7. WATER QUALITY

7.1 INTRODUCTION

7.1.1 What is water quality?

“Water quality” is a term used to express the suitability of water to sustain various uses, such as agricultural, domestic, recreational, and industrial, or aquatic ecosystem processes. A particular use or process 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.

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 effects of human intervention 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. feacal 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 (DWA, 2010).

7.1.2 What is this chapter all about

This chapter provides an overview of water quality and aquatic ecosystem monitoring in the Western Cape as well a gap analysis to identify monitoring that needs to be undertaken in the province to fill some of the knowledge gaps that exist. The present water quality status is then reviewed for the Olifants/Doring WMA, the Berg WMA, the Breede WMA, the Gouritz WMA, and the small portion of the Western Cape that extends into Fish to Tsitsikamma WMA. Sources of point and nonpoint source pollution are then reviewed and the chapter is concluded with a first assessment of priority pollution concerns that should be addressed.

7.2 WATER QUALITY MONITORING

7.2.1 Introduction

Sound water quality monitoring is essential for facilitating proactive management of water resources. Water quality monitoring is undertaken for various purposes, namely (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, (d) tracing deviations from background or baseline conditions, and (e) remediation efforts. This evaluation of water quality monitoring programmes focuses on programmes that are aimed at detecting/describing water quality status and trends at a provincial scale.

7.2.2 Definition of monitoring

"Monitoring" refers to all physical water related monitoring systems that collect data and information to manage the resource in an integrated manner in accordance to the requirements of the National Water Act (Act 36 of 1998) (NWA) and Water Services Act (Act 108 of 1997). In accordance with chapter 14 of the NWA:

137. (1) The Minister must establish national monitoring systems on water resources as soon as reasonably practicable.
(2) The systems must provide for the collection of appropriate data and information necessary to assess, among other matters -

- *(a) the quantity of water in the various water resources;*
- *(b) the quality of water resources;*
- *(c) the use of water resources;*
- *(d) the rehabilitation of water resources;*
- *(e) compliance with resource quality objectives;*
- *(f) the health of aquatic ecosystems; and*
- *(g) atmospheric conditions which may influence water resources.*

7.2.3 Water quality monitoring programmes

A total of eleven resource quality monitoring programmes are currently run by the Department of Water Affairs (DWA), see **Table 7.2.1**. The main purpose of these monitoring programmes is to assess the status of the water resources and track water quality trends.

There are four main databases that are populated with monitoring data, these are:

- **HYDSTRA:** This is a commercial, off-the-shelf Hydrological Information System for the storage, editing, retrieval, manipulation, and analysis of surface water, water quality, and groundwater time series data and related hydrological information in support of water resources management.
- **NGIS:** The National Groundwater Information System is a groundwater based portfolio of applications and projects which provides data storage, web-enabled capturing (capturing released in Oct 2008), and data dissemination capabilities for groundwater related data, tools for data and information representation as well as reporting.
- **WARMS:** The Water Use Authorisation Registration Management System (WARMS) application solution supports the business environment with the management and administration of water use related activities and authorisations.
- **WMS:** The Water Management System (WMS) is a computer system designed to support the water resource management function of the department with emphasis on water and environmental quality and assisting in the assessment of impacts and compliance.

The custodians of the monitoring data are situated in various Head Office (HO) directorates of the DWA.

The Regional Offices (RO) are the operators and are responsible for the physical data collection in the field. A summary of all the resource quality monitoring programmes is provided in **Table 7.2.1**. A brief over-view of the purpose of the monitoring programmes and databases is provided below.

- Chemical monitoring (**NCMP**)
  The National Chemical Monitoring Programme (NCMP) aims to provide data and information on the surface inorganic chemical water quality of South Africa's water resources (http://www.dwaf.gov.za/iwqs/water_quality/NCMP/default.aspx). The majority of samples are collected at gauging weirs as the surface water quality monitoring network was simply superimposed on the existing surface water gauging programme (Nomquphu, 2005).

- Eutrophication monitoring (**NEMP**)
  Eutrophication[1] is of concern because it can have numerous negative impacts. These include ecological impacts (like the deterioration of water quality and loss of biodiversity), aesthetic, recreational, and human health impacts. All these impacts have a significant economic impact (http://www.dwaf.gov.za/iwqs/eutrophication/NEMP/default.aspx). The NEMP was designed in response to demands for information concerning eutrophication of surface water. The main purpose of the data is to describe water quality status, detect trends in nutrient concentrations, and provide decision support for management efforts (Nomquphu, 2005).

- Microbiological Monitoring (**NMMP**)
  The objectives of the National Microbiological Monitoring Programme for Surface Water is (1) to provide information on the status and trends of the extent of faecal pollution, in terms of the microbial quality of surface water resources in priority areas and (2) to provide information to help assess the potential health risk to humans associated with the possible use of faecally polluted water resources (http://www.dwaf.gov.za/iwqs/microbio/nmmp.aspx). The main monitoring variables are *E. coli* (Faecal Coliforms) which are sampled bi-weekly (Nomquphu, 2005).

- Aquatic Ecosystem Health Monitoring (**NAEHMP**)
  The National Aquatic Ecosystem Health Monitoring Programme is a national programme managed by Resource Quality Services with support from the Water Research Commission, CSIR, and various regional and provincial authorities. The most well-known component of the National Aquatic Ecosystem Health Monitoring Programme is the River Health Programme (http://www.dwaf.gov.za/iwqs/rhp/naehmp.aspx). The South African River Health Programme (**RHP**) primarily makes use of biological indicators to assess the condition or health of river systems. The rationale for using biological monitoring is that the integrity of biota inhabiting river ecosystems provides a direct, holistic, and integrated measure of the integrity or health of the river as a whole (http://www.dwaf.gov.za/iwqs/rhp/goal.html). The RHP focuses on the following biological indicators and indices: (1) Aquatic invertebrates using the South African Scoring System (SASS) index; (2) Fish Response Assessment Index (FRAI); (3) Riparian Vegetation Index (RVI); (4) Index of Habitat Integrity (IHI); and (5) Geomorphologial Driver Assessment Index (GAI) (Nomquphu, 2005).

[1] Eutrophication is the process of nutrient enrichment of waters which results in the stimulation of an array of symptomatic changes amongst which increased production of algae and aquatic macrophytes (plants), deterioration of water quality, and other symptomatic changes are found to be undesirable and interfere with water uses.

Table 7.2.1 National monitoring programmes (DWAF, 2004).

Monitoring Programme	Purpose	Measurement	Database	Custodian	Operators	Reporting: (1) Information products (2) Frequency
National Microbial Monitoring Programme (NMMP)	Status and trends	Microbes (*E. coli*, Faecal coliform)	WMS: HO	HO: RQS	HO: RQS DoH	(1) Microbial Status Report (2) Bi-monthly and Annually
River Health Programme (RHP)	Status and trends	Biological indicator (fish, vegetation, invertebrates)	WMS: HO (River database)	HO: RQS DEAT WRC	RO: RQS PPT +++	(1) State of Rivers Report (2) Annually
National Chemical Monitoring Programme (NCMP)	Status and trends	Water quality samples	WMS: RO	HO: RQS	RQS RO Agents HMP	(1) Assessment and Planning Reports (2) Variable
National Eutrophication Monitoring Programme (NEMP)	Status and trends	Phosphate, Nitrogenous compounds, Chlorophyll, Algae, Cyanobacteria	WMS: HO	HO: RQS	RO RQS	(1) Eutrophication Status Reports (2) Annually
National Radioactivity Monitoring Programme (NRMP)	Status and trends	Dose calculation (concentration of radio nucleotides)	WMS: HO	HO: RQS NNR***	Being designed	(1) Radiological Water Quality Status Report (2) Regularly
National Toxicity Monitoring Programme (NTMP)	Status and trends	Toxicants and toxicity	WMS: HO	HO: RQS	Being designed	(1) Toxicological Water Quality Status Report (2) Regularly
Ecological Reserve Determination and Monitoring	Ecological Reserve monitoring: compliance, conformance. Status and trends	**	WMS: HO	HO: (D: RDM) HO: (D: RQS)	HO: RDM/RQS	(1) Ecological Status (2) Interim
Hydrographic Surveys for sedimentation	Sedimentation			Business information	Business information	(1) Reservoir Volume and Sedimentation (2) Every 20 years per dam

Monitoring Programme	Purpose	Measurement	Database	Custodian	Operators	Reporting: (1) Information products (2) Frequency
Dam walls (dam safety)	Dam safety			Business information	Business information	(1) Coordinates and diagrams (2) Biannually
Hydrological Monitoring Programme (HMP)	Status and trends	Water quality samples for RQS (i) Continuous surface water levels at gauging stations, canals, and dams and flow rates in pipelines (ii) Rainfall and evaporation (daily, monthly, annually)	Hydstra (Regions and HO) HO performing auditing function RO populating database	HO (Hydrological Services) RO	HO (Hydrological Services) RO	(1) Flow and Dam Records, Total Flow Regime, Evaporation and rainfall records (2) Various (continuous, daily, monthly, annually)
Geohydrological Monitoring Programme (GMP)	Status and trends	(i) Rainfall depth and chemical character (ii) EC and temperature (iii) Groundwater level (iv) Isotope (v) Trace elements	HO RO	HO RO	National groundwater monitoring coordinator	(1) Groundwater balance, Geochemical trends and spatial changes, Geohydrological Reports (2) Hourly readings of groundwater levels. Bi-annual sampling of quality

** (1) Development of integrated biological and ecological indices and methods for ecological Reserve specifications
(2) Development of methods to integrate present ecological state of components into eco-status. Includes development of some predictive capability.
(3) Development of adaptive resource monitoring and management systems for ecological Reserve.

- Toxicity Monitoring (**NTMP**)
  The objective of the NTMP is to measure, assess and regularly report on the status and trends of the nature and extent of: (1) potentially toxic substances in South African water resources (watercourses, groundwaters and estuaries), and (2) the potential for toxic effects to selected organisms in a manner that will support strategic management decisions in the context of fitness for use of those water resources, be mindful of financial and capacity constraints, yet, be soundly scientific (http://www.dwaf.gov.za/iwqs/water_quality/ntmp/index.htm).

7.2.4 Why the need for water quality monitoring?

In support of the DWA's objective to provide effective management solutions and policy guidance to address the current water quality management challenges facing South Africa today, there is a need to provide information on water quality status and trends that measure, assess and report on the current status 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 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 their receiving bodies of water. This is critical because local decisions related to land-use planning and development or other human actions in individual catchments can contribute significantly to the cumulative or overall impact on the quality of the downstream resource and receiving water. 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 helps to:

- 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 (DWA, 2010).

The fundamental concept of a water quality monitoring programme is that the information must be "user-centric'. In other works, all monitoring should be justified by serving specific information with the water resource quality information they need to perform their management functions (DWA, 2010).

7.2.5 Water quality monitoring

7.2.5.1 Monitoring institutions

The following institutions are involved in water quality monitoring:

- DWA: Head Office
- DWA: Western Cape Regional Office
- Catchment Management Agencies (CMAs) - Breede-Overberg CMA

- Local municipalities (Water Service Providers)
- Water User Associations

7.2.5.2 Routine monitoring programmes operational in the Province

The Department of Water Affairs has undertaken a situational analysis of water resources monitoring in the Western Cape, to propose an integrated monitoring strategy, and to develop a spatial model to manage relevant information (Africon, 2006). As part of the project a monitoring catalogue was compiled for the Western Cape to document “who does what where and how often”. The catalogue documented the following monitoring categories: Surface water, Groundwater, Estuaries, Marine, Meteorological, and Wastewater monitoring. For each monitoring programme the following information was collated: programme type, programme owner, clients, purpose, frequency, and spatial extent. A GIS database was also developed for all monitoring activities. This database was obtained and is being updated for the current project.

In summary, the following, **Table 7.2.2** institutions were involved in water resource monitoring in the Western Cape.

Table 7.2.2 Overview of water resources monitoring programmes operational in the Western Cape.

Level	Institution	Operational Programmes
National	Department of Water Affairs	National hydrological monitoring programme National groundwater monitoring programme National chemical monitoring programme National microbial monitoring programme National eutrophication monitoring programme
Provincial	Department of Water Affairs	Wastewater Treatment Works and Industrial dischargers
	Cape Nature	Research oriented flow and quality monitoring of surface and groundwater
	Agricultural Research Council	Meteorological monitoring
Local	City of Cape Town	Catchment monitoring Aquatic ecosystem monitoring Water and Wastewater treatment works Pollution management Wellfield management Atlantic and False Bay coastlines Estuary monitoring
	Stellenbosch municipality	Water and wastewater treatment works Eerste River water quality monitoring
	Drakenstein municipality	Water and wastewater treatment works Berg River water quality monitoring
Research oriented	CSIR	Mountain catchment and afforestation monitoring
	Universities	Research project related monitoring

Maps indicating the water quality monitoring points in each of the WMAs of the Province, are situated in the WMA specific chapters of this report.

7.2.5.3 Information systems and access to data

All the water quality data collected by DWA is stored in the Department's central water quality database, WMS (Water Management System). Water samples collected for national monitoring programmes are preserved and sent to the laboratories at Roodeplaat Dam near Pretoria. Here the samples are analysed and the analysis data is transferred directly into WMS. The analysis data of water samples collected by the Western Cape Regional Office and analysed at local laboratories are first stored locally and transferred to WMS on a regular basis. Water quality data can be requested from the Department, either via the Regional Office in Bellville, or from Resource Quality Services who is responsible for maintenance of the database.

Resource Quality Services developed a water quality data exploration tool which can be used with Google Earth (http://www.dwaf.gov.za/iwqs/wms/data/000key.asp). The browser tool provides access to the Water Affairs water quality sites, some monitored as early as the 1950s. Many are groundwater sites with only one record, others are river sites with thousands of samples. Links are available to pre-packaged PDF graphs and text data files listing the more common water quality constituents. Files for displaying data in Google Earth help the users to see sites in relation to one another. The exploration tool allows a user to quickly identify water quality monitoring points in a specific region, determine the length of the data record at a point, retrieve summary statistics, and even raw data. It the most recent data is required then it can be requested form the Department who will supply it in a format that can easily be opened in a spread sheet programme like Excel.

Data collected by local authorities generally reside with them in spread sheet databases. This data is not transferred to a centralised water quality database. Data can be made available if requested from the Local Authority.

Data on the quality of potable water supplies are stored in eWQMS. The Department of Water Affairs together with the Institute of Municipal Engineering of Southern Africa (IMESA) rolled out an internet-based Water Quality Management System (eWQMS) to water supply authorities (WSAs). eWQMS is a comprehensive Water Quality Management tool, has been set up to assist WSAs to meet the National Drinking Water Quality Management Framework requirements, and is a full management system. The eWQMS utilises Open Source Software and is able to guide (i) regulatory compliance by WSAs, (ii) the timeous supportive intervention in water quality failures, (iii) infrastructure improvement, and (iv) capacity development of municipal staff. The eWQMS is accessible via the internet (www.wqms.co.za), and is a very useful means for allowing a range of participating parties (including Water Service Authorities, Provincial and National Government, etc.) to guide the tracking, reviewing and improving of water quality.

7.3 BIO-MONITORING

The River Health Programme (RHP), initiated by the DWA in 1994, is a monitoring programme designed to provide information on the overall ecological status of river ecosystems in South Africa. The RHP primarily makes use of in-stream and riparian biological communities (e.g. fish, invertebrates, vegetation) to characterise the response of the aquatic environment to 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, assesses and report on the ecological state of aquatic ecosystems;
- Detect and report on spatial and temporal trends on the ecological state of aquatic ecosystems;
- Identify and report on emerging problems regarding aquatic ecosystems; and
- Ensure that all reports provide relevant information (in terms of scientific content and management recommendations) for national aquatic ecosystem management.

7.3.1 Frequency

The frequency of bio-monitoring surveys is linked to the preparation of State-of-Rivers reports. Prior to the preparation of a report, at least 3-4 macro-invertebrate surveys are undertaken per year and the other ecosystem components monitored at least once per year. It is the intension that State of Rivers reports be updated every 5 years. For example, the Breede River Basin was surveyed in 2007-2008, and the Overberg rivers in 2004-2005.

It is also the intent of the River Health programme to undertake macro-invertebrate monitoring every quarter and to monitor the other ecosystem components (fish, riverine vegetation, habitat integrity, and geomorphology) on an annual basis. However with some 400 bio monitoring sampling sites in the Western Cape alone, this has not been possible with the capacity available in the Western Cape. Maps illustrating the location of River Health Monitoring Points in each WMA, are located in the WMA specific chapters, from Chapter 8 onwards of this report.

7.3.2 State of Rivers Reports

The following State-of-Rivers reports have been published for the Western Cape and are available in hard copy from the Department of Water Affairs, and in electronic format on the River Health website[2]:

- 2007 Rivers of the Gouritz Water Management Area
- 2006 Olifants/Doring and Sandveld Rivers
- 2005 Greater Cape Town's Rivers
- 2004 Berg River System
- 2003 Diep, Houtbay, Lourens and Palmiet River System
- 2003 Hartenbos and Klein Brak

Posters for some of the Western Cape Rivers have also been prepared:

- Rivers of the Overberg Region
- Goukou and Duiwenhoks Rivers
- Cape Town's Rivers
- Berg River

The State-of-Rivers report for the Breede River basin has been completed and is due for publication during the second quarter of 2011. The update of the Berg River system State-of-Rivers report is currently in progress and is due for completion during the first half of 2011 (Belcher, pers. comm.).

The present ecological status of rivers in the Western Cape, excluding the Breede River basin which has not been published yet, has been summarised in **Annexure C**.

7.4 GAP ANALYSIS

The importance of water quality monitoring cannot be over emphasized. Information is critical for decision making, as 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 contaminants to their source and

[2] http://www.dwa.gov.za/iwqs/rhp/state_of_rivers.html

identifying a prevention and/or treatment plan. A brief over-view of the water quality monitoring gaps is provided below.

7.4.1 Toxicants

Exposure 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. 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 (such as heavy metals) and organic toxicants (like pesticides, petroleum products, pharmaceuticals, etc.) can enter water resources and have devastating impacts on ecosystem integrity. Some of the critical ecological issues include:

- 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 higher 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) 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.

The National Toxicity Monitoring Programme (NTMP) only covers Persistent Organic Pollutants (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 POPs accumulate in the sediment and concentrations can exceed guideline values compared to concentrations in the water. These are then remobilised during flood events or when anoxic conditions develop. Sediment is therefore an important source of potential pollution. However, sediment as a sampling medium is not included in any monitoring programme.

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 storm water runoff was identified as a major concern in the DWA assessment (DWA, 2010).

7.4.2 Persistent organic pollutants (POPs)

Persistent organic pollutants (POPs) are organic compounds that are resistant to environmental degradation. Because of this, they have been observed to persist in the environment, to be capable of long-range transport, bio-accumulate in human and animal tissue, bio-magnify 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 (ratified in 2002) 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. It is relevant to note that 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 (DWA, 2010).

7.4.3 Endocrine Disrupting Compounds (EDCs)

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 has launched 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).

7.4.4 Early warning systems and continuous monitoring

Routine, fixed frequency monitoring is good for detecting spatial and seasonal trends but not for identifying pollution incidents. Continuous monitoring can identify pollution incidents and serve as an early warning system for water resource managers. The easiest parameter to measure on a continuous basis is salinity and water temperature and the DWA has a network of such monitoring points at key locations along the Berg River. The data collected from this network is available on request from the DWA Regional Office. Rand Water has a similar network in the Vaal Dam catchment, but they measure more parameters including dissolved oxygen and turbidity. Rand Water uses the dissolved oxygen concentrations as an indicator of organic pollution. When there is a rapid drop in the dissolved oxygen levels, inspectors are sent out to determine the possible cause because the drop is often a symptom of more serious problems. It is recommended that the need for continuous monitoring at selected "hot spots" be reviewed with DWA and local authorities.

7.4.5 Salinity

The water quality in South Africa's aquatic ecosystems is declining primarily because of salinization 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. Salinization 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 salinization impacts, it is important to set maximum salinity targets. It is also important to identify taxa or other indicators of salinity impacts so that bio-monitoring 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. In the Western Cape, irrigation return flows are the main anthropogenic source of salinity. This is particularly evident in the Breede River WMA where the Bokkeveld shales introduce naturally occurring salinity to the Middle and Lower Breede River. Salinity is generally low in the upper reaches of the Breede River and its tributaries, but becomes increasingly more saline in a downstream direction. Where irrigation is intensive, return flows aggravate the salinity problem through the leaching of salts into the rivers. Tributaries such as the Vink, Kogmanskloof, and Poesjenels Rivers have very high salinity concentrations. The Middle and Lower Breede River carries the brunt of salinization, receiving naturally saline water and irrigation return flows. The lower Breede River eventually becomes unsuitable for agricultural use due to increased salinity.

River dilution is most commonly used to mitigate the impacts of saline irrigation return flows. This is inefficient use of water (requiring "freshette" releases of stored good quality water from dams) and will become more difficult as water becomes limiting in highly developed catchments.

In the Breede River WMA, some natural freshening takes place downstream of the Riviersonderend River confluence and again downstream of the Buffeljags River confluence as a result of better quality water arising from those two catchments. The salinity levels in the headwaters of the Riviersonderend River are low but increase downstream of Theewaterskloof Dam due to agricultural practices. A concern is that salinity in the lower reaches of the Riviersonderend River shows an increasing trend over time which would negatively affect the freshening effects on the lower Breede River. To date it has not been considered necessary to make freshening releases out of Theewaterskloof Dam. Options to manage salinity in the Breede River include:

- Maintaining current practices to meet salinity targets in the middle Breede River;
- Consideration to lowering the chloride targets in the middle Breede River;
- Intercepting and storing or evaporating irrigation return flows on farms;
- Controlling further irrigation development on saline soils; and
- Promoting research and the development of guidelines for on-farm containment of saline return flows (DWA, 2010).

7.4.6 Organic matter (COD/BOD) and dissolved oxygen

Organic matter discharged to rivers exerts a demand on the dissolved oxygen concentration available in the water as it decomposes. This can have a detrimental effect on aquatic biota if the dissolved oxygen drops to low concentrations. Dissolved oxygen and indicators of organic matter, such as biochemical oxygen demand (BOD) or chemical oxygen demand (COD), are not monitored routinely in Western Cape Rivers. Sources of organic matter include poorly treated domestic wastewater, urban runoff, runoff from informal settlements, and runoff from feedlots. Discharges from wineries and fruit processing industries are also high in organic content. The need for monitoring dissolved oxygen and organic matter should be reviewed in collaboration with aquatic ecologists to identify “hot spots” where monitoring should be undertaken to protect the aquatic ecosystem.

7.4.7 Microbial water quality – limited coverage

There is a need to improve the spatial coverage and frequency of microbial monitoring in the province. The location of NMMP monitoring points is a function of known pollution sources and known downstream users. This is balanced with logistical requirements to deliver water samples to a microbiological laboratory within 8 hours of collection, which is why there are a limited number of NMMP monitoring points in the province. At present there are no NMMP monitoring points in the Overberg area due to a shortage of samplers. In order to protect the certification requirements of the fruit export industry, more sampling points should be established in sensitive irrigation areas and the sampling frequency should be increased to at least weekly sampling during the active growth season.

In order to support pollution source management, microbiological surveys should be undertaken in problem areas to identify sources of pollution, which may be from an individual point (e.g. WWTW) or from an area (e.g. urban runoff from an informal settlement). Routine monitoring is not sufficient to identify individual sources where management interventions are required.

7.4.8 Water quality status reporting and dissemination

There is a need to collate and disseminate information on the water quality status of rivers in the Western Cape on at least an annual basis. National reports such as State of the Rivers reports and the Planning Level Review of Water Quality in South Africa (DWA, 2010) are prepared infrequently. National assessment reports tend to focus on large scale concerns and often miss localised water quality problems. In future, Catchment Management Agencies could have the responsibility to prepare annual reports but it would probably take a few years before this becomes standard practice. In the meantime it is recommended that an annual water resource status report be prepared for rivers in the Western Cape to start raising the profile of water resource quality in the province. The report should be aimed at the general public and political decision makers to influence perceptions and elicit support for action against pollution.

7.5 WATER QUALITY SITUATION ASSESSMENT

7.5.1 Introduction

The South African Water Quality Guidelines (SAWQGs) have been developed as discrete values that depict the change from one category of fitness for use[3] to another. 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. The following fitness for use categories are linked to the SAWQGs:

[3] Fitness for use is a scientific judgment, 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.

- **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 encountered; usually for a limited period only
- **Unacceptable:** water cannot be used for its intended use under normal circumstances at any time

A review of the surface water status of selected water quality variables was undertaken in 2010 by the DWA (DWA, 2010. Directorate Water Resource Planning Systems: Water Quality Planning. Resource Directed Management of Water Quality. Planning Level Review of Water Quality in South Africa). This review included extracting data from the WMS with a stipulated data range from 1 January 1999 to 31 December 2008. The monitoring sites from the National Chemical Monitoring Programme were selected as this programme has a spatial resolution covering South Africa with approximately 330 sites situated on rivers. Six variables were selected to serve as indicators of the general water quality status, as they provide insight into the salinity and eutrophication status, mining related impacts, and variability of the country's water resources. These variables were selected on the following reasoning:

- **Electrical conductivity (EC) (mS/m):** to provide an indication of salinization of water resources
- **Orthophosphate (PO_4-P) (mg/l):** as an indicator of the nutrient levels in water resources
- **Sulphate (SO_4^{2-}) (mg/l):** as an indicator of mining impacts
- **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
- **pH (pH units):** as an indicator for mining impacts as well as natural variability

The water quality status (fitness for use) of the surface water resources in the WMAs which are located within the Western Cape is presented as hexagons at the selected monitoring points on the map for each WMA. The maps are situated in WMA specific chapter. Each piece of the hexagon represents the compliance of the water quality variable along the river with a generic set of Resource Water Quality Objectives (RWQO) that are applicable to all the rivers across the entire country. The 95^{th} percentile values were used to assess EC, sulphate, chloride, ammonia, and pH compliance to the RWQO, while the 50^{th} percentile values were used to assess phosphate compliance (DWA, 2010).

7.6 SOURCES OF POLLUTION

7.6.1 Introduction

7.6.1.1 Distinguishing between point and nonpoint sources of pollution

In its simplest terms, a pollutant is a substance that enters the environment and elevates the "natural" background concentration of that substance. Pollution originating from a single, identifiable source, such as a discharge pipeline from an industry or a wastewater treatment works. The most common point source surface water pollutants are high temperature discharges, micro-organisms (such as bacteria and viruses), and nutrients (such as nitrogen and phosphorus). In contrast, pollution that does not originate from a single point or source is called nonpoint pollution. Nonpoint source pollution is contamination affecting a water resource from diffuse sources, such as polluted runoff from agricultural areas which drain into a river, urban storm water runoff, and runoff from informal unserviced areas. Nonpoint source pollution is usually found spread out throughout a large area and it is often difficult to trace the exact origin of these pollutants as they result from a wide variety of human activities. The most common nonpoint source pollutants are sediment, nutrients, micro-organisms, and toxins (http://www.waterencyclopedia.com/Po-Re/Pollution-Sources-Point-and-Nonpoint.html).

7.6.1.2 Methodology

South Africa has built a substantial wastewater management industry that comprises of approximately 970 treatment plants, extensive pipe networks, and pump stations, transporting and treating an average of 7 589 000 kilolitres of wastewater on a daily basis. The country runs a prominent wastewater treatment business with capital replacement value of >R 23 billion and operational expenditure of >R 3.5 billion per annum. The province of Western Cape, and its Water Service Authorities, currently owns, operates and maintains 156 WWTWs. A national survey on Wastewater Treatment in South Africa (undertaken in 2006 by the DWA) reported that a significant number of WWTWs are not properly operated and maintained and discharge poor quality effluent to streams and rivers. This situation is unacceptable as it impacts directly on the downstream water users, the quality of natural waters and the cost and availability of potable water and its treatment in South Africa.

The function of wastewater treatment lies primarily with Water Service Authorities and their Providers to operate and maintain the physical infrastructure and the chemical/biological processes. As Sector Leader, the DWA has an oversight and regulatory role. The DWA is intensifying its efforts to determine and improve the status of WWTW's in South Africa. An extensive assessment and intervention plan is geared towards assisting WSA/WSP's to improve their technical proficiency and legal compliance with effluent discharge specifications. Mobilisation of all necessary resources, funds and political commitment is required to rectify cases of non-compliances.

In 2009, the DWA undertook a comprehensive desktop assessment of all the WWTWs in the Western Cape (DWAF, 2009. Executive summary of first order assessment of municipal wastewater treatment works in the Western Cape Province). The purpose of this assessment was to develop a priority list of WWTWs with potentially high risk profiles based on:

- Status of hydraulic design capacity and actual flow received;
- Status of effluent quality as compared to legal discharge standards; and
- Status of technical and health/safety skills and compliance to legal requirements.

The authorisation of the WWTWs by the DWA in terms of the NWA, although not critically impacting on health or environment, is a legislative requirement, and forms a crucial aspect in water resource planning and allocation. In terms of the NWA, there are a number of types of authorisations, including a Water Use Licence and a General Authorisation. The type of authorisation required for the WWTWs is determined by a number of factors, including the design capacity of the works and if treated effluent is discharged to a water resource or irrigated onto land. The current authorisation of WWTWs by DWA in the Province is included in **Annexure E**.

An estimated 28% of the WWTWs in the Western Cape are not authorised by the DWA. This is a major concern as without an authorisation there is no regulatory control of these WWTWs and no conditions against which compliance of the WWTWs can be measured (DWAF, 2009).

7.6.1.3 Analysis of WWTW in the province

Generally accepted, wastewater treatment plants can be categorised in the following size categories:

- micro size plants <0.5 Mℓ/day;
- small size plants 0.5-2 Mℓ/day (General Authorisations could apply);
- medium size plants 2-10 Mℓ/day;
- large size plants 10-25 Mℓ/day;
- macro size plants >25 Mℓ/day.

There are 156 WWTWs within the Western Cape, with the majority falling within the micro, small and medium classification. ***Figure 7.6.1*** shows the proportions of the various size categories schematically. There are no macro sized WWTWs within the Western Cape. Of concern is the number of WWTWs with an “unknown” design capacity.

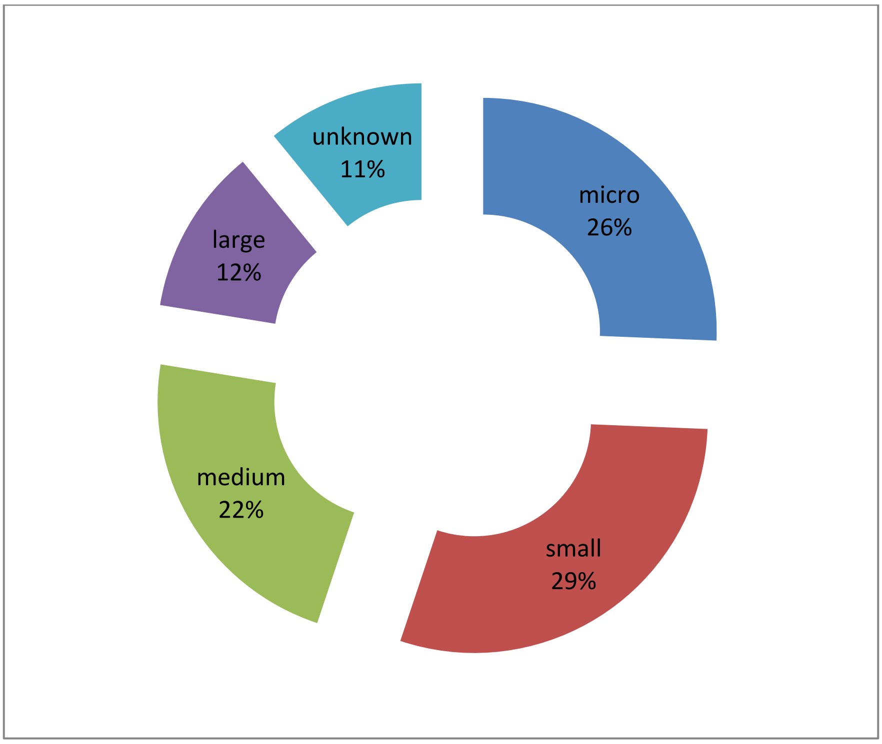

Figure 7.6.1 Distribution of wastewater treatment works in the Western Cape.

An assessment of the WWTWs in terms of compliance with discharge standards showed that the majority of the WWTW failed to meet one of more of the standards (see ***Table 7.6.1***.). The next level of assessment would need to determine why these WWTWs are not complying, especially for those works which are consistently failing to meet the required discharge standards.

Table 7.6.1 Wastewater Treatment Works and priority for water quality standards not being met.

Town	Responsible municipality / organisation	water quality standards not being met	Priority	BITT Report Priority
Athlone	Cape Metropolitan Council	E.coli, FC; $PO_4^{2-;}$ SS	1	
Bellville	Cape Metropolitan Council	E.coli, FC; NH_4^+ ,NO_3^- ; NO_2^-;COD; SS	2	
Cape Flats	Cape Metropolitan Council	E.coli, FC; COD	3	
Caltizdorp	Kannaland LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	4	
Laingsburg	Lainsburg LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	5	
Pacaltsdorp	George LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	6	
Gouritzmond	Hessequa LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	7	
De Rust	Oudtshoorn LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	8	
Eendekuil	Berg River LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	9	
Koekenaap	Matzikama LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	10	
Lutzville West	Matzikama LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	11	

Town	Responsible municipality / organisation	water quality standards not being met	Priority	BITT Report Priority
Zandvliet	Cape Metropolitan Council	E.coli, FC; NO_3^- ; NO_2^-; SS	12	
Macassar (Strand)	Cape Metropolitan Council	E.coli, FC; EC;NO_3^-; NO_2^-	13	
Riebeeck West	Swartland LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	14	
Koringberg	Swartland LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	15	
Chatsworth	Swartland LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	16	
Kalbaskraal	Swartland LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	17	
Riebeeck Kasteel	Swartland LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	18	
Stellenbosch	Stellenbosch LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	19	
Green Point Outfall	Cape Metropolitan Council	E.coli, FC;NH_4^+ ,NO_3^- ; NO_2^-; COD; SS	20	
Kraaifontein	Cape Metropolitan Council	E.coli, FC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}	21	
Worcester	Breede Valley LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	22	
Mitchells Plain	Cape Metropolitan Council	E.coli, FC; NO_3^- ; NO_2^-; PO_4^{2-}	23	
Merweville	Beaufort West LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	24	
Struisbaai	Cape Agulhas LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	25	
Klipheuwel	Cape Metropolitan Council	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	26	
Dwarskersbos	Cape Metropolitan Council	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	27	
Plettenberg Bay - Hartenbos	Bitou LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	28	
PPC	Swartland LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	29	
Paarl	Drakenstein LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	30	
Borcherd's Quarry	Cape Metropolitan Council	E.coli, FC; NO_3^- ; NO_2^-; PO_4^{2-}; SS	31	
Murraysburg	Central Karoo DM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	32	
Leeu Gamka	Prince Albert LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	33	
Harold's Bay	George LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	34	
Jongensfontein	Hessequa LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	35	
Witsand	Hessequa LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	36	
Melkhoutfontein	Hessequa LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-} ;COD; SS	37	
Herbertsdale	Mossel Bay LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	38	
Brandwag	Mossel Bay LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	39	
Aurora	Berg River LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	40	
Wuppertal	Cederberg LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	41	
Ebenhaeser	Matzikama LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	42	
Friemersheim A (large)	Mossel Bay LM	E.coli, FC; NH_4^+ ,NO_3^-; NO_2^-	43	
Beaufort West	Beaufort West LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	44	
Hout Bay	Cape Metropolitan Council	E.coli, FC; EC; NH_4^+ ,NO_3^- ; NO_2^-; COD; SS	45	
Potsdam (Milnerton)	Cape Metropolitan Council	E.coli, FC; NO_3^- ; NO_2^-	46	

Town	Responsible municipality / organisation	water quality standards not being met	Priority	BITT Report Priority
Botrivier	Theewaterskloof LM	E.coli, FC; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-} ;COD; SS	47	
Slangrivier	Hessequa LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	48	
Klawer	Matzikama LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	49	
Barrydale	Swellendam LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	50	
Greyton	Theewaterskloof LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	51	
Scottsdene	Cape Metropolitan Council	E.coli, FC; NO_3^-; NO_2^-	52	
Nelpoort	Beaufort West LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	53	
Napier	Cape Agulhas LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	54	
Waenhuiskrans	Cape Agulhas LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	55	
Philadelphia	Cape Metropolitan Council	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	56	
Klaarstroom	Prince Albert LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	57	
Prince Albert	Prince Albert LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	58	
Uniondale	Eden DM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	59	
Graafwater	Cederberg LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	60	
Eland's Bay (Piketberg)	Cederberg LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	61	
Lambert's Bay	Cederberg LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	62	
Strandfontein	Matzikama LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	63	
Doringbaai	Matzikama LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	64	
Lutzville	Matzikama LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	65	
Van Rhynsdorp	Matzikama LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	66	
Vredendal North	Matzikama LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	67	
Suurbraak	Swellendam LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	68	
Koornland	Swellendam LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-} ;COD; SS	69	
Klipperivier	Swellendam LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	70	
Riviersonderend	Theewaterskloof LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	71	
Franschhoek	Stellenbosch LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	72	
Ceres	Ceres LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	73	
Hermon	Drakenstein LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	74	
La Motte	Stellenbosch LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	75	
Wemmershoek	Stellenbosch LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	76	
Groot Springfontein (Dover)	Cape Metropolitan Council	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	77	
Langebaan	Saldanha Bay LM	E.coli, FC; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	78	
Gouda	Drakenstein LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	79	

Town	Responsible municipality / organisation	water quality standards not being met	Priority	BITT Report Priority
Simon's Town	Cape Metropolitan Council	E.coli, FC; NH_4^+ ,NO_3^-; NO_2^-; COD; SS	80	
Wellington	Drakenstein LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	81	
Melkbosstrand	Cape Metropolitan Council	E.coli, FC; NO_3^-; NO_2^-	82	
Wildevoelvlei	Cape Metropolitan Council	E.coli, FC;NO_3^-; NO_2^-	83	
Kurland	Bitou LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	84	
Zoar	Kannaland LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	85	
Rheenendal (Beacon)	Knysna LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	86	
Velddrift	Berg River LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	87	
Camps Bay Outfall	Cape Metropolitan Council	E.coli, FC; NH_4^+ ,NO_3^- ; NO_2^-; COD; SS	88	
Op-die-berg	Witzenberg LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	89	
Friemersheim B (small)	Mossel Bay LM	E.coli, FC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}	90	
Gansbaai	Overstrand LM	E.coli, FC; EC; NH_4^+ ,NO_3^- ; NO_2^-; COD; SS	91	
Dysselsdorp	Oudtshoorn LM	E.coli, FC; NH_4^+ ,NO_3^- ; NO_2^-; $PO_4^{2-;}$COD; SS	92	
Vredendal South	Matzikama LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	93	
Raithby	Stellenbosch LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	94	
Outeniqua	George LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	95	
Gwaing	George LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	96	
Oudtshoorn	Oudtshoorn LM	E.coli, FC; NH_4^+ ,NO_3^-; NO_2^-; SS	97	
Wesfleur (domestic) Atlantis	Cape Metropolitan Council	E.coli, FC;NO_3^- ; NO_2^-	98	
Malmesbury	Swartland LM	E.coli, FC	99	
Paternoster	Saldanha Bay LM	E.coli, FC; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	100	
Klapmuts	Stellenbosch LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	101	
Pniel	Stellenbosch LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	102	
Moorreesburg	Swartland LM	E.coli, FC; EC; NH_4^+ ,NO_3^-; NO_2^-	103	
Ruitersbos	Mossel Bay LM	E.coli, FC; NH_4^+ ,NO_3^- ; NO_2^-	104	
Ladismith	Kannaland LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	105	
Albertina	Hessequa LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	106	
Stilbaai	Hessequa LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	107	
Montague	Breede River Winelands LM	E.coli, NH_4^+ , PO_4^{2-}; COD; SS	108	
Bredasdorp	Cape Agulhas LM	E.coli, FC; EC; NH_4^+ ,NO_3^- ; NO_2^-	109	
Oudekraal	Cape Metropolitan Council	E.coli, FC; NH_4^+ ,NO_3^-; NO_2^-; SS	110	
Miller's Point	Cape Metropolitan Council	E.coli, FC; NO_3^-; NO_2^-; PO_4^{2-}; COD	111	
Grabouw	Theewaterskloof LM	E.coli, FC; NH_4^+ ,NO_3^-; NO_2^-;	112	
Knysna	Knysna LM	E.coli, FC; NO_3^-; NO_2^-	113	
Riversdale	Hessequa LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^-; NO_2^-; PO_4^{2-}; COD; SS	114	
Darling	Swartland LM	E.coli, FC; NO_3^- ; NO_2^-; PO_4^{2-}	115	
Genadendal	Theewaterskloof LM	E.coli, NO_3^-; NO_2^-	116	

Town	Responsible municipality / organisation	water quality standards not being met	Priority	BITT Report Priority
Gordon's Bay	Cape Metropolitan Council	E.coli, FC; NO_3^-; NO_2^-	117	
Touwsrivier	Breede Valley LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^-; NO_2^-; PO_4^{2-}; COD; SS	118	
Sedgefield - Hartenbos	Knysna LM	E.coli, FC; NH_4^+, NO_3^-; NO_2^-; COD	119	
Citrusdal	Cederberg LM	E.coli, FC; NH_4^+ ,NO_3^-; NO_2^-; PO_4^{2-}	120	
Laingville (St Helena Bay)	Saldanha Bay LM	E.coli, FC; NH_4^+ ,NO_3^-; NO_2^-; SS	121	
Saron	Drakenstein LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^-; NO_2^-; PO_4^{2-}; COD; SS	122	
Llandudno	Cape Metropolitan Council	E.coli, FC;NH_4^+; PO_4^{2-}	123	
Saldanha	Saldanha Bay LM	E.coli, FC; EC; NH_4^+ ,NO_3^-; NO_2^-; PO_4^{2-}	124	
Hermanus	Overstrand LM	E.coli, FC; NO_3^-; NO_2^-; SS	125	
Villiersdorp	Theewaterskloof LM	E.coli, FC; NO_3^-; NO_2^-	126	
Rheenendal (Petro)	Knysna LM	E.coli, FC; NO_3^-; NO_2^-; PO_4^{2-}	127	
Brenton-on-Sea (Uitzigt)	Knysna LM	E.coli, FC; NO_3^-; NO_2^-; PO_4^{2-}	128	
Karatara	Knysna LM	E.coli, FC; NO_3^-; NO_2^-; PO_4^{2-}	129	
Porterville	Berg River LM	E.coli, FC; NH_4^+ ,NO_3^-; NO_2^-	130	
Caledon	Theewaterskloof LM	E.coli,NO_3^-; NO_2^-; PO_4^{2-}	131	
Bonnievale	Breede River Winelands LM	E.coli, NH_4^+, PO_4^{2-}	132	
Robertson	Breede River Winelands LM	E.coli, EC; NH_4^+	133	
Parow	Cape Metropolitan Council	E.coli, FC; NO_3^-; NO_2^-	134	
De Doorns	Breede Valley LM	E.coli, FC; pH; EC; NH_4^+, NO_3^-; NO_2^-; PO_4^{2-}; COD; SS	135	
Heidelberg	Hessequa LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	136	
Vredenburg	Saldanha Bay LM	E.coli, FC; NO_3^-; NO_2^-; PO_4^{2-}; SS	137	
Kleinmond	Overstrand LM	E.coli, FC; NH_4^+; NO_3^-; NO_2^-	138	
Mossel Bay - Hartenbos (Regional @ Hartenbos)	Mossel Bay LM	E.coli, FC; NH_4^+	139	
Rawsonville	Breede Valley LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	140	
Kleinkranz	George LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	141	
Piketberg	Berg River LM	E.coli, FC; NO_3^-; NO_2^-	142	
Clanwilliam	Cederberg LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^- ; NO_2^-; PO_4^{2-}; COD; SS	143	
Stanford	Overstrand LM	E.coli, FC; NO_3^-; NO_2^-; SS	144	
Ashton	Breede River Winelands LM	E.coli, NH_4^+	145	
McGregor	Breede River Winelands LM	E.coli, NH_4^+, PO_4^{2-}	146	
Grootbrak	Mossel Bay LM	E.coli, FC; ,NO_3^- NO_2^-; SS	147	
Hopefield	Saldanha Bay LM	E.coli, FC; NH_4^+ ,NO_3^-; NO_2^-; SS	148	
Kliprug	Drakenstein LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^-; NO_2^-; PO_4^{2-}; COD; SS	149	
Tulbagh	Witzenberg LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^-; NO_2^-; PO_4^{2-}; COD; SS	150	
Wolseley	Wolseley LM	E.coli, FC; pH; EC; NH_4^+ ,NO_3^-; NO_2^-; PO_4^{2-}; COD; SS	151	
Belvedere (Uitzigt)	Knysna LM	E.coli, FC; NO_3^-; NO_2^-	152	
Pinnacle Point	Mossel Bay LM	E.coli, FC; PO_4^{2-}	153	
Hawston	Overstrand LM	E.coli, FC; NH_4^+ ,NO_3^-; NO_2^-	154	
Buffelsjag	Swellendam LM	E.coli, FC; NH_4^+ ,NO_3^-; NO_2^-; COD	155	

Town	Responsible municipality / organisation	water quality standards not being met	Priority	BITT Report Priority
Sandy Point (Shelly Point)	Saldanha Bay LM	E.coli, FC; NO_3^-; NO_2^-;	156	

Maps indicating the location of the WWTWs in the respective WMAs are included in the WMA specific chapters, from Chapter 8 onwards.

7.6.2 Non-point Sources

7.6.2.1 Salinity

Salinization of rivers in the Western Cape is largely a natural phenomenon (due to the geology) but accelerated by agricultural practices. For example, the predominant water quality problem throughout much of the Breede River Basin is one of salinity. The Bokkeveld shales introduce naturally occurring salinity to the Middle and Lower Breede River. Salinity is generally low in the upper reaches of the Breede River and its tributaries, but becomes increasingly more saline in a downstream direction. Where irrigation is intensive, return flows aggravate the salinity problem through the leaching of salts into the rivers. Agricultural practices expose the shales to leaching. Tributaries such as the Vink, Kogmanskloof, and Poesjenels Rivers have very high salinity concentrations. The Middle and Lower Breede River carries the brunt of salinization, receiving naturally saline water and irrigation return flows. The lower Breede River eventually becomes unsuitable for agricultural use due to increased salinity. A similar situation exists in the Berg River downstream of Paarl/Wellington and in the Olifants River downstream of Clanwilliam Dam.

7.6.2.2 Nutrients

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 often manifests 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 are the ultimate stage of eutrophication. The impacts of eutrophication are ecological, social, and economical.

In the Western Cape, nutrient enrichment of rivers is largely related to the discharge of nutrient rich treated wastewater to rivers. This is a problem associated with point sources. However, nonpoint sources of nutrients include urban runoff from dense settlement areas with poor sanitation services, intensive agricultural activities and seepage or wash-off of fertilisers into the river, as well as seepage from the irrigation of winery effluents near water courses.

7.6.2.3 Microbial

Nonpoint sources of microbial pollution are mainly urban runoff from informal settlements and urban areas with poor sanitation services.

7.6.3 Summary of pollution source issues

- Pollution issues in the Western Cape can be summarised as follows: Salinity – Salinization of rivers in the Western Cape is largely related to intensive irrigation practices and irrigation return flows high in salts being returned to rivers.
- Nutrient enrichment and eutrophication – Nutrient enrichment of rivers and reservoirs in the Western Cape are mostly the result of nutrient rich effluents being discharged from municipal wastewater treatment works. However, urban runoff, runoff from informal settlements, and

washoff of fertiliser from agricultural lands also contribute to the enrichment of rivers with nutrients.
- Organic pollution – The discharge of wastewater high in organic content affects the dissolved oxygen content of rivers. This problem is largely associated with the discharge of poorly treated municipal wastewater and urban runoff.
- Microbial pollution – Microbial pollution is largely related to urban runoff (leaking sewers, informal settlements, grey water disposal) and poorly operated municipal wastewater treatment works. This poses a health risk to downstream users.
- Agro-chemicals – contamination of streams with pesticides and herbicides from spray drift and washoff is a concern in intensively cultivated agricultural areas.
- Suspended solids – Increased turbidity is a concern in areas where poor land management practices lead to high erosion rates.

7.7 PRIORITY AREAS / ISSUES THAT REQUIRE ATTENTION

7.7.1 Monitoring

The deterioration of the quality of South Africa's water resources is one of the major threats to South Africa's capability to provide sufficient water of appropriate quality to meet developmental needs (including economic and basic human needs) while ensuring environmental sustainability. In order to ensure that the water quality meets the developmental and environmental needs, it is essential to monitor the quality of the resources, especially as they will be coming under increasing stress from persistent and emerging challenges, including population growth, urbanisation, new contaminants, and climate change. Water quality monitoring data is thus critical for decision making.

The following water quality management interventions have been identified:

- **Co-operative governance**
  The DWA is responsible for the management of South Africa's water resources. Water quality management is complex and requires strong institutional capacity at national and regional level and co-operation with local government, Department of Mineral Resources, Department of Environmental Affairs, and the Department of Agriculture. The overarching philosophy is that everyone is downstream, hence all water users need to work co-operatively.

- **Regulatory tools**
  The DWA has regulatory tools, which include water use authorisations, compliance reporting, guidelines, and load reduction strategies, which need to be applied in an effective and consistent manner. The current legislation provides every opportunity for the protection and conservation of natural resources. It is the implementation of these laws that is lacking.

- **Fiscal tools**
  The DWA is developing a Waste Discharge Charge system, based on the "*polluter pays*" principle, to promote waste reduction, water reuse and water conservation.

- **Resource quality management**
  The NWA defined a series of measures which are intended to ensure the comprehensive protection of all water resources. These include (i) Water Resource Classification, (ii) the determination of the Reserve, and (iii) setting of Resource Quality Objectives (RWQOs). The challenge that must now be faced is the implementation of these measures.

  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. The speedy implementation of the Reserve is thus crucial to the entire process.

- **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.

- **Increased variables to be monitored**
  The water quality variables that are analysed do not include trace metals or organic analysis. In addition, not all POPs are analysed due to lack of resources. Many constituents accumulate in the sediment and concentrations can exceed guideline values. However, sediment as a sampling medium is currently not included in any monitoring programme. Many of South Africa's water resources are characterised by high turbidity caused by the presence of suspended silt. However, there is very limited data on turbidity or suspended solids. It is recommended that turbidity (NTU) is included in the national water quality monitoring programme. The existing toxicity tests did not show any response to the pesticide / trace metal contamination. An investigation to relook at the various tests, including endocrine disrupting compounds, is recommended.

- **Inadequate water quality guidelines**
  The current South African Water Quality Guidelines are out-dated and do not include all the variables of concern. The guidelines should be updated to reflect frequently detected variables. Sediment quality guidelines should also be developed.

- **Lack of Regional Office use of the Water Management System (WMS)**
  The WMS is a national source of chemical water quality data. However, despite active training within the Regional Office, this system has not been adopted as the "one and only catch all system" for water quality data. This has resulted in gaps in the database as many of the regional water quality monitoring programmes are not included in the WMS.

- **Education and capacity building**
  One of the most important strategies for improving water quality is through building social change through education and capacity building. Capacity building and education efforts are needed at every scale (DWA, 2010). The scope of capacity building includes creating an enabling environment with appropriate policy and legal frameworks, institutional development, community participation, awareness raising, human resources development, and strengthening of managerial systems. Capacity building defines the efficiency mechanisms that are essential to ensure the sustainability of monitoring programmes. These are: (1) skills development and training, (2) institutional collaboration and coordination, (3) research and development, (4) design improvement and upgrading, (5) public participation, and (6) funding (DWAF, 2004). An example of a programme initiated by the DWA to involve communities in the management of their local water resources is the Adopt-a-River initiative.

7.8 PROBLEM SYNTHESIS

The problems and gaps identified in this Chapter are broadly summarised as follows:

- Surface water quality monitoring is generally acceptable but data collected by local authorities and other institutions resides with them, typically in spread sheet databases. This data is not transferred to a centralised water quality database.

- Where water quality issues do occur at locations of high risk, then it is recommended that continuous monitoring at selected “hot spots” be reviewed with DWA and local authorities.
- Salinity problems (both from natural geology and irrigation practises) in the Breede River require freshening releases out of Brandvlei Dam. Possible mitigation measures include intercepting and storing or evaporating irrigation return flows on farms, and controlling further irrigation development on saline soils.
- Discharges from wineries and fruit processing industries are high in organic content. Collaboration with aquatic ecologists to identify “hot spots” where monitoring should be undertaken to protect the aquatic ecosystem is recommended.
- Many WWTWs fail to meet at least one of more of the required discharge standards, and it is imperative to determine why these WWTWs are not complying, particularly those works which are consistently failing to meet the required discharge standards. Again this problem is linked to technical capacity and financial constraints.
- The following water quality management interventions have been identified:
    - Stronger focus on co-operative governance
    - Current legislation provides every opportunity for the protection and conservation of natural resources but it is in the implementation of these laws that there are problems.
    - The DWA Waste Discharge Charge system, based on the “polluter pays” principle is a step in the right direction and will also promote waste reduction, water reuse and water conservation.
    - The implementation of DWAs water resource quality objectives must continue to be rolled out.
    - The setting of management classes of the water resources (Class I, II or III) has commenced in the Olifants-Doorn WMA, and will be extended into the rest of the Province. This critical to be able to implementation the Reserve.
    - An investigation to relook at the need for monitoring a wider range of variables, including endocrine disrupting compounds, is recommended.