for the growing of some high value crops, together with the availability of water along the Orange River. Due to the climate, a window of opportunity exists for the provision of high quality table grapes to Europe early in the season when prices are at their highest. Other products include dates, raisins, wine, flowers, vegetables, grain and fodder crops. The wine grapes of Oranjerivier Wine Cellars originate from 930 producers all along the Orange River. These pockets of vineyard land stretch over a distance of more than 300 kilometers between Groblershoop and Blouputs. Five wineries have been established in Kakamas, Keimoes, Grootdrink and Groblershoop. The Oranjerivier Wine Cellars is one of the biggest wine cellars in South Africa.

Less than 1% of the Gross Domestic Product (GDP) of South Africa originates from the Lower Orange WMA, which is the second lowest of all WMAs in the country.

Water Quality Status

The water quality in the Douglas Barrage on Vaal River (C9R003) was generally poor because of high TDS (740 mg/ℓ), pH (8.44) and high phosphate concentration (0.044 mg/ℓ).

The water quality in the Orange River at Marksdrift (D3H008) was good with most of the parameters in the ideal or acceptable range. The mean phosphate concentration of 0.030 mg/ℓ is considered to be largely natural. Similar phosphate concentrations were also encountered at Upington, Pella and Vioolsdrift.

The water quality at Boegoeberg Dam (D7H008) was also good apart from for the unacceptable high phosphate concentration (0.090 mg/ℓ). High phosphate concentrations usually stimulate algal growth.

The salt concentrations show an increasing trend downstream with high concentration at Pella (447 mg/ℓ). Long-term studies indicated that the overall dissolved salt concentrations in the Orange River are increasing significantly (in time and space), especially in the Lower Orange River (below Marksdrift) (DWAF, 2009b).

Flow regulation and increased salinity are recognised as the two main factors that have impacted (and continue to impact) negatively on the environmental health of the lower Orange River (DWAF, 2009b).

Water quality issues and concerns

Impacts of agriculture

One of the key issues is the arid climate of the region and limited potential of water resources which naturally occur in the WMA. Surface and groundwater are already fully developed and utilized. The virtual total dependence of the Lower Orange WMA on water released from the Upper Orange WMA, and the dominant influence of water utilization in upstream WMA on water resource management in the Lower Orange WMA. Another issue is insufficient measurement, monitoring and control of water used by irrigation, which is by far the largest water use sector in the WMA (94%). Water use efficiency by irrigation is also subject to improvement (DWAF, 2003f).

Huge volumes of irrigation return flows enter the Orange River. These return flows have a major impact on the water quality of the river. The extent of the impact is not well understood. The regularly exceeds of 500 mg/ℓ TDS between Boegoeberg Dam and Kakamas is concerning.

WMA 14 WATER QUALITY STATUS MAP

Impact on sustainability of agriculture is a concern. Salinisation of irrigated soil could lead to greater salt loads on the river, ultimately to the point where quality may be impaired and the uses of the water restricted. The salt load from the Vaal River needs to be taken into account in the siting of future dams.

The concentration of some metals, aluminium, cadmium, copper and lead, were occasionally unacceptable high and potentially harmful for human health and for the aquatic environment – the reason for the high metal concentrations in the lower Orange are unclear and should be investigated further. (DWAF, 2009b).

Groundwater

Groundwater plays a pivotal role in especially rural water supplies. The quality of groundwater is largely good, and unpolluted in the eastern, high rainfall, portions of the basin, but becomes mineralised and brackish in the drier western areas and in the vicinity of salt pans.

Mean annual groundwater recharge in the Orange Basin increases from <5 mm in the western regions near the river mouth to 25 - 50 mm in the upper reaches. In parts of the Kalahari, groundwater quality is poor, and in places it may be too saline for use (DWAF, 2003f).

In terms of groundwater usage, of strategic importance are the so-called "lenses" of fresh water occurring on top of underlying saline water. It has been identified that there is a need for monitoring of this water to ensure that the boreholes are not over-extracted, which will permanently destroy the availability of fresh water in the Northern Cape and most likely else-where (DWA, Northern Cape Regional Office 2011, Personal Communication).

Eutrophication and Algal blooms

During 2000 the first major cyanobacterial outbreak in the Orange River downstream of the confluence of the Vaal and the Orange River caused uproar in the sparsely populated area (Van Ginkel & Conradie 2001). The findings of a study during this event indicated that the problem species originated in the Spitskop Dam. During high flows the cyanobacterial species were transported downstream causing problems for all the treatment works that was designed to handle high turbidity in the supply waters and not cyanobacterial or algal blooms. Since March 2003 to the present the Orange River has again shown a major *Oscillatoria* and *Cylindrospermopsis* bloom. The Orange River incident has resulted in the initiation of an eutrophication-monitoring programme in the Orange River itself, as well as in dams on the river (Van Ginkel, 2004).

Boegoeberg Dam is classified as an oligotrophic system because of the general low chlorophyll-*a* concentrations (algal biomass), but cyanobacterial species (*Microcystis spp., Oscillatoria sp.,* and *Cylindrospermopsis sp.*), have occasionally dominate the algal assemblage.

Water Transfers and Stream Flow changes

Substantial transfers take place from the Upper Orange to the Lower Orange (1 886 Mm^3/a). However, the water volume flow has been much reduced in the Lower Orange River, as has the frequency, duration and magnitude of flooding (DWAF, 2009b).

Inter- and intra-catchment water transfer schemes, river diversions (primarily for irrigation), and evapotranspiration have reduced the natural stream flow in the lower Orange River (below Marksdrift) to half or less than the natural levels, e.g. from about 350 m^3/s to 150 m^3/s at Upington. Lower streamflow increases the susceptibility of the river to pollution because it will reduce its capacity to attenuate and degrade wastes, will concentrate pollutants and increase salinity, as the dilution effects of the Orange River will be reduced (DWAF, 2009b).

Major outbreaks of pest blackflies (*Simulium chutteri*) – from Hopetown to Sendelingsdrift, have resulted in annual losses to livestock farmers. These outbreaks are ascribed to the artificial and relative constant flow regime.

There continues to be a need for reliable data on water resources water demand by sector and region and with the unequal distribution of water resources and varied water demand growth there is a clear need for the development and application of integrated water resources management.

Orange River mouth

The Orange River mouth (estuary) is regarded as the sixth most important coastal wetland in southern Africa. It is an important resting site on the migration route of many aquatic bird species. However, declining water quality and river health in the lower basin has resulted in the RAMSAR status of the Orange River mouth being rescinded and placed on the Montreux Record. The lack of flow variability and the overall reduction in water volume poses a serious threat to the integrity of the river mouth Ramsar wetland.

The riparian vegetation has been severely damaged on the South African side of the river mouth. Special efforts and management strategies should be investigated and implemented to restore this Ramsar site (DWAF, 2009b). A comprehensive Reserve must however, still be determined for the Orange River.

9.15 WATER MANAGEMENT AREA 15: FISH TO TSITSIKAMMA

Background

The Fish to Tsitsikamma WMA covers an area of 97 023 km^2, of which, except for a small area that falls in the Northern Cape Province, the entire area falls in the Eastern Cape Province. The main rivers of this area are the Great Fish, Sundays, Bushmans, Kowie and Kariega rivers. All these rivers drain to the Indian Ocean.

The mean annual precipitation ranges from 150 mm in the north-western interior, where the climate is semi-arid, and rainfall generally occurs in the period from March to May, to more than 1 100 mm along the coast in the south-west, where rainfall occurs throughout the year. Mean annual evaporation in the WMA ranges from 1 450 mm (in the south-east) to 2 050 mm (in the north-west).

The population of the WMA in 1995 was approximately 1 623 000 people. Some 13% of the population lived in rural areas, and 87% of the total population lived in the towns of the WMA. About 64% of the population lives in the Algoa Coastal area, mainly within the boundaries of the Nelson Mandela Metropolitan Municipality. Much of the economic activity is concentrated in the south-western portion of the WMA, with the Port Elizabeth/Uitenhage area contributing 82% of the GGP in 1997. The GGP of the whole WMA was R21,8 billion in 1997, with the most important economic sectors, in terms of their contributions to GGP, being manufacturing (28,3%), trade (18,0%), and government (16,6%). Transport and manufacturing have comparative advantages relative to other WMAs.

Water requirements in 1995 were estimated to total 1 158 million m^3/a, excluding the requirements of the ecological Reserve, but including water use by afforestation and alien vegetation.

The natural MAR of the Fish to Tsitsikamma WMA was 2 154 million m^3/a and the yield utilised from surface water resources in 1995 was 425 million m^3/a at 1:50 year assurance. The maximum potential utilisable yield of the WMA is estimated to be 943 million m^3/a, which is 478 million m^3/a more than the utilised yield in 1995 (DWAF, 2002a).

Water Quality Status

With the exception of a few coastal catchments, the water quality in the Fish to Tsitsikamma WMA is dominated by elevated salinities mostly from natural sources. High salinity concentrations occurred in most of the Gamtoos River, even at monitoring points in the upper reaches of the river. In the Groot River tributary, electrical conductivity and total dissolved solids concentrations were in an "unacceptable" category (L3R001, L7H007Q01 and L7H006Q01). Phosphate concentrations varied between "tolerable" and "unacceptable" and elevated sulphate concentrations occurred in the lowest monitoring point, probably due to some marine impacts. An exception in the Gamtoos catchment was the Kouga River where salinity and most other constituents were in an "ideal" category (L8H005Q01 and L8R001Q01). Phosphate concentrations in the Kouga River varied from "tolerable" to "unacceptable" which may indicate some man-made impacts in this catchment (intensive vegetable and fruit production).

Water quality in the middle and lower Swartkops River (M1H012Q01) was largely in an "unacceptable" category probably due to urban and industrial impacts on water quality.

Water quality in the lower Sundays River (N4H003Q01) was also characterised by high salinity even though water was transferred from the Orange River into the upper reaches of the system. Natural salinity and irrigation return flows contributed to the elevated salinity in the river. Phosphates, sulphates and pH were also unacceptably high in the lower reaches of the river.

Salinities were also in an "unacceptable" category in the Kariega and Kowie rivers (P3H001Q01 and P4H001Q01) as were phosphate concentrations. Ammonia, nitrate nitrogen and sulphate concentrations were low and varied between "ideal" and "acceptable" categories.

Salinities in the upper Fish River (Q1H012Q01, Q1H022Q01 and Q1H001Q01) tended to be in an "acceptable" category but increased in a downstream direction to an "unacceptable" category (Q9H012Q01 and Q9H018Q01). Salinities in its south flowing tributaries like the Tarka River (Q4H013Q01), Baviaans River (Q6H003Q01), Konaap River (Q9H002Q01) and the Kat River (Q9H029Q01) tended to vary between "unacceptable" and "tolerable" categories. Salinities in the Little Fish River at Q7H005Q01 and Q8H008Q01 were in an "unacceptable" category. Phosphate concentrations throughout the Fish River basin were in an "unacceptable" category. The pH categories varied from an "acceptable" category in the upper reaches of the catchment to "unacceptable" in the middle and lower reaches due to pH values greater than 8.4. This was largely a natural phenomenon. Ammonia, nitrate and sulphate concentrations varied between an "ideal" category and "acceptable" category.

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WMA 15 WATER QUALITY STATUS MAP

"Tolerable" ranges of sulphate and ammonia concentrations were recorded in the middle and lower reaches of the Fish River (Q9H012Q01 and Q9H018Q01). Elevated ammonia concentrations are often associated with treated wastewater discharges.

Trend analysis indicated that although water quality in the Kouga River was still classified as "ideal" there was a declining trend which could indicate a slow deterioration in quality due to man-made impacts.

Water quality issues and concerns

Natural salinity in Fish and Sundays Rivers

The relatively flat topography, low MAR, high evaporation and underlying mudstones generally give rise to saline groundwater and resulting saline base flows in the Fish and Sundays rivers, irrespective of water transferred in from the Orange or irrigation return flows. It is likely that natural surface water would often have been unsuitable for most uses if not diluted with water transferred from the Orange River basin. Salinities in both rivers can vary widely over short periods. Water transfers to meet irrigation requirements and to maintain a 650 mg/l TDS target in the lower reaches reduce the salinity concentrations. However interruptions in the transfers can quickly result in short-term increases in salinity. Isolated rainfall-runoff events in the tributary catchments can also lead to a temporary increase in salinity of up to 3000 mg/l TDS. The water quality challenge in these two catchments are to even out these short-term changes by carefully managing irrigation releases, dilution releases and irrigation return flows in the system.

Impacts of dense settlements on microbial water quality

Dense settlement problems related to the informal housing areas are experienced in Grahamstown, Port Elizabeth and Uitenhage. The current level of services is often inadequate and problems are for example being experienced with nightsoil, grey water, litter and solid waste. The Bucket Eradication Programme has been implemented in Grahamstown and sanitation is being improved. The Dense Settlements Programme (see Text Box 17) has been implemented but some problems are still being experienced. There are large impacts on water resources, especially on the Bloukrans tributary of the Kowie River, which has an extremely high bacteriological population. These problems contribute to poor microbiological water quality in stormwater runoff and dry weather flows from informal settlements and poorly serviced high density settlements. These raise the risk of water-borne diseases, impacts on human health and aquatic ecosystem impacts such as low dissolved oxygen concentrations.

Orange-Fish-Sunday Water Supply Scheme

Water quality management is an important component of the management of the system, especially in the lower Fish River, where total dissolved solids can be in excess of 6 000 mg/l. Releases in the lower Fish River are made with the aim of achieving a water quality of less than 650 mg/l at Hermanuskraal Weir, where water for Grahamstown and the Lower Fish GWS irrigation is abstracted. This requires a large volume of water which is effectively lost to other users, inclusive of flows to the sea. The current operational objective of releases from Darlington Dam (where extensive citrus plantations are sensitive to chloride) is to try to keep the TDS of water released to below 600 mg/l.

Compliance to effluent standards

Concerns have been raised about poor compliance to effluent standards especially in rural areas. The 2009 Green Drop Report (DWA, 2009a) found that the average Green Drop score for the Eastern Cape was only 29% even though some of the municipalities such as the Nelson Mandela Metro scored relatively high.

Industrial impacts

Concerns have also been raised about the impacts of intensive industrial developments in the Port Elizabeth/Uitenhage area on heavy metal concentrations in the Swartkops River. Iron and manganese problems and high dissolved organic carbon (DOC) levels which lead to trihalomethane (THM) compounds in drinking water have been identified in the Kouga and Loerie dams. This has lead to increased water treatment costs. These problems were probably associated with stratification in the dams rather than man-made impacts.

Agrochemicals

Concerns have been raised about the breakdown products of agricultural pesticide and herbicide used in the Fish and Sundays River irrigation schemes. These can have a negative impact on aquatic ecosystems. Similarly intensive irrigation agriculture is practised alongside the Kouga River (Langkloof Valley) and Gamtoos River where vegetables, fruit and tobacco is produced. Pesticide residues are also associated with the production of these crops and may be an issue.

Text Box 17: Dense Settlements

Dense Settlements

Pollution from densely populated settlements is still one of South Africa's most complex pollution problems, affecting not only downstream water users, but having an impact on the community itself in creating atrocious living conditions in many settlements with consequent human health impacts.

Pollution from settlements has been demonstrated to be caused by the physical failure of waste disposal and/or sanitation services. However, these physical causes are normally underlain by social and institutional causes where social causes may stem from the misuse of the system, either through a lack of awareness or sometimes the deliberate misuse of services. On the other hand institutional causes arise when the service provider does not maintain or operate the services properly. Pollution from settlements, and in particular densely populated settlements, is usually caused by a combination of these factors. The implications or costs of dense settlements' pollution are therefore wide ranging, including human health costs, social costs, environmental and downstream water use costs.

In terms of the DWA policy, reactive interventions would be used where regional DWA, or Catchment Management Agencies, want to address downstream water quality problems associated with pollution from settlements. Proactive interventions would be aimed at planning appropriate services, as well as ensuring the ongoing effective management of waste and sanitation services, even where the impacts on the water resource are less significant. Both of these interventions would require the co-operation of National, Provincial and Local Government in collaboration with the community itself. (Source: DWAF, 2002. Managing the Water Quality Effects of Settlements:- The National Strategy: Policy Document U 1.3)

9.16 WATER MANAGEMENT AREA 16: GOURITZ

Background

The Gouritz WMA is situated in the southwest region of South Africa and falls predominately within the Western Cape Province, with small portions in the Eastern Cape Province and the Northern Cape Province. The Gouritz WMA consists of primary drainage region J and part of primary drainage regions K (K1 to K7) and H (H8 to H9). The Gouritz is the largest WMA in the Western Cape with a total surface area of 53 139 km^2. The mean annual temperature ranges between 16ºC along the south-east coast to 17ºC in the interior, with an average close to 17ºC for the catchment as a whole. The mean annual rainfall decreases from east to west, ranging from as high as 1000 mm in the south-east along the coast to as low as 160 mm toward the north of the WMA.

Gouritz River is the main river, and contributes 41% of the surface flow in the WMA. Its main tributaries are the Buffels, Touws, Groot, Gamka, Olifants and Kammanassie rivers, which drain the inland area. Several smaller rivers drain the coastal belt and all the inland rivers drain *via* the Gouritz into the Indian Ocean. The Duiwenhoks River Dam supplies 1.1 million m^3/a to the Duiwenhoks Rural Water Supply Scheme, of which 0.7 million m^3/a is transferred into the Breede WMA to supply farmers. There are no inter-basin transfers into the Gouritz WMA and approximately 70% of the available water is surface water.

The Gouritz WMA contributes less than 1% to South Africa's Gross Domestic Product (GDP), making it, from an economic perspective, one of the weakest WMAs in the country. The agricultural sector provides a wide range of products including wine grapes, fruit, fodder, vegetables, grains, hops, dairy, timber, tobacco, ostriches, sheep, cattle and goats. The fish and shellfish industry are significant for the economy of the coastal region. The ostrich industry also plays a part in the region's economy. Land use in the WMA, from a water resources perspective, is dominated by irrigation and afforestation activities.

The Gouritz WMA is one of the WMAs with the lowest population in the country. In the year 2000, the total population was estimated at 436 800 (DWAF, 2004i)). The inland region of the WMA is sparsely populated with 60% of the population situated along the coast. Of that 60%, about 90% reside in urban areas.

Water Quality Status

The water quality of the Gouritz River is characterised by elevated salt concentrations. Water quality is good in the headwaters of the tributaries but salinity increases in a downstream direction due to the geology of the region, high evaporation, and agricultural impacts. In the Buffalo River at Floriskraal Dam (J1H028) the salinity is "tolerable" but further downstream on the Groot River at Vanwyksdorp (J1H019), it has deteriorated to "unacceptable" levels. In the lower Gamka River at J2H010, the lower Olifants River at J3H011, and in the Gouritz River at J4H002, elevated EC and TDS concentrations were categorised as mostly "unacceptable". Elevated salt concentrations were also recorded in the Duiwenhoks River (H8H001) and the Goukou River (H9H005) where the water was categorised as "unacceptable". Salinity in the short coastal rivers of the K catchment is generally regarded as "ideal" in the Kaaimans River (K3H001), Knysna River (K5H002) and the Bloukrans River (K7H001). In the lower reaches of the Brandwag River (K1H004) and Moordkuil River (K1H005) salinity was "acceptable" to "tolerable". However, salinities in the lower reaches of the Groot-Brak River (K2H002), Maalgate River (K3H003), Swartvlei (K4R002) and Hoëkraal River (K4H001) were regarded as "unacceptable". Some of these monitoring points might have been affected by saltwater intrusion from the sea (like the one in Swartvlei). Nitrogen and ammonia concentrations were "ideal" in the coastal (K catchment) rivers but sulphate concentrations were "unacceptable" in the Groot-Brak River and Swartvlei, probably the effect of seawater intrusion.

Phosphate concentrations are regarded as unacceptable throughout the catchment. This could be due to the impacts of agricultural return flows in the catchment and discharges from wastewater treatment works.

In the Duiwenhoks River (H8H001) all the constituents exhibit an increasing trend over time except phosphates that shows a decreasing trend. However, in the Goukou River (H9H005), constituents show a slight increasing trend and phosphates slight decreasing trend. Constituents in the Touws River (J1H018) show an increasing trend except for phosphate and pH. In the Groot River (J1H019) and Olifants River (J3H011) constituents show a decreasing trend except for ammonia in the Groot and ammonia and nitrates in the Olifants River. Increases in nitrogen are generally associated with treated wastewater effluent discharges. The Gouritz River (J4H002) exhibits a slight increase in salinity but large increases in ammonia and nitrates.

Water quality issues and concerns

Salinity in the Great and Little Karoo

The elevated salinity found in the Gouritz River and its major tributaries occurs naturally over the inland catchments of the Great and Little Karoo as a result of the natural geology and high evaporation. This is a historical situation and one to which the ecology and the farmers have adapted.

WMA 16 WATER QUALITY STATUS MAP

The selection of crop types by farmers has allowed them to continue financially viable farming operations, making best use of the available water for irrigation. Outside of government controlled irrigation schemes, irrigation is largely opportunistic in the inland catchments. Elevated salinities do not occur to the same extent in the coastal catchments (H8 and H9) and the K catchment.

Water quality issues and concerns

Salinity in the Great and Little Karoo

The elevated salinity found in the Gouritz River and its major tributaries occurs naturally over the inland catchments of the Great and Little Karoo as a result of the natural geology and high evaporation. This is a historical situation and one to which the ecology and the farmers have adapted. The selection of crop types by farmers has allowed them to continue financially viable farming operations, making best use of the available water for irrigation. Outside of government controlled irrigation schemes, irrigation is largely opportunistic in the inland catchments. Elevated salinities do not occur to the same extent in the coastal catchments (H8 and H9) and the K catchments.

Nutrient enrichment and eutrophication

Concerns have been expressed about nutrient enrichment and eutrophication problems in the Olifants River downstream of Oudtshoorn and the Goukou River as well as estuaries such as the Hartenbosch estuary, Knysna lagoon, Goukou estuary and the estuary near Stilbaai. Nutrient enrichment is the result of farming activities (fertiliser leaching and washoff, dairy and animal wastes), and WWTW discharges high in nutrients. Problems associated with nutrient enrichment include excessive growth of rooted and free-floating aquatic plants and algae, and choking of river channels with water plants and reeds.

Urban impacts on water quality

In the developed urban areas, particularly the more densely populated coastal towns, man-made activities result in problems commonly associated with urban water use. These include discharge of water containing waste, WWTWs not meeting their required effluent water quality standards and diffuse pollution from informal settlements. Concerns were also raised about the impacts of a number of tanneries in the Oudtshoorn area.

Sewage and wastewater treatment systems

Concerns have been expressed about sewage and wastewater treatment systems in the WMA. In the larger urban centres such as Oudtshoorn, vandalism of the sewage reticulation and pump station infrastructure occasionally leads to sewage spills into the Olifants River. The industrial expansion taking place in the Oudtshoorn area would introduce additional loads on the WWTW and upgrading of the works will be necessary to avoid spills. It was the opinion of water quality managers that many of the WWTWs in the WMA were over-capacity resulting in poor quality discharges. Concerns were also expressed about the impacts these have on the microbiological quality of the receiving rivers. Runoff from informal settlements and poorly-serviced housing areas has resulted in pollution of rivers near urban areas such as the Olifants River and Knysna lagoon.

Disposal of wood processing waste

The disposal of wood processing waste is a potential problem throughout the coastal catchments (K catchment). Many saw mills operate without the necessary permits for discarding their waste. Leachate, consisting of organic acids and of high COD concentration from sawdust and woodchips, is undesirable from a water quality perspective. Woodwaste from treated wood, results in leaching of inorganic chemicals. The extent of unlawful disposal of this waste is not well known and the extent of impact on water quality has not been determined yet.

Dissolved oxygen and dairy farming

Concerns have been expressed about the organic loading of rivers and streams from dairy farming activities and dairy processing facilities in the George and Riversdal areas. The breakdown of organic compounds reduces dissolved oxygen concentrations in rivers which have a negative impact on aquatic organisms.

Sand mining and turbidity

Concerns have been raised about sand mining in the K catchment and at Wittedrift near Plettenberg Bay. Elevated turbidity cause silting of water ways, smothering of aquatic ecosystem habitats, and suspended sediment particles are good sites for adsorbing phosphates and water-borne pathogens.

9.17 WATER MANAGEMENT AREA 17: OLIFANTS DOORN

Background

The major river in the Olifants Doorn WMA is the Olifants River, of which the Doring River (draining the Koue Bokkeveld and Doring areas) and the Sout River (draining the Knersvlakte) are the main tributaries (DWAF, 2005b). It comprises the E primary drainage region.

The Olifants River rises in the mountains in the south-east of the Water Management Area and flows in a north-westerly direction. Its deep narrow valley widens and flattens downstream of Clanwilliam until the river flows through a wide floodplain downstream of Klawer. The Doring River is a fan-shaped catchment with the main river rising in the south and flowing in a northerly direction. Its main tributaries are the Groot River, Tra-Tra River and the Tankwa River. The northern part of the WMA is flatter and much of the basin lies between 500 and 900 m above sea level. In the east there are significant mountain ranges, the Hantam near Calvinia and the Roggeveld to the south, which rise to about 1 500 m above sea level. West of Nieuwoudtville lies the Bokkeveld Mountains escarpment, where the plateau elevation of about 700 m drops to about 300 m. The rolling hills and plains of the 30 to 40 km wide strip along the coast from the southern boundary of the WMA to the estuary of the Olifants River are known as the Sandveld. The deep sandy deposits overlaying the bedrock in this area are “primary” aquifers which provide a significant groundwater resource (DWAF, 2002b).

Climatic conditions vary considerably with minimum temperatures in July ranging from –3 to 3 ºC and maximum temperatures in January ranging from 39 to 44 ºC. The area lies within the winter rainfall region, with the majority of rain occurring between May and September. The mean annual precipitation is up to 1 500 mm in the Cederberg Mountains in the south-west, but decreases sharply to about 200 mm to the north, east and west thereof, and to less than 100 mm in the far north. Average gross mean annual evaporation (Symons pan), ranges from 1 500 mm (in the south-west to greater than 2 200 mm (in the dry northern). Due to the diverse soil types and variance in rainfall distribution, vegetation is varied and includes at least six veld types and several thousand plant species. Karoo and Karroid Types, False Karoo Types, Temperate and Transitional Forest Types, Scrub Types, and Sclerophyllous Bush Types occur in the Olifants/Doorn WMA.

The Olifants River and its tributary, the Doring River, are important from a conservation perspective because they contain a number of species of indigenous and endemic fish that occur in no other river systems, and that are endangered. Some of the tributaries are virtually unspoiled and are of high to very high ecological importance. The Olifants estuary is one of only three permanently open estuaries on the west coast of South Africa and represents a critical habitat to many estuarine-associated fish and bird species.

The Olifants/Doorn WMA is the least populated WMA in the country with approximately 0.25% of the national population residing in the area. Approximately 113 000 people live in the WMA (DWAF, 2005b). More than half of the population live in urban or peri-urban areas, and the rest in rural areas. About 65% of the population is concentrated in the south-western portion of the WMA. The population growth expected for the area appears to follow the general trend of decreasing rural populations which can be attributed to the lack of strong economic growth.

Water Quality Status

Water quality in the upper Olifants River, upstream of Clanwilliam Dam, is “ideal” and is suitable for all uses (E1H013 and E1H013). There is evidence of elevated phosphate concentrations which may be the result of agricultural activities and wastewater return flows in the Citrusdal area. The good quality water is stored in Clanwilliam Dam and Bulshoek Dam from where it is distributed *via* a system of canals to irrigation farmers in the middle and lower Olifants River valley. In the Olifants River downstream of Clanwilliam Dam and upstream of the Doring River confluence, the water quality remains suitable though it is progressively impacted by irrigation return flows from the highly cultivated Lower Olifants River irrigation scheme. The result is that water in the lower Olifants River just before the estuary (E1H018) is “unacceptable” and salinity exceeds the requirement for irrigation use.

Previous studies (Olifants Doring Basin Study Phase 1, 1998) found that there was a difference between unimpacted catchments and the main stem of the Olifants River that was impacted by agricultural activities. Tributaries in the upper Olifants River, like the Jan Dissels River, were largely unimpacted by human development. These rivers showed evidence of seasonal changes in quality. Salinities tended to be higher at the end of the dry summer period while low salinities were observed at the end of winter. However, in the middle and lower Olifants River it was found that there were strong seasonal variations in water quality. High salinities were observed early in winter probably originated from the wash-off of accumulated salts from the irrigated lands by the early rainfall. Lower salinities were observed at the end of winter when most of the salts have been washed off the catchment.

WMA 17 WATER QUALITY STATUS MAP

Water quality in the Koue Bokkeveld is ideally suited for all uses (E2H002). A trend of increasing TDS over time was observed in the Leeu River even though the quality is still acceptable. Marked seasonal differences were also found, with higher salt concentrations being observed in summer than in winter (DWAF, 1998).

The quality of water in the upper Doring River, when flowing, is suitable for agriculture and domestic water supplies. However, TDS concentrations in the Kruis River are very high and variable and the water quality has been classified as “tolerable” to “unacceptable” (DWAF, 1998).

Water quality in middle Doring River becomes marginal and TDS concentrations increase in a downstream direction. In the lower reaches, the water quality varies between “acceptable” at the end of winter and “tolerable” at the end of summer, probably as a result of the predominantly winter rainfall in the catchment. The water quality is still suitable for all uses but it does indicate deterioration. It has been reported that farmers stop irrigating when the water begins tasting salty.

Highly saline flows from the Tankwa Karoo tributaries have a sporadic influence on the Doring River.

The water quality status of non-perennial rivers like the Wolf, Koebee and Oorlogskloof, Sout, Krom and Hantams are not known. The Knersvlakte is a naturally saline system.

In the Sandveld sub-area water quality is “tolerable” to completely “unacceptable” in the Kruis River catchment (upper reaches of the Verlorenvlei River) due to elevated salinities. It improves slightly in a downstream direction but the lack of data precludes any concrete conclusions about water quality in the Verlorenvlei River and in Verlorenvlei. The cause of the poor water quality is the result of agricultural activities on the Malmesbury shales, which are high in salts and cover a large part of the Kruis River catchment (Sinclair et al., 1986).

Water quality issues and concerns

Microbiological water quality in the Upper Olifants River

The Olifants River supports a very important fruit export industry in the middle and lower Olifants River valley. Poor quality treated effluents from the towns of Citrusdal and Clanwilliam can put this industry at risk. The impacts of the effluent return flows should be monitored and reviewed on a regular basis in light of the European Common Agricultural Policy standards (e.g. EUREPGAP) to ensure that the export market is not jeopardised. Water quality management in the upper Olifants River should ensure that export standards for the agricultural industry are met. Many households use water from the irrigation canals for domestic purposes. Preventing microbial pollution would also protect these users.

Nutrient enrichment in the upper Olifants River

The Citrusdal valley experiences nutrient enrichment problems which are largely attributed to agricultural return-flows, especially in the summer months when the flow is relatively low in the river. Treated domestic wastewater, municipal solid waste management and informal settlements contribute towards this problem. Effluent from fruit and wine industries also needs to be monitored in Citrusdal.

Impacts of irrigation return flows

Agricultural activities in this WMA include a wide variety of crop types, many of which are high-value produce. The cultivation of wine and table grapes, rooibos tea, citrus, deciduous fruit, wheat, potatoes, flower cultivation and wildflower harvesting, livestock and fisheries contribute to the sector. Wine and dried fruit are important value-added products. Irrigation water use is the largest water user and only a small percentage of crops are dry-land crops due to the low rainfall over most of the WMA. Irrigation is with good quality water from the irrigation canals but farmers need to over-irrigate in order to leach out salts that accumulate in their irrigated soils. The leach water is returned to the middle and lower Olifants River resulting in a progressive deterioration of water quality. The irrigation farming industry should investigate alternative disposal and/or re-use practices to reduce their impact on the river.

Concerns have also been raised about the impacts of effluents from fruit and wine industries which cause seasonal water quality problems and it was recommended that the wine industry effluents from Klawer, Vredendal and Lutzville required on-going monitoring and management.

Impacts of agro-chemicals

Concerns have been raised about the impacts of residues from agricultural chemicals such as pesticides and herbicides on surface and sub-surface waters in intensive irrigation areas. Such impacts have not been studied in the middle and lower Olifants River but research in similar irrigation developments have shown that residues should at least be monitored.

Protection of upper Olifants River catchment

The high winter rainfall and the natural geology in the upper reaches of the Olifants River ensure that the water quality is good. Catchment management should focus on protecting the upper Olifants River to protect the water quality in Clanwilliam Dam, the main source of water to the Olifants River government water scheme.

Sand mining activities

Concerns have been expressed about sand mining activities in the WMA. It is poorly controlled and results in an increase in turbidity and suspended sediment concentrations, increased salinity, which causes silting of rivers and streams and smothering of habitat of aquatic organisms.

Proposed mining and impacts on Verlorenvlei

Concerns have been expressed about the proposed development of a tungsten mine in the catchment of the Verlorenvlei wetland and the impacts this may have on salinity and ecosystem health in this ecologically sensitive wetland.

9.18 WATER MANAGEMENT AREA 18: BREEDE

Background

The Breede Water Management Area (WMA) is situated in the south-west corner of South Africa, falling entirely within the Western Cape Province and is comprised of the tertiary drainage regions G40 (excluding G40A), G50 which makes up the Overberg Area and H10 to H70 which makes up the Breede River basin. Rainfall is highest in the mountainous regions in the southwest where the mean annual precipitation is as high as 3 000 mm per annum, whilst the central and north-eastern areas receive as little as 250 mm per annum. The mean annual temperature varies between 17ºC in the east to 15ºC along the south-west coast, with an average of 17ºC for the whole WMA. The average potential mean annual evaporation (measured by S-Pan) ranges from 1200 mm in the south to 1700 mm in the north of the WMA.

The Breede River is the main river in the catchment and its largest tributary is the Riviersonderend River. Other rivers in the Overberg area include the Sout, Klein, Bot and Palmiet.

A major inter-basin transfer takes place between the Breede and Berg WMAs via the Riviersonderend-Berg-Eerste River Government Water Scheme; approximately 161 million m^3/a is exported into the Berg WMA for the City of Cape Town water users. Another 9.5 million m^3/a is transferred into the Berg WMA and an additional 2.5 million m^3/a is transferred into the Olifants/Doorn WMA via the Inverdoon Canal.

The primary economic activities in the Breede WMA include irrigated agriculture, wheat cultivation and associated activities such as processing and packaging. Of the employed population in the WMA, 43% are active in the agricultural sector. The contribution of this WMA to the national Gross Domestic Product (GDP) is less than 1%, and is among the lowest in the country. Agriculture, trade and manufacturing are the most significant economic contributors in the Breede WMA. Land use in the WMA, from a water resources perspective, is dominated by intensive irrigation. Large expanses of dry land cultivation are characterised in the south of the region, where wheat is the predominant crop type.

Of the total population of 382 400, estimated in 1995, 66% reside in urban and peri-urban areas and 34% in rural areas. No significant population increase was anticipated.

Water Quality Status

Water quality in the headwaters of the Breede and many of its tributaries are ideal but it becomes progressively poorer in terms of salinity in a downstream direction. The biggest increase occurs in the middle Breede River due to intensive farming activities. Salinity measured as EC is “acceptable” in the Upper Breede near Ceres (H1H003Q01) and near Brandvlei Dam (H1H015). Further downstream at Le Chasseur (H4H017) it is still “acceptable”. However, downstream of the Zanddrift canal, salinity is “unacceptable” as measured at H5H004 near Secunda, H5H005 near Drew, and H7H006 near Swellendam. Salinity in the Breede River between Brandvlei Dam and the Zanddrift canal near Ashton is managed to meet irrigation water quality requirements through freshening releases from Brandvlei Dam. Downstream of that point salinity is high and riparian farmers can only use water during high flow conditions when there is sufficient dilution of the saline irrigation return flows. Salinities in the lower reaches of tributaries such as the Hex River (H2H010), Nuy River (H4H020), Kogmanskloof River (H3h011), and Riviersonderend River (H6H009) were “unacceptable”.

The increase in salinity in the Breede River and its tributaries is the result of poor quality irrigation return flows, irrigation and farming practices, and the geology (Bokkeveld shales) of the region (DWAF, 2000b). Sulphate concentrations range from “ideal” in the headwaters of the Breede River to “acceptable” in the lower reaches of the river.

Nitrogen concentrations along the Breede River remain “ideal” with little possibility of affecting crop yields.

The water quality in the Buffeljags River near Swellendam with respect to EC were within the irrigation and domestic water use requirements along the entire river reach (DWAF, 2000b). The river is also moderately enriched with nutrients and moderately enriched or even eutrophic conditions could exist.

In the Overberg, water in the lower Palmiet River is “ideal” for all constituents except phosphates. However, the river is highly impacted by WWTWs, discharges from fruit processing industries and urban runoff in te Grabouw/Elgin area. In the Klein River (G4H006), upper Sout River (G5H008) and lower Sout River at De Hoopvlei (G5R001) the salinity is naturally high and classified as “unacceptable”. The sulphate concentrations and pH in the entire Sout River are “unacceptable”.

Elevated phosphate concentrations are a concern throughout the WMA, probably the result of intensive agricultural activities in the basin and effluent return flows.

WMA 18 WATER QUALITY STATUS MAP

Water quality issues and concerns

Salinity in the Breede River basin

Salinisation of the middle and lower Breede River and its tributaries are the result of the irrigation return flows discharged to the rivers, the geology of the area, and agricultural practices.

Of particular concern is the intentional leaching of natural salts where new lands are cleared and soils purposefully leached to prepare those lands for irrigation. Acceptable salinity levels in the Breede River are maintained by freshening releases out of the Greater Brandvlei Dam.

Salinity is managed as far downstream as the Zanddrift Canal off-take, just upstream of the Kogmanskloof River confluence. Recommendations have been made regarding possible remedial measures such as the use of interceptor drains to limit the saline return flows entering the river. Another option is the demarcation of saline soils and the issuing of water use licences with conditions as to where new lands can be established. A more extreme (and costly) alternative is the construction of high-level canal systems to convey water directly to irrigators rather than using the river channel. Such an option would expose the river to the effects of saline return flows and place farmers and the ecosystem downstream of the water scheme in an even worse position.

Nutrient enrichment in the Breede River

Concerns were expressed about the occurrence of algal blooms and excessive filamentous algal growth under low flow conditions at certain locations within the Middle Breede River, clogging of canals by filamentous algae, and aquatic weed infestations (water hyacinth). These concerns were related to nutrient enrichment. This problem can be controlled by ensuring WWTW meet the effluent standards and by controlling fertilizer runoff from diffuse sources. Concerns were also expressed about algal blooms in the Theewaterskloof Dam which resulted in taste and odour complaints when the water was treated for domestic water use. Farmers have also complained about algal blooms in farm dams.

Microbiological quality in the WMA

The discharge of inadequately treated wastewater effluent from WWTWs, and irrigation with untreated winery and other industrial effluent are further concerns. Most municipal WWTWs and larger industries are attempting to meet licence conditions but the cumulative effect of many smaller operators irrigating with effluent which does not meet the general authorisation requirement, remains a concern. Diffuse pollution from poorly serviced informal settlements and the use of soak-aways on the banks of the Lower Breede River are also of concern to the microbiological quality of the Breede River and other rivers in the WMA. Stormwater runoff from informal settlements and poorly serviced urban areas has increased microbial counts in receiving rivers. Microbial impacts tended to be localised due to the die-off of pathogens in the water.

Agrochemicals in irrigation return flows

Studies in the Hex River valley have detected pesticide residues in irrigation return flows (London, 1999, London *et al*, 2000). It is probably reasonable to assume that the same patterns of pesticide contamination would occur in the rest of the Breede River Basin where intensive irrigation agriculture and spraying of orchards and vineyards is practised.

Dissolved oxygen and the dairy industry

Concerns have been expressed about the impacts of intensive dairy farming and dairy industries on the organic loads to rivers. In rivers the breakdown of organic compounds reduces dissolved oxygen concentrations which have a negative impact on aquatic organisms. Similar concerns have been raised about local authorities and wineries irrigating their high chemical oxygen demand (COD) effluents. These effluents can be washed into rivers during high rainfall events increasing the organic loads to the receiving rivers. The impacts of piggeries in the Bonnievale area on organic loads have also been a concern to water quality managers. Runoff and effluent discharges high in COD has negatively affected estuaries in or near coastal towns in the eastern Overberg area resulting in calls for their protection and rehabilitation.

Turbidity and impacts of sand mining

Sand mining activities in the Barrydale, Ashton and Suurbraak areas result in increased turbidity and suspended sediment concentrations in rivers. This leads to siltation problems and smothering of aquatic habitats. Bulldozing of streams and tributary rivers in the Breede valley has similar impacts on sediment loads.

9.19 WATER MANAGEMENT AREA 19: BERG

Background

The Berg Water Management Area (WMA) is situated in the extreme southwest corner of South Africa and falls entirely within the Western Cape Province. The Berg WMA consists of secondary drainage region G1 and G2, as well as the quaternary G30A in the north and G40A in the south. The mean annual temperature varies between 16 °C in the east to 18°C along the West Coast, with an average temperature of 16°C for the whole WMA. The entire Berg WMA is a winter rainfall region with the annual rainfall varying from 3 200 mm to 300 mm and the annual evaporation varies between 1 300 mm in the south and 1 700 mm in the north.

The major rivers include the Berg, Steenbras and Diep. A net transfer of 194 million m^3/a (in 2000) is exported from the Breede WMA via the Riviersonderend-Berg River Tunnel System into the Berg WMA for domestic water supply and use of farmers. No water is transferred out of the WMA.

The Berg WMA contributes about 12% to South Africa's Gross Domestic Product, of predominantly commercial trade and industrial activities. Other economic sectors that contribute towards the GDP include manufacturing, trade and agriculture. Land use in the WMA is characterised by residential, industrial and extensive irrigation areas (DWAF, 2004j).

Waste pollution from sewerage treatment plants and informal settlements along riverbanks threaten the river systems of the Berg WMA. During the late summer months (dry season) there is too little flow left in the rivers to dilute the pollutants and with a damaged river ecology pollutants can no longer be cleaned effectively. Salinity and siltation problems occur in the rivers of the southern region of the WMA. Salinity problems occur in the northern tributaries of the Berg River.

The total population of the Berg WMA is approximately 3 247 000 people, of which 95% reside in urban areas. Of that 95%, 87% of the people are concentrated in the Greater Cape Town area as they are attracted by employment opportunities. The winelands, which include the towns of Stellenbosch, Paarl, Wellington and Franschhoek, represent moderately populated areas.

Water Quality Status

Water quality in the Berg WMA varies not only between the individual river basins but also within individual river systems. The natural geology, agricultural practises, point and non-point source pollution all play a role in determining the quality of water in this WMA.

Most of the rivers in the water management area rise from the Table Mountain Group mountain catchments which provide very good quality water with total dissolved solids concentrations of less than 60 mg/l. The Berg River arises in the mountains near Franschhoek and the runoff is characterised by ideal water quality. However, the quality deteriorates in a downstream direction as a result of human activities. In Paarl (G1H020) the water is still regarded as "ideal" although phosphate concentrations are a concern. In the Upper Middle Berg area, which corresponds largely to the southern portion of the Drakenstein Municipal Area, the water quality of the Berg River has been severely impacted as a result of agricultural activities (coupled with river modification, water abstraction and runoff of pollutants) and general urban and informal settlement developments at Paarl/Wellington. Water quality at Hermon (G1H036) is regarded as "ideal" to "acceptable" although phosphate concentrations are still unacceptably high and a concern. Discharges from the Paarl and Wellington WWTWs are probably responsible for the elevated phosphate concentrations in this part of the river.

In the Lower Middle Berg area at Drie Heuwels (G1H013) the water quality has been severely affected by diversion weirs, disruption of flow patterns in the Klein Berg and Vier-en-Twintig rivers, and as a result of agricultural activities (largely the building of flood-protection levees and the use of pesticides). Water quality in this reach is regarded as "acceptable" in terms of salinity. By the time the river reaches the Misverstand Weir where water is abstracted for distribution to the West Coast towns and industries at Saldanha, salinity has increased to levels where the water is regarded as "acceptable". Phosphate concentrations are still unacceptably high. Many of the lower Berg River tributaries are underlain by Malmesbury shales of marine origin and therefore have naturally high salinity concentrations. Industrial users (steel manufacturers) in the Saldanha area need to pre-treat this water before being able to utilise it in their industrial processes.

Irrigators are limited to the types of crops they can cultivate, due to increased salinity levels. Water quality in the lower Berg River at G1H023 is poor with salinity and phosphates at "unacceptable" levels and sulphates at "acceptable" levels.

Water quality in the Klein Berg River which originates in the mountains near Tulbach is regarded as "ideal" at G1H008 where water is diverted into Voëlvlei Dam. Phosphate concentrations are high due to treated domestic and winery effluent from the Tulbach area.

WMA 19 WATER QUALITY STATUS MAP

Treated wastewater effluents and poor quality runoff from informal settlements into the Eerste River in the Stellenbosch area is a concern. By the time the Eerste River drains into the sea, the water quality is regarded as "acceptable" in terms of salinity, "acceptable" for ammonia and nitrates and phosphate concentrations are "unacceptable".

This is a reflection of urban and intensive agricultural activities in the catchment. Serious concerns have been expressed about the microbiological quality of the Eerste River in Stellenbosch due to runoff from informal settlements with poor sanitation services.

Water quality in the upper Diep River at Malmesbury (G2H012) is regarded as "unacceptable" in the upper reaches; a result of the geology (saline Malmesbury shales) and agricultural practices. In the lower reaches at G2H042 the river was not classified in terms of salinity and phosphates but is regarded as "acceptable" to "ideal" in terms of nitrogen compounds. The Malmesbury WWTW discharges into the upper reaches of the Diep River. The Rietvlei wetland, a highly valued ecosystem, receives treated effluent from the Potsdam WWTW. Its impacts are of particular concern with respect to water quality and ecosystem health.

The Lourens River, most of the Peninsula Rivers, the Cape Flats rivers and vleis have all been impacted by urban runoff. The Kuils River and Salt River are also impacted by large wastewater discharges that have changed these seasonal rivers into perennial rivers. These urban rivers can probably not be rehabilitated but their condition must at least be maintained at levels that will not introduce social, health and aesthetic problems.

Water quality issues and concerns

Salinity in the middle and lower Berg River

A significant water quality problem in the Berg River catchment is salinisation in the middle and lower reaches. This is caused by leaching from the natural geology, which extends from the north of Paarl to the Berg River mouth and consists of Malmesbury shale, as well as agricultural practises and the wash-off of salts from irrigated and dryland agricultural practices. The problem is exacerbated during the first winter rains, when accumulated salts are washed into the river resulting in elevated salinity in the Misverstand Dam (G1H031).

Nutrient enrichment in the Berg River

A further concern in the Berg River is nutrient enrichment as a result of the discharge of treated sewage effluent from WWTWs, irrigation with treated winery effluent and the direct discharge of winery effluent. Diffuse pollution from informal settlements in the Klein Berg catchment impacts on the quality of water diverted into the Voëlvlei Dam (see Text Box 18). This has lead to increasing problems with nuisance algae in the middle and lower Berg River and Voëlvlei Dam, and higher domestic water treatment costs.

Microbiological water quality

Concerns have been expressed about the microbiological quality of rivers affected by treated wastewater effluent discharges and runoff from informal settlements. Rivers such as the Plankenberg and Eerste rivers near Stellenbosch, Stiebeul River near Franschhoek, and the Kuils River in Bellville are affected by poor quality effluents and runoff from informal settlements and high density settlements with poor sanitation services. Aging sewerage infrastructure and pump station breakdowns contribute to these problems. Some improvements in microbial water quality have in recent time been achieved in areas such as Stellenbosch and Paarl/Wellington due to interventions by the local municipalities. Concerns have also been expressed about the management and impacts of many small "package" WWTP's that fall outside local authorities such as on golf estates and wineries.

Water quality problems in urban rivers

Many of the urban river systems in the Berg WMA serve as conduits for treated effluent discharged to the sea. The Bellville, Scottsdene, Kraaifontein, Zandvliet, Stellenbosch and Macassar WWTWs discharge treated effluent into the Kuils/Eerste River system. Borcherds Quarry and Athlone WWTWs discharge into the Black/Salt River and the Potsdam WWTW discharges into the Diep River, which feeds into the ecologically sensitive Rietvlei wetland system. The Cape Flats WWTW discharges into the canal downstream of the Zeekoevlei outlet control weir. These rivers no longer display seasonal flow patterns, and some, notably the Black/Salt and Kuils rivers have become severely modified. High residual nutrients can lead to eutrophication-related problems such as nuisance algal growth and excessive growth of aquatic weeds. Other problems associated with urban rivers include leaking sewers, contaminated stormwater runoff, litter, oil and toxic spills. The constant and high base flows in these rivers also impact on the estuaries and many have lost their tidal variation.

Agro-chemicals and endocrine disrupting chemicals

There are concerns about the accumulation of pesticide and herbicide residues in the surface waters, biota and sediments downstream of intensive irrigation areas. Concerns have also been expressed about the presence of endocrine disrupting chemicals (EDCs) in surface waters near intensive irrigation systems. EDCs interfere with the hormonal balance of organisms and can be found in the breakdown products of pesticides, pharmaceuticals, plasticizers, household products and industrial chemicals. Persistent organic pesticides (POPs) and EDCs are not monitored routinely in the Berg River WMA.

Dissolved oxygen, piggeries and organic effluents

Concerns have been expressed about the impacts of many piggeries in the WMA on the organic loads to rivers. Organic compounds consume oxygen when they decompose in rivers thereby reducing the dissolved oxygen concentrations and negatively impacting aquatic organisms. Discharges not complying with COD standards and irrigated effluents high in organic content that are washed into rivers, have similar impacts on aquatic ecosystems.

Deterioration in the quality of irrigation

There is growing concern regarding the general deterioration of water quality and the availability of good quality water for irrigation. Poor water quality impacts on the availability of irrigation water for produce earmarked for export to the European Union. This has serious consequences for the country as a whole.

Text Box 18: Berg WMA

BERG WMA

Change in state of Voëlvlei Dam

Voëlvlei Dam is an off-channel storage dam, fed with water diverted from the Klein Berg River and the Twenty Four Rivers, and it supplies domestic water to the City of Cape Town and towns in the Swartland district. In the past Voëlvlei Dam was a stable clear water dam with abundant rooted water plants and it was a favourite bass fishing venue. During the drought of 2005/6, the water level in the dam dropped very low and wind re-suspension caused an increase in turbidity. Since then the dam has remained in this turbid state even though the dam filled up again and remained relatively full. Bottom feeding carp and barbel are now the dominant fish species. Algal concentrations have also increased and the two water treatment works at the dam are experiencing more frequent problems with algal blooms and geosmin, a compound that cause taste and odours in treated drinking water.

Re-use of wastewater

The City of Cape Town is currently investigating the re-use of wastewater as part of its Integrated Water Resources Planning Study and has an objective of achieving zero effluent discharge at some future date. Treated effluent from the Greater Cape Town Metropolitan Area represents a significant opportunity for re-use. This particularly the case where there is a need to augment water supplies. The development of new water resources infrastructure will not be sanctioned by DWA until it is apparent that the potential for wastewater re-use has been determined and implemented, where it is proven cost effective to do so.

10 Climate Change

Although climate change is a natural phenomenon, there is increasing concern about the impact of human-induced climate change. While a scientifically contested concept, there is general consensus that climate change is a current reality and it is likely that climate change will affect all facets of human existence globally including the planet's economy, the health and social structure of its populations, infrastructure provision and maintenance, and the viability of natural systems.

Water availability is likely to be a significant issue, as temperature and evaporation rates increase and changes in the distribution of rainfall occur. These trends may have an impact on reservoir storage capabilities. Changes in temperature and rainfall are also likely to affect vegetation distribution. Geographical shifts in the distribution of vegetation and productivity patterns are similarly possible. Migration of animal species to areas of more suitable climate is also likely to increase.

Under these conditions, a number of health-related problems are likely to occur. For example, an increase in malaria and cholera in areas where rainfall intensity increases and flooding occurs. These problems are further exacerbated by overcrowding, poverty and poor sanitation. Agricultural productivity is also likely to be affected, especially in drought-prone areas. Major impacts on food production may arise from changes in temperature, moisture and carbon dioxide levels, and the spread of pests and diseases. This is particularly important for the poorest members of society who are directly dependant on the land for survival. Furthermore, a carbon dioxide rich climate could aggravate desertification through the alteration of spatial and temporal patterns of temperature and precipitation.

The general assessment of climate change effects on southern Africa has been done in the framework of the IPCC 4th assessment report (Christensen *et al*. 2007). Results presented indicate that by the end of 21st century temperatures are expected to increase by 2-3.5 deg C compared to values observed from 1980 to 1999. Increases at the top of this range are expected to occur in the interior, while coastal regions are expected to have increases corresponding to the lower bound of that range. Winter (June-August) temperature increases are projected to be stronger than summer (December-February) ones. Results of assessments carried out specifically for South Africa (e.g.) corroborate these results. Changes in temperature and higher ultraviolet light penetration are likely to severely affect freshwater systems and human populations which rely upon them. Projections of changes in climate (temperature, rainfall and runoff) are extremely difficult to model, and assessing projected climate impacts on freshwater ecosystems is even more challenging, particularly with regard to human influences and responses. The consequences of human-induced impacts include the following effects on aquatic systems, and are likely to be exacerbated with the effects of climate change (Kernan *et al*., 2007):

- Acidification and eutrophication by sulphur and nitrogen compounds
- Invasive species introduction, which alters flow patterns

- Mobilization of organic substances from soils
- Dam building and river diversion
- Erosion and sedimentation
- Increased ultra-violet radiation
- Habitat fragmentation.

It is important to note that algal blooms, and especially blue green algae (Figure 10), result in many human-related impacts (see Text Box 19). The potential impacts of global warming will increase the frequency of toxic algal blooms and this will have a greater chance of human related impacts such as diarrhea and even potentially toxic algal related fatalities for communities that drink water directly from the river. Management of eutrophication is of particular concern, since this presents severe problems for the treatment of water and presents a potential health threat when trihalomethanes (THMs) are formed after chlorination.

The cyanobacteria cells accumulate along shorelines because they are positively buoyant and are driven into shallow water or onshore by prevailing winds accumulation along shoreline.

Figure 10: A typical cyanobacterial bloom

Text Box 19: Impacts of algae on water use

Impacts of algae on water use

Algal blooms:

A pervasive result of enrichment of lakes and rivers with nutrients is increasing growth of algae. Algae, especially cyanobacteria (blue-green algae) respond to cultural eutrophication by the development of massive populations, including blooms, scums and mats. Such mass populations are increasingly attracting the attention of environment agencies, water authorities, and human and animal health organizations, because cyanobacteria can present a range of amenity, water quality treatment problems, and hazards to human and animal health. The increasing number of events of cyanobacterial blooms in South African impoundments and rivers is a cause of concern to the Department of Water Affairs and Forestry (Van Ginkel, 2004).

Human and animal health risk:

Freshwater toxins are produced almost exclusively by Cyanobacteria. Surveys in different parts of the world have revealed that between 25% and 75% of cyanobacterial blooms are toxic. Toxic blooms of cyanobacteria in freshwaters have been reported in many water bodies throughout South Africa (Van Ginkel, 2004). Cyanobacteria can produce a diverse range of cyanobacterial toxins, known as 'cyanotoxins', which are hazardous to human and animal health. Potential health concerns arise from exposure to the toxins through ingestion of drinking-water, during recreation and through showering.

Water treatment processes only partially filter out cyanobacteria and dilute their toxins. These toxins have caused massive mortality among wild and domestic animals and also constitute a hazard to human health, particularly by ingestion, and skin irritation and even death of humans exposed to microcystins during haemodialysis.

Perhaps the most widespread risk to human health posed by toxic algae is exposure while engaged in recreational activities in waters with blooms. Swimming, sailing and water-skiing are popular and valued pastimes for South Africans, while also being economically significant for local communities because of the associated tourist infrastructure. Human illness – ranging from minor rashes and other allergic reactions to gastroenteritis and even more severe illnesses – is known to result from contact with affected water during recreational activities. Ingestion of cyanobacterial toxins can also cause vomiting and diarrhoea and may have long-term effects such as liver damage and the promotion of tumour growth. Possibly a greater risk to humans from algal toxins comes from long-term, low level consumption of the liver toxins, as these poisons are known to promote the growth of liver tumours.

Water treatment problems:

One of the most expensive problems caused by nutrient enrichment is the increased treatment required for drinking water. Nutrient enrichment commonly cause drinking water treatment plant filters to clog with algae, impede coagulation and filtration. High algal biomass in drinking water sources require greater volumes of water treatment chemicals, increased back-flushing of filters, and additional settling times to attain acceptable drinking water quality (USEPA, 2000).

The treatment processes used at conventional surface water treatment plants are normally effective in removing cyanobacterial cells, but are not effective in removing or destroying dissolved cyanotoxins. To remove the cyanotoxins need additional water treatment, such treatment ranges from granular activated carbon filtration, followed by reverse osmosis, to more elaborate treatment including membrane filtration. Human health risks in water supplies are toxins by cyanobacteria and carcinogenic trihalomethanes may be formed when water is chlorinated during purification.

Water quality managers are frequently concerned with the effect that blooms of nuisance algae have on the taste and odour of water in municipal water supplies. Taste and odour compounds are produced by microscopic organisms such as algae, bacteria, fungi and protozoa. Periods of fishy water and periods of musty water, prompted significant consumer complaint. Control measures by water purification plants to remove taste and odour are usually expensive. Water boards are reluctant to implement expensive control measures when the ecological, environmental and health details of these compounds remain unknown. However, consumers' demands for high quality water will remain or increase. Taste and odour events erode consumer confidence in municipal drinking water supplies leading to a rise in the use of bottled water.

Other problems:

Excessive growth of nuisance algae in response to impaired water quality can reduce both the aesthetic appearance and use of rivers and lakes. Decreases in the perceived aesthetic value of the water body (amenity value degraded). Riparian property values may decrease. The effects of algal blooms on the aquatic ecosystem are severe, *inter alia*: Species diversity decreases (thus lower biodiversity), low ecological stability, extreme oscillations occur in physical and chemical parameters as well as in the growth of many planktonic organisms – growth in pulses and sudden collapses, depletion of dissolved oxygen, reduced ecosystem integrity; loss of some ecosystem components and functions, and increased probability of fish kills.

Filamentous algae may impede water flow in canals (loss of hydraulic capacity). Clogging of reticulation systems by filamentous benthic algae, and can contribute to the corrosion of pipes. High algal concentrations cause a severe clogging hazard for drip irrigation systems. The recreational use of water surfaces may also be adversely affected, e.g. closure of local waterways for swimming, fishing and boating with a threat to tourism of the affected area with a potential loss of income.

Conclusions:

The development and prevalence of dense cyanobacterial blooms is the main symptom of progressive and often uncontrolled eutrophication processes in rivers and water storage reservoirs. Cyanobacterial blooms (frequency and intensity) in South African aquatic systems are increasing. Without a radical improvement in eutrophication management approaches and treatment technologies, eutrophication will continue to decrease the benefits and increase the cost associated with use of these resources.

In the long-term, reducing nutrient inputs is the best preventative measure. Catchment management to reduce sewage spills and cutting down the input of fertilisers and other pollutants is the key to reducing the incidence of algal blooms and associated problems.

11 Role of Water Quality Planning

11.1 Water Quality

Constant media claims, in many cases backed by scientific evidence, frequently raise concerns about the deterioration over time of the water quality in many of our water resources. Resource water qualities that are unfit for use have also been reported in certain isolated cases. Such scenarios must be avoided, since it potentially poses adverse human health effects, while also jeopardizing sustainable development. It is evident that a worsening resource water quality situation can only be reversed and prevented if proper and focused planning is complemented by appropriate management interventions.

11.2 Proactive intervention

Current tendencies are emphasising the need for pro-active intervention, as far as water quality management (WQM) is concerned. This specifically applies to WQP, which in essence represent a pro-active approach towards securing water resources that are fit for use. WQP must be supported by suitable pro-active and re-active source control measures.

11.3 Water Quality Management

Prior to the 2003 Macro-Restructuring of the Department's Policy and Regulation Branch, WQM constituted the mandate of a single DWA Directorate, *viz*. the then Directorate WQM. However, today WQM no longer constitutes the responsibility of a single organisational unit. Instead – WQM constitutes a DWA effort that is serviced and maintained by different role-player directorates that fulfil specific functions which collectively make up the Department's broader WQM function.

Such an approach has a number of advantages which theoretically includes the establishment of specialised organisational units, the extension of the Department's WQM capacity and allowing for more focussed cooperation amongst individual DWA role-players. Conversely, in the absence of effective integration of these specialised functions and roles, the above said advantages are largely nullified, potentially rendering a Departmental WQM function that is largely ineffective. A co-ordinated planning role is necessary to improve the effectiveness of the Department's broader WQM function.

11.4 Planning coordination

Generally speaking, the Department's Integrated Water Resource Planning (IWRP) component provides the required Resource Planning and Management cohesion that links Resource Objectives with Water Use Management (see Figure 11). Within the Department's IWRP function WQP is focused on "connecting" Resource Water Quality Objectives with water quality Water Use Management, and hence, it functionally fulfils the coordination role from a water quality perspective.

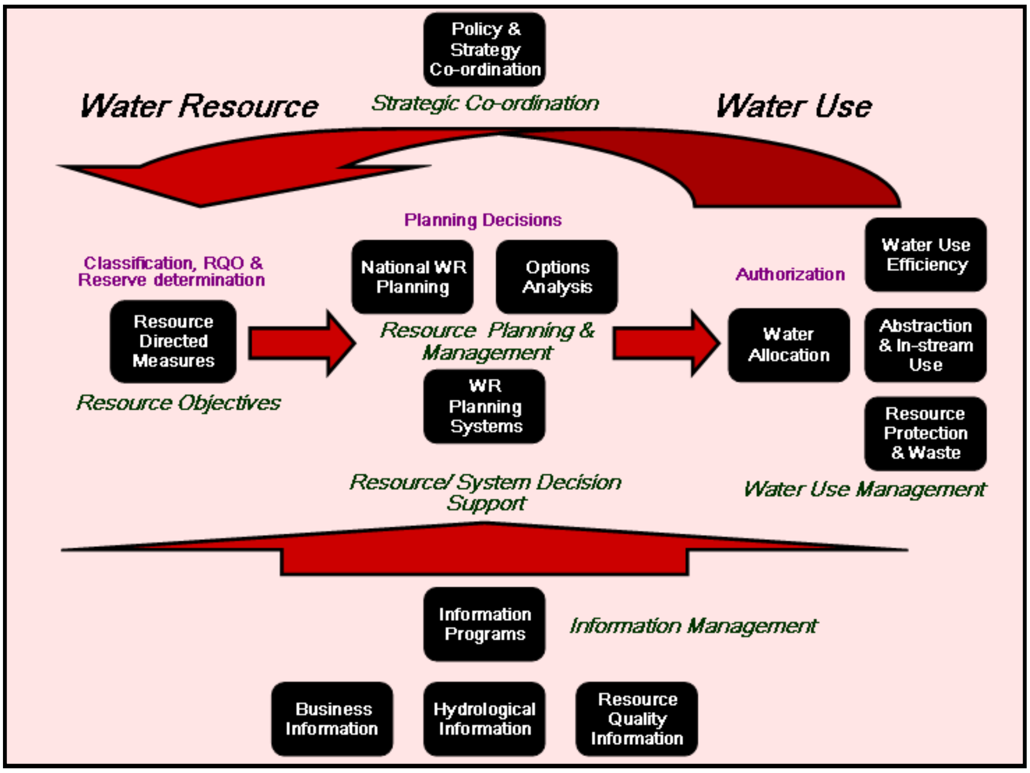

Figure 11: Planning provides the "glue" that links resource protection and source control efforts

11.5 Integration

Since the current DWA structure houses various "water quality role-player" directorates, an effective and structured collaborative effort is crucial. This is particularly true for WQP, as WQP is, on the one side, reliant on water quality and catchment data and information that are mostly to be supplied by the Department's Information Management group, while, on the other side, it is not directly involved in source control, but only responsible for the provision of strategic catchment and resource guidance to the Department's Water Use Management group. In addition, WQP is also obliged to provide WQP support and input to the Department's Resource Directed Measures (RDM) group. Large room for improvement exists when linking resource planning decisions-making with the determination of RDMs, the implementation of source control and enforcement, and the supply of useful and appropriate planning data and information. In addition, relationships within the broader water quality governance structure, such as with Catchment Management Agencies (CMAs), also deserve attention and agreement.

11.6 Water Quality Planning

The goal of the Department's WQP function is to develop and maintain integrated WQP related instruments and processes, and to generate WQP solutions that support the protection, use, development, conservation, management and control of South Africa's water resources, including water resources shared with neighbouring countries.

The roles of this function are-

- to develop (or revise), and participate in the implementation and maintenance of integrated WQP related instruments[1] and processes;
- to ensure and support long-term strategic water quality planning, scenario analysis, reconciliation, and foresight;
- to support integrated water resource planning and management, including the implementation of RDMs and water allocations;
- to support WQP related research;
- to provide WQP related strategic and specialist technical assistance to our clients;
- to build WQP related capacity, internally and externally;
- to monitor, and audit the implementation of the said integrated WQP related instruments[1] and processes; and
- to identify and support WQP related management information needs.

If translated into practice, the abovementioned means that the determination of resource objectives and the provision of water quality input to RDMs, *i.e.* the Reserve, Resource Quality Objectives (RQOs) and the Water Resource Management Class, is largely informed through WQP, while the strategies and plans on how to achieve those are also inherently products of WQP. As such the Department's WQP function includes planning assessment (CAS), forecasting and water quality trend analysis, scenario analysis, catchment visioning, determination of Resource Water Quality (planning) Objectives (RWQOs), water quality availability assessment, water quality reconciliation and water quality allocation planning, intervention planning and management implementation co-ordination, WQP information and decision support by means of modelling and other predictive and planning systems, and planning auditing and improvement (see Figure 12).

[1] WQP related instruments include policies, strategies, programmes, procedures, guidelines, models, systems, methodologies, regulations and criteria that will apply to WQP at the international, national, water management area and/ or catchment levels.

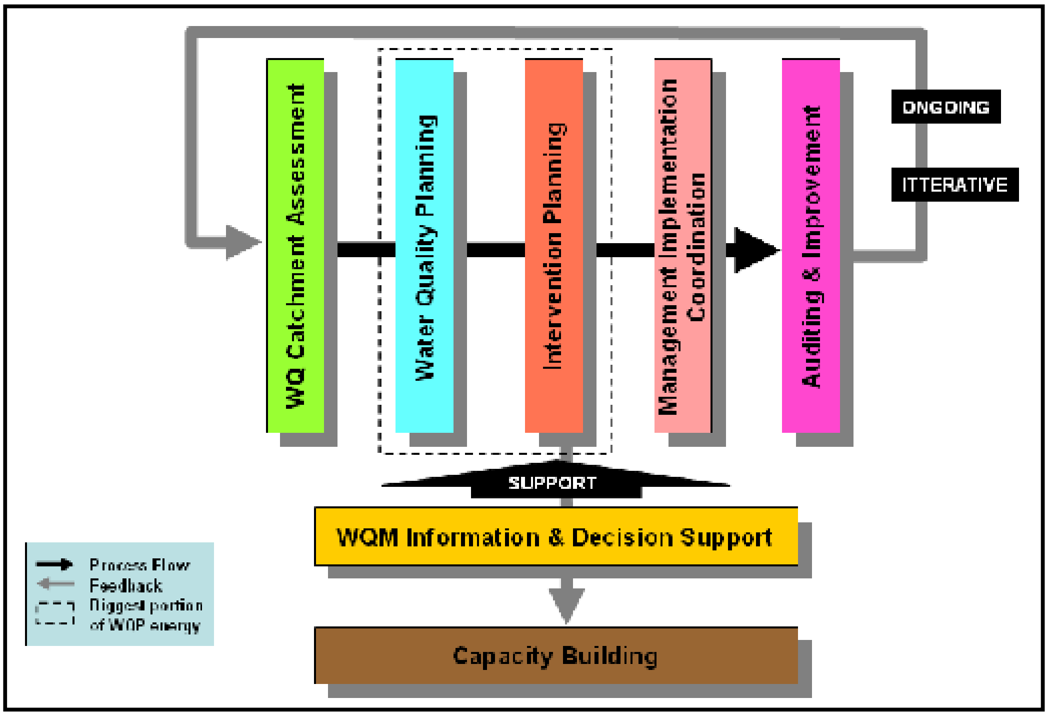

Figure 12: Water Quality Planning business flow diagram

12 Future Water Quality Management Interventions

The deterioration of the quality of our water resources is one of the major threats to South Africa's capability to provide sufficient water of appropriate quality to meet developmental needs while ensuring environmental sustainability. The water quality problems are influenced by uncontrolled sources of pollution and challenges in executing measures to manage pollution.

In the coming decade, water resources will be under increasing stress from persistent and emerging challenges including population growth, urbanization, new contaminants and climate change. Increasing population, urbanisation and expanding economies coupled with a lack of capacity, funds or willingness to apply pollution regulations are factors increasingly resulting in greater scarcity of good quality water resources.

In summary the focus areas for future water quality management intervention are discussed in the sections that follow.

12.1 Management Approaches

12.1.1 Co-operative Governance

The DWA is responsible for the management of the nation’s water resources. Water quality management in South Africa is complex and requires strong institutional capacity (well-trained resources, active, effective systems and appropriate finances) at a national and regional level. Unless DWA increases its capacity and works cooperatively with the Department of Mineral Resources, Department of Environmental Affairs and Department of Agriculture and local government the water quality in the country will continue to deteriorate and the episodic fish and crocodile kills will become a more regular occurrence.

Multi-sectoral participation in water quality management is required. Sustainable management of the country’s water resources will be achieved only if all sectors of society find effective means of working together in partnership. Where there is political will, it is possible to put in place policies, laws, financing arrangements and stable public institutions for water management.

We need an Environmental Agency (EA) or a legislatively effective enforcement body that is responsible for dealing with water pollution incidents in South Africa. The focus of the EA would be enforcement of regulations against polluters. The EA should be well resourced with notably qualified people so that effective enforcement actions can take place.

The overarching philosophy is that everybody is downstream and hence water quality needs to be collectively and cooperatively managed by all users in civil society.

12.1.2 Regulatory tools

The DWA has the regulatory tools but these need to be applied in an effective and consistent manner. These tools include source regulation through water use authorizations (linked to integrated water and waste management plans), guidelines and regulations and load reduction strategies.

The current suite of South African environmental and natural resources legislation provides every opportunity for the protection and conservation of natural resources. It creates a framework to rights and obligations, which bind the government and its agents, landowners and the civil society. However, the implementations of these laws are lacking.

Load reduction is crucial to the management of the water quality in rivers. This includes strategies such as centralised mine water treatment works which can be modularly expanded as more water needs to be treated. The eMalahleni and Optimum mine water treatment works are good examples of how industry and local government have cooperated to turn a waste resource (mine water) into a product (drinking water).

Compulsory licences in stressed catchments need to be applied and managed. Licence compliance reports need to be collated and regular feedback given to appropriate river forums so that water quality management becomes more transparent and collective solutions can be sought in a cooperative manner.

The Green Drop System also serves as a tool to facilitate the relationship between Regulation and Management of Wastewater Services, while also keeping relevant stakeholders informed on compliance trends of all registered systems. The system serves as information basis for the Green Drop Certification programme which is an incentive-based regulation. The poor compliance to chemical, physical and microbiological requirements is an indication of a break-down in cooperative governance and enforcement of regulations. There is an urgent need to get wastewater treatment works just to comply with their current water use authorisations.

12.1.3 Fiscal Tools

The DWA is developing a Waste Discharge Charge System (WDCS), based on the polluter pays principle, to promote waste reduction and water conservation. It forms part of the Pricing Strategy and is being established under the National Water Act 9 (Act 36 of 1998).

The WDCS aims to:

- promote the internalisation of environmental costs by impactors;
- promote the sustainable development and efficient use of water resources;
- create financial incentives for dischargers to reduce waste and use water resources in an optimal way; and
- recover the costs of mitigating the impacts of waste discharge on water quality.

The basis of the polluter pays principle is that the costs of environmental impacts should be borne by those responsible for the impacts. The National Water Act specially refers to the polluter pays principle as an economic mechanism for achieving effective and efficient water use.

To date only test cases of the WDCS have been undertaken in the Witbank Dam and Crocodile (West) catchments. The roll out and implementation of the WDCS is however becoming essential to the water quality management of water resources specifically related to load reduction and mitigation measures.

12.1.4 Self Regulation

Without a culture of self regulation water quality management in South Africa, it is going to remain the responsibility of DWA to catch the perpetrators. Most of the large water users, be they mines, industry or water treatment works, have sets of standards that they have to comply with in their processes, as well as their discharge standards.

All of the international companies have international quality systems that they need to comply with. All export companies need to comply with international standards that relate to health and safety as well as environmental compliance.

Self-regulatory management instruments such as the ISO 14000 series of environmental standards are used by industries to improve their own environmental performance. Other examples include the CEO Water Mandate which is a United Nations initiative designed to assist companies in the development, implementation and disclosure of water sustainability policies and practices. Large multinational companies such as Coca-Cola, Cadbury, SAB Miller, Pepsi and Sasol are signatories to this compact. Other examples include the adoption of cleaner production principles to enhance efficiency, industry action programmes such as "Responsible Care" and Waste Minimization Clubs.

The Department can use self-regulation or voluntary mechanisms to their advantage by giving recognition to industries and companies that actively participate in such initiatives.

Environmental auditing and the potential imposition of green taxes are important tools to assist the culture of self regulation. Without this culture the water quality status of our rivers and impoundments will continue to deteriorate.

12.1.5 Civil management instruments

These instruments are based on transparent and participative management of water resources and water quality. The involvement of catchment forums and water user associations in the development of catchment management strategies creates a mechanism through which the Department can leverage support for water quality management as well as the role out of most water management strategies. A further example is the Adopt-a-River initiative that the Department has launched to involve NGOs and communities to protect and manage water resources at a local scale. The Department should use the enthusiasm of local NGOs to monitor water quality and to bring pollution incidents to the attention of regional official's *i.e* the recommendation is for greater involvement in forums, Catchment Management Committees and other stakeholder consultative institutions.

12.2 Resource Quality Management

12.2.1 Resource Quality Objectives/ Resource Water Quality Objectives Approach to Management

Chapter 3 of the National Water Act (NWA) (Act No. 36 of 1998) lays down a series of measures which are together intended to ensure the comprehensive protection of all water resources, *i.e.* i) Water Resource Classification, ii) the determination of the Reserve, and iii) setting Resource Quality Objectives (and associated Resource Water Quality Objectives). To date a suite of instruments have been developed to support this. The challenge that is now to be faced is the implementation of these RWQO's.

The setting of the management class of the water resource (Class I, II or III) will determine its level of protection needed to allow for sustainable utilisation. Currently the water resources in three WMAs (Olifants, Vaal and Olifants-Doorn) are being classified in terms of the newly established classification system. The Reserve set together with RWQOs cater for the level of protection required by the aquatic ecosystem and water users. These then translate back to source directed measures to achieve the RWQOs. The RWQOs dictate the load reductions required, discharge qualities and standards.

This translation back to source directed controls is the current challenge being faced with regard to the implementation of Resource Directed Measures (RDMs). Attempts at implementation have been done through Integrated Water and Waste Management Plans (IWWMPs) and licence conditions and do occur in some catchments (e.g. the Vaal and Upper Olifants). However large scale consistent implementation is still required. What is required for successful implementation is installed water quality modelling systems to support the relationship between source requirements and RWQOs. Capacity building will be required so that these models can be run and maintained.

RQOs still need to be confirmed per WMA and will only become legally defendable once they have been gazetted. However RWQO's currently being used in the interim still serve as the management objectives to achieve the desired resource water quality.

12.2.2 The Reserve

Speedy implementation of the Reserve should be a high priority.

Water quality is one of the most important drivers of the ecological Reserve process and is used throughout the process.

Implementation of ecological Reserve allocations and associated environmental flows

If environmental flows are implemented and their effectiveness monitored there should be an improvement in the present ecological status of the aquatic organisms in the WMA's or catchments. It is important that the proposed Ecological specifications (Ecospecs) for water quality and associated water quality monitoring programmes are implemented and revised according to the ongoing monitoring findings.

12.2.3 Water Resource Classification

The ultimate goal of the Water Resource Classification System (WRCS) is to recommend a normative desired condition for each water resource in a given catchment. Once the management class has been determined, there is a need for catchment-scale water quality planning to account for the cumulative impacts of multiple discharges to ensure that RWQOs are not exceeded when considering a new water use licence application for effluent discharge, or when considering curtailment of existing over-allocation of assimilative capacity in order to restore water quality to meet RWQOs. Quantitative tools to support such catchment-scale planning is not well developed or commonly used. In future this gap will become crucial in the meeting of RQOs and RWQOs.

12.3 Information Management

12.3.1 Water Quality Monitoring

Good data and ongoing monitoring are the cornerstones of an effective effort to improve water quality. In order to protect and improve water quality, water managers, governments, and communities need to know what pollutants are in the water, how they entered the waterway, and if efforts to improve water quality have been effective.

The importance of water quality monitoring cannot be over emphasized. Information is critical for decision making. The lack of data has been made evident through this status assessment.

Monitoring of system change is crucial, but more importantly the system must be audited against the desired state, to ensure that the goals of management are met and the system is maintained in the desired state and if not, then DWA must respond because they have a responsibility. It has been said that our water monitoring programmes (e.g. River Health Programme- RHP) only record the deterioration of water quality and the extinction of aquatic biota, but it means nothing because no actions are taken against offenders (polluters). If somebody is violating the laws (polluting the water) then DWA must take action against them.

The RHP will need to be expanded to cover the chosen Reserve (Environmental Water Requirement) sites. This will include increased biomonitoring (typically fish and macroinvertebrates) which can be used to determine the effects of water quality on the aquatic ecosystems.

More funding and resources are required at a national level to address the current monitoring information gaps. The capacity at Regional Offices on water quality sampling, data collection, data compilation and interpretation and information reporting needs to be strengthened and expanded.

Plans to improve water quality cannot be implemented without a clear understanding of what contaminants are in the water and how they are affecting the ecosystem and human health. Addressing water quality challenges will mean tracing water contaminants to their source and identifying a prevention and/or treatment plan. Once the treatment plan is implemented, ongoing monitoring of water quality will help to ascertain whether the remediation efforts have been successful. Based on this information, the treatment plan can be continued or modified to include treatment of additional point sources and pollutants until desired levels of water quality constituents in the water resource are reached.

12.3.2 Increased variables to be monitored

The Department's Resource Quality Services (RQS) water quality database (WMS) is the national source of the chemical water quality data. The water quality variables that are analysed do not include trace metals nor organic analysis.

The National Toxicity Monitoring Programme (NTMP) only covers POPs and some of the pesticides of concern but lacks pesticides like the organophosphates, chlorpyrifos, dimethoate, fenamiphos, etamidophos, mevinphos, prothiofos and terbufos due to the lack of resources.

Many constituents accumulate in the sediment and concentrations can exceed guideline values compared to concentrations in the water. These are remobilized during flood events or when anoxic conditions develop. Sediment is therefore an important source of potential pollution. However, sediment as a sampling medium is currently not included in any monitoring programme and need to be addressed (probably in a separate monitoring programme).

An important feature of many South African rivers and reservoirs is high turbidity caused by the presence of suspended silt, thus, soil erosion, sediment transport and siltation of dams are a major issue in South Africa. However, very limited data on turbidity or suspended solids is available for aquatic systems. Turbidity influences the quantity and the quality of light penetrating water as well as the biota and the transport of chemicals. As light is a driving force for primary production, changes in light attenuation will have a direct influence on the trophic dynamics of aquatic ecosystems. Turbidity is important because it affects the growth rates of phytoplankton, transport of contaminants, and the effectiveness of disinfection. Therefore, it is recommended that turbidity (NTU) is included in the national water quality monitoring programme. The determination of turbidity is an easy and cheap method.

Existing toxicity tests (within the NTMP) did not show any response to the pesticide/ trace metal contamination in the water and did not reflect the predicted effect of water quality guidelines. An investigation is recommended to relook at various tests, including endocrine disrupting activity and other chronic toxicity tests, in order to understand the effect of these pesticides on the aquatic ecosystem.

The National Microbial Monitoring Programme should be expanded because the microbial quality of rivers receiving poor quality effluents and contaminated stormwater runoff was identified as a major concern in this study.

12.3.3 Inadequate Water Quality Guidelines

The current South African Water Quality Guidelines (DWAF, 1996) do not include many of the variables of concern and it is recommended to include frequently detected variables like DDE-4,4, DDD-4,4, phthalates, phenanthrene, dibenzo furan, chlorpyrifos, dimethoate, metamidophos and others.

It is recommended that the DWA develop guidelines that are site specific. The interaction of these chemicals in terms of toxicity need to be taken into consideration.

There are no sediment quality guidelines developed yet. The frequent detection of chemicals in the sediment requires that sediment-specific guidelines are developed.

12.3.4 Lack of Regional Office use of the Water Management System (WMS)

The DWA Resource Quality Services (RQS) water quality database Water Management System (WMS) is the national source of the chemical water quality data. Despite many years of training within the regional offices of DWA this system has not been adopted as the “one and only catch-all system” for water quality data. This has left gaps in this data base as many of the regional water quality monitoring programmes are not included in the WMS. Coupled to this is the inconsistent monitoring frequency as well as the limited numbers of monitoring sites nationally.

The WMS programme needs to be used by all regions in order to effectively manage the nation’s water quality.

12.3.5 Water Quality Information data/information management

Education and capacity building

Water quality improvements can be achieved through the difficult work of changing social norms, advocating for improved policies, and demanding smarter investments. One of the most important strategies in the arsenal of the water quality advocate is the tool of building social change through education and capacity building. Particularly in an unregulated environment, it is easy to throw things into the water, like industrial byproducts, agricultural waste, or human waste (UNEP, 2010).

Regulations and enforcement can help change behavior and lead to new technologies and financial investments to improve water quality. But all of these strategies can only be implemented once a society decides that water quality is a problem. To have societies make improving water quality a priority, they need to have knowledge about its connections to the things they care about.

Capacity building and education efforts are needed at every level. This capacity building is an important part of education so that positive results can flow from increased knowledge.

Thus,

- Implement environmental awareness campaigns and information programmes and
- Encourage environmental responsibility of individuals and communities.

Volunteer monitoring

The Department recently launched the Adopt-a-River initiative to involve communities more closely in the management of their local water resources. Volunteer monitoring is often viewed as a way to mobilise community members. The Department should encourage such activities by providing resources such as sampling manuals, booklets, etc. on the topic, as well as providing an information system where such data can be stored (refer to documentation produced for implementing the Adopt-a-River programme). Communities can act as the eyes for the Department in the early detection of water pollution.

12.4 Eutrophication

Eutrophication effects and problems are profound in several aquatic ecosystems in South Africa and have become a matter of major concern to all water users. Causes of nutrient over-enrichment or eutrophication of aquatic ecosystems can be attributed to agriculture, urbanization (mainly sewage effluent), forestry, impoundments, and industrial effluents. Increased rates of primary production typical of eutrophic ecosystems is often manifest as excessive growth of algae and the depletion of oxygen, which can result in the death of fish and other animals. Mass mortality and anoxia is the ultimate stage of eutrophication. The impacts of eutrophication are ecological, social and economical – discussed elsewhere. Various preventative and control options are available for eutrophication, but only major input and output controls are listed.

12.4.1 Nutrient reduction

Control of eutrophication can only be reached effectively by drastic reduction of the total nutrient load of an overloaded water system. Controlling phosphorus should be the primary focus of any nutrient control strategy. Although wastewater effluent is the principal contributor to the degradation of the aquatic system, it is also one of the impacts that is most easy to mitigate. It is easy to focus on point sources because they are easily identified, measured, and susceptible to control by policies and regulation.

12.4.2 Upgrading infrastructure

Frequent exceeding of water quality standards by sewerage treatment works (see Green Drop Report, 2009a) constitutes a serious risk to South Africa's aquatic ecosystem. Therefore, urgent attention should be given by the municipalities to upgrade the sewerage infrastructures and minimise operational spillages.

12.4.3 Chemical treatment

Sediments play a significant role in the process of eutrophication of water bodies. Major controls of nutrients inputs have been implemented in many instances however their recovery may be delayed due to the very high levels of nutrients contained in the sediment. Chemical remediation may be used to reduce sediment phosphate (P) flux. The use of alum may be a viable option to treat and reduce elevated levels of readily exchangeable sediment phosphate in impacted streams, such as downstream from wastewater treatment plants (WWTPs). Thus, alum or iron chloride treatment of streams may be a feasible option to mitigate P release from benthic sediments after external P sources are reduced.

12.4.4 Biological filters

Establishment of artificial wetlands at wastewater treatment plants must seriously be considered – this ecological purification process is economical and could be a useful alternative way of treating sewage in rural areas, smaller towns and townships. Establishment of riparian buffers could control and mitigate the impact of non-point source pollutant loading (e.g. modern agriculture) into surface water. Numerous studies have shown the effectiveness of riparian buffers in reducing sediments, pathogens and nutrient loads into surface and groundwater in agricultural catchments.

12.4.5 Flow manipulation

Flow manipulation appears to be a most promising area for management of eutrophication in rivers because it addresses both of the key drivers of algal blooms: water residence time and stratification. Altering the timing and size of the discharge through the river system must be seen as a potential cyanobacterial management strategy. Thus, much greater attention needs to be given to flow management to provide flushing flows, to reduce pollution levels, and endeavouring to provide flows that are closer to the natural situation.

12.4.6 Monitoring

Strengthen and expand the National Eutrophication Monitoring Programme (NEMP). The key for the success of these policies in providing solutions to the problems of pollution is the ability to conduct continuous and routine monitoring. Ideally, chlorophyll-*a* concentrations should be monitored weekly or biweekly.

12.4.7 Modelling

Modelling of salinity has progressed to a level that has been incorporated into the planning models. Nutrient models need to be developed to the same level as salinity. This is more difficult as nutrients are non-conservatives. Modelling of nutrients will allow planning-level decisions to be made regarding source management and discharge standards. Modelling needs to feed back into discharge standards for sewage and industrial waste discharges.

12.4.8 Integrated management

An important rule for the management of freshwater ecosystems is to remember that the conditions, water quality and biota of any body of freshwater are the product and reflection of events and conditions in its catchment. An extremely important factor is that substances added to the atmosphere, land, and water generally have relatively long time scales for removal or clean up.

Environmental and conservation issues need to be placed within the context of social and economic uses of the river by the community and therefore requires the perception of local residents, landowners, the water industry and other stakeholders to be taken into account. Science has an important role to play in the decision-making process.

Finally, the concept that eutrophication is permanent and will remain, should be considered in these new approaches to the problem. Therefore, the integrated management should be adaptive, constantly producing new mechanisms, ideas and tools. This can only be achieved with solutions and activities at the local level with political and managerial support. In this context education at all levels plays a fundamental and unique role. Public participation and awareness, practical focus, institutional capacity, articulation continuity and adequate scope should be some of the essential components of integrated water management focusing on eutrophication and related issues.

Successful control of the phosphorus in the aquatic environment requires the following:

- Effective legislative measures and their strict implementation by the national and regional governments.
- Surveillance by monitoring programs to check compliance with the regulations.
- Starting the control measures early before the eutrophication process becomes irreversible.
- Strong public support by the citizens and stakeholders.

Therefore, policy alone will not solve many of the degradation issues, but a combination of policy, education, scientific knowledge, planning, and enforcement of applicable laws can provide mechanisms for solving the rate of degradation and provide human and environmental protection. Such an integrated approach is needed to effectively manage land and water resources.

12.4.9 Nutrient Limits

Nutrients (primarily nitrogen and phosphorus) are the major driving force for eutrophication and algal blooms. The nitrogen (nitrate) concentration ranges used for the Status Report is based on the effects of nitrate on human health (drinking water), but is unacceptable from an eutrophication point of view.

The average NO_3-N concentration for the 300 sites studied was only 1.08 mg/ℓ, therefore 95+% of the sites were in the 'Ideal' range, which give a false impression in terms of plant nutrients in the aquatic systems. A NO_3-N concentration of 6 mg/ℓ (current Ideal) is already in the range of a hypertrophic system. To limit nitrogen concentrations and thus eutrophication we therefore propose a new set of nitrate concentrations for aquatic ecosystems – see Table 5. These concentrations are based on national and international literature and practical experience and expertise.

However, ammonium (NH_4-N) is also a nitrogen source available for plant and algal growth, and should also be considered. Therefore, if one look at nitrogen availability, then it is better to work with the total inorganic nitrogen (TIN) concentration available, *i.e.* the nitrate plus ammonium concentrations – see Table 6.

The phosphate concentrations used for this assessment and planning review is very strict (therefore there is a general non-compliance to phosphate throughout the country) and probably only applicable to dams (reservoirs). However, most of the 275 sites used in the report are in rivers, therefore a new set of ranges is proposed that is applicable for phosphate concentrations in streams and rivers (Table 5). These concentrations are more practical and still strict enough to limit eutrophication.

Table 5: Proposed Generic nutrient ranges

Variable	Units	Ideal	Acceptable	Tolerable	Unacceptable
NO_3 (NO_3-N)					
Current:	*mg/ℓ*	*6*	*10*	*20*	*>20*
Proposed:	mg/ℓ	0.50	1.50	2.50	>2.50
PO_4-P					
Current (dams):	*mg/ℓ*	*0.005*	*0.015*	*0.025*	*>0.025*
Proposed - Rivers:	mg/ℓ	0.025	0.075	0.125	>0.125

Table 6: Additional nitrogen ranges to consider

Variable	Units	Ideal	Acceptable	Tolerable	Unacceptable
NH_4 (NH_4-N)					
Current:	*mg/ℓ*	-	-	-	-
Proposed:	mg/ℓ	0.05	0.15	0.25	>0.25
DIN*					
Current:	*mg/ℓ*	-	-	-	-
Proposed:	mg/ℓ	0.70	1.75	3.0	>3.0

* DIN = Dissolved inorganic nitrogen
(NO3-N + NH4-N) = TIN (Total inorganic nitrogen)

While the above concentrations are proposed for rivers the management of nutrients still requires an integrated approach that should consider the impacts of these rivers on dams. Investigations into the response of dams need to be undertaken in a catchment context before RWQOs for nutrients are set for rivers.

12.5 Salinisation of the Country's Water Resources

The water quality in South Africa's aquatic ecosystems is declining primarily because of salinisation and eutrophication. Anthropogenic increases in salinity and electrical conductivity in surface waters are largely due to agriculture, mining, urbanisation and industrial activities.

Changing salinity in freshwater systems can have detrimental impacts on biodiversity. Salinisation can also lead to changes in the physical environment that will affect ecosystem processes, for example, higher TDS concentrations in the rivers evidently decrease the turbidity of the water that will have a direct influence on the primary productivity of aquatic ecosystems.

To prevent or minimise salinisation impacts, it is important to set maximum salinity targets. It is also important to identify taxa or other indicators of salinity impacts so that biomonitoring can identify impacts before they become severe or irreversible.

There are two main anthropogenic sources of salinity, point and nonpoint source discharges from mines (acid mine drainage), and irrigation return flows from large-scale irrigation schemes. The salinity of South Africa's water resources is being threatened by acid mine drainage. Coal mining activities are expanding in the Olifants, Upper and Middle Vaal catchments. The

Waterberg will be further developed in the future. The eastern, western and central gold mining basins are decanting or in the process of filling. The decant volumes that are expected in the future are large and of poor quality. The impact of the water quality will be large if this excess water is not managed properly.

The most viable long-term solution for acid mine drainage related salinity is desalination of contaminated water. The success of the eMalahleni mine water treatment works demonstrated that it is a viable solution if implemented at a regional scale. Controlled release schemes offers a short-term solution to managing river salinity but in the long term salts would accumulate in a system if the residence time is sufficiently long.

Currently river dilution is most commonly used to mitigate the impacts of saline irrigation return flows. This is inefficient use of scarce water supplies and will become more difficult as water becomes limiting in highly developed catchments. The collection or evaporation of saline return flows are used in Israel and in the Colorado River. This offers an on-site solution but it is not common practice in South Africa. It is recommended that the Department also collaborate with the Department of Agriculture and Agricultural Research Council to pilot test evaporation ponds as a means of capturing saline return flows.

12.6 Re-use of Wastewater

The direct and in-direct re-use of domestic waste water is receiving much greater attention in South Africa. Treated domestic waste water can be used directly for potable water supply. The Windhoek water reclamation works is an example of direct re-use. Indirect re-use generally entails blending treated waste water by discharging it to a dam or river and abstracting it elsewhere for treatment to domestic standards. The middle Vaal River is an example of indirect re-use from a river and the Garden Route Dam at George is an example of in-lake blending before abstraction. Other common options include the irrigation of sports fields and gardens in urban centers, irrigation of crops not eaten raw, and aquifer recharge. The Department's requirement that large urban centers consider re-use of wastewater before any new supply schemes are developed is having the desired effect and should be continued.

The key driver for the implementation of water re-use is increased utilization of a limited water resource. However in terms of water quality, protection of receiving water bodies may restrict the discharge of treated wastewater back to streams and aquifers, thus encouraging the use of reclaimed water.

Re-use of water would have positive benefits, specifically on the water resource, *viz*:

- Protection of aquatic ecosystems by not having to abstract more water from a water source, and
- Avoiding degradation of water resources by not discharging wastewater.

Water re-use projects may, however, still have an environmental footprint and energy usage depending on the water reclamation technologies used. In the South African context, re-use of mine wastewater results primarily in a brine and sludge waste stream with some useful byproducts such as gypsum. The re-use of domestic wastewater results in a saline waste stream which contains recalcitrant organic compounds. These waste streams have to be managed appropriately and responsibly within the environmental regulatory framework, to ensure that they do not negate the benefits of the water re-use.

Water re-use must therefore be evaluated in the context of other water supply and water augmentation options with consideration of water quality, environmental impacts, carbon footprint, ecological footprint and energy usage.

12.7 Inadequate Protection of Surface Water Resources

A higher hazard for the water resource needs to be taken into consideration by Department of Agriculture (DoA) during the regulation of pesticide application. It is suspected that aerial application of pesticides pose a higher hazard compared to ground application. This needs to be confirmed in a more intensive study together with Department of Environmental Affairs (DEA) (air sampling) and DoA (application patterns).

Awareness campaigns on safe and responsible use of pesticides for farmers, pesticide applicators and community members should be recommended to DoA.

Existing toxicity tests (within the NTMP) do not show any response to the pesticide/ trace metal contamination in the water and do not reflect the predicted effect of water quality guidelines. It is suggested that the toxicity tests be expanded to include endocrine disrupting activity and other chronic toxicity tests in order to understand the effect of these pesticides on the aquatic ecosystem.

12.7.1 Endocrine Disrupting Compounds

Endocrine disrupting compounds (EDCs) are chemicals that interfere with the structure and function of hormone-receptor complexes. They cause endocrine disruptive effects at very low levels. Impacts include testicular and prostatic cancer, decline in male fertility, and impacts on aquatic organisms. The Water Research Commission (WRC) has launced a research programme to develop an understanding of the situation in South Africa. It is recommended that the Department collaborates with the WRC to make an informed decision whether a baseline monitoring programme for EDCs should be implemented in high risk areas. A similar approach was followed in the development of the National Microbial Monitoring Programme (NMMP).

12.8 Enforcing Appropriate Land Use

Existing urban infrastructure is not adequate to accommodate increasing urbanization. Unfortunately this has resulted in severe impacts on water quality, unsanitary conditions in settlements, open waste sites and degradation of agricultural land and natural vegetation. Coastal areas are particularly vulnerable and impacted because of their complex ecosystems and many demands placed on them.

Protection of riparian vegetation and wetlands losses can be used to improve runoff and ultimately water quality in our rivers. There is a need for DWA, provincial and local authorities to integrate water quality planning and management in the development of land use plans, particularly to consider high impact land use activities.

12.9 Diffuse Pollution

Internationally it has become recognised that diffuse sources of pollution (also known as non-point sources of pollution) plays a major role in the degradation of water quality, specifically with respect to salinity, eutrophication (nutrient enrichment), sediments, pathogens, persistent organic pollutants (POPs) and some heavy metals. It is now accepted that it is not feasible to properly manage water quality without addressing the contribution from diffuse sources. Consequently, attention is increasingly being devoted to the quantification of diffuse water source pollution and to identify means to control it cost-effectively at source.

In South Africa the major water user is agriculture and as a consequence diffuse pollution from the sector has a large impact on surface and ground water quality. The agricultural use of fertilizers and pesticides impacts water quality due to rainfall runoff and leachate into the soils and water table. Typically the diffuse water quality impacts from agriculture results in increased salinity, eutrophication and POPs.

Coal and gold mines (operational, closed and abandoned mining operations), are the most significant sources of diffuse contamination in terms of surface and groundwater in South Africa. Typical diffuse pollutants from the mines include sulphates, acid mine drainage, salinity, metals (including aluminium, iron and manganese), and toxic and radioactive substances such as uranium from goldmines. Many of these pollutants contribute to the three types of non-point pollution caused by mining *i.e.* surface water, groundwater and atmospheric pollution. Typical sources of diffuse mine pollution are waste rock dumps, slimes dams and open cast mines.

Uranium pollution of surface and groundwater in the Wonderfonteinspruit catchment and potential health risk to humans in the area and downstream users such as Potchefstroom (Boskop Dam) are also further identified concerns.

The risk of the uncontrolled releases (decanting) of acid mine drainage (AMD) to the environment and rising levels of groundwater to infrastructure are diffuse pollution risks facing our country's water resources.

Runoff from urban areas and large industries also contribute to diffuse water pollution of both surface and groundwater.

Specific plans and strategies are required to manage diffuse sources of pollution, specifically from the agricultural sector as the increase in nutrients and agrochemicals cannot continue to increase in water resources unabated, as well as acid mine drainage which currently poses a serious threat to the country's water resources.

12.10 Sewage Treatment Work Discharges

A key contributor to the deterioration in the water quality of South Africa's water resources and the marked increase in nutrients and microbiological contaminants with associated health risks are as a result of untreated or partially treated domestic wastewater discharges from sewage treatment works. This situation will continue unless plans or a management strategy is developed to address the current *status quo*. Serious efforts must be made to finance or support the improvement of wastewater treatment works at local government level.

12.10.1 Green Drop Report – Key findings

Recent investigations and audits of South African municipal wastewater treatment plants confirmed that the situation with regard to waste water treatment and compliance must be addressed as a matter of urgency. The municipal waste water services business is generally considered to be far from acceptable, when compared to the required national standards and international best practice. Only 53% (449 out of 852) of municipal waste water treatment works (WWTW) were assessed for the first Green Drop Certification programme. In other words 403 systems (47%) failed to submit any data to DWA. The Department should expand its waste water regulatory initiative to obtain more information on these systems not assessed during the certification programme. Only 32 (out 449 assessed) *i.e.* 7.1% achieved the Green Drop Status by scoring 90% and above in terms of the seven critical performance areas (DWA, 2009a).

Two hundred and two (203) of the WWTWs, out of the 449 (45%) assessed, scored between 50 and 89%. In this case there is room for improvement in some of the critical performance areas. However, there remains concern over the 55% (of systems) that scored between 0% and 49%, meaning that drastic improvement is required. Thus, in total 76%, *i.e*. 649/852 waste water treatment works in South Africa are dysfunctional and pose a serious pollution threat to our water resources and should urgently be addressed by DWA and local governments.

A "turn-around intervention" is not only dependant on the replacement/ refurbishment of existing infrastructure and expansion of infrastructure. The strategic decrease of the risk factor is a reachable target which will have significant benefits to the environmental health of the receiving water bodies.

12.10.2 Efficient Enforcement

One of the greatest challenges to water quality management is effective and efficient enforcement. In light of the current situation regarding non-compliant wastewater discharges specifically that of wastewater treatment works DWA needs to refocus efforts on enforcement. A management strategy should be developed to address the issue.

12.11 Technology

Many effective technologies and approaches are available to improve water quality. Appropriate technologies can be used to treat wastewater if funding is available to communities to implement needed technology and infrastructure. A tremendously cost-effective approach to improving water quality is through pollution prevention. In cases where contaminants result from domestic, industrial, or agricultural activities, wastewater must be treated. When water quality and watersheds are adversely impacted by poor water quality, strategies to remediate pollution and restore watershed functions are important.

Technologies and infrastructure to prevent, treat, and restore water quality must be employed in every region of the world by (UNEP, 2010):

- connecting communities, governments, and businesses to effective water quality technologies and approaches;
- developing new technologies when needed to meet the particular environmental or resource conditions in a particular location;
- providing financing to implement needed technologies and infrastructure projects; and
- providing technical and logistical support to help communities and governments implement technology and infrastructure projects to improve water quality.

12.12 Water Quality Modelling

Water quality modelling tools are used locally and internationally to assist with water quality management.

In South Africa there have been several studies that DWA have funded to assess the current status of water quality modelling tools, the gaps in data as well as the needs of the country for these tools.

Many of these models are propriety international models that need to be customized for our conditions or are commercially available at high prices (purchase and license prices). Despite these studies there is a still a lack of competent water quality modellers and limited models used for water quality management. Coupled to this is the lack of confidence in the modelled outcomes due to the shortage of data (many variables not monitored and not frequently enough) that these models require.

There is an urgent need for the continued support of local water quality models and skills development through tertiary institutions.

12.13 Consequences of failure

The decisions made in the next decade will determine the path we take in addressing the South African water quality challenge. Disturbing scenarios of the future are certainly possible if we fail to address water pollution now. Increased industrial and sewage waste will continue to strain our surface water resources.

A greater proportion of people will be effected by preventable waterborne diseases if the problem of safe sanitation and clean drinking water remains unsolved. Industries and farms will spend more and more money to find and treat water that is clean enough to use. However, taking bold steps internationally, nationally, and locally to protect water quality will mean a much different future. Water resources can again become the centerpieces of cities and villages, the cultural and social gathering places, and residents will once again turn toward the rivers and streams that gave them life (UNEP, 2010). Drastic actions and interventions are however necessary sooner rather than later to achieve this future.

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APPENDIX A:

National water quality monitoring sites assessed as part of planning level review of water quality

Monitoring Points Assessed for Planning level review of Water Quality
A2H006 PIENAARSRIVIER 90 JR AT KLIPDRIFT ON PIENAARSRIVIER
A2H010Q01 MALONEY'S EYE AT STEENEKOPPIE
A2H013 SCHEERPOORT 477 JQ MAGALIES RIVER AT SCHEERPOORT
A2H019Q01 ROODEKOPJES DAM ON CROCODILE RIVER: DOWN STREAM WE
A2H021Q01 PIENAARS RIVER AT BUFFELSPOORT
A2H027Q01 PIENAARS RIVER AT BAVIAANSPOORT
A2H059 VAALKOP 192 JQ AT ATLANTA ON KROKODILRIVIER
A2H061Q01 APIES RIVER AT RONDAVEL
A2H111Q01 VAALKOP DAM ON ELANDS RIVER: DOWN STREAM WEIR
A2H132 HAAKDOORNDRIFT 373 KQ @ PAUL HUGO DAM ON KROKODILRIVI
A3H040Q01 MARICO RIVER AT MOOIPLAATS/TZWASA WEIR ABSTRACTIO
A3R003 KROMELLENBOOG DAM AT KROMELLENBOOG 104 JP NEAR DAM WA
A3R004 MOLATEDI DAM AT EERSTEPOORT 136 KP ON MARICORIVIER NE
A4H013Q01 MOKOLO RIVER AT MOORDDRIFT/VUGHT
A4H014 ZANDPAN 63 LQ AT SAMEVLOEIDAM ON MOKOLO
A5H006Q01 AT BOTSWANA STERKLOOP ON LIMPOPO RIVER
A5H008Q01 GA-SELEKA VILLAGE BOSSCHE DIESCH 53 LQ R572 BRIDGE ON LEPHALALA RIVER
A7H008Q01 DOWN STREAM OF BEIT BRIDGE ON LIMPOPO RIVER
A8H009Q01 LUPHEPHE DAM ON LUPHEPHE RIVER: DOWN STREAM WEIR
A9H001Q01 LUVUVHU RIVER AT WELTEVREDEN/SCHUYNSHOOG
A9H011Q01 LUVUVHU RIVER AT PAFURI/KRUGER NATIONAL PARK
A9H012Q01 AT MHINGAS ON LUVUVHU RIVER
A9H013 AT MUTALE BEND KRUGER NATIONAL PARK ON MUTALE
B1H005Q01 OLIFANTS RIVER AT WOLVEKRANS
B1H010Q01 WITBANK DAM ON OLIFANTS RIVER: DOWN STREAM WEIR
B1H015Q01 MIDDELBURG DAM ON LIT. OLIFANTS RIV: DOWN STREAM
B2H016 @ WATERVAL ON WILGERIVIER
B3H001Q01 OLIFANTS RIVER AT LOSKOP NORTH
B3H021Q01 ELANDS RIVER AT SCHERP ARABIE
B4H003Q01 STEELPOORT RIVER AT BUFFELSKLOOF
B4H011Q01 STEELPOORT RIVER AT ALVERTON
B6H001Q01 BLYDE RIVER AT WILLEMSOORD
B6H004Q01 BLYDE RIVER AT CHESTER
B7H007Q01 AT OXFORD ON OLIFANTS RIVER
B7H015Q01 OLIFANTS RIVER AT MAMBA/KRUGER NATIONAL PARK
B7H017Q01 OLIFANTS RIVER AT BALULE REST CAMP/KRUGER NAT PAR
B7H019Q01 GA-SELATI RIVER AT LOOLE/FOSKOR
B8H008Q01 AT LETABA RANCH ON GROOT LETABA
B8H018Q01 GREAT LETABA RIVER AT ENGELHARDT DAM/KRUGER NAT P
B8H028Q01 GREAT LETABA RIVER AT MAHLANGENE/KRUGER NAT PARK
B8H033 TABAAN STATE LAND ON KLEIN-LETABA

Monitoring Points Assessed for Planning level review of Water Quality
B9H002 AT SILVERVIS DAM/KRUGER NAT PARK ON SHINGWIDZI
C1H002 STERKFONTEIN DELANGESDRIFT ON KLIPRIVIER
C1H007Q01 VAAL RIVER AT GOEDGELUK/BLOUKOP
C1H008Q01 ELANDSLAAGTE ON WATERVALRIVIER
C1H012Q01 VAAL RIVER AT NOOITGEDACHT/GLADDEDRIFT
C1H017 VILLIERS 492 AT FLOOD SECTION ON VAALRIVIER
C1H019Q01 GROOTDRAAI DAM ON VAAL RIVER: DOWN STREAM WEIR
C1R002Q01 GROOTDRAAI DAM - GROOTDRAAI DAM ON VAALRIVIER: NEA
C2H001Q01 MOOI RIVER AT WITRAND
C2H004Q01 SUIKERBOSRANT RIVER AT VEREENIGING WEIR (RW S2)
C2H005Q01 RIETSPRUIT AT KAALPLAATS (RW RV2)
C2H007 PILGRIMS ESTATE 272 AT ORKNEY ON VAALRIVIER
C2H011 GERHARDMINNEBRON EYE AT GERHARDMINNEBRON
C2H018Q01 VAAL RIVER AT DE VAAL/SCHOEMANSDRIFT
C2H061 PALMIETFONTEIN 250 - AT KLIPPLAATDRIFT ON VAALRIVIER
C2H065Q01 LEEUDORING SPRUIT AT KLIPSPRUIT
C2H066Q01 AT VLIEGEKRAAL ON MAKWASSIESPRUIT
C2H067Q01 AT LEEGTE ON SANDSPRUIT
C2H069Q01 MOOIRIVIERLOOP (RIVER) AT BLAAUWBANK
C2H073Q01 @ GOEDGENOEG 150M U/S ORKNEY BRIDGE ON SKOONSPRUIT
C2H085Q01 MOOI RIVER AT HOOGEKRAAL/KROMDRAAI
C2H122Q01 VAAL DAM ON VAAL RIVER: DOWN STREAM WEIR
C2H131Q01 RW C-S1 COLLIERY POINT ON SUIKERBOSRANT RIVER
C2H139Q01 KOEKEMOER SPRUIT AT BUFFELSFONTEIN
C2H140Q01 VAAL RIVER AT WOODLANDS/GOOSE BAY CANYON
C2H141Q01 KLIP RIVER AT WITKOP (NEW BRIDGE)
C2H260Q01 AT KROMDRAAI LOW WATER BRIDGE ON VAALRIVIER
C2R005Q01 KLIPDRIFT 395 IQ - KLIPDRIF DAM ON LOOPSPRUIT NEAR
C2R008Q01 LTS24 VAAL BARRAGE ON VAAL RIVER NEAR BARR WAL
C3H003Q01 AT TAUNG ON HARTSRIVIER
C3H007 ESPAGSDRIF SEODING 25 BRIDGE AT THE WEIR ON HARTS RIV
C3H016Q01 AT DELPORTSHOOP LLOYDS WEIR ON HARTSRIVIER
C4H004Q01 FAZANTKRAAL AT NOOITGEDACHT ON VETRIVIER
C4H016 MOND VAN DOORNRIVIER 38 - @ BLOUDRIF ON SANDRIVIER
C4H017Q01 SAND RIVER AT DORINGRIVIER/BLOUDRIF
C4R002Q01 CORANNAKRAAL 87 - ERFENIS DAM ON VETRIVIER NEAR DA
C5H003Q01 AT LIKATLONG / SANNASPOS ON MODDERRIVIER
C5H012Q01 RIET RIVER AT KROMDRAAI/RIETWATER
C5H030Q01 @ RIETRIVIER SETT. JACOBSDAL ON ORANGE-RIET CANAL
C5H039Q01 KRUGERSDRIFT DAM ON MODDER RIVER: DOWN STREAM WEI
C5H048Q01 AT ZOUTPANSDRIFT ON RIETRIVIER

Monitoring Points Assessed for Planning level review of Water Quality
C5H053Q01 CYPRESS 89 - AT GLEN ON MODDERRIVIER
C6H002Q01 BOTHAVILLE GROOTDRAAI 408 - @ RIVER BANK ON VALSRI
C6H003Q01 BOTHAVILLE MOOIFONTEIN 624 - @ RIVER BANK ON VALSR
C6H007Q01 KROONSTAD - @ R721 ROAD BRIDGE ON VALSRIVIER (OLD
C7H003Q01 AT DANKBAAR MISPAH ON HEUNINGSPRUIT
C7H006Q01 RENOSTER RIVER AT ARRIESRUST
C8H001Q01 WILGE RIVER AT FRANKFORT
C8H009Q01 AT TIJGER HOEK ON TIERKLOOF RIVER
C8H010Q01 FRASER SPRUIT 94 HARRISMITH ON OUBERGSPRUIT
C8H026Q01 AT FREDERIKSDAL ON LIEBENBERGSVLEI RIVER
C8H027Q01 AT BALLINGTOMP ON WILGE RIVER
C8H028Q01 WILGE RIVER AT BAVARIA (FLOOD SECTION)
C8H032Q01 AT STERKFONTEINDAM ON NUWEJAAR SPRUIT
C9H008 NAZARETH FARM STUDAM 1KM DOWNSTREAM OF VAALHARTS DAM
C9H009Q01 VAAL RIVER AT DE HOOP
C9H024Q01 SMIDTS DRIFT OUTSPAN 23 SCHMIDTSDRIFT @ WEIR ON VA
C9R003Q01 ST CLAIR 148 - EGMONT DAM ON WITSPRUIT @ DAM WALL
D1H001Q01 WONDERBOOM/STORMB. SPRUIT AT DIEPKLOOF/BURGERSDOR
D1H003Q01 ORANGE RIVER AT ALIWAL NORTH
D1H006Q01 KORNET SPRUIT AT MAGHALEEN
D1H009Q01 ORANGE RIVER AT ORANJEDRAAI
D1H011Q01 KRAAI RIVER AT ROODEWAL
D2H012 CALEDONSPOORT 190 THE POPLARS 199 AT THE POPULARS ON
D2H035Q01 CALEDONRIVER AT FICKSBURG/FICKSBURG BRIDGE
D2H036Q01 CALEDONRIVER AT KOMMISSIEDRIFT
D2H037Q01 CALEDON RIVER AT WILGEDRAAI/HOBHOUSE
D2R004Q01 WELBEDACHT 285 - WELBEDACHT DAM ON CALEDONRIVIER:
D3H008Q01 AT MARKSDRIFT ON ORANGE RIVER
D3H012Q01 ORANGE RIVER AT DOOREN KUILEN (DOWN STREAM D3R003
D3H013 ROODEPOORT ON ORANJERIVIER
D3H015Q01 SEEKOEI RIVER AT DE EERSTE POORT
D4R003Q01 DISANENG DAM ON MOLOPO RIVER: NEAR DAM WALL
D4R004Q01 MOLOPO (RATSHIDI) - MODIMOLA DAM ON MOLOPORIVIER:
D7H005Q01 ORANGE RIVER AT UPINGTON
D7H008Q01 ORANGE RIVER AT BOEGOEBERG RESERVE/ZEEKOEBAART
D8H003Q01 AT VIOOLSDRIFT ON ORANGE
D8H008Q01 ORANGE RIVER AT PELLA MISSION
E1H011Q01 CLANWILLIAM DAM ON OLIFANTS RIVER: DOWN STREAM WE
E1H013 MIDDELPOS 553 AT CITRUSDAL ON OLIFANTSRIVIER
E1R001 KROMME VALLEY 113 BULSHOEK DAM ON OLIFANTSRIVIER: NEA
E2H002Q01 AT ELANDS DRIFT ASPOORT ON DORINGRIVIER

Monitoring Points Assessed for Planning level review of Water Quality
E2H003Q01 AT MELKBOOM ON DORINGRIVIER
E2H016 OLIFANTS RIVER AT LUTZVILLE
G1H008 NIEUWKLOOF 198 - ON KLEIN BERGRIVIER
G1H013Q01 AT DRIEHEUVELS ON BERGRIVIER
G1H020Q01 AT DAL JOSAFAT NOORDER PAARL ON BERGRIVIER
G1H023Q01 AT JANTJIESFONTEIN ON BERGRIVIER
G1H031Q01 AT MISVERSTAND DIE BRUG ON BERGRIVIER
G1H036Q01 AT VLEESBANK HERMON BRIDGE ON BERGRIVIER
G2H012Q01 DIEP RIVER AT MALMESBURY
G2H015Q01 AT FAURE ON EERSTERIVIER
G2H042 ADDERLEY 155 - ON DIEPRIVIER
G4H006Q01 KLEIN RIVER AT CAN Q5-8/WAGENBOOMSDRIFT
G4H007Q01 PALMIET RIVER AT FARM 562-WELGEMOED/KLEINMOND
G5H008Q01 SOUT RIVER AT KYKOEDY
G5R001Q01 AT DE HOOP NATURE RESERVE JETTY ON DE HOOPVLEI SOU
H1H003Q01 BREE RIVER AT CERES COMMONAGE
H1H015Q01 BREE RIVER AT DIE NEKKIES (ONDER BRANDVLEI)
H2H010Q01 HEX RIVER AT WORCESTER/DRIE RIVIERE (BRIDGE)
H3H011Q01 KOGMANSKLOOF RIVER AT GOUDMYN
H4H017Q01 BREE RIVER AT LA CHASSEUR
H4H020Q01 NUY RIVER AT DOORNRIVIER
H5H004Q01 BREE RIVER AT WOLVENDRIFT/SECUNDA
H5H005Q01 BREE RIVER AT WAGENBOOMSHEUVEL/DREW
H6H009Q01 RIVIERSONDEREND AT REENEN
H7H006Q01 AT SWELLENDAM ON BREE RIVER
H8H001Q01 DUIWENHOKS RIVER AT DASSJES KLIP
H9H005Q01 AT FARM 216 SWQ 4A-11 ON GOUKOU
J1H018Q01 TOUWS RIVER AT OKKERSKRAAL
J1H019Q01 AT BUFFELSFONTEIN VAN WYKSDORP ON GROOTRIVIER
J1H028Q01 FLORISKRAAL DAM ON BUFFELS RIVER: DOWN STREAM WEI
J2H010Q01 GAMKA RIVER AT HUISRIVIER
J3H011Q01 OLIFANTS RIVER AT WARM WATER
J4H002Q01 GOURITS RIVER AT ZEEKOEDRIFT/DIE POORT
K1H004Q01 AT BRANDWACHT ON BRANDWAGRIVIER
K1H005Q01 MOORDKUIL RIVER AT BANFF
K2H002Q01 AT WOLVEDANS ON GROOT-BRAKRIVIER
K3H001Q01 KAAIMANS RIVER AT UPPER BARBIERS KRAAL
K3H003Q01 MAALGATE RIVER AT KNOETZE KAMA/BUFFELSDRIFT
K4H001Q01 HOEKRAAL RIVER AT EASTBROOK
K4R002Q01 SWART VLEI AT RONDE VALLEY/HOOGEKRAAL
K5H002Q01 KNYSNA RIVER AT MILWOOD FOREST RESERVE/LAER STREE

Monitoring Points Assessed for Planning level review of Water Quality
K7H001Q01 BLOUKRANS RIVER AT LOTTERING FOREST RES/BLAAUW KR
K8H005Q01 AT GEELHOUTBOOM ON TSITSIKAMA
K8H006Q01 AT ROOIWAL ON GROOTRIVIER
K9H003Q01 IMPOFU/ELANDSJAGT DAM ON KROM RIVER: DOWN STREAM
L3R001Q01 BEERVLEI DAM ON GROOT RIVER: NEAR DAM WALL
L7H006Q01 GROOT RIVER AT GROOTRIVIERSPOORT (UP/S KOUGA CONF
L7H007Q01 GROOT RIVER AT SANDPOORT 170
L8H005Q01 KOUGA RIVER AT STUURMANSKRAAL
L8R001Q01 TWEE RIVIEREN 37 - KOUGA (PAUL SAUER) DAM ON KOUGA
L9H004Q01 GAMTOOS RIVER AT BUFFELSHOEK (RAIL BRIDGE)
M1H012Q01 SWARTKOPS RIVER AT UITENHAGE/NIVENS BRIDGE
N4H003Q01 SUNDAYS RIV AT ADDO DRIFT EAST/ADDO BRIDGE
P1H003Q01 BOESMANS RIVER AT DONKER HOEK/ALICEDALE
P3H001Q01 KARIEGA RIVER AT SMITHFIELD/LOWER WATERFORD
P4H001Q01 KOWIE RIVER AT BATHURST/WOLFSCRAG
Q1H001Q01 AT KATKOP ON GROOT-VISRIVIER
Q1H012Q01 TEEBUS RIVER AT JAN BLAAUWS KOP/BEACONSFIELD
Q1H022Q01 GRASSRIDGE DAM ON GREAT BRAK RIV: RIVER OUTLET-RI
Q2H002Q01 AT ZOUTSPANS DRIFT ZOUTPAN ON GROOT-VISRIVIER
Q3H005Q01 AT RIETFONTYN WAAIKRAAL ON GROOT-VISRIVIER
Q4H013Q01 TARKA RIVER AT BRIDGE FARM/TARKA BRIDGE (NEW WEIR
Q6H003Q01 AT BOTMANSGAT DE KLERKDAL ON BAVIAANSRIVIER
Q7H003Q01 AT LEEUWE DRIFT ON GROOT-VISRIVIER
Q7H005Q01 AT SOUT VLEIJ SHELDON ON KLEIN-VISRIVIER
Q8H008Q01 LITTLE FISH RIVER -DOORN KRAAL
Q9H002Q01 KOONAP RIVER AT ADELAIDE
Q9H012Q01 AT BRANDT LEGTE PIGGOT'S BRIDGE ON GROOT-VISRIVIER
Q9H018Q01 AT MATOMELA'S RESERVE OUTSPAN ON GROOT-VISRIVIER
Q9H029Q01 KAT RIVER AT FORT BEAUFORT
R1H015Q01 FARM 7 ABOUT 220M U/S OF HOWARD SHAW BRIDGE ON KEI
R2H027 POTSDAM NDANTSANE AT MHLABATI NEEDS CAMP ON BUFFALO R
S1R001Q01 XONXA DAM ON WHITE KEI RIVER: NEAR DAM WALL
S3H006Q01 KLAAS SMITS RIVER AT WELTEVREDEN/QUEENSTOWN
S3H013 AT HOT FIRE HIGH CLERE ON SWART - KEIRIVIER
S5H002Q01 AT WYK MADUMA TSOMO ON TSOMO
S7H001Q01 GCUWA RIVER AT BUTTERWORTH
S7H004Q01 AT AREA 8 SPRINGS B ON GROOT-KEIRIVIER
T1H001Q01 XUKA RIVER (1) AT THE BRIDGE ON R61
T1H010 CLARKEBURY ON MGWALI RIVER
T1H013 @ GXWALI BOMVU ON MBASHE
T1H014 @ RUNE ON MBASHE

Monitoring Points Assessed for Planning level review of Water Quality
T1H015 @ RARA 34 COLLYWOBBLES ON MBASHE
T3H004Q01 MZIMNTLANA RIVER AT SLANGFONTEIN/KOKSTAD
T3H005Q01 TINA RIVER ON N2 BRIDGE TO MT FRERE
T3H006Q01 TSITSA RIVER AT N2 BRIDGE TO QUMBU
T3H007 MZIMVUBU RIVER ON N2 BRIDGE KU-MAKHALA TO MT AYLIFF
T3H008Q01 MZIMVUBU RIVER AT KROMDRAAI/INUNGI
T4H001Q01 MTAMVUNA RIVER AT GUNDRIFT/MTAMVUNA
T5H002Q01 AT NOOITGEDACHT BISI ON BISI
T5H003Q01 POLELA RIVER AT COXHILL/HIMEVILLE
T5H004Q01 AT FP 1609030/THE BANKS ON MZIMKHULU
T5H007Q01 AT BEZWENI/ISLAND VIEW ON MZIMKHULU
T7H001Q01 MNGAZI RIVER AT MGWENYANA 22/NMGAZI
U1H005Q01 MKOMAZI RIVER AT LOT 931821/CAMDEN
U2H006Q01 KARKLOOF RIVER AT SHAFTON
U2H014Q01 ALBERT FALLS DAM ON MGENI RIVER: DOWN STREAM WEIR
U2H041Q01 MSUNDUZE RIVER AT HAMPSTEAD PARK/MOTO-X (DARV)
U2H043Q01 MGENI RIVER AT INANDA/NAGLE DAM OUTFLOW (NARO)
U2H048Q01 MIDMAR DAM ON MGENI RIVER: DOWN STREAM WEIR
U2H055Q01 AT INANDA LOCATION EGUGWINI ON MGENI
U3H005Q01 HAZELMERE DAM ON MDLOTI RIVER: D/ S WEIR (HMRO)
U4H002Q01 MVOTI RIVER AT MISTLEY
U6H003Q01 AT UMLAAS ROAD ON MLAZI
U6H004Q01 MLAZI RIVER AT FARM 10936/SHONGWENI DAM INFLOW (V
U7H008Q01 NUNGWANA DAM ON NUNGWANA RIVER: DOWN STREAM WEIR
U8H001Q01 FAFA RIVER AT COWICK/NEVER DESPAIR
U8H003Q01 MPAMBANYONI RIVER AT UMBELI BELLI
V1H001Q01 TUGELA RIVER AT TUGELA DRIFT/COLENSO
V1H010Q01 LITTLE TUGELA RIVER AT WINTERTON
V1H038Q01 KLIP RIVER AT LADYSMITH TOWNLANDS/ARMY CAMP
V2H008Q01 MOOI RIVER AT KEATE'S DRIFT
V3H002Q01 AT SCHURVEPOORT ON BUFFELSRIVIER
V3H010Q01 @ TAYSIDE ON BUFFELSRIVIER
V5H002Q01 AT MANDINI ON TUGELA RIVER
V6H002Q01 AT TUGELA FERRY ON TUGELA
V6H004 KLEIN FONTEIN 1262 GT ON SUNDAYS RIVER
V7H012Q01 LITTLE BOESMANS RIVER AT ESTCOURT
VS1 VAAL RIVER ORIGIN AT N17 BRIDGE (GDDC01)
VS2 VAAL RIVER AT R29/N2 BRIDGE AT CAMDEN (GDDC10)
VS2-3 BLESBOK SPRUIT AT R39 BRIDGE RIETVLEY (GDDC12)
VS2-4 LEEUSPRUIT AT R39 WELBEDACHT BRIDGE (GDDC19)
VS3 VAAL RIVER ON N11 BRIDGE TO AMERSFORT

Monitoring Points Assessed for Planning level review of Water Quality
W1H009Q01 MHLATUZE RIVER AT RIVERVIEW 11459
W1H032Q01 UMHLATUZE VALLEY PUMP STATION (SUGAR FACTORY)
W2H005Q01 AT OVERVLOED/ULUNDI ON WIT-MFOLOZI
W2H006Q01 AT RESERVE NO 12 ON SWART - MFOLOZI
W2H028Q01 AT EKUHLENGENI ON SWART - MFOLOZI
W2H032Q01 UMFOLOZI RIVER AT STATE LAND/MONZI
W3H015Q01 HLUHLUWE RIVER AT VALSBAAI/ST LUCIA INFLOW
W3H032Q01 MKUZE RIV AT OVERWIN - D/S MONDI IRR & VORSTER (M
W4H004Q01 AT WELGELEGEN PIVAANSBAD ON BIVANE
W4H006Q01 PHONGOLO RIVER AT M'HLATI
W4H009Q01 PHONGOLO RIVER AT NDUME GAME RESERVE
W4H013Q01 PONGOLAPOORT DAM ON PHONGOLO RIVER: DOWN STREAM W
W5H022Q01 AT ZANDBANK ON ASSEGAAIRIVIER
W5H024Q01 MPULUZI RIVER AT DUMBARTON
W5H025Q01 USUTU RIVER AT STAFFORD
W5H026Q01 NGWEMPISI RIVER AT MERRIEKLOOF
X1H001Q01 KOMATI RIVER AT HOOGGENOEG
X1H003Q01 AT TONGA ON KOMATI RIVER
X1H014Q01 MLUMATI RIVER AT LOMATI
X1H018Q01 KOMATI RIVER AT GEMSBOKHOEK
X1H049Q01 @ SCHOEMANSDAL DRIEKOPPIES DAM DOWNSTREAM WEIR
X2H013Q01 CROCODILE RIVER AT MONTROSE
X2H016Q01 AT TEN BOSCH KRUGER NATIONAL PARK ON CROCODILE RIV
X2H022Q01 KAAP RIVER AT DOLTON
X2H032Q01 CROCODILE RIVER AT WELTEVREDE
X2H036Q01 @ KOMATIPOORT KRUGER NATIONAL PARK ON KOMATI RIVER
X2H046Q01 CROCODILE RIVER AT RIVERSIDE/KRUGER NATIONAL PARK
X3H006Q01 SABIE RIVER AT PERRY'S FARM
X3H008Q01 SAND RIVER AT EXETER
X3H015Q01 SABIE RIVER AT LOWER SABIE REST CAMP/KRUGER NAT PARK

APPENDIX B:

Summary of Trends at monitoring sites assessed as part of the planning level review of water quality

Monitoring Point	pH	EC	Phosphate	Ammonia (NH3-N)	Sulphate	Chloride
A2H006 PIENAARSRIVIER 90 JR AT KLIPDRIFT ON PIENAARSRIVIER	J	-	J	J	-	L
A2H010Q01 MALONEY'S EYE AT STEENEKOPPIE	J	L	L	-	-	J
A2H012 KALKHEUWEL 493 JQ ON KROKODILRIVIER	J	J	L	J	J	L
A2H013 SCHEERPOORT 477 JQ MAGALIES RIVER AT SCHEERPOORT	J	L	-	-	-	L
A2H019Q01 ROODEKOPJES DAM ON CROCODILE RIVER: DOWN STREAM WE	-	L	L	L	J	L
A2H021Q01 PIENAARS RIVER AT BUFFELSPOORT	-	L	L	-	L	L
A2H027Q01 PIENAARS RIVER AT BAVIAANSPOORT	J	L	L	L	L	L
A2H059 VAALKOP 192 JQ AT ATLANTA ON KROKODILRIVIER	J	L	L	L	L	L
A2H061Q01 APIES RIVER AT RONDAVEL	J	L	L	L	-	L
A2H111Q01 VAALKOP DAM ON ELANDS RIVER: DOWN STREAM WEIR	-	L	-	-	L	L
A2H132 HAAKDOORNDRIFT 373 KQ @ PAUL HUGO DAM ON KROKODILRIVI	-	L	L	L	-	L
A3H040Q01 MARICO RIVER AT MOOIPLAATS/TZWASA WEIR ABSTRACTIO	-	L	J	L	L	L
A3R003 KROMELLENBOOG DAM AT KROMELLENBOOG 104 JP NEAR DAM WA	J	L	L	L	-	L
A3R004 MOLATEDI DAM AT EERSTEPOORT 136 KP ON MARICORIVIER NE	L	L	J	L	L	L
A4H013Q01 MOKOLO RIVER AT MOORDDRIFT/VUGHT	L	L	L	L	L	L
A4H014 ZANDPAN 63 LQ AT SAMEVLOEIDAM ON MOKOLO						
A5H006Q01 AT BOTSWANA STERKLOOP ON LIMPOPO RIVER	J	-	J	J	L	L
A5H008Q01 GA-SELEKA VILLAGE BOSSCHE DIESCH 53 LQ R572 BRIDGE ON LEPHALALA RIVER		L	L	-	L	L
A7H008Q01 DOWN STREAM OF BEIT BRIDGE ON LIMPOPO RIVER	J	J	J	J	J	J
A8H009Q01 LUPHEPHE DAM ON LUPHEPHE RIVER: DOWN STREAM WEIR	-	J	J	-	J	L
A9H001Q01 LUVUVHU RIVER AT WELTEVREDEN/SCHUYNSHOOG	J	L	-	L	J	L
A9H011Q01 LUVUVHU RIVER AT PAFURI/KRUGER NATIONAL PARK	J	-	J	L	J	J
A9H012Q01 AT MHINGAS ON LUVUVHU RIVER	J	L	J	L	J	L
A9H013 AT MUTALE BEND KRUGER NATIONAL PARK ON MUTALE	L	J	J	L	J	J
B1H005Q01 OLIFANTS RIVER AT WOLVEKRANS	J	J	L	L	-	J
B1H010Q01 WITBANK DAM ON OLIFANTS RIVER: DOWN STREAM WEIR	J	J	L	-	J	J
B1H015Q01 MIDDELBURG DAM ON LIT. OLIFANTS RIV: DOWN STREAM	J	L	L	L	L	L
B2H016 @ WATERVAL ON WILGERIVIER	-	L	-	-	L	L
B3H001Q01 OLIFANTS RIVER AT LOSKOP NORTH	J	L	-	J	L	L

Monitoring Point	pH	EC	Phosphate	Ammonia (NH3-N)	Sulphate	Chloride
B3H021Q01 ELANDS RIVER AT SCHERP ARABIE	-	L	J	J	L	L
B4H003Q01 STEELPOORT RIVER AT BUFFELSKLOOF	J	J	-	J	-	L
B4H011Q01 STEELPOORT RIVER AT ALVERTON	J	J	-	J	J	L
B6H001Q01 BLYDE RIVER AT WILLEMSOORD	J	J	-	J	L	L
B6H004Q01 BLYDE RIVER AT CHESTER	J	-	-	-	L	L
B7H007Q01 AT OXFORD ON OLIFANTS RIVER	J	L	J	L	L	L
B7H015Q01 OLIFANTS RIVER AT MAMBA/KRUGER NATIONAL PARK	J	J	-	L	-	J
B7H017Q01 OLIFANTS RIVER AT BALULE REST CAMP/KRUGER NAT PAR	-	L	-	L	J	L
B7H019Q01 GA-SELATI RIVER AT LOOLE/FOSKOR	J	J	L	L	L	L
B8H008Q01 AT LETABA RANCH ON GROOT LETABA	J	L	J	L	L	L
B8H018Q01 GREAT LETABA RIVER AT ENGELHARDT DAM/KRUGER NAT P	J	J	J	L	L	J
B8H028Q01 GREAT LETABA RIVER AT MAHLANGENE/KRUGER NAT PARK	J	L	L	L	-	L
B8H033 TABAAN STATE LAND ON KLEIN-LETABA	J	L	J	L	J	L
B9H002 AT SILVERVIS DAM/KRUGER NAT PARK ON SHINGWIDZI	J	J	J	L	J	J
C1H002 STERKFONTEIN DELANGESDRIFT ON KLIPRIVIER	-	L	L	L	L	L
C1H007Q01 VAAL RIVER AT GOEDGELUK/BLOUKOP		L	L	L	-	L
C1H008Q01 ELANDSLAAGTE ON WATERVALRIVIER	J	J	L	L	J	J
C1H012Q01 VAAL RIVER AT NOOITGEDACHT/GLADDEDRIFT	-	J	-	-	-	L
C1H017 VILLIERS 492 AT FLOOD SECTION ON VAALRIVIER	J	J	J	L	L	L
C1H019Q01 GROOTDRAAI DAM ON VAAL RIVER: DOWN STREAM WEIR	J	-	J	L	-	L
C1R002Q01 GROOTDRAAI DAM - GROOTDRAAI DAM ON VAALRIVIER: NEA	L	L	-	L	L	L
C2H001Q01 MOOI RIVER AT WITRAND	-	L	L	L	-	L
C2H004Q01 SUIKERBOSRANT RIVER AT VEREENIGING WEIR (RW S2)	J	J	L	L	J	J
C2H005Q01 RIETSPRUIT AT KAALPLAATS (RW RV2)	J	J	L	L	J	J
C2H007 PILGRIMS ESTATE 272 AT ORKNEY ON VAALRIVIER	-	L	L	-	-	L
C2H011 GERHARDMINNEBRON EYE AT GERHARDMINNEBRON	J	L	-	-	L	L
C2H018Q01 VAAL RIVER AT DE VAAL/SCHOEMANSDRIFT	J	-	L	-	J	L
C2H061 PALMIETFONTEIN 250 - AT KLIPPLAATDRIFT ON VAALRIVIER	J	L	-	-	-	L
C2H065Q01 LEEUDORING SPRUIT AT KLIPSPRUIT	J	J	L	L	-	L
C2H066Q01 AT VLIEGEKRAAL ON MAKWASSIESPRUIT	-	L	-	L	L	L

Monitoring Point	pH	EC	Phosphate	Ammonia (NH3-N)	Sulphate	Chloride
C2H067Q01 AT LEEGTE ON SANDSPRUIT		-	J	J	J	L
C2H069Q01 MOOIRIVIERLOOP (RIVER) AT BLAAUWBANK	-	L	L	L	L	L
C2H073Q01 @ GOEDGENOEG 150M U/S ORKNEY BRIDGE ON SKOONSPRUIT	J	-	-	-	-	L
C2H085Q01 MOOI RIVER AT HOOGEKRAAL/KROMDRAAI	-	L	L	L	L	L
C2H122Q01 VAAL DAM ON VAAL RIVER: DOWN STREAM WEIR	J	J	L	L	-	J
C2H131Q01 RW C-S1 COLLIERY POINT ON SUIKERBOSRANT RIVER	J	L	J	L	J	J
C2H139Q01 KOEKEMOER SPRUIT AT BUFFELSFONTEIN	-	L	L	L	L	L
C2H140Q01 VAAL RIVER AT WOODLANDS/GOOSE BAY CANYON	J	J	L	-	J	L
C2H141Q01 KLIP RIVER AT WITKOP (NEW BRIDGE)	J	-	J	J	-	J
C2H260Q01 AT KROMDRAAI LOW WATER BRIDGE ON VAALRIVIER	J	L	L	L	-	L
C2R005Q01 KLIPDRIFT 395 IQ - KLIPDRIF DAM ON LOOPSPRUIT NEAR	J	L	-	-	L	L
C2R008Q01 LTS24 VAAL BARRAGE ON VAAL RIVER NEAR BARR WAL	J	J	J	L	J	-
C3H003Q01 AT TAUNG ON HARTSRIVIER	J	J	-	-	-	J
C3H007 ESPAGSDRIF SEODING 25 BRIDGE AT THE WEIR ON HARTS RIV	L	J	L	L	-	L
C3H016Q01 AT DELPORTSHOOP LLOYDS WEIR ON HARTSRIVIER	-	L	-	-	L	L
C4H004Q01 FAZANTKRAAL AT NOOITGEDACHT ON VETRIVIER	J	J	L	L	J	L
C4H016 MOND VAN DOORNRIVIER 38 - @ BLOUDRIF ON SANDRIVIER	J	L	-	J	L	L
C4H017Q01 SAND RIVER AT DORINGRIVIER/BLOUDRIF	J	L	L	-	L	L
C4R002Q01 CORANNAKRAAL 87 - ERFENIS DAM ON VETRIVIER NEAR DA		J	L	-	-	L
C5H003Q01 AT LIKATLONG / SANNASPOS ON MODDERRIVIER	J	J	J	J	-	L
C5H012Q01 RIET RIVER AT KROMDRAAI/RIETWATER	-	L	-	L	L	L
C5H030Q01 @ RIETRIVIER SETT. JACOBSDAL ON ORANGE-RIET CANAL	J	-	-	-	-	J
C5H039Q01 KRUGERSDRIFT DAM ON MODDER RIVER: DOWN STREAM WEI	J	-	L	L	-	L
C5H048Q01 AT ZOUTPANSDRIFT ON RIETRIVIER	J	J	-	-	J	L
C5H053Q01 CYPRESS 89 - AT GLEN ON MODDERRIVIER	J	L	L	-	-	L
C6H002Q01 BOTHAVILLE GROOTDRAAI 408 - @ RIVER BANK ON VALSRI	-	L	L	-	L	L
C6H003Q01 BOTHAVILLE MOOIFONTEIN 624 - @ RIVER BANK ON VALSR	J	-	L	-	-	L
C6H007Q01 KROONSTAD - @ R721 ROAD BRIDGE ON VALSRIVIER (OLD	J	J	J	-	-	L
C7H003Q01 AT DANKBAAR MISPAH ON HEUNINGSPRUIT	J	J	L	-	J	J
C7H006Q01 RENOSTER RIVER AT ARRIESRUST	J	J	-	-	-	J

Monitoring Point	pH	EC	Phosphate	Ammonia (NH3-N)	Sulphate	Chloride
C8H001Q01 WILGE RIVER AT FRANKFORT	J	J	L	L	-	J
C8H009Q01 AT TIJGER HOEK ON TIERKLOOF RIVER	J	L	J	J	-	L
C8H010Q01 FRASER SPRUIT 94 HARRISMITH ON OUBERGSPRUIT	J	J	J	-	-	L
C8H026Q01 AT FREDERIKSDAL ON LIEBENBERGSVLEI RIVER	J	J	J	-	J	J
C8H027Q01 AT BALLINGTOMP ON WILGE RIVER	-	J	J	-	-	L
C8H028Q01 WILGE RIVER AT BAVARIA (FLOOD SECTION)	J	-	-	-	-	L
C8H032Q01 AT STERKFONTEINDAM ON NUWEJAAR SPRUIT		L	-	L	-	L
C9H008 NAZARETH FARM STUDAM 1KM DOWNSTREAM OF VAALHARTS DAM	J	L	L	-	L	L
C9H009Q01 VAAL RIVER AT DE HOOP	L	J	-	L	-	L
C9H024Q01 SMIDTS DRIFT OUTSPAN 23 SCHMIDTSDRIFT @ WEIR ON VA	L	-	-	L	-	L
C9R003Q01 ST CLAIR 148 - EGMONT DAM ON WITSPRUIT @ DAM WALL	-	L	L	L	J	L
D1H001Q01 WONDERBOOM/STORMB. SPRUIT AT DIEPKLOOF/BURGERSDOR	J	L	L	L	-	J
D1H003Q01 ORANGE RIVER AT ALIWAL NORTH	J	J	L	-	-	L
D1H006Q01 KORNET SPRUIT AT MAGHALEEN	J	-	J	-	-	L
D1H009Q01 ORANGE RIVER AT ORANJEDRAAI	J	J	J	-	-	J
D1H011Q01 KRAAI RIVER AT ROODEWAL	J	J	J	L	J	L
D2H012 CALEDONSPOORT 190 THE POPLARS 199 AT THE POPULARS ON	J	L	J	-	-	L
D2H035Q01 CALEDONRIVER AT FICKSBURG/FICKSBURG BRIDGE	J	-	J	-	-	L
D2H036Q01 CALEDONRIVER AT KOMMISSIEDRIFT	J	L	J	-	L	L
D2H037Q01 CALEDON RIVER AT WILGEDRAAI/HOBHOUSE	J	L	J	L	L	L
D2R004Q01 WELBEDACHT 285 - WELBEDACHT DAM ON CALEDONRIVIER:	J	L	-	-	L	L
D3H008Q01 AT MARKSDRIFT ON ORANGE RIVER	J	L	J	L	-	L
D3H012Q01 ORANGE RIVER AT DOOREN KUILEN (DOWN STREAM D3R003	J	L	-	L	-	L
D3H013 ROODEPOORT ON ORANJERIVIER	J	L	-	L	-	L
D3H015Q01 SEEKOEI RIVER AT DE EERSTE POORT	J	L	L	-	L	L
D4R003Q01 DISANENG DAM ON MOLOPO RIVER: NEAR DAM WALL	-	L	L	L	L	L
D4R004Q01 MOLOPO (RATSHIDI) - MODIMOLA DAM ON MOLOPORIVIER:	L	L	L	L	L	L
D7H005Q01 ORANGE RIVER AT UPINGTON	J	J	L	J	-	L
D7H008Q01 ORANGE RIVER AT BOEGOEBERG RESERVE/ZEEKOEBAART	J	L	J	L	-	L

Monitoring Point	pH	EC	Phosphate	Ammonia (NH3-N)	Sulphate	Chloride
D8H003Q01 AT VIOOLSDRIFT ON ORANGE	J	L	J	L	-	L
D8H008Q01 ORANGE RIVER AT PELLA MISSION	J	L	J	L	-	L
E1H011Q01 CLANWILLIAM DAM ON OLIFANTS RIVER: DOWN STREAM WE	L	J	J	L	L	J
E1H013 MIDDELPOS 553 AT CITRUSDAL ON OLIFANTSRIVIER	-	L		L	L	L
E1R001 KROMME VALLEY 113 BULSHOEK DAM ON OLIFANTSRIVIER: NEA	L	J	L	L	J	J
E2H002Q01 AT ELANDS DRIFT ASPOORT ON DORINGRIVIER	-	J	L	L		J
E2H003Q01 AT MELKBOOM ON DORINGRIVIER	-	J	L	L	J	J
E2H016 OLIFANTS RIVER AT LUTZVILLE	J	J	J	L	J	J
G1H008 NIEUWKLOOF 198 - ON KLEIN BERGRIVIER	-	L	-	L	J	L
G1H013Q01 AT DRIEHEUVELS ON BERGRIVIER	-	L	-	L	-	L
G1H020Q01 AT DAL JOSAFAT NOORDER PAARL ON BERGRIVIER	L	L	-		J	L
G1H023Q01 AT JANTJIESFONTEIN ON BERGRIVIER	L	L		L	L	L
G1H031Q01 AT MISVERSTAND DIE BRUG ON BERGRIVIER	-	L	J	L	-	L
G1H036Q01 AT VLEESBANK HERMON BRIDGE ON BERGRIVIER	-	L	J	L	J	L
G2H012Q01 DIEP RIVER AT MALMESBURY	-	L	L	L	L	L
G2H015Q01 AT FAURE ON EERSTERIVIER	J	J	J	L	J	J
G2H042 ADDERLEY 155 - ON DIEPRIVIER		J	J	J	J	J
G4H006Q01 KLEIN RIVER AT CAN Q5-8/WAGENBOOMSDRIFT	-	J	J		L	L
G4H007Q01 PALMIET RIVER AT FARM 562-WELGEMOED/KLEINMOND	J	L	L	L	J	L
G5H008Q01 SOUT RIVER AT KYKOEDY	L	J	L	L	J	J
G5R001Q01 AT DE HOOP NATURE RESERVE JETTY ON DE HOOPVLEI SOU	L	J	J	J	J	J
H1H003Q01 BREE RIVER AT CERES COMMONAGE	-	L	L	J	L	L
H1H015Q01 BREE RIVER AT DIE NEKKIES (ONDER BRANDVLEI)	L	L	L	L	L	L
H2H010Q01 HEX RIVER AT WORCESTER/DRIE RIVIERE (BRIDGE)	-	J	J	L	L	J
H3H011Q01 KOGMANSKLOOF RIVER AT GOUDMYN	J	L	-	J	J	L
H4H017Q01 BREE RIVER AT LA CHASSEUR	-	L	L	L	L	L
H4H020Q01 NUY RIVER AT DOORNRIVIER	-	J	L	L	J	J
H5H004Q01 BREE RIVER AT WOLVENDRIFT/SECUNDA	-	L	J	L	L	L
H5H005Q01 BREE RIVER AT WAGENBOOMSHEUVEL/DREW	-	L	L	L	J	L

Monitoring Point	pH	EC	Phosphate	Ammonia (NH3-N)	Sulphate	Chloride
H6H009Q01 RIVIERSONDEREND AT REENEN	L	L		L	L	L
H7H006Q01 AT SWELLENDAM ON BREE RIVER	L	L		L	L	L
H8H001Q01 DUIWENHOKS RIVER AT DASSJES KLIP	L	L	J	L	L	L
H9H005Q01 AT FARM 216 SWQ 4A-11 ON GOUKOU	L			L		L
J1H018Q01 TOUWS RIVER AT OKKERSKRAAL	J	L	J		L	L
J1H019Q01 AT BUFFELSFONTEIN VAN WYKSDORP ON GROOTRIVIER	J	J	J	L	J	J
J1H028Q01 FLORISKRAAL DAM ON BUFFELS RIVER: DOWN STREAM WEI	J	J	-	J	J	J
J2H010Q01 GAMKA RIVER AT HUISRIVIER	J	J	J	L	J	J
J3H011Q01 OLIFANTS RIVER AT WARM WATER	J	J		L	J	J
J4H002Q01 GOURITS RIVER AT ZEEKOEDRIFT/DIE POORT	J			L	L	L
K1H004Q01 AT BRANDWACHT ON BRANDWAGRIVIER	-	L		L		L
K1H005Q01 MOORDKUIL RIVER AT BANFF	L	L		L		L
K2H002Q01 AT WOLVEDANS ON GROOT-BRAKRIVIER	-	J	-	L	J	J
K3H001Q01 KAAIMANS RIVER AT UPPER BARBIERS KRAAL	L	J			J	J
K3H003Q01 MAALGATE RIVER AT KNOETZE KAMA/BUFFELSDRIFT	L	L		L		L
K4H001Q01 HOEKRAAL RIVER AT EASTBROOK	L	L		L	L	L
K4R002Q01 SWART VLEI AT RONDE VALLEY/HOOGEKRAAL	-	L	J	L	J	J
K5H002Q01 KNYSNA RIVER AT MILWOOD FOREST RESERVE/LAER STREE	L	L	L	L	J	L
K7H001Q01 BLOUKRANS RIVER AT LOTTERING FOREST RES/BLAAUW KR	L	L	-	L	J	L
K8H005Q01 AT GEELHOUTBOOM ON TSITSIKAMA	L	J	L	L	L	L
K8H006Q01 AT ROOIWAL ON GROOTRIVIER	L	L	L	L	L	L
K9H003Q01 IMPOFU/ELANDSJAGT DAM ON KROM RIVER: DOWN STREAM	J	J	-	L	J	J
L3R001Q01 BEERVLEI DAM ON GROOT RIVER: NEAR DAM WALL	-	J	L	J		J
L7H006Q01 GROOT RIVER AT GROOTRIVIERSPOORT (UP/S KOUGA CONF	J	J	J	-	J	J
L7H007Q01 GROOT RIVER AT SANDPOORT 170	J		J		J	J
L8H005Q01 KOUGA RIVER AT STUURMANSKRAAL	-	L		L	L	L
L8R001Q01 TWEE RIVIEREN 37 - KOUGA (PAUL SAUER) DAM ON KOUGA	L		L	L	L	L
L9H004Q01 GAMTOOS RIVER AT BUFFELSHOEK (RAIL BRIDGE)		L	J	L	L	L

Monitoring Point	pH	EC	Phosphate	Ammonia (NH3-N)	Sulphate	Chloride
M1H012Q01 SWARTKOPS RIVER AT UITENHAGE/NIVENS BRIDGE	L	J	L	L	J	J
N4H003Q01 SUNDAYS RIV AT ADDO DRIFT EAST/ADDO BRIDGE	L	L	J	L	L	J
P1H003Q01 BOESMANS RIVER AT DONKER HOEK/ALICEDALE	-	□	□	□	□	L
P3H001Q01 KARIEGA RIVER AT SMITHFIELD/LOWER WATERFORD	J	L	J	L	J	J
P4H001Q01 KOWIE RIVER AT BATHURST/WOLFSCRAG	J					J
Q1H001Q01 AT KATKOP ON GROOT-VISRIVIER		J	L	L	J	J
Q1H012Q01 TEEBUS RIVER AT JAN BLAAUWS KOP/BEACONSFIELD	J	J		L	J	L
Q1H022Q01 GRASSRIDGE DAM ON GREAT BRAK RIV: RIVER OUTLET-RI	-	J	J	J	-	L
Q2H002Q01 AT ZOUTSPANS DRIFT ZOUTPAN ON GROOT-VISRIVIER	J	J	J	L	J	L
Q3H005Q01 AT RIETFONTYN WAAIKRAAL ON GROOT-VISRIVIER	-	J	J	J	J	J
Q4H013Q01 TARKA RIVER AT BRIDGE FARM/TARKA BRIDGE (NEW WEIR	J	J	J	L	J	J
Q6H003Q01 AT BOTMANSGAT DE KLERKDAL ON BAVIAANSRIVIER	J	J	-	-	J	J
Q7H003Q01 AT LEEUWE DRIFT ON GROOT-VISRIVIER	J	J	J	L	J	J
Q7H005Q01 AT SOUT VLEIJ SHELDON ON KLEIN-VISRIVIER	-	J	J	L	J	J
Q8H008Q01 LITTLE FISH RIVER -DOORN KRAAL	J	J	J	L	J	J
Q9H002Q01 KOONAP RIVER AT ADELAIDE	J	J	J	L	J	J
Q9H012Q01 AT BRANDT LEGTE PIGGOT'S BRIDGE ON GROOT-VISRIVIER	J	J	J	-	J	J
Q9H018Q01 AT MATOMELA'S RESERVE OUTSPAN ON GROOT-VISRIVIER	-	J	J	L	J	J
Q9H029Q01 KAT RIVER AT FORT BEAUFORT	J	J	J	J	J	J
R1H015Q01 FARM 7 ABOUT 220M U/S OF HOWARD SHAW BRIDGE ON KEI	J	J	J	J	L	L
R2H027 POTSDAM NDANTSANE AT MHLABATI NEEDS CAMP ON BUFFALO R	J	L	L		J	L
S1R001Q01 XONXA DAM ON WHITE KEI RIVER: NEAR DAM WALL	J	J				J
S3H006Q01 KLAAS SMITS RIVER AT WELTEVREDEN/QUEENSTOWN	J	L	J	J	L	L
S3H013 AT HOT FIRE HIGH CLERE ON SWART - KEIRIVIER	L	L	J	L	L	J
S5H002Q01 AT WYK MADUMA TSOMO ON TSOMO	J	J	J	L	L	L
S7H001Q01 GCUWA RIVER AT BUTTERWORTH	J	J	J	L	□	J
S7H004Q01 AT AREA 8 SPRINGS B ON GROOT-KEIRIVIER	J	J	J	L	J	J
T1H001Q01 XUKA RIVER (1) AT THE BRIDGE ON R61	J	J	L	L	L	L
T1H010 CLARKEBURY ON MGWALI RIVER	L			L	J	J

Monitoring Point	pH	EC	Phosphate	Ammonia (NH3-N)	Sulphate	Chloride
T1H013 @ GXWALI BOMVU ON MBASHE	L	L	L	J	J	J
T1H014 @ RUNE ON MBASHE		L	L	L	L	L
T1H015 @ RARA 34 COLLYWOBBLES ON MBASHE		L	J	L	J	L
T3H004Q01 MZIMNTLANA RIVER AT SLANGFONTEIN/KOKSTAD	J	L	J	L	J	L
T3H005Q01 TINA RIVER ON N2 BRIDGE TO MT FRERE	J	J	L	L	J	L
T3H006Q01 TSITSA RIVER AT N2 BRIDGE TO QUMBU	J	J	J	L	J	L
T3H007 MZIMVUBU RIVER ON N2 BRIDGE KU-MAKHALA TO MT AYLIFF	J	J	L	L	J	L
T3H008Q01 MZIMVUBU RIVER AT KROMDRAAI/INUNGI	J	J	J	L	J	J
T4H001Q01 MTAMVUNA RIVER AT GUNDRIFT/MTAMVUNA	J	L	-	-	-	L
T5H002Q01 AT NOOITGEDACHT BISI ON BISI	J	J	-	-	J	L
T5H003Q01 POLELA RIVER AT COXHILL/HIMEVILLE	J	J	-	-	J	J
T5H004Q01 AT FP 1609030/THE BANKS ON MZIMKHULU	J	-	-	-	-	J
T5H007Q01 AT BEZWENI/ISLAND VIEW ON MZIMKHULU	J	L	L	L	L	L
T7H001Q01 MNGAZI RIVER AT MGWENYANA 22/NMGAZI	J	J	-	L	-	J
U1H005Q01 MKOMAZI RIVER AT LOT 931821/CAMDEN	-	-	J	-	-	J
U2H006Q01 KARKLOOF RIVER AT SHAFTON	L	L	-	-	J	L
U2H014Q01 ALBERT FALLS DAM ON MGENI RIVER: DOWN STREAM WEIR	L	L	L	L	J	L
U2H041Q01 MSUNDUZE RIVER AT HAMPSTEAD PARK/MOTO-X (DARV)	-	L	J	L	-	L
U2H043Q01 MGENI RIVER AT INANDA/NAGLE DAM OUTFLOW (NARO)	-					L
U2H048Q01 MIDMAR DAM ON MGENI RIVER: DOWN STREAM WEIR	L	L	L	L	J	J
U2H055Q01 AT INANDA LOCATION EGUGWINI ON MGENI	J	L	J	L	-	L
U3H005Q01 HAZELMERE DAM ON MDLOTI RIVER: D/ S WEIR (HMRO)	L	L	J	L	L	J
U4H002Q01 MVOTI RIVER AT MISTLEY	J	-	L	-	J	L
U6H003Q01 AT UMLAAS ROAD ON MLAZI	J	L	-	-	-	L
U6H004Q01 MLAZI RIVER AT FARM 10936/SHONGWENI DAM INFLOW (V	L	L	J	L	L	L
U7H008Q01 NUNGWANA DAM ON NUNGWANA RIVER: DOWN STREAM WEIR	L	L	J	-	J	L
U8H001Q01 FAFA RIVER AT COWICK/NEVER DESPAIR	J	J	J	L	J	L
U8H003Q01 MPAMBANYONI RIVER AT UMBELI BELLI	J	J	J	L	-	J
V1H001Q01 TUGELA RIVER AT TUGELA DRIFT/COLENSO	J	L	J	L	-	L

Monitoring Point	pH	EC	Phosphate	Ammonia (NH3-N)	Sulphate	Chloride
V1H010Q01 LITTLE TUGELA RIVER AT WINTERTON	-	L	L	L	L	J
V1H038Q01 KLIP RIVER AT LADYSMITH TOWNLANDS/ARMY CAMP	J	L		L	J	L
V2H008Q01 MOOI RIVER AT KEATE'S DRIFT	J	L	L	L	J	L
V3H002Q01 AT SCHURVEPOORT ON BUFFELSRIVIER	J	J	L	L	L	L
V3H010Q01 @ TAYSIDE ON BUFFELSRIVIER	J	J	J	L	J	J
V5H002Q01 AT MANDINI ON TUGELA RIVER	J	L	-	L	L	L
V6H002Q01 AT TUGELA FERRY ON TUGELA	J	L	-	-	L	L
V6H004 KLEIN FONTEIN 1262 GT ON SUNDAYS RIVER		J	L	L	J	L
V7H012Q01 LITTLE BOESMANS RIVER AT ESTCOURT	J	L	L	L	J	L
VS1 VAAL RIVER ORIGIN AT N17 BRIDGE (GDDC01)	-		-	L	-	J
VS2 VAAL RIVER AT R29/N2 BRIDGE AT CAMDEN (GDDC10)	-		J	-	-	J
VS2-3 BLESBOK SPRUIT AT R39 BRIDGE RIETVLEY (GDDC12)	-		L	L	J	L
VS2-4 LEEUSPRUIT AT R39 WELBEDACHT BRIDGE (GDDC19)	J		L	L	J	J
VS3 VAAL RIVER ON N11 BRIDGE TO AMERSFORT	L		L	L	L	L
W1H009Q01 MHLATUZE RIVER AT RIVERVIEW 11459	J	J	J	L	J	J
W1H032Q01 UMHLATUZE VALLEY PUMP STATION (SUGAR FACTORY)	J	J	L	L	J	J
W2H005Q01 AT OVERVLOED/ULUNDI ON WIT-MFOLOZI	J	L	J	L	J	L
W2H006Q01 AT RESERVE NO 12 ON SWART - MFOLOZI	J	L	L	L	J	L
W2H028Q01 AT EKUHLENGENI ON SWART - MFOLOZI	J	L	L	L		L
W2H032Q01 UMFOLOZI RIVER AT STATE LAND/MONZI	L	L	J	L	J	L
W3H015Q01 HLUHLUWE RIVER AT VALSBAAI/ST LUCIA INFLOW	L	J	J	L	J	J
W3H032Q01 MKUZE RIV AT OVERWIN - D/S MONDI IRR & VORSTER (M	L	L		L		L
W4H004Q01 AT WELGELEGEN PIVAANSBAD ON BIVANE	J	L	L	L	J	L
W4H006Q01 PHONGOLO RIVER AT M'HLATI	J	J	L	J	J	J
W4H009Q01 PHONGOLO RIVER AT NDUME GAME RESERVE	-					L
W4H013Q01 PONGOLAPOORT DAM ON PHONGOLO RIVER: DOWN STREAM W	J	L	J	L	J	L
W5H022Q01 AT ZANDBANK ON ASSEGAAIRIVIER		L	L	L	L	L
W5H024Q01 MPULUZI RIVER AT DUMBARTON	-	L	J	L	J	L
W5H025Q01 USUTU RIVER AT STAFFORD	-	L	J	L	J	L

Monitoring Point	pH	EC	Phosphate	Ammonia (NH3-N)	Sulphate	Chloride
W5H026Q01 NGWEMPISI RIVER AT MERRIEKLOOF	J	-	J	-	J	L
X1H001Q01 KOMATI RIVER AT HOOGGENOEG	J	J	L	L	-	L
X1H003Q01 AT TONGA ON KOMATI RIVER	J	L	J	-	-	L
X1H014Q01 MLUMATI RIVER AT LOMATI	J	L	-	-	-	L
X1H018Q01 KOMATI RIVER AT GEMSBOKHOEK	J	J	L	L	L	L
X1H049Q01 @ SCHOEMANSDAL DRIEKOPPIES DAM DOWNSTREAM WEIR	J	J	-	-	J	L
X2H013Q01 CROCODILE RIVER AT MONTROSE	J	L	L	J	-	L
X2H016Q01 AT TEN BOSCH KRUGER NATIONAL PARK ON CROCODILE RIV	J	L	-	J	L	L
X2H022Q01 KAAP RIVER AT DOLTON	J	L	J	-	L	L
X2H032Q01 CROCODILE RIVER AT WELTEVREDE	-	L	L	L	L	L
X2H036Q01 @ KOMATIPOORT KRUGER NATIONAL PARK ON KOMATI RIVER	-	L	-	-	L	L
X2H046Q01 CROCODILE RIVER AT RIVERSIDE/KRUGER NATIONAL PARK	J	L	J	J	L	L
X3H006Q01 SABIE RIVER AT PERRY'S FARM	-	L	J	J	-	L
X3H008Q01 SAND RIVER AT EXETER	L	L	L	L	L	L
X3H015Q01 SABIE RIVER AT LOWER SABIE REST CAMP/KRUGER NAT P	J	-	L	L	-	L

Legend	
-	water quality stable
L	water quality deteriorating (concentrations are increasing)
J	water quality improving (concentrations are decreasing)
blank	insufficient data available to determine trends

APPENDIX C:

List of stakeholder workshop attendees

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APPENDIX D:

National Water Quality Status Map