PREPARED FOR:

DWAF NUMBER: PWMA 11/000/00/2609

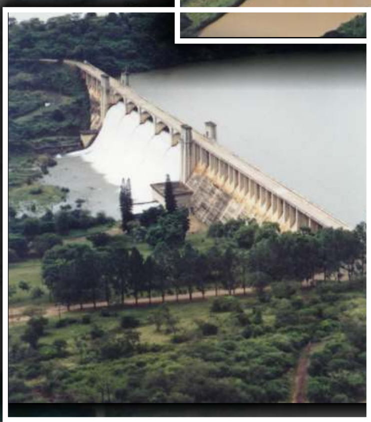
water & forestry

Department:
Water Affairs and Forestry
REPUBLIC OF SOUTH AFRICA

DIRECTORATE: NATIONAL WATER RESOURCE PLANNING

Water Reconciliation Strategy Study for the Kwazulu Natal Coastal Metropolitan Areas

Water Quality Review Report



JANUARY 2009

SUBMITTED BY:

DMM

Golder Associates

KV3 KWEZI V3 ENGINEERS

WRP A Miya Group Company

ZITHOLELE CONSULTING

WRP_FC0918.CDR

WATER RECONCILIATION STRATEGY STUDY FOR THE KWAZULU-NATAL COASTAL METROPOLITAN AREAS

WATER QUALITY REVIEW REPORT

REFERENCE

This report is to be referred to in bibliographies as:

Department of Water Affairs and Forestry, South Africa, 2008. ***WATER RECONCILIATION STRATEGY STUDY FOR THE KWAZULU-NATAL COASTAL METROPOLITAN AREAS*: WATER QUALITY REVIEW REPORT**

Prepared by:

DMM Development Consultants, Golder Associates Africa, Kwezi V3 Engineers, WRP Consulting Engineers and Zitholele Consulting.

DWAF Report No. PWMA 11/000/00/2609

Title:	***Water Quality Review Report***
Authors:	*J Roos, F Hassan and T Coleman*
Project Name:	***Water Reconciliation Strategy Study for the KwaZulu-Natal Coastal Metropolitan Areas***
DWAF Report No:	*PWMA 11/000/00/2609*
Status of Report:	*Final*
First Issue:	*January 2008*
Second Issue:	*January 2009*
Final Issue:	*January 2009*

Consultants: DMM / Golder Associates Africa / Kwezi V3 / WRP and Zitholele

Approved for the Consultants by:

....

P G van Rooyen

Study Leader

DEPARTMENT OF WATER AFFAIRS & FORESTRY

Directorate National Water Resource Planning

Approved for DWAF by:

....

N van Wyk 14/4/2010

Chief Engineer: National Water Resource Planning East

(Project Manager)

....

J A van Rooyen

Director: National Water Resource Planning

Acknowledgements

The authors wish to express our sincere gratitude and appreciation to the following persons and institutions that contributed to the completion of this report:

- Umgeni Water, Ethekwini and DWAF for provision of water quality data.
- Mr. Ockie Scholtz from the Centre of Environmental Management for field assistance and laboratory analyses.
- The various steering committees and stakeholders for their input into the process.

Glossary

Term	**Definition**
Algal bloom	The rapid excessive growth of algae or phytoplankton, which can form a dense surface scum; generally caused by high nutrient levels, favourable light and temperature conditions.
Alkalinity	Capacity of water to neutralize acids by its content of bicarbonates, carbonates, and/or hydroxides – The buffer capacity of a water body.
Assimilative Capacity	Natural ability of a waterbody to neutralize or decompose potential pollutants without harmful effects to the environment.
Bioaccumulation	Build-up of a pollutant in the body of an aquatic organism by uptake food of and directly from the surrounding water.
Biota	The sum of the living organisms of any designated area.
Bloom	See algal bloom
Cyanobacteria	A division of photosynthetic bacteria, formerly knew as blue-green algae, that can produce strong toxins.
Denitrification	The biological reduction of NO_3^- or NO_2^- to N_2 or gaseous nitrogen oxides.
DO	Dissolved oxygen concentration in water (mg/L or % saturation) and readily available to fish and other aquatic organisms.
Ecological integrity (health)	The 'health' or 'condition' of an ecosystem, i.e. the ability of the ecosystem to support and maintain key ecological processes and organisms so that their species composition, diversity and functional organisations are as comparable as possible to those occurring in natural habitats within a region.
Eutrophication	The process of enrichment of waters with plant nutrients, primarily phosphorus, causing abundant aquatic plant and algal growth. A water body is generally categorised as oligotrophic, mesotrophic, eutrophic or hypertrophic. Oligotrophic are systems with low nutrient levels with limited algal growth. Mesotrophic systems have higher levels of nutrients with nuisance level growth of aquatic plants and limited algal blooms. Eutrophic systems have highly productive systems with nuisance growth of aquatic plants and blooms of blue green algae at levels which could be toxic to man and livestock. A

	hypertrophic system is a more productive system than eutrophic system with a greater potential for nuisance growth of plants and blooms of toxic blue green algae.
Heavy metals	Metallic elements with high atomic weights e.g., copper, mercury, chromium, cadmium, arsenic or lead. Heavy metals can damage living things at low concentrations and tend to accumulate in the food chain.
Nitrification	The biological oxidation of ammonium to nitrate ($NH_4^+ \rightarrow NO_3^-$) with nitrite ($NO_2^-$) as an intermediate in the reaction sequence.
Nutrients	Elements essential for plant or animal growth. Major nutrients include nitrogen, phosphorus, carbon, oxygen, sulphur, and potassium.
Pathogen	Disease-causing biological agent such as a bacterium, virus, or fungus.
Phytoplankton	Small (often microscopic) aquatic plants suspended in water.
Plankton	Plants (phytoplankton) and animals (zooplankton), usually microscopic, floating in aquatic systems.
Pollution	An undesirable change in the physical, chemical, or biological characteristics of air, water, soil, or food that can adversely affect the health, activities, or survival of humans or other living organisms.
Retention/	Is the time required for the water to move through the lake or the
Residence time	time to fill the lake, or to replace all the water in the lake.
Salinisation	Is the process by which the concentration of dissolved solids in inland waters is increased.
TDS	Total dissolved solids – a measure of the inorganic salts (and organic compounds) dissolved in water.
Turbidity	measure of water cloudiness due to suspended solids. Turbidity is a murkiness of water, reflecting the amount of sediment in the water, measured in Nepholemetric turbidity units (NTU).

Water quality	Describe the physical, chemical, biological and aesthetic properties of water which determines its fitness for use and its ability to maintain the health of farmed aquatic organisms.
Zooplankton	The animal portion of the plankton.

Water Reconciliation Strategy Study for the KwaZulu-Natal Coastal Metropolitan Areas

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

APPENDICES

Water Reconciliation Strategy Study for the KwaZulu-Natal Coastal Metropolitan Areas

Water Quality Review Report

1 INTRODUCTION

1.1 BACKGROUND

South Africa's available freshwater resources are already almost fully utilised and under stress. At present many water resources are polluted by industrial effluents, domestic and commercial sewage, acid mine drainage, agricultural runoff and litter. Agriculture, deforestation, and urbanization have resulted in increasing eutrophication and salinisation of rivers and lakes. Most of South Africa's rivers have an eutrophication problem. The demand for water in South Africa is projected to increase by 50 % in the next 30 years (NSoER, 1999).

The term "water quality" is used to describe the physical, chemical, biological and aesthetic properties of water, which determines its fitness for use and its ability to maintain the health of aquatic organisms (DWAF, 1996). Thus water quality expresses 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. Consequently, water quality can be defined by a range of variables which limit water use. Human health is affected directly by the proximity, availability and quality of water resources.

Rapidly increasing *water use* for basic human and domestic needs, development and recreation is the reason why water resource management has a high priority in South Africa. Water uses inevitably results in the discharge of water containing waste and return flows, and reduces assimilative capacity in stream flow. As river catchments become increasingly populated and developed, the effects of point and diffuse sources of pollution are likely to mask the natural cyclic patterns in aquatic ecosystems to an even greater extent.

The majority of the water requirements in the study area are supplied from dams constructed on the Mgeni and Mdloti Rivers. The major water supply dams constructed on the Mgeni River are the Midmar, Albert Falls, Nagle and Inanda Dams with the Hazelmere Dam on the Mdloti River. Dams and weirs on rivers alter its natural flow regime drastically (Todd & Claasen, 2000). Flow regulation by dams and diversions is a key component of virtually all large river development programs. Alteration of flood timing, magnitude, frequency, and duration disturb both terrestrial and aquatic communities. This trend in regulation of flow has an impact (usually negative) upon the quality and the quantity of water. It alters sediment transport and, as a result, the transport of substances attached to sediments, such as plant nutrients which may enhance cyanobacterial growth (WHO, 1999).

The Mgeni River catchment in KwaZulu-Natal is the most socially and economically important catchment in the region (Jewitt & Kotze, 1999) as the majority of the water requirements are supplied from this system. The water requirements in the KwaZulu-Natal coastal metropolitan areas are growing and the water requirements are reaching the available water that can be supplied from the current water supply infrastructure. The purpose of this study is to develop a strategy to reconcile the water requirements with the available water. The reconciliation strategy could include the construction of further dams, exploitation of groundwater, re-use of treated sewage effluent and desalination of sea water.

1.2 SCOPE OF WORK FOR WATER QUALITY REVIEW

The process of developing the **Water Reconciliation Strategy Study for the KwaZulu-Natal Coastal Metropolitan Areas** involves formulating supply options which could include additional dams, re-use of effluents and desalination of sea water. The unit reference values of the options will be calculated and compared to determine the best scheme. Whatever the reconciliation strategy, there will be an impact on the water quality. Ideally the impact of the supply options on water quality should be modelled and the economic impacts of the changes in water quality on the users determined and brought into the costs of the supply options. Currently the required water quality models are not available for the study area and would take some time to set up and calibrate. The immediate need is to develop a reconciliation strategy. However provision has been made in the scope of work to provide qualitative water quality input into the options to ensure that the impact of the proposed schemes does not result in a significant deterioration in water quality. If the qualitative assessment shows that the water quality impact could be significant then the need for more detailed quantitative modelling will be identified for that option.

The purpose of the water quality review is to use the available water quality data and water quality reports from previous studies to develop an understanding of the water quality profiles of the major rivers in the study area. The understanding achieved will be used to provide the qualitative input on the impact that the reconciliation options could have on water quality.

1.3 APPROACH TO WATER QUALITY REVIEW

The approach to the water quality review involves the following :-

- A review of the literature including water quality, limnological and ecological studies. The major water quality study on the Mgeni River System was undertaken by Ninham Shand and BKS for Umgeni Water and the Department of Water Affairs and Forestry (DWAF) in 1994. The main findings of this study are summarised in the literature review report produced as part of this reconciliation study.

- Collection and review of water quality data from the Department of Water Affairs and Forestry and Umgeni Water's water quality databases. The salinity related water quality variables, nutrients and the microbiological water quality were assessed using data supplied by Umgeni Water over the time period 1997 to 2006. The number of water quality variables analysed at the different monitoring points varied depending on the data availability. Where possible at least electrical conductivity (EC) as an indicator of salinity and soluble reactive phosphorus

(SRP) as an indicator of eutrophication were assessed at each site. The data was analysed to identify any trends and fitness for use. Where possible sources of pollution were also identified. The percentiles of the data used in the review are given in Table form in Appendix A. A number of the stations are monitored by the Department of Water Affairs and Forestry and Umgeni Water. A table is given in Appendix A showing the relationship between the DWAF and Umgeni monitoring station reference numbers.

- A site visit in June 2007 to the study area
- The study area was divided into resource units. The resource units are :-
  - Midmar – The Midmar Dam catchment at the headwaters of the Mgeni River
  - Albert Falls – The incremental Albert Falls Dam catchment between Midmar Dam and Albert Falls Dam
  - Nagle – The incremental catchment between Albert Falls Dam and Nagle Dam
  - Msunduze – The Msunduze River catchment
  - Inanda – The incremental catchment from Inanda Dam to the Mgeni River mouth
  - Mooi – The Mooi River catchment down to the abstraction at Mearns weir
  - Mdloti – The Mdloti and Tongati River catchments
  - Mvoti – Mvoti River catchment in the north of the study area
  - Mkomazi – Mkomazi River catchment in the south of the study area.

The locations of the resource units are shown in Figure 1.

Figure 1 : Location of resource units used to analyse water quality data

2 WATER QUALITY USER REQUIREMENTS

During the 1994 study under taken by Ninham Shand and BKS, a set of raw water quality guidelines for the most sensitive users was produced (See Table 1). The target range given in Table 1 is the ideal range for water quality i.e the range of concentrations which have no noticeable impact on the water users. The critical limit is the maximum permissible concentration or value for a water quality variable at which impacts on water users or the aquatic ecosystem becomes significant. At this stage, Resource Water Quality Objectives have not been set for the study area.

The values presented in Table 1 were prepared in 1994 before the set of South African Water Quality Guidelines (DWAF, 1996) were published. The water quality requirements of the most sensitive user based on the South African Water Quality Guidelines of 1996 (DWAF, 1996) are also included in Table 1. The SABS-241: 2001 – drinking water standards are used for setting some of the domestic water quality requirements. The value used for industry is based on the water quality requirements of the most sensitive industry.

The values given in Table 1 can be used as a guideline in assessing any impacts that may result from the reconciliation options.

Table 1 : Summary of generalised raw water quality guidelines for most sensitive users (from DWAF, 1994)

Water Quality Variable	Units	Target Range 1994 study	Critical limit 1994 study	Most Sensitive User for 1994 study	Target range from 1996 guidelines
Conductivity	mS/m	0-70	150	Domestic and irrigation	0 - 40 – Irrigation salt sensitive crops 0 - 70 - Domestic
TDS	mg/L	0-300	1000	Livestock (chickens) Domestic	0 - 260 - Irrigation salt sensitive crops 0 -450 - Domestic
pH	-	7 - 8	<6 and >9	Domestic	6.5 – 8.5
Calcium	mg/L	10 - 50	150	Domestic	0-32 Domestic Class 0* 0 – 80 Domestic Class 1*
Magnesium	mg/L	0 - 20	100	Domestic	0 – 70 Domestic Class 0* 0 – 100 Domestic Class 1*
Sodium	mg/L	0 - 100	400	Domestic	0 – 70 Irrigation 0 – 100 Domestic Class 0*
Chloride	mg/L	0 - 50	150	Irrigation and domestic	0-20 industry 0-100 Domestic Class 0*
Sulphate	mg/L	0 - 200	600	Domestic	0 – 30 industry 0 – 200 Domestic Class 0*
Nitrate (NO_3 as	mg/L	0 - 6	10	Domestic	0 – 6 Domestic

Water Quality Variable	Units	Target Range 1994 study	Critical limit 1994 study	Most Sensitive User for 1994 study	Target range from 1996 guidelines
N)					Class 0*
Ammonia (NH_4 as N)	mg/L	0 – 0.03	0.2	Aquatic life	0.007 as NH_3 as N - Aquatic 0.58 as NH_4 as N - Aquatic
E-Coli	cells/100 mL	0 (1000)	10 (2000)	Domestic untreated water use (1000) if full treatment (2000) Recreation	130 for full contact recreation
Aluminium	µg/L	-	-	-	10 – Aquatic 150 – Domestic Class 0*
Iron	mg/L	0 – 0.1	1.0	Aquatic life and domestic	0.1 - Industry 0.5 – Domestic Class 0*
Manganese	mg/L	0 – 0.05	1.0	Aquatic life and domestic	0.05 - Industry 0.1 – Domestic Class 0*
Suspended Solids	mg/L	0 - 25	80	Domestic	0 – 3 Industry
Turbidity	NTU	0 – 1 (10)	10 (200)	Domestic untreated raw water. Values in brackets for full treatment	0 – 0.1 Domestic Class 0* 0 – 1.0 Domestic Class 1*
Dissolved	mg/L	>5	>6	Aquatic life	80% saturation -

Water Quality Variable	Units	Target Range 1994 study	Critical limit 1994 study	Most Sensitive User for 1994 study	Target range from 1996 guidelines
Oxygen					Aquatic
PO_4(SRP) as P –					
River	mg/L	0 – 0.02	0.05	Eutrophication	0 – 0.005 – Oligotrophic
Impoundment	mg/L	0 – 0.005	0.01	Eutrophication	0.005 to 0.025 - Mesotrophic
Total P as P –					-
River	mg/L	0 – 0.04	0.10	Eutrophication	
Impoundment	mg/L	0 – 0.01	0.025	Eutrophication	
Algae	Cells/mL	0 - 2000	5000	Eutrophication	-
Chlorophyll-a	mg/L	0 – 0.005	0.01	Eutrophication	0 – 0.03

* SABS – 241: 2001 – Drinking Water

3 MIDMAR RESOURCE UNIT

3.1 INTRODUCTION

The Mgeni Catchment, 4 400 km^2 in area, is one of South Africa's most developed catchments and produces approximately 20 % of South Africa's gross national product (refer to Figure 1). It is home to some 3.5 million people, approximately 45 % of the population of the province of KwaZulu-Natal (Ninham Shand, 1996). The river length is 225 km from source to mouth (RHP, 2002). The main land use in this region is forestry and agriculture. The Midmar Dam catchment has an area of 926 km^2.

The Mgeni River rises in the Mgeni Vlei area in the Midmar Dam resource unit. The Mgeni vlei area is an ancient wetland surrounded by a rim of hills, at the west end of the catchment 1 760 m above sea level. The importance and value of the wetlands in the Midmar Resource Unit has been highlighted in the MCMP (NSI, 1996). However, damage to wetlands is widespread. The continued loss and degradation of Mgeni wetlands is serious given their positive impact on river health by purifying water, controlling erosion and regulating water flow through the catchment (RHP, 2002). Nevertheless, to date no overarching implementation plan, for the Midmar Resource Unit, or for the wetlands in the unit has been developed (Jewitt & Kotze, 1999).

The major land-uses in the Midmar Resource Unit are agriculture and forestry. The urban areas in the unit are expanding with the development of the areas to the south of the dam. This development will put further pressure on the water quality of the dam. The extent of this impact will depend on the management of urban runoff and the types and management of the sanitation systems employed.

The location of the water quality monitoring points in the Midmar resource unit whose data was analysed is shown in Figure 2.

3.2 MIDMAR DAM (UW 36.1)

The construction of Midmar Dam was completed in 1964 and lies in the upper Mgeni River catchment at the head of the series of reservoirs situated along the river course. The Midmar Dam wall was recently raised to increase the storage capacity of the dam. Midmar Dam is one of the major inland water resorts of KwaZulu Natal and it has been estimated that more than 500 000 people visit the dam annually. The dam is popular for recreational activities such as boating, fishing and the annual Midmar Mile swimming race (Figure 3).

The different aspects of the water quality of the Midmar Dam are discussed in the sections below.

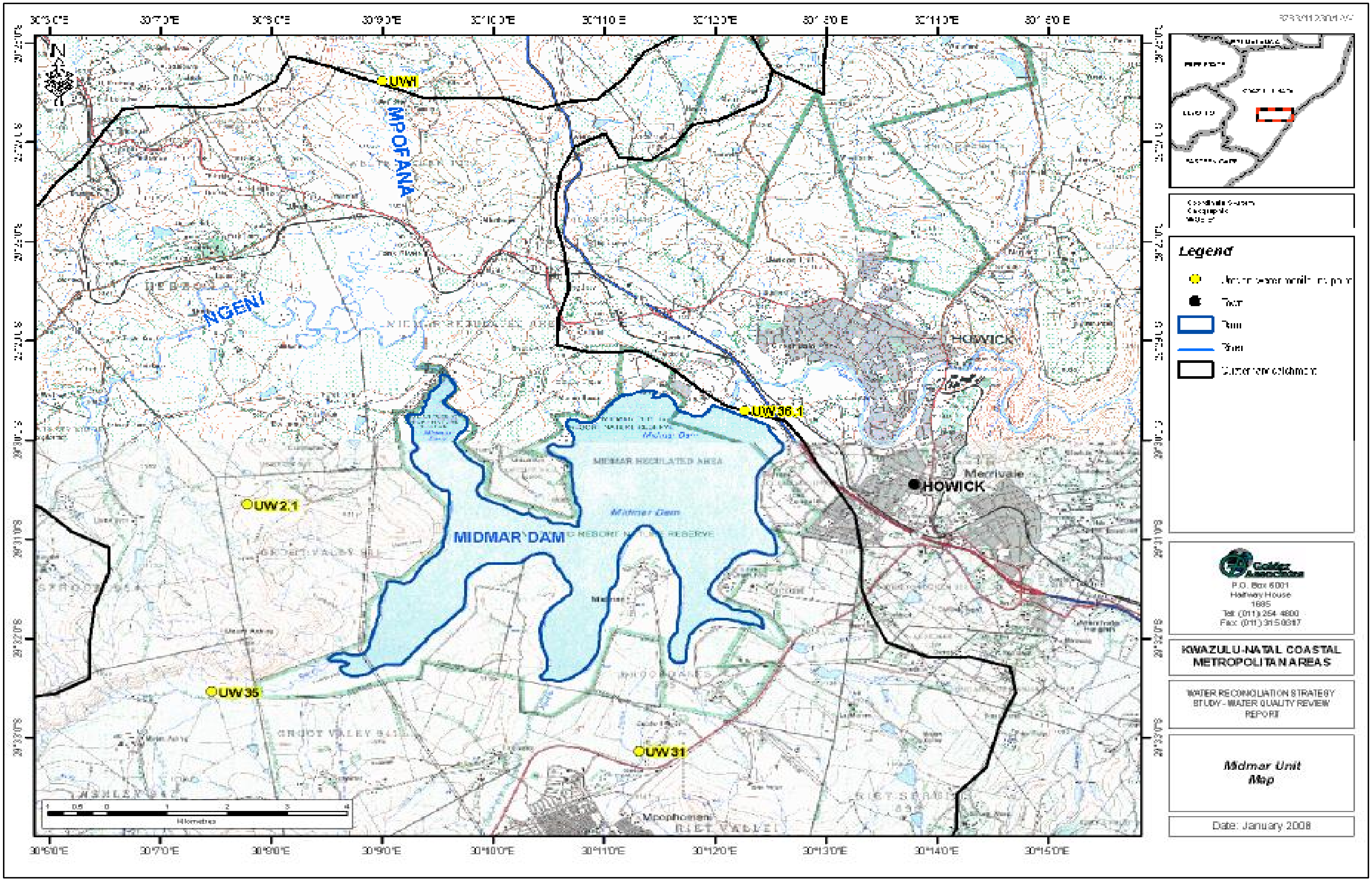


Figure 2 : Location of water quality monitoring points used in the review of the Midmar Resource Unit

Figure 3: Midmar Dam – popular for recreational activities

3.2.1 Conductivity

The amount of current conducted through water (EC) is proportional to the concentration of ions in solution and therefore, also proportional to both the concentration and extent of dissociation of the dissolved salts.

The total dissolved salts (TDS) concentration is directly proportional to the electrical conductivity (EC) of water. An approximate conversion of EC to TDS (at 25 °C) in freshwater systems is:

EC (mS/m) x 6.5 = TDS (mg/L)

The EC in Midmar Dam ranged between 5.85 and 23.6 mS/m (average 6.77 mS/m) during the past 10 years. The mean conductivity in Midmar Dam was very low (mean, 6.77 mS/m), which equates to a TDS concentration of about 47 mg/L, but shows an increasing trend over the study period (Figure 5). The global mean salinity of river water is 120 mg/L (Wetzel, 1983). Archibald and co-authors (1980) report 30 years ago (1977/78) lower EC values; minimum, 4.0, maximum, 7.4 with an average of 5.6 mS/m.

The ionic composition of the TDS in Midmar Dam is dominated by bicarbonates and characterized by very low sulphates. The concentration of major ions in Midmar Dam exists in the proportions of:

Cations, $Ca^{2+} \geq Na^{+} > Mg^{2+} > K^{+}$ and of
Anions, i.e. CO_3-$HCO_3^{-} > Cl^{-} > SO_4^{2-}$

A pie chart showing the make up of the TDS concentration in Midmar Dam is given in Figure 4.

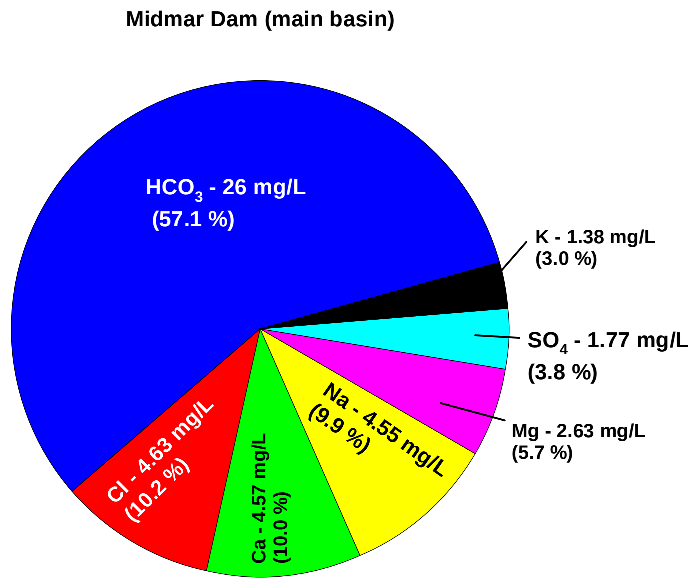


Figure 4: Pie chart of major ions in Midmar Dam (averages during the past 10 years)

3.2.2 Alkalinity

Alkalinity is the acid-neutralising capacity of water and is usually expressed as mg $CaCO_3$/L. Alkalinity is mostly taken as an indication of the concentration of carbonate, bicarbonate and hydroxide, but may include contributions from borate, phosphates, silicates and other basic compounds.

Total alkalinity (TAL) is considered as a rather conservative property of natural waters (Kempe, 1990). The total alkalinity concentrations typically found in freshwater system range between 50 and 250 mg/L. The alkalinity in Midmar Dam was very low and ranged between 19.6 and 33.7 mg/L (mean, 26 mg/L), which means the Dam has a low buffer capacity. The time series of TAL in Midmar Dam is shown in Figure 5.

3.2.3 pH

The pH is an important variable in water quality assessment, as it influences many biological and chemical processes within a water body. The pH of most natural waters is between 6.0 and 8.5, although lower values can occur in diluted waters rich in organic content, and higher values in eutrophic waters, and salt lakes. (DWAF, 1995). The high nutrients support generally high algal biomass with associated high pH values.

The pH values in Midmar Dam were fairly constant during the last 10 years and ranged between 6.8 to 8.9 (average 7.57), which is within the target water quality range for aquatic ecosystems (Figure 5).

3.2.4 Metals

Trace metals are important in aquatic ecosystems and occur in all natural waters, sometimes in minute quantities, because they are products of geological weathering. Water quality guidelines provide an objective means for judging the quality needed to maintain a particular environmental value (DWAF, 1996).

Heavy metals are taken up by both fauna and flora. This uptake could provoke an increase in the concentration of the metal in the organism; if the excretion phase is slow, this can lead to the bioaccumulation phenomenon. Thus, even in what appears to be pristine waters, some metals are reaching surprisingly high levels in fish.

Metals may be taken up in the inorganic or organic form. For some elements, such as arsenic and copper, the inorganic form is the most toxic. For others, such as Hg, Sn and Pb, the organic forms are the most toxic. At low concentrations many heavy metals, including Hg, Cd, Pb, As and Cu, inhibit photosynthesis and phytoplankton growth.

- **Aluminium (Al):**

Aluminium (Al) occurs naturally and makes up about 8 % of the surface of the earth. Al is one of the more toxic of the trace metals and is probably not an essential nutrient for any organism.

The world average concentration in unpolluted rivers is 40 µg/L (Chapman, 1996). However, the acid from acid rain can easily dissolve the bond between these elements. So, as pH in a lake or stream decreases, Al levels increase.

Waters containing high concentrations of aluminium can become toxic for aquatic life if the pH is lowered (as in acid rain). Generally, the recommended guideline for freshwater aquatic life is 10 µg Al/L (Table 1). The total Al concentration in Midmar Dam ranged between 10 µg/L and 540 µg/L with an average of 120 µg/L. The time series of total Al concentrations in Midmar Dam is shown plotted in Figure 5. Al in solution is highly dependent on the pH of the water body. Under acid conditions (pH<4.0), the majority of the Al will be in solution and highly toxic. In the pH range of the water in Midmar Dam, the Al will largely in the insoluble hydroxide form which has a low bio-availability. The Al concentration data used in this analysis is total AL which represents all forms of Al present in the sample including the Al associated with the suspended solids. The Al data presented in Figure 5 cannot therefore be compared directly to the guidelines presented in Table 1. Given the pH range in Midmar Dam, the bio-available Al is likely to be at a level that meets the guidelines.

- **Iron (Fe):**

Iron (Fe) is one of the most common metals in the earth's crust and occurs in small amounts in almost all clays, soils, and granite rocks. It is found in natural freshwaters at levels ranging from 0.5 to 50 mg/L (WHO, 2004). The mean Fe concentration in world surface lakes and rivers is approximately 0.04 mg/L (Wetzel, 1983). All organisms need iron and there is a considerable demand for it in the environment.

However, the available data showed that Fe concentrations in Midmar Dam water were relatively low and ranged between 0.02 and 1.26 mg/L; average 0.28 mg/L. The time series of total iron concentrations in Midmar Dam is shown plotted in Figure 5. The mean concentration in world rivers is 0.67 mg/L (Wetzel, 1983). The domestic guidelines are <0.5 mg/L for Class 0 domestic water, <1.0 mg/L for Class 1 domestic water and the target water quality range for irrigation is <5.0 mg/L. These guidelines are for dissolved iron and therefore cannot be directly compared to the data analysed which is total iron

- **Manganese (Mn):**

Manganese (Mn) is one of the most abundant metals in the Earth's crust, usually occurring together with iron. Mn is an essential micronutrient for plants and animals, although high concentrations are toxic. The mean Mn concentration in World surface lakes and rivers is 0.035 mg/L (Wetzel, 1983).

Mn concentrations in Midmar Dam were low and ranged between 0.01 and 0.11 mg/L (average 0.013 mg/L). The time series of total Mn concentrations in Midmar Dam is shown plotted in Figure 5. The TWQR for freshwater aquatic ecosystems is 0.18 mg/L (DWAF, 1996). This TWQR is however for dissolved manganese and the data used in the review cannot be directly compared to the TWQR.

3.2.5 Turbidity

Turbidity influences both the quantity and the quality of light penetrating into water. More turbid water prevents the penetration of sunlight, thereby reducing the growth and activity of phytoplankton. The concentration of suspended solids increases with the discharge of sediment washed into rivers or dams, due to soil erosion and re-suspension of deposited sediment in the river beds.

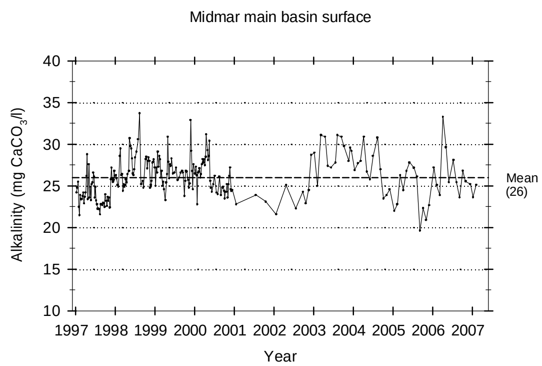
The turbidity in Midmar Dam was low and ranged between 0.19 and 42.4 NTU (average 6.33 NTU). The time series plot of turbidity in Midmar Dam is shown in Figure 6.

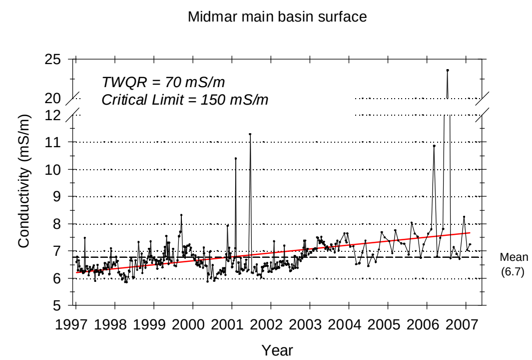
3.2.6 Nutrients

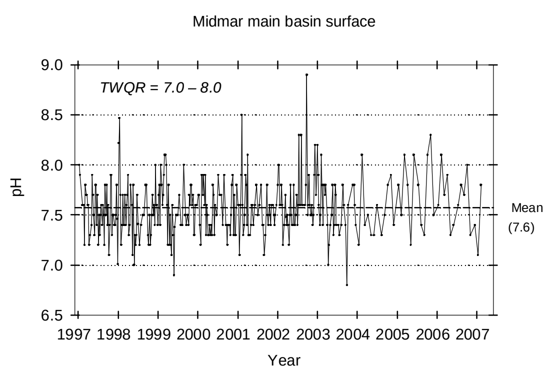
Inorganic nutrients provide the chemical constituents on which the entire food web is based. Nutrient cycling implies by definition that nutrients pass among different components of a cell, community, or ecosystem and can be cycled and reutilised by some of these components. Nutrient cycling occurs at many spatial and temporal scales.

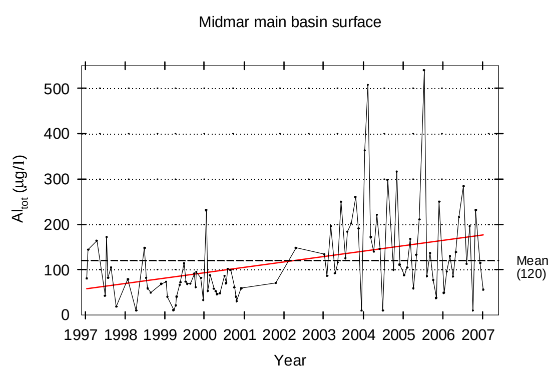
Nitrogen is always present in aquatic ecosystems; most abundantly as an inert gas (N_2) that is unavailable to most of the algae. Nitrate, ammonia, nitrite, urea, and dissolved organic compounds are less abundant, but usually of more biological interest. In both oxic and anoxic conditions, nitrogen cycles between all these compounds and in different phases, i.e. gaseous, soluble, and particulate forms.

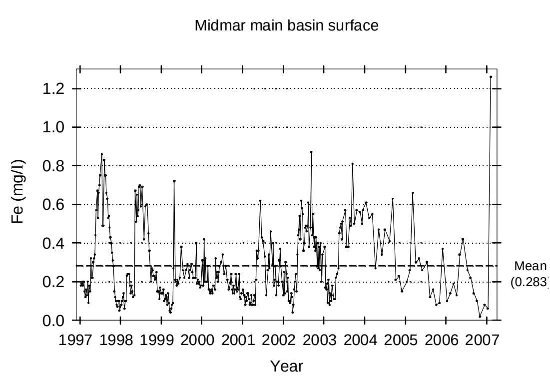
Processes such as denitrification, organic matter burial in sediments, sediment sorption, and plant and microbial uptake can remove N from the river, and thus affect the amount of N that is transported by rivers to coastal ecosystems (Billen *et al.*, 1991). However, not all nitrogen loaded into rivers is ultimately exported to estuaries or the ocean.











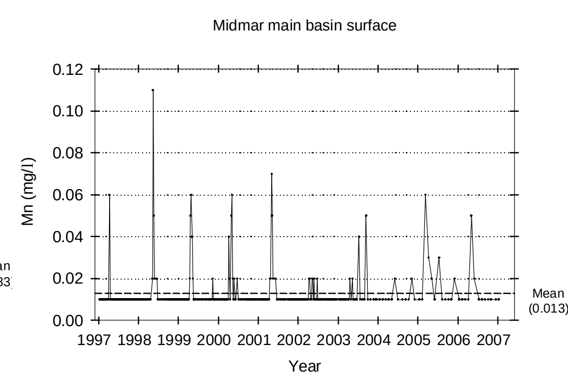


Figure 5: Variation in important variables concentrations in Midmar Dam during the ten years period (1997 – 2007)

- **Ammonium (NH_4)**

Ammonia occurs naturally in water bodies arising from the breakdown of nitrogenous organic and inorganic matter in soil and water, excretion by biota, reduction of the nitrogen gas by microorganisms and from gaseous exchange within the atmosphere. Ammonia exists in water bodies in two forms viz as unionised (free) ammonia (NH_3) and as the ionised ammonium ion (NH_4^+). The unionised form is toxic to aquatic organisms while the ionised form is non-toxic. The extent to which the two forms exist in a water body is driven by pH and temperature. The target water quality range for unionised ammonia is 0.007 mg/ L. The ammonium value of 0.58 mg/L quoted in Table 1 was based on a temperature of 20 ^{0}C and a pH of 7.5. Generally water samples are tested for free and saline ammonia ie. both the unionised and ionised forms of ammonia.

Ammonium (NH_4^+) is most easily assimilated by photosynthetic organisms. Assimilation of ammonia requires the least energy, followed by nitrate, then fixation of molecular nitrogen.

Ammonia is a common pollutant and is one of the nutrients that contribute to eutrophication. The principle form of inorganic nitrogen in sewage is ammonia. However, the ammonium concentrations in Midmar Dam were very low and ranged between 0.01 and 0.63 mg/L (mean, 0.07 mg/L). The time series plot of ammonium in Midmar Dam is shown in Figure 6. The most common natural concentration of pristine streams is 0.015 mg/L (Meybeck & Helmer, 1989).

- **Nitrate (NO_3^{2-})**

Nitrate is normally the most common form of combined inorganic nitrogen in lakes and streams. Natural concentrations, which seldom exceed 0.1 mg/L NO_3-N, may be enhanced by municipal and industrial wastewaters, including leachates from disposal sites and sanitary landfills (Chapman, 1996).

The time series plot of nitrate concentration in Midmar Dam is shown in Figure 6. The nitrate nitrogen (NO_3-N) concentrations in Midmar Dam during the last 10 years were low and ranged between 0.05 and 1.90 mg/L (average 0.253 mg/L), and were within the target water quality range of aquatic ecosystems.

The dissolved inorganic nitrogen was dominated by nitrate (78 %), with a relatively low proportion of ammonium. The high nitrate to ammonium ratio (3.6:1) nitrate indicated that nitrification (conversion of ammonium to nitrate) is effectively taking place, which indicate aerobic conditions in the dam.

- **Total Phosphorus (TP)**

Phosphorus is an essential nutrient for living organisms and exists in water bodies as both dissolved and particulate species. Total phosphorus (TP) occurs in aquatic systems in three different components, i.e.

i) Soluble reactive phosphorus (SRP) or phosphate (PO_4), the form thought most likely to represent P directly available for algal growth;

ii) Soluble non-reactive P, largely organic and at least partially available to algal growth through enzymatic hydrolysis; and

iii) Particulate P, stored in living cells, present in organic detritus, and adsorbed to abiotic particulate surfaces (Wetzel, 1983).

Phosphorus is generally the limiting nutrient for algal growth and therefore controls the primary productivity of a water body. Artificial increases in concentrations, due to human activities are the principal cause of eutrophication.

Phosphorus is the major nutrient controlling the occurrence of water blooms of cyanobacteria in many regions of the world. Thus, the TP concentrations in the aquatic system are usually strongly associated with trophic level and cyanobacteria (blue-green algae) increase with an increase in TP concentration.

The average TP in Midmar Dam was very low, i.e. 26.23 µg/L, which is amongst the lowest concentrations reported for an aquatic system in South Africa. The time series plot of TP in Midmar Dam is shown in Figure 6.

- **Phosphate (PO_4)**

Phosphorus is rarely found in high concentrations in freshwaters as plants and algae actively take it up. As a result there can be considerable seasonal fluctuations in concentrations in surface waters. In most natural surface waters, phosphorus ranges from 5 to 20 µg/L PO_4-P (Chapman, 1996).

The soluble reactive phosphorus (SRP) concentrations in Midmar Dam were low and ranged between 1.66 and 24.7 µg/L (average, 5.25 µg/L), which is in the range of oligo-mesotrophic system (Figure 6). However, indications are that the SRP concentration in Midmar Dam has increased significantly (70 %) during the past 10 years.

However, The high DIN:DIP ratio in Midmar Dam (average 60:1) indicates that phosphorus is probably the limiting nutrient in the system (Figure 6).

3.2.7 Bacteriological

Escherichia coli (E. coli) are used to evaluate the quality of wastewater effluents, river water, raw water, and treated drinking water. *E. coli*, a direct indicator of faecal contamination of the water, is often used as an indicator of the potential presence of all microbial pathogens, including viruses and parasites, as well as bacteria which cause external infections and respiratory illness.

The *E. coli* concentrations in Midmar Dam were generally very low and ranged between 0 and 1 530 cfu/100 mL (average 20 counts/100 mL; Figure 6). Mediam counts <130/100 mL pose a low risk of gastrointestinal illness during full contact recreation.

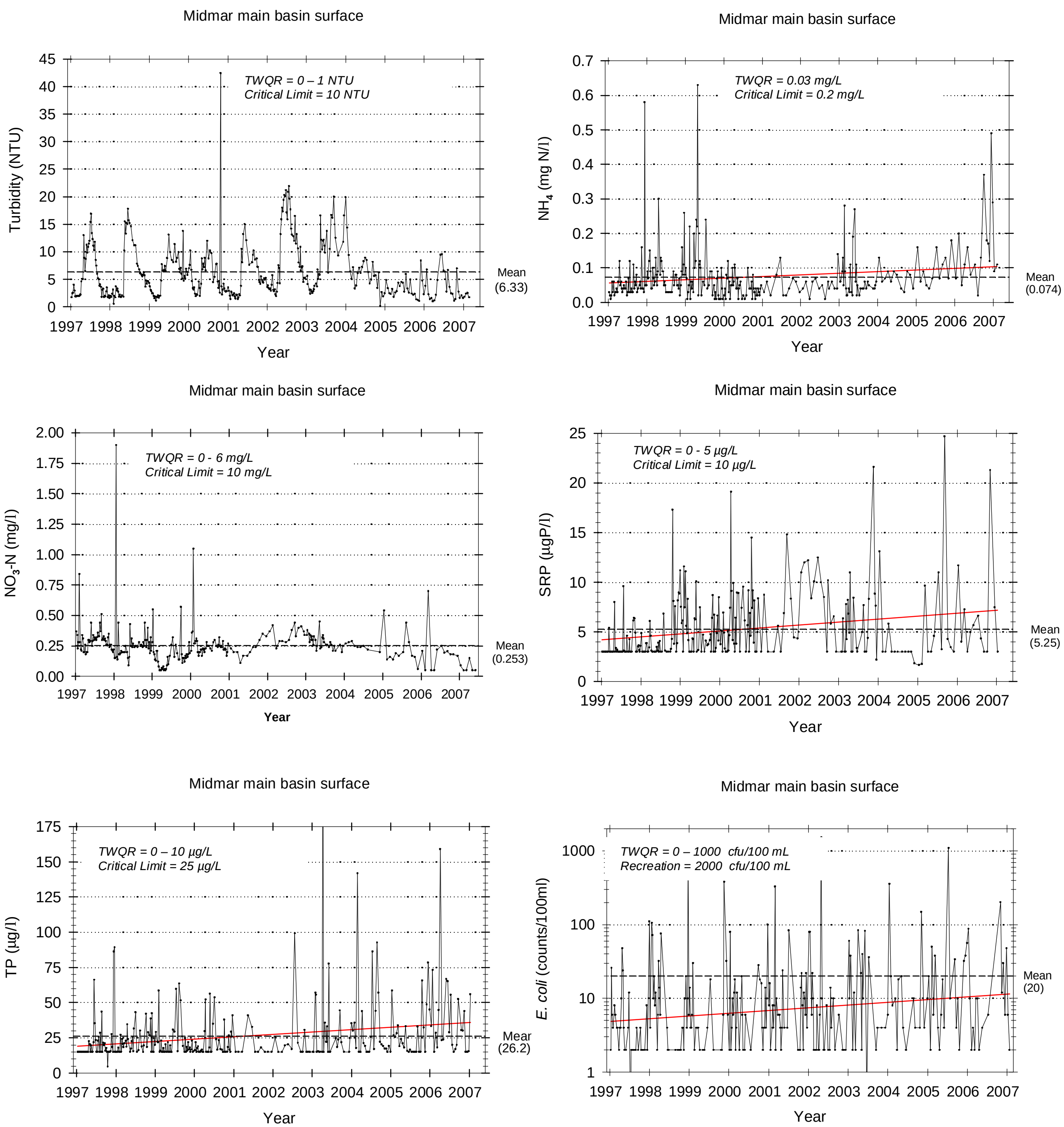


Figure 6: Variation in important variables concentrations in Midmar Dam during the ten

years period (1997 – 2007)

3.3 MGENI AT PETRUS STROOM – UPSTREAM OF MIDMAR DAM (UW 2.1)

The nutrient concentrations in the Mgeni at Petrus Stroom were very similar to those in Midmar Dam (cf. Figure 6 and Figure 7). However, the *E. coli* counts at Petrus Stroom (average 223 cfu/100 ml) were significantly higher than in Midmar Dam (average 20 cfu/100 ml). This reduction in the dam is due to the die off of *E. coli* as they are exposed to UV radiation during the extended retention time in the dam.

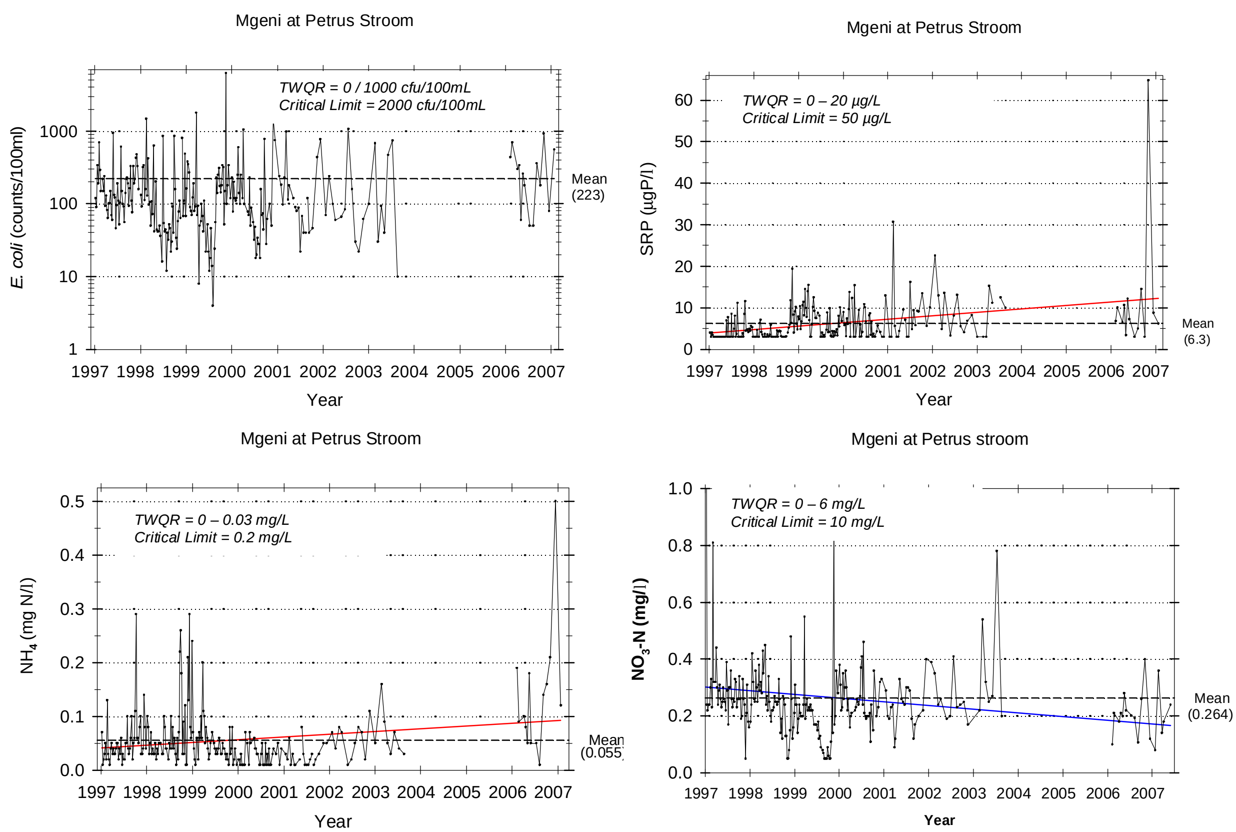


Figure 7: Variation in important variables concentrations in the Mgeni River at Petrus Stroom during the ten years period (1997 – 2007)

3.4 TRIBUTARIES

3.4.1 Kwagqishi Midmar inflow (UW 35)

The water quality data sets at the inflow to Midmar Dam on the Kwagqishi River at Ashley Grange were incomplete ending in 2004. The time series of SRP and nitrate concentrations are shown plotted in Figure 8 . The available data shows that the nutrient concentrations in the Kwagqishi River are fairly high, especially the nitrate concentration (mean, 0.848 mg/L).

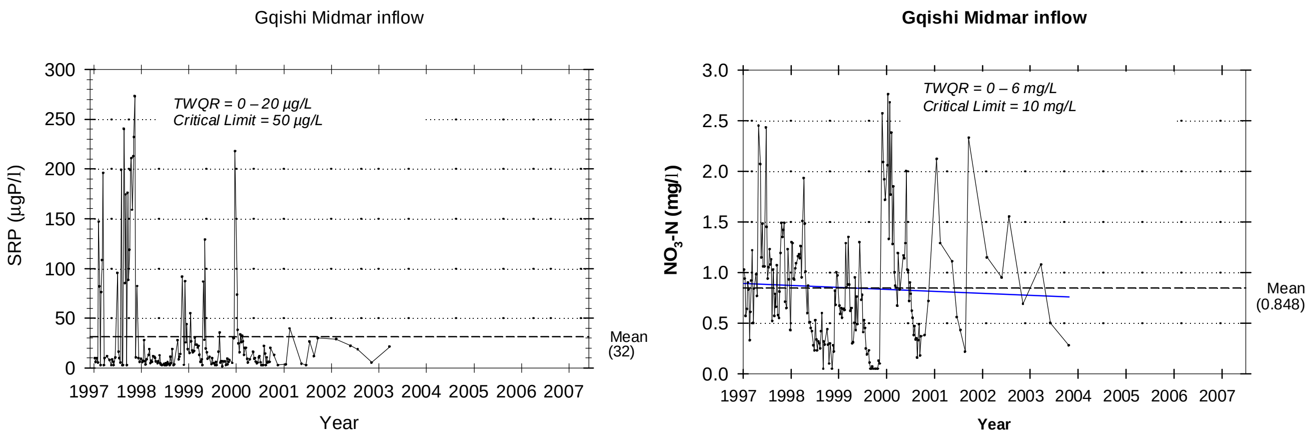


Figure 8: Variation of SRP and nitrate concentrations in the Kwagqishi River over time

3.4.2 Mthinzima Midmar inflow (UW 31)

The concentrations of nutrients entering Midmar Dam via the smaller streams were generally low with the exception of the Mthinzima River which drains the Mpophomeni Township. The average phosphate concentration measured at Rietvallei/Goodwill was almost 600 µg/L and the nitrate concentrations 2.35 mg/L (Figure 9).

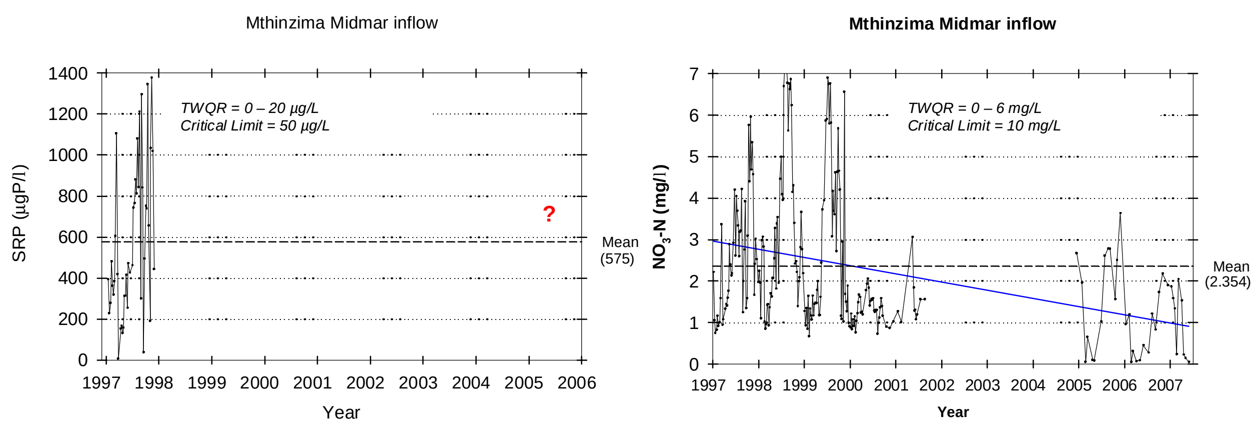


Figure 9: Variation over time in SRP and nitrate concentrations in the Mthinzima River

3.4.3 Lions River at Weltevreden (UW 1)

The time series plots of the water quality data collected in the Lions River at Weltevreden are shown in Figure 10. The plots shows signs of contamination with high *E. coli* counts (average 1 165 cfu/100 ml) and high nitrate concentrations (average 0.404 mg/L). The phosphate concentration also shows an increasing trend. The water quality at this monitoring point is affected by the discharge of transfer water from the Mearns Weir on the Mooi River. The transferred water is discharged into the Mpofana River which is a tributary of the Lions River. The high *E. coli* counts could be associated with the runoff from agricultural areas. Another source could be the water from the Mooi River as the Mooi River was identified as a source of *E. coli* in the Mooi-Mgeni transfer feasibility study. Similarly the mean SRP concentration of 0.0107 mg/L in the Lions River is similar to the mean of 0.0098 mg/L for the Mearns Dam.

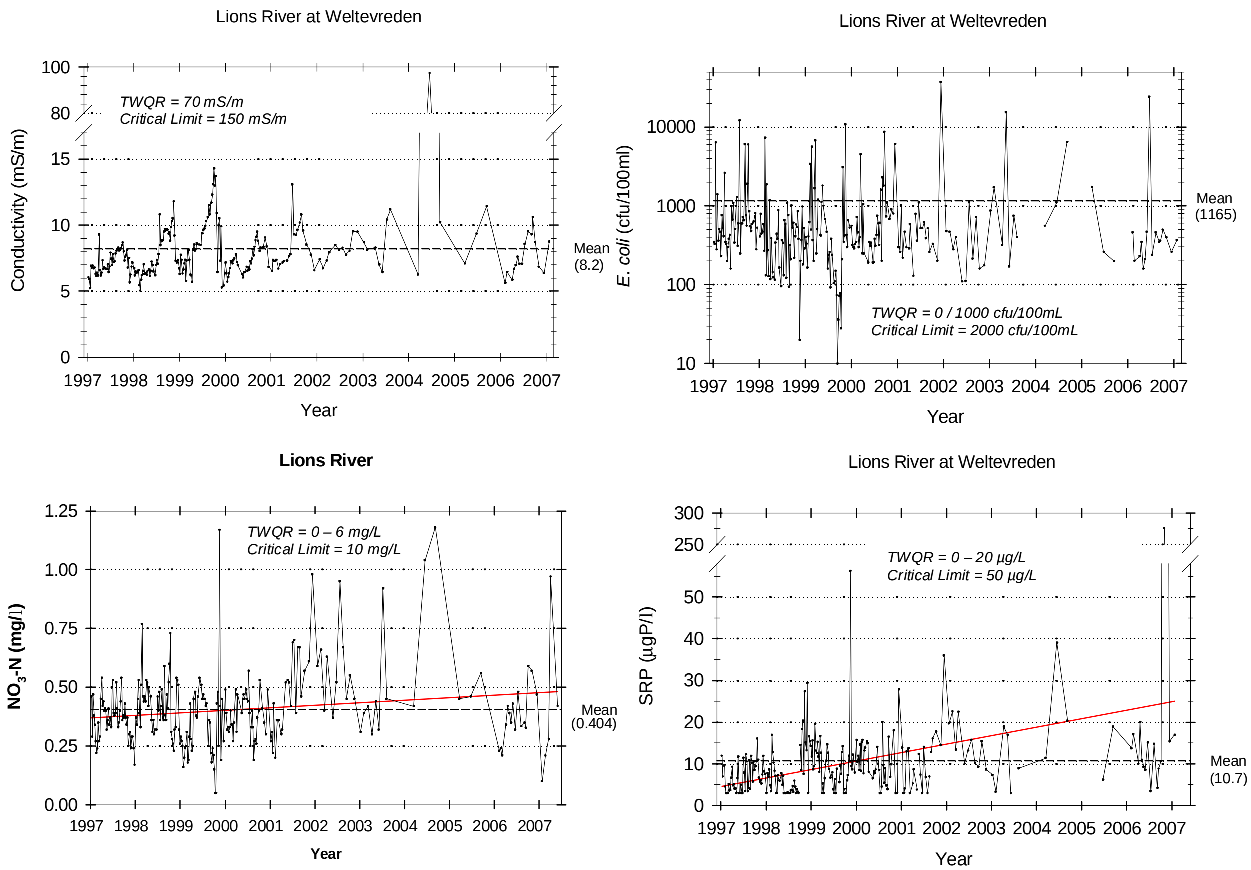


Figure 10: Variation in important variables in the Lions River during the ten years period (1997 – 2007)

3.5 CONCLUSIONS

The water quality of the Mgeni River has remained very good for many years (Archibald, 1996). This has been due to the self-purification properties (assimilative capacity) of the upper Mgeni River, as well as the benefits of the succession of dams on the Mgeni which provide “in-situ metabolism”, providing water of a high quality (Todd & Claasen, 2000). However, over the past 10 years a slight deterioration in the water quality has been observed at a number of monitoring stations.

The water quality in the Midmar Dam is of a good quality and meets the water user requirements of all the water users. However, the available data does show deterioration in the water quality in the Midmar Resource Unit. The increase in the nutrient concentrations, in particular phosphorus, in Midmar Dam is significant. The decline could be ascribed to agriculture, in particular dairies, piggeries and maize production, impacting moderately on river health through excessive nutrient input into rivers (RHP, 2002). However the increased pollution from the growing Mphophomeni settlement and future expansion in urban areas around Midmar Dam requires management (RHP, 2002).

4 ALBERT FALLS RESOURCE UNIT

4.1 INTRODUCTION

Below Midmar Dam, the Mgeni River plunges over the Howick Falls and into the Mgeni Valley where remnants of the Midland forest can be seen. The Karkloof tributary then joins before the Mgeni flows into the Albert Falls Dam. The Doringspruit enters the dam from the south-west and drains the Otto's Bluff region while the Nculwane River which drains the greater Cramond valley, reaches the dam from the north-west (Archibald *et al.*, 1980). The construction of the Albert Falls Dam was completed in 1976 and is the largest reservoir on the Mgeni River.

Water releases from Albert Falls Dam are particularly "unnatural" as flow tends to be highest in the dry winter months, and low during summer (RHP, 2002). This flow pattern can disrupt ecological processes. A considerable portion of the Albert Falls and Nagle catchments (in the upper reaches) are under plantation forests and invasive alien trees which reduce the flow of the river (RHP, 2002).

An integrated approach to control of aquatic weeds comprising biological control and herbicide spraying was undertaken and required close cooperation between Umgeni Water and DWAF Working for Water. 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 (Umgeni Water, 2006).

The major tributary of the Mgeni River in this resource unit is the Karkloof. The major land use is agriculture with a large portion of the catchment developed with commercial forests and some sugar cane plantations.

The locations of the water quality monitoring points used in the review of the Albert Falls Resource Unit are shown in Figure 11.

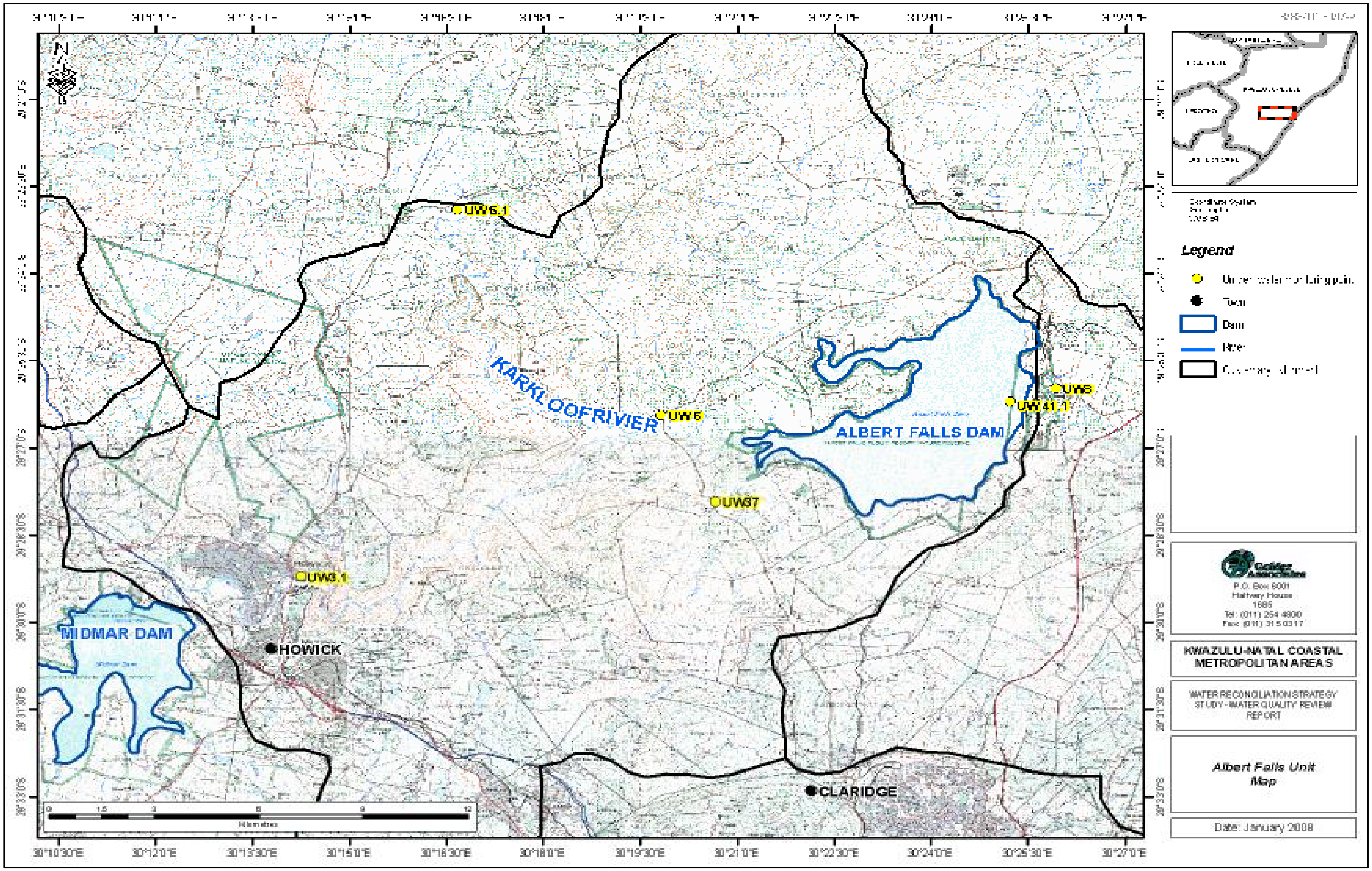


Figure 11 : Location of water quality monitoring points in the Albert Falls Resource Unit

4.2 MGENI AT HOWICK (UW 3.1)

The data sets at this monitoring point are incomplete. The available water quality data is shown plotted in Figure 12. The analysis shows that the nutrient concentrations at Howick were slightly higher than those at the outflow from Midmar Dam. This indicates that any additional nutrient load added between Midmar Dam and the Howick monitoring point is being assimilated.

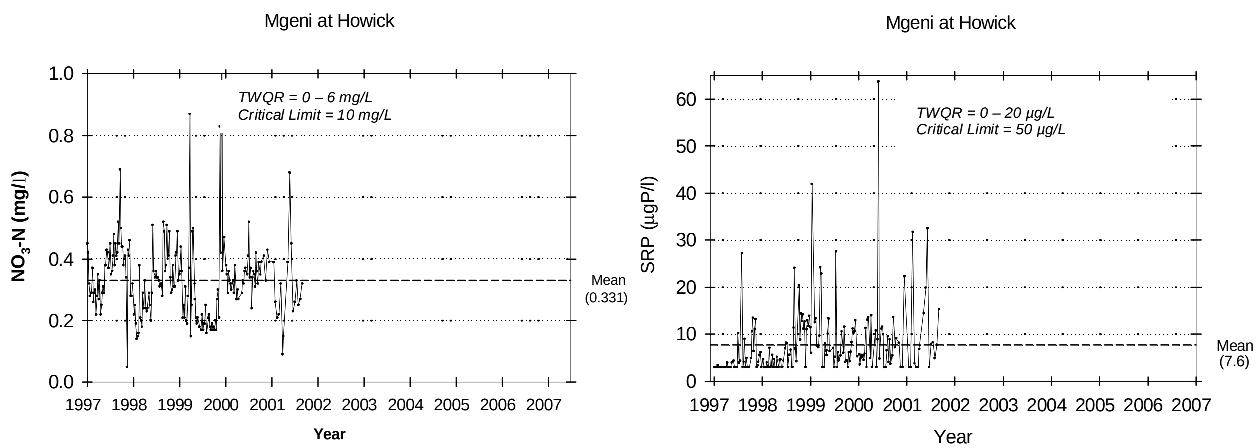


Figure 12: Variation over time in the concentration of SRP and nitrate in the Mgeni River at Howick

4.3 MGENI AT MORTON'S DRIFT (UW 6)

The plots of time series of selected water quality variables measured on the Mgeni River at Morton's Drift are shown in Figure 13 .The analysis of the available data shows that the water quality deteriorates between the Howick and Mortons Drift monitoring points. There is an increase in nitrate concentrations (average 0.427 mg/L and increasing), high phosphate concentrations (average 0.24 mg/L and increasing). Even the metal concentrations were high, i.e. Fe (average, 0.58 mg/L), Al (average, 0.142 mg/L), and Mn (average 0.04 mg/L). The bacteriological contamination (*E. coli* - mean, 510 cfu/100 mL) also exceeded the water quality guideline for full contact recreation with relatively high turbidity (mean, 17.4 NTU).

The land use in the catchment area between the Howick and Mortons Drift monitoring points is characterised by agriculture and the urban developments of Howick and Hilton. The urban developments include both formal and informal type settlements. The deterioration in water quality between the two monitoring points is probably due to return flows and runoff from the agricultural areas and the runoff from the urban areas in particular the informal settlements. The analysis of the water quality data for the Karkloof catchment (See section 4.5.2) showed that the *E. coli* was elevated for this catchment. The runoff from this catchment enters the Mgeni River upstream of the Morton's Drift monitoring point.

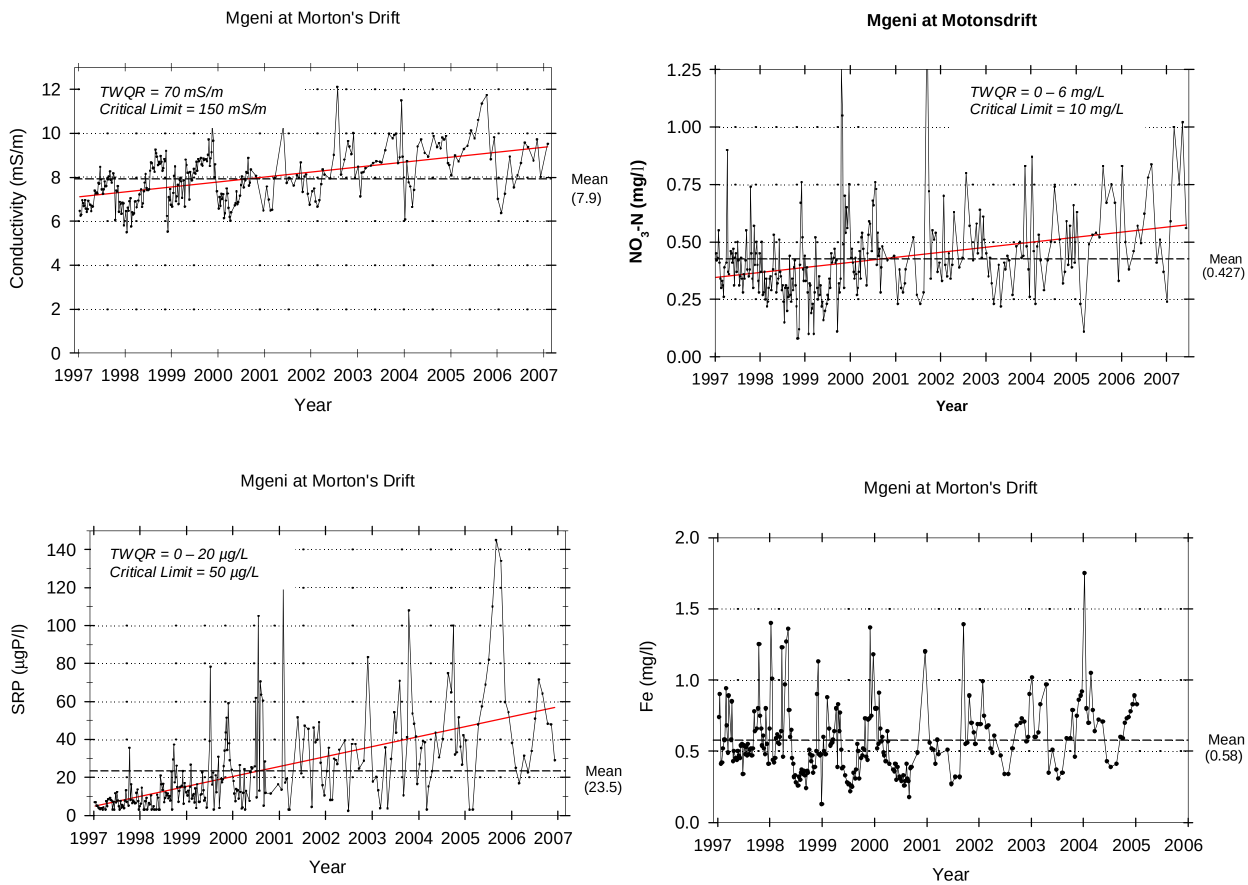


Figure 13: Variation over time of selected water quality variables in the Mgeni River at Morton's Drift during the ten years period (1997 – 2007)

4.4 ALBERT FALLS DAM – MAIN BASIN (UW 41.1)

Archibald *et al.* (1980) described the Albert Falls Dam as a young unstable system with high diversity of both phytoplankton and zooplankton species. It was classified as a clear water, oligotrophic, phosphate-limited system with no measurable evidence of deterioration in the water quality of the Mgeni River in its passage from Midmar Dam through Howick to Albert Falls Dam.

However, water releases from Albert Falls Dam are particular "unnatural" as flows tend to be highest in the dry winter months, and low during summer (RHP, 2002). Degradation of river systems is widespread, and coincides with reduced diversity and abundance of native fish species. Flow regulation has played an important role in the unsatisfactory condition of many rivers surveyed.

The conductivity in Albert Falls Dam has increased about 28 % during the past 10 years from 7 mS/m to 9 mS/m. The average of 7.6 mS/m (approx. 50 mg/L salts) is still relatively low (Figure 14). The average *E. coli* count of 19 cfu/100 ml is low and dissolved inorganic nitrogen of 0.170 mg/L is the lowest in the Mgeni river system. However, the SRP concentration increased significantly during the past 10 years (i.e. from about 4 µg/L to about 9 µg/L), that result in a significant decrease in N:P ratio (Figure 14). If the SRP concentrations continue to increase and the N:P ratio reduces the trophic status of the dam will trend towards the mesotrophic status.

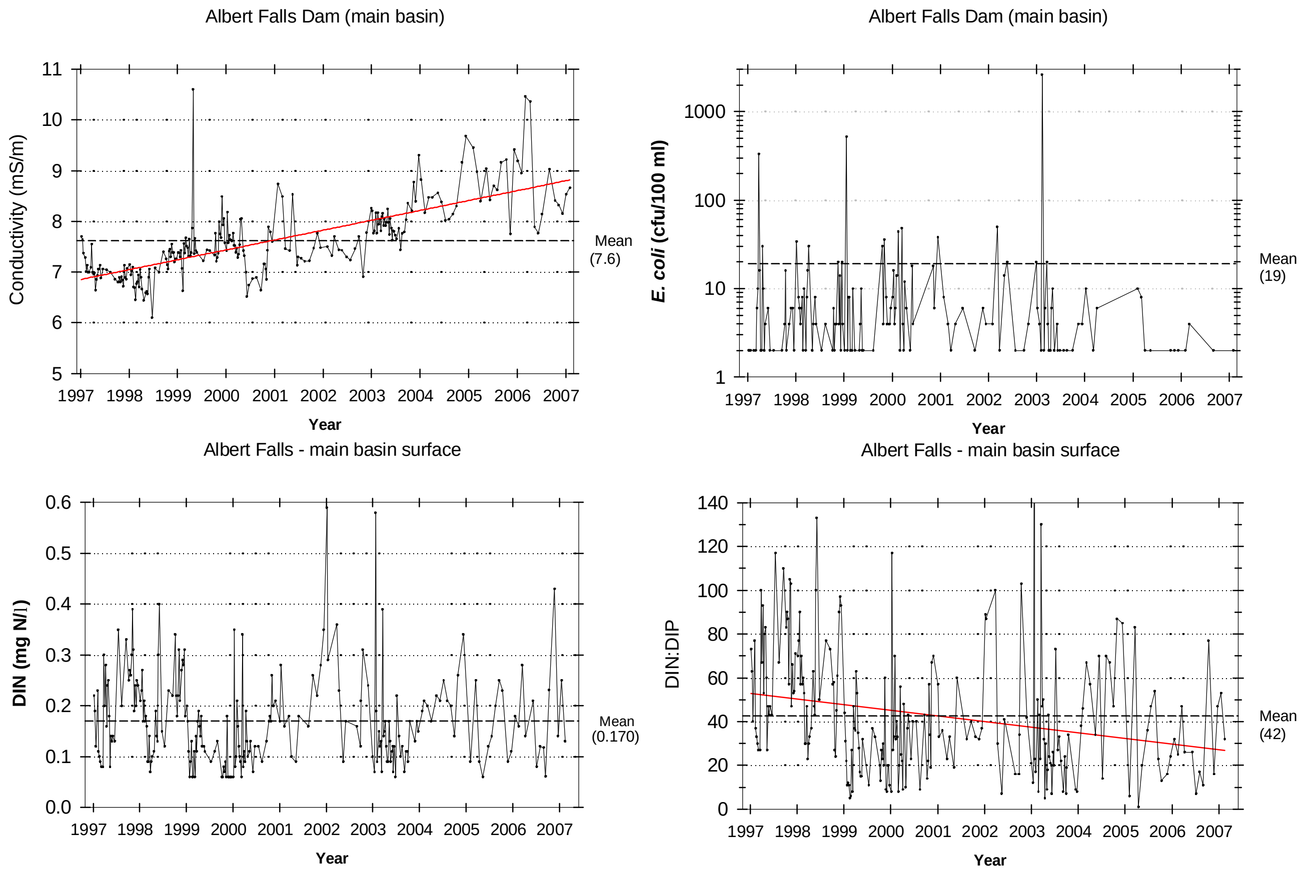
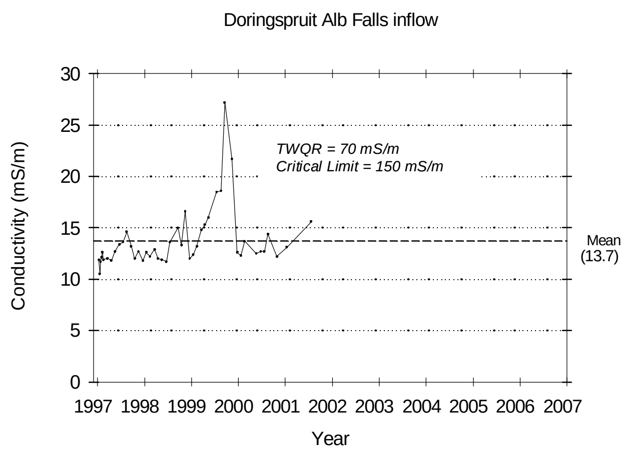


Figure 14: Variation in important variables in Albert Falls Dam during the ten years period (1997 – 2007)

4.5 TRIBUTARIES

4.5.1 Doringspruit (UW 37)

The water quality in Doringspruit (at Albert Falls inflow) was fair with moderate salinity (approx. 90 mg/L) and phosphates concentration (mean, 8.9 µg/L). The plots of the available data are shown plotted in Figure 15. However, the *E. coli* counts were high (mean, 558 cfu/100 ml)) and the average nitrate concentration was high (mean, 0.494 mg/L).



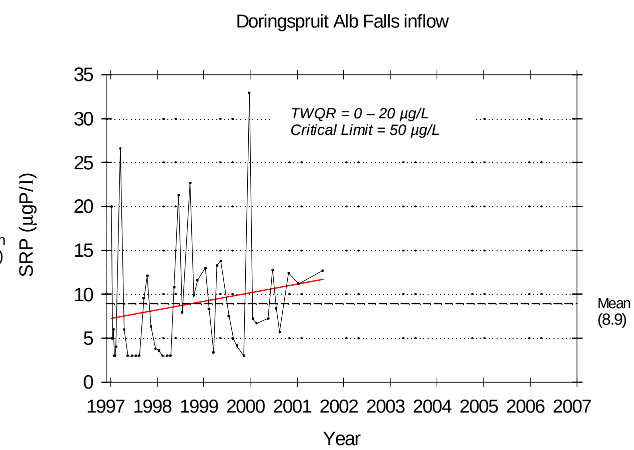
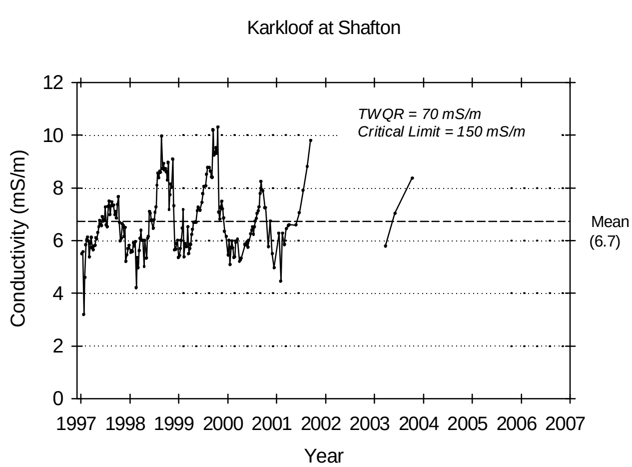


Figure 15: Variation of variables in Doringspruit

4.5.2 Karkloof at Shafton (UW 5.1)

The conductivity values in Karkloof were low (mean, 6.7 mS/m; approx. 44 mg TDS/L), with relative high concentrations during the winter months (Figure 16). The phosphate concentrations were relatively low and show no significant trend (Figure 16). However, the *E. coli* counts were high (mean, 620 cfu/100 ml) and the turbidity was also high (23.15 NTU).



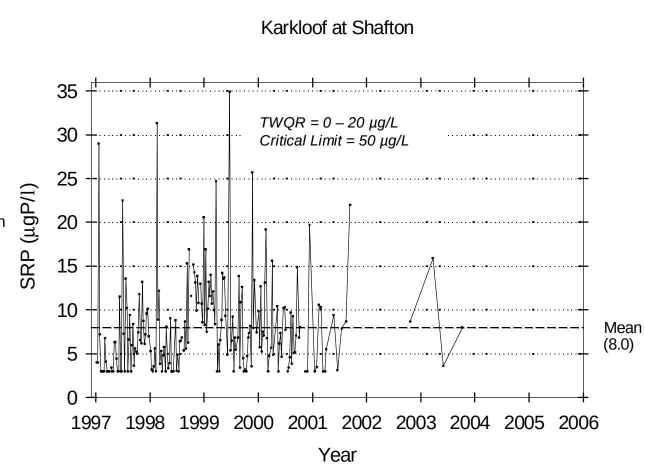


Figure 16: Variation in time of important variables in Karkloof at Shafton

4.6 MGENI ALBERT FALLS OUTFLOW (UW 8)

The flow and water quality of releases from Albert Falls Dam are measured at the weir downstream of the dam. The weir is shown in Figure 17. The water quality in the Albert Falls Dam outflow was analysed and plots of the more important variables are shown plotted in Figure 18. The analysis of the available data showed the water to be of good quality with the upward trend in conductivity in the main dam basin reflected in the outflow. The water quality is good, with low phosphate concentrations (mean, 6.5 µg/L), low turbidity (mean, 15.1 NTU) and low salts (7.66 mS/m).

Figure 17: Gauging weir just downstream of Albert Falls Dam

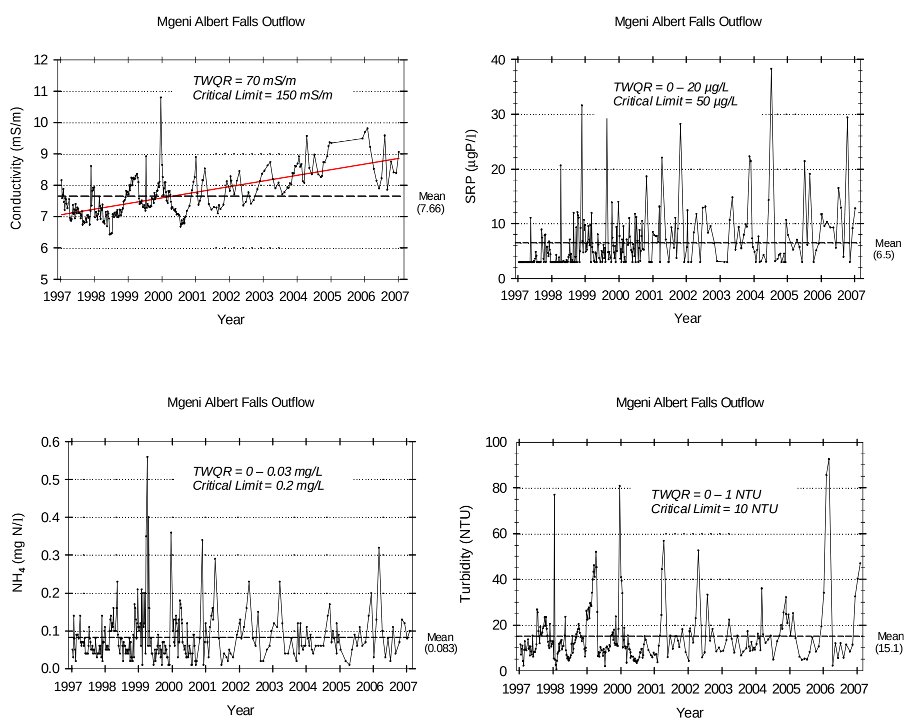


Figure 18: Variation in important variables in Mgeni River at Albert Falls outflow during the ten year period (1997 – 2007)

5 NAGLE RESOURCE UNIT

5.1 INTRODUCTION

A photograph of the Nagle Dam is shown in Figure 19 .The major land use in the Nagle Resource Unit is similar to the Albert Falls unit with commercial forests and sugar cane plantations. There are also scattered rural settlements and feed lots (Figure 20). The considerable forests in the resource unit reduce the flow of water to the river (RHP, 2002). Nagle Dam is used for recreation in particular boating and rowing.

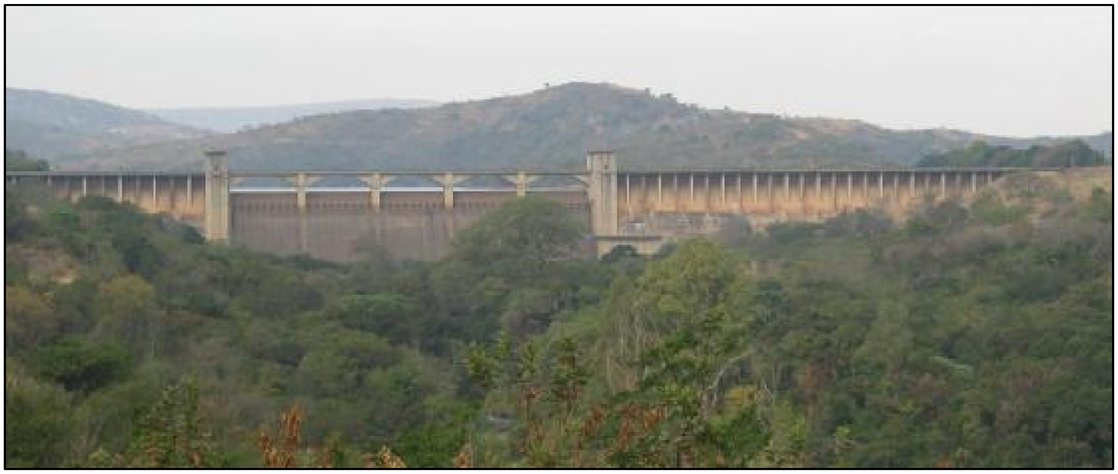


Figure 19: Nagle Dam wall (June, 2007)

Figure 20: Cattle feedlot just below Albert Falls Dam (13/06/2007)

The locations of the water quality monitoring points used in the review of the Nagle Resource Unit are shown in Figure 21.

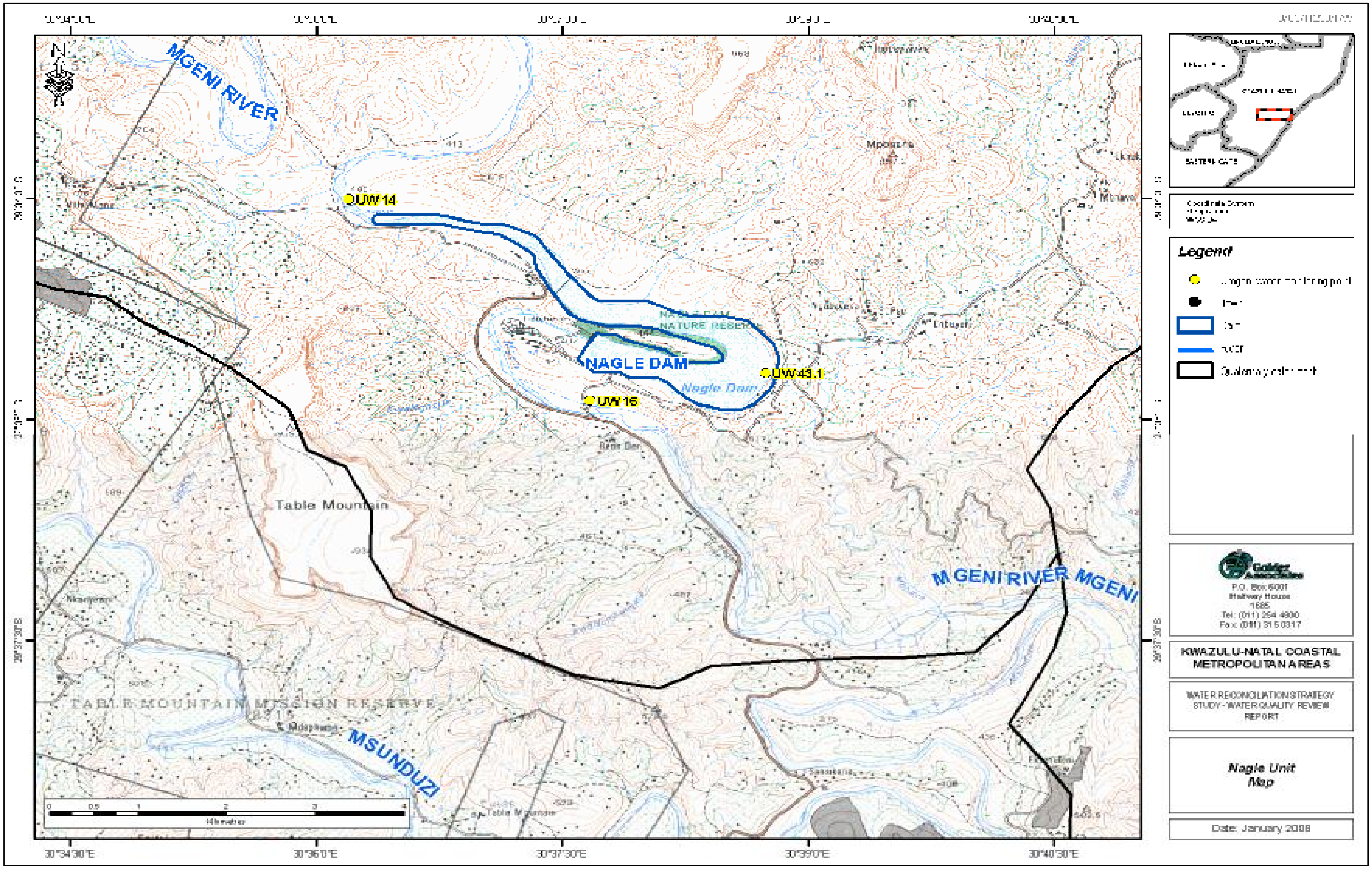


Figure 21: Location of water quality monitoring points in the Nagle Resource Unit

5.2 MGENI WEIR UPSTREAM OF NAGLE DAM (UW 14)

The plots shown in Figure 22 illustrate increasing trends in the conductivity and the SRP concentrations at the inflow to Nagle Dam. The SRP concentrations have moved from the oligotrophic range into the mesotrophic range (min, 3; max. 77; mean, 7.7 µg/L).

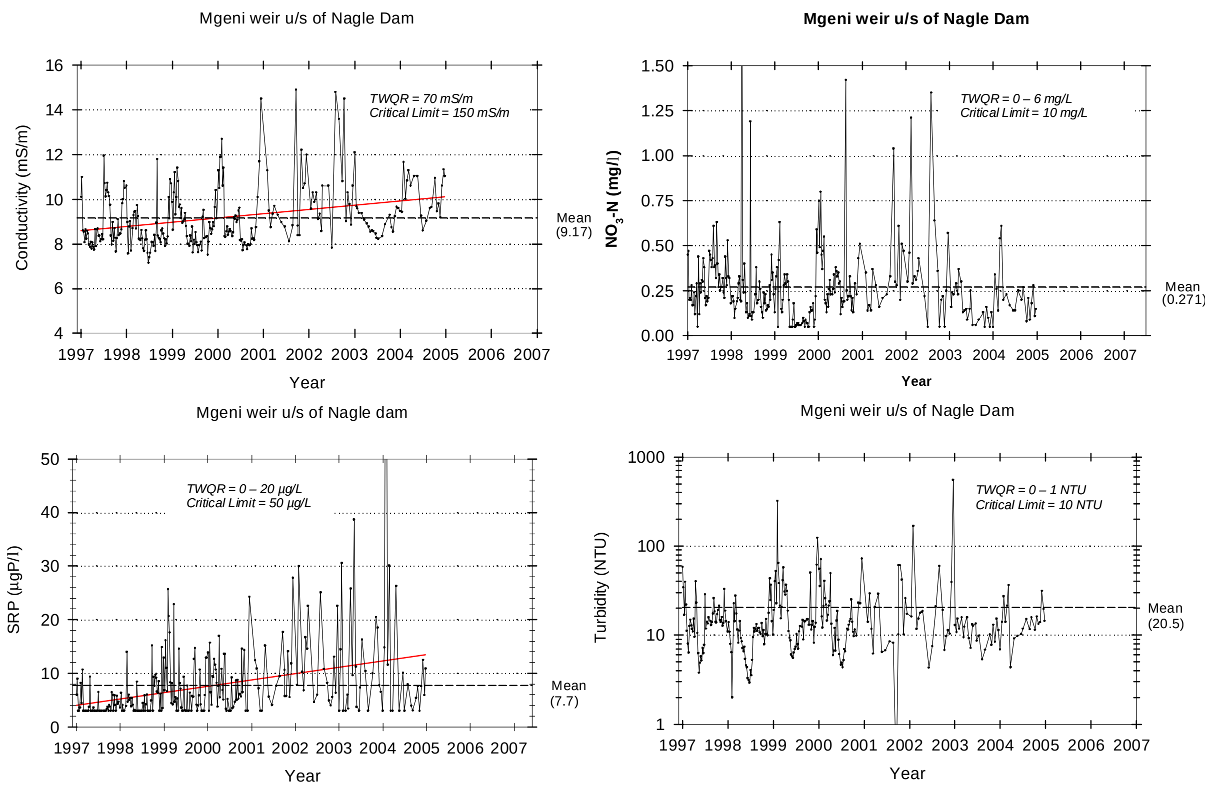


Figure 22: Variation in important variables in Mgeni weir upstream of Nagle Dam during the ten years period (1997 – 2007)

5.3 NAGLE DAM (MAIN BASIN) (UW 43.1)

Nagle Dam was the first reservoir to be built on the Mgeni River. It was completed in 1950 and initially served as an important supplementary source of water for the city of Durban but supply proved inadequate to meet the ever increasing demand (Archibald *et al*., 1980).

Archibald et al (1980) reported that phytoplankton populations were dominated by *Ankistrodesmus* and a small *Cosmarium* species during the summer of 1977/78 and the dominant winter diatom was *Melosira distans*. The cyanobacteria *Anabaena* and *Microcystis* species were recorded during the year ('77/'78) on some occasions and the latter species showed an increasing trend during spring.

During a field trip (June, 2007), patches of cyanobacteria (*Microcystis* sp.) were noticed in the upper reaches of Nagle Dam (Figure 23). Algal blooms develop when water nutrient concentrations are high enough to support excessive growth.

Figure 23: Cyanobacterial (*Microcystis* sp.) bloom in Nagle Dam (13/06/2007)

The very low turbidity in Nagle Dam (mean, 6.8 NTU) indicates the clarity of the water with a favourable underwater light climate for algal growth.

The water quality data showed that the average phosphate concentration in Nagle Dam was low (mean, 5.75 µg/L; min, 3; max. 84 µg/L), but also shows a slight increasing trend (Figure 24). The recent concentrations are significantly higher than those recorded in 1977/78 of min, 1; max, 5; mean 1 µg/L (Archibald *et al.*, 1980). The trend shown in Figure 24 is influenced by the 84 µg/L maximum concentration which could be an outlier.

The nitrate concentrations were relatively low (mean, 0.211 mg/L) and show a decreasing trend (Figure 24). Several studies indicate that bacterial denitrification in anaerobic sediments may play a major part in removing nitrogen from water during river transport (Hill, 1979; Abril & Frankignoulle, 2001, and Laursen & Seitzinger, 2002). Thus, not all nitrogen loaded into rivers is ultimately exported to estuaries or the ocean. Processes such as denitrification, organic matter burial in sediments, sediment sorption, and plant and microbial uptake can remove N from the river, and thus affect the amount of N that is transported by rivers to coastal ecosystems (Billen *et al.*, 1991).

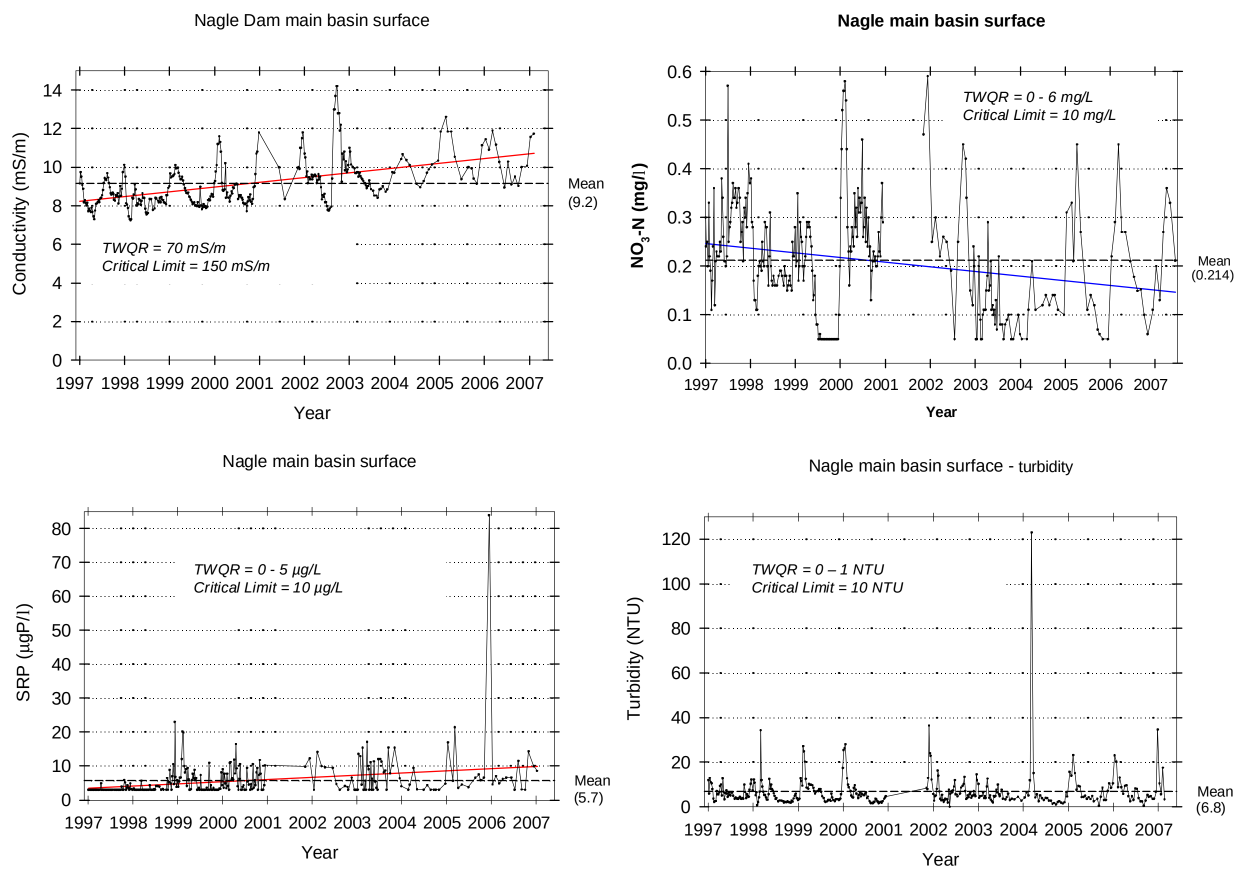
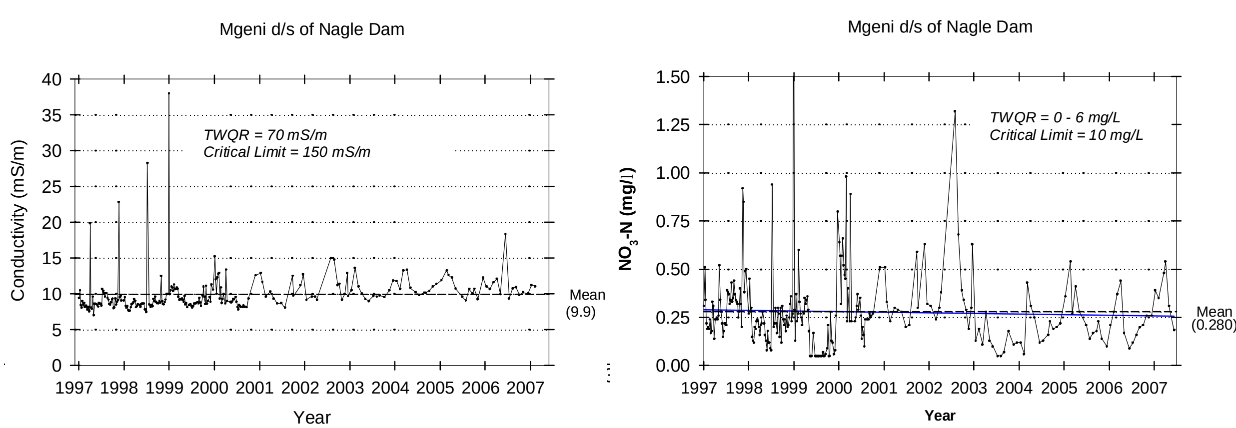


Figure 24: Variation in important variables in Nagle Dam (main basin surface) during the ten years period (1997 – 2007)

5.4 MGENI DOWN STREAM OF NAGLE DAM (UW 16)

The water quality in the Mgeni River down stream of Nagle Dam was slightly poorer than in the dam (compare Figure 24 and Figure 25). The higher nitrate, phosphate and higher turbidity could be ascribed to water released from the dam from lower layers.



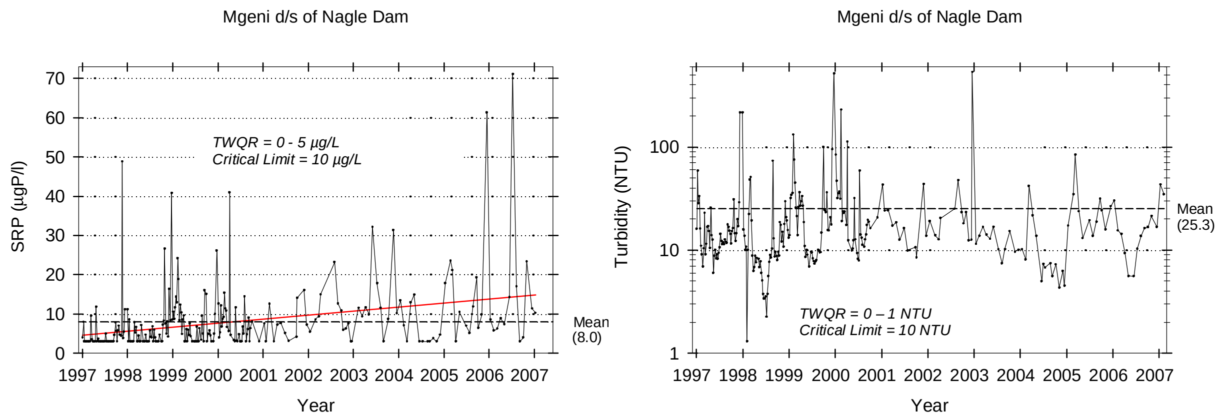


Figure 25: Variation in important variables in Mgeni at Albert Falls outflow during the ten years period (1997 – 2007)

6 MSUNDUZE RESOURCE UNIT

6.1 INTRODUCTION

The Msunduze River is one of the major tributaries of the Mgeni River. It rises near Elandskop on the road to Bulwer (1 500 m above sea level) and flows eastward to Henley Dam, Edendale and Pietermaritzburg (RHP, 2002). The confluence of the Msunduze River with the Mgeni River is below Nagle Dam.

This resource unit is dominated by the urban sprawl of Pietermaritzburg (altitude 750 m), a mix of formal city, residential and industrial suburbs and informal housing developments (RHP, 2002).

The Msunduze Resource Unit can be divided into the Vulindlela, Henley and the reach downstream of Henley Dam. The headwater catchment of the Vulindlela area is unregulated. There are approximately 11000 people living in the catchment largely in informal settlements. The area is overgrazed which has exacerbated the erosion problems in this area. The water quality issues in this area are limited to erosion, some nutrients and faecal contamination.

The Henley Dam acts as a sink for pollutants from the upstream catchment in particular sediment, nutrients and microbiological contamination. Releases from the dam can be used to improved downstream water quality through dilution and flushing when required.

The water quality in the Msunduze downstream of Henley Dam is seriously affected by sewer infrastructure problems such as broken and blocked sewers and wash aways of sewer lines. There is excessive ingress of rain water into the sewer system which results in surcharges, hydraulically overloading Darvill WWTP and increased probability of blockage. Pit latrines are also extensively used in this area. These are not always adequately installed and protected from stormwater ingress. Pit contents can get mobilised during storm events

The Darvill WWTP is the single most important nutrient point source to the downstream Inanda catchment. The WWTP meets the current licence conditions reasonably well. However attention will have to be given in the future to setting more stringent nutrient discharge standards to better protect the downstream Inanda Dam.

Downstream of Darvill WWTP there are a number of irrigators and large informal population of about 100 000 people. This area is characterised by poorly managed subsistence agriculture, overgrazing and poor sanitation systems.

The locations of the monitoring stations in the resource unit are shown in Figure 26.

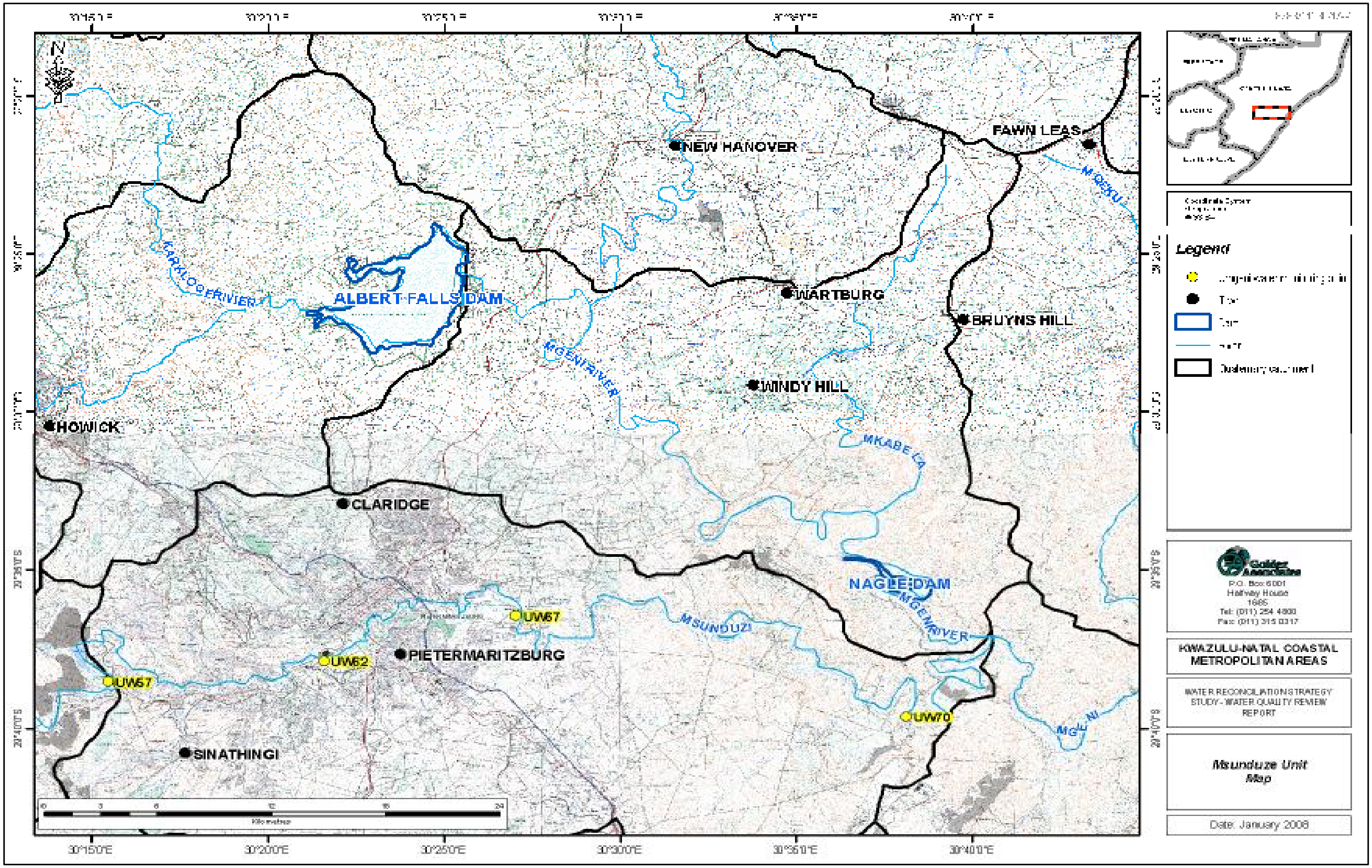


Figure 26: Location of water quality monitoring points in the Msunduze Resource Unit

6.2 MSUNDUZE AT HENLEY WEIR (UW 57))

The water quality in the Msunduze at Henley weir was fairly good, with relatively low salts, low nutrients, but spoiled by high turbidity (mean, 86.5 NTU) and faecal contamination (mean *E. coli* counts of 2 011 cfu/100 ml) (Figure 27). RHP (2002) also reported that invertebrates up and downstream of Henley Dam suggest that the river is in good condition. Species diversity is good, and many sensitive organisms are found here.

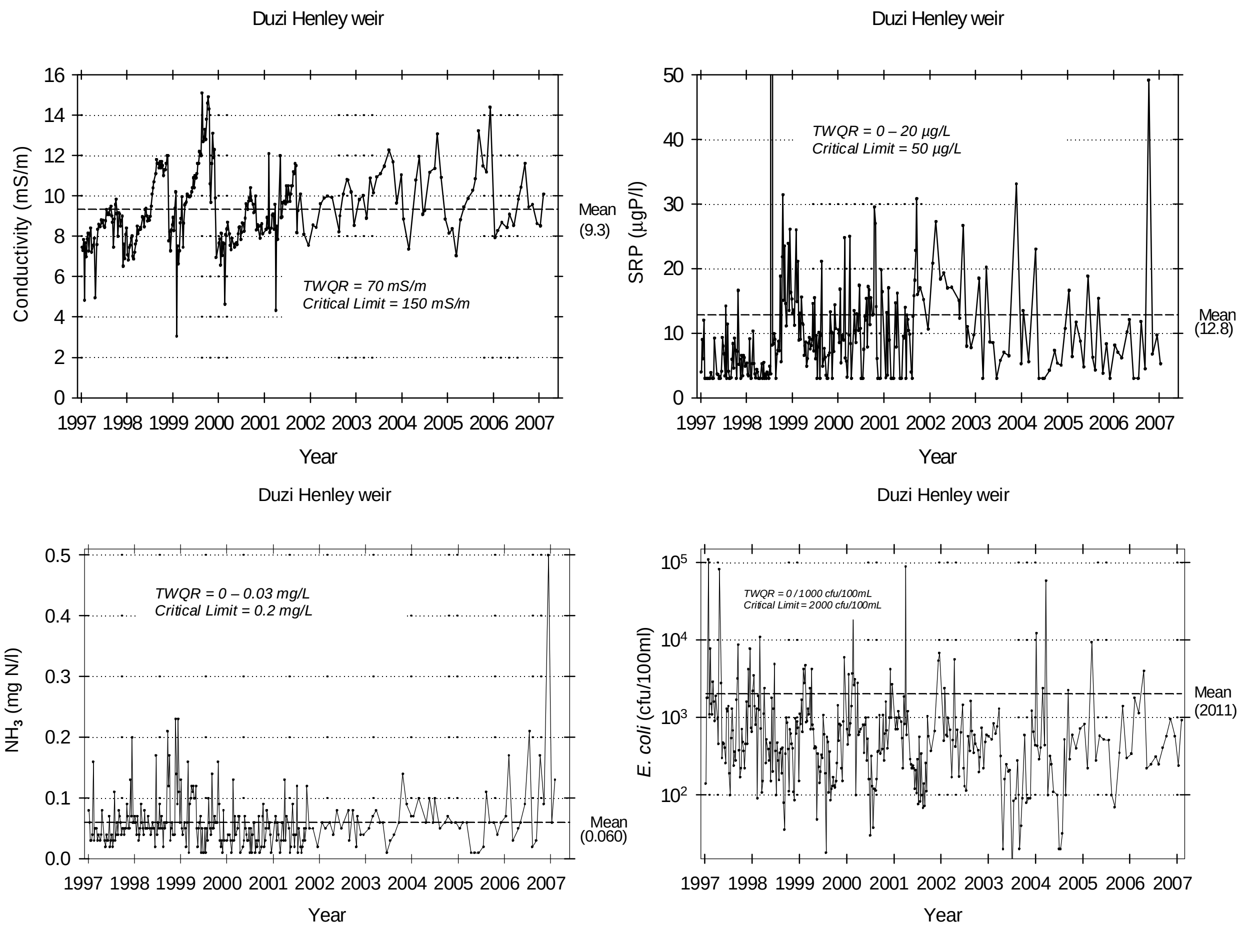


Figure 27: Variation in important variables in Msunduze River at Henley weir during the ten years period (1997 – 2007)

6.3 MSUNDUZE AT CAMPS DRIFT WEIR (UW 62)

The water quality in the Msunduze River at Camps Drift weir (Figure 28) was poor, with very high *E. coli* counts (mean, 6 768 cfu/100 ml), and high dissolved inorganic nitrogen (mean, 1.30 mg/L; Figure 29). The turbidity was still high (mean, 68.8 NTU) and ranged between 3.9 and 2 125 NTU.

Water quality in the lower end of the resource unit is poor mainly due to faecal contamination and the water quality declines as the river passes through the city. Interestingly, the effluent from Darvill Wastewater Works often improves the quality of the river water (RHP, 2002).

Figure 28: Msunduze River at Camps Drift weir (June, 2007)

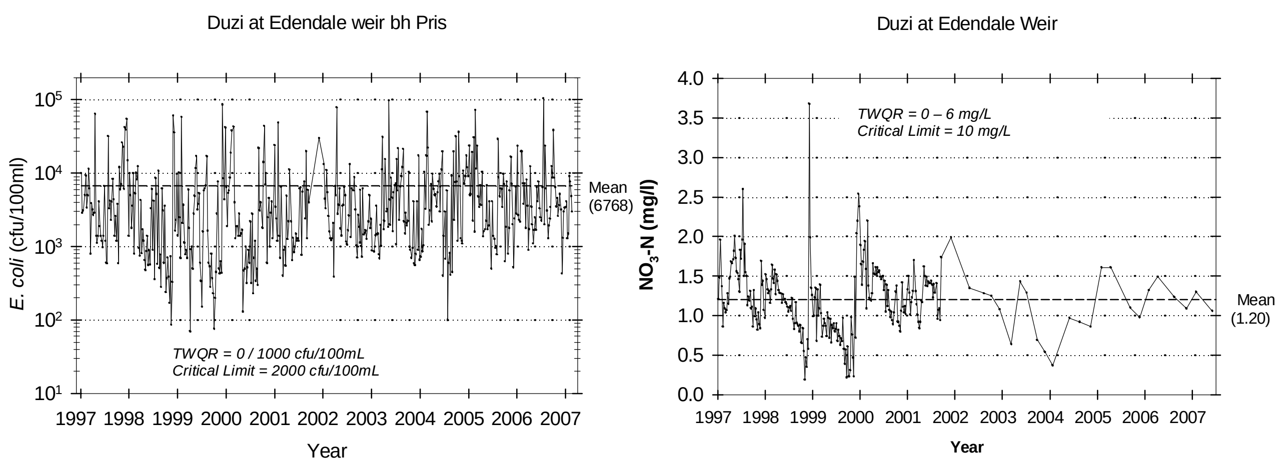


Figure 29: Variation in some variables in the Msunduze River at Camps Drift weir during the ten years period (1997 – 2007)

6.4 MSUNDUZE AT MOTORCROSS (UW 67)

The water quality in the Msunduze at Motorcross is the worst in the river system. The high *E. coli* counts (mean, 11 200 cfu/100 ml) suggest that raw sewage enters the system frequently.

Ammonia is a common pollutant and is one of the nutrients that contribute to eutrophication. The principal form of inorganic nitrogen in sewage is ammonia. The target range of ammonium nitrogen (NH4-N) concentration in unpolluted rivers is 0.58 mg/L (DWAF, 1996). The average NH4-N concentration in the Msunduze River at Motorcross was very high at 0.606 mg/L (range 0.010 to 9.700 mg/L (Figure 30). High ammonia usually indicates a high organic load to the system, because heterotrophic bacteria generate ammonia (NH3) as a primary end product of decomposition of organic matter (ammonification process).

The high nutrient (especially N & P) concentrations fall in the range of eutrophic systems that can trigger algal blooms and weed growth. The popular Dusi canoe marathon is threatened by faecal contamination and by water hyacinth choking the river near the estuary. The conductivity was also very high (mean, 30 mS/m) and display a significant increase during the past 10 years (Figure 30).

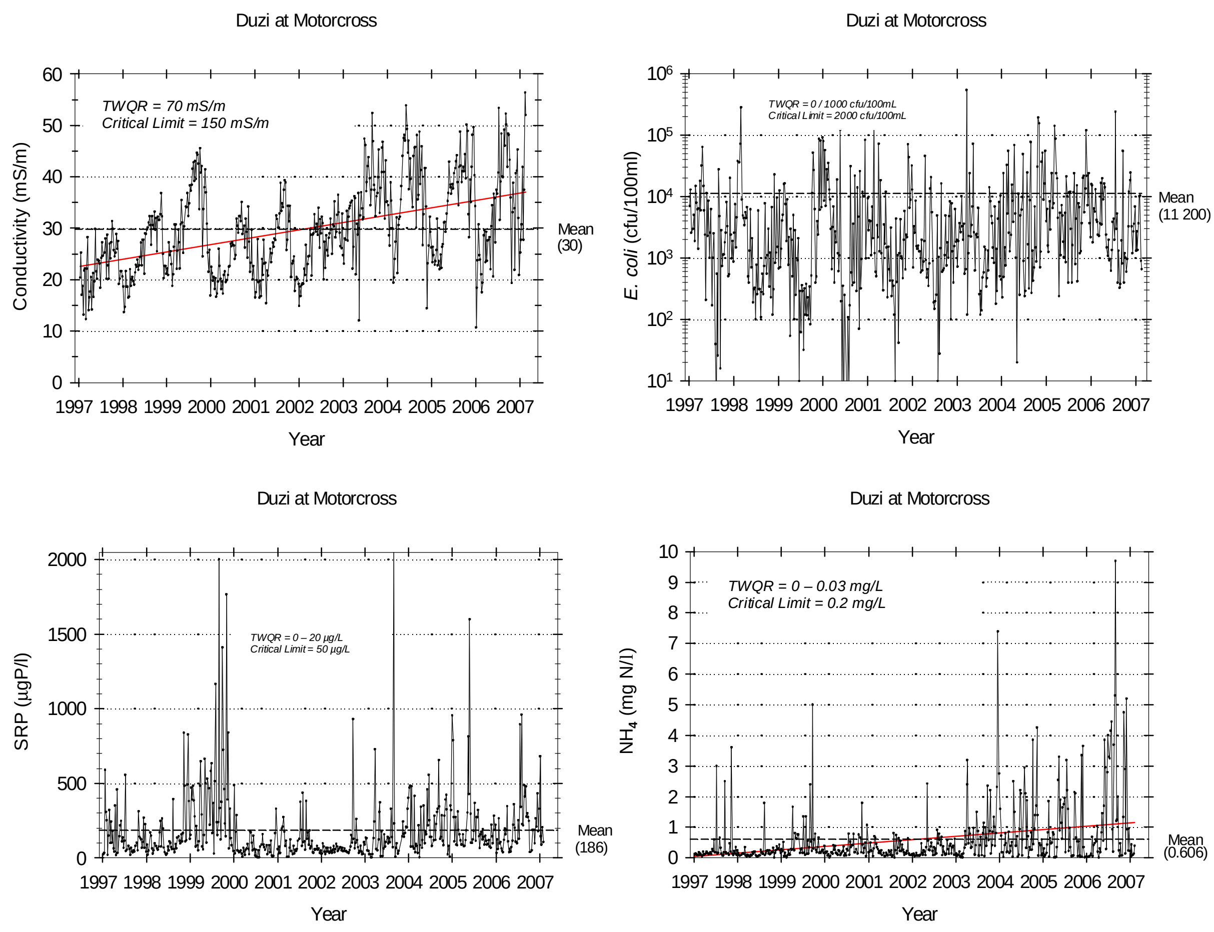


Figure 30: Variation in important variables in Msunduze River at Motorcross during the ten years period (1997 – 2007)

6.5 MSUNDUZE AT EDDY HAGAN DRIVE (UW 70)

The faecal contamination in the Msunduze River at Eddy Hagan Drive was also very high. The *E. coli* concentration ranged between 2 and 1 700 000 with an average of 9 304 cfu/100 ml (Figure 31). The nutrient concentrations were also very high and fall in the range of eutrophic systems, i.e. nitrate (mean, 2.02 mg/L), ammonium (mean, 0.085 mg/L) and phosphorus (mean, 145 µg/L) (Figure 31). These values are comparable to the polluted Vaal River.

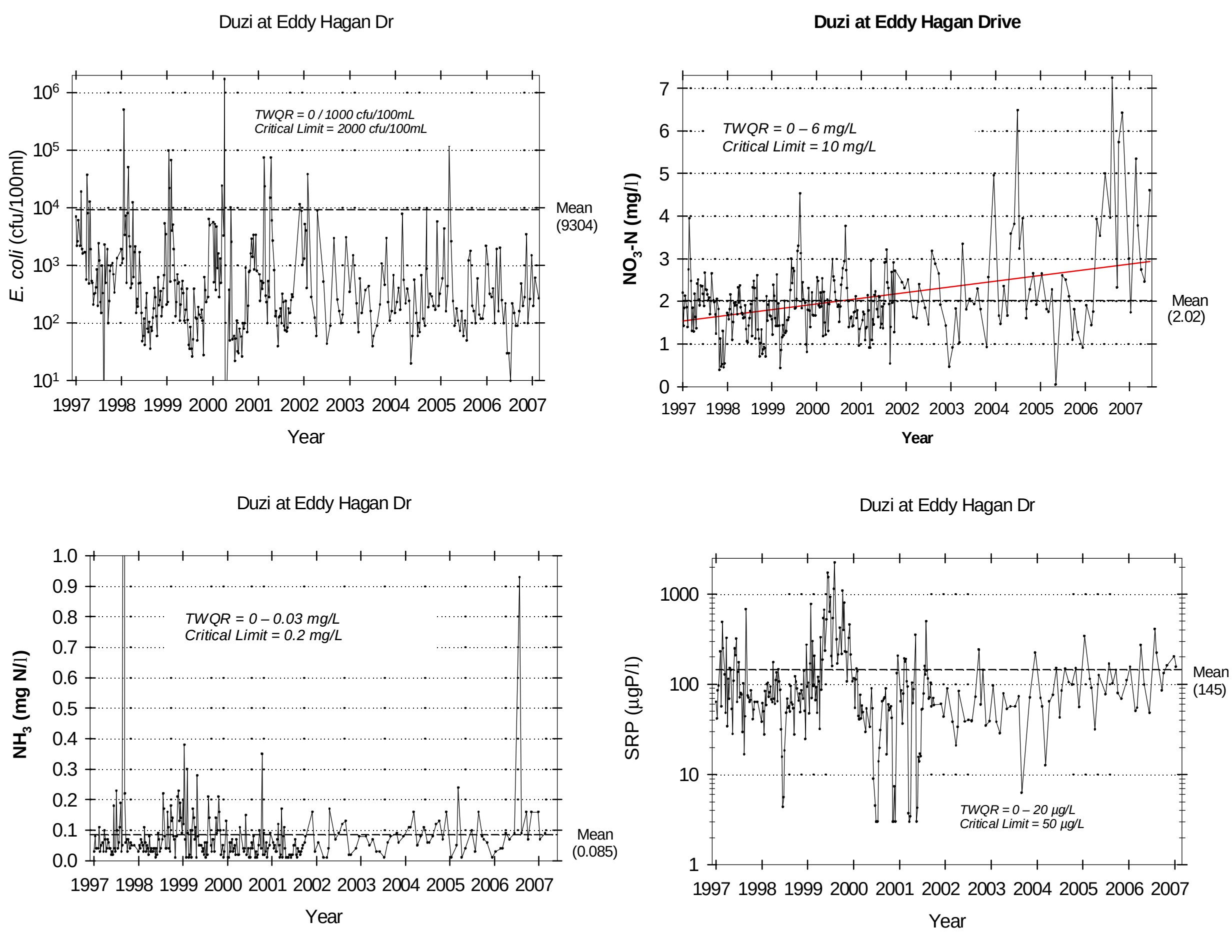


Figure 31: Variation in important variables in the Msunduze River at Eddy Hagan Drive during the ten years period (1997 – 2007)

6.6 CONCLUSIONS

It is concluded that the current water quality in the middle and lower Msunduze River is very poor, with a high faecal coliform content and nutrient over-enrichment. There is a significant risk of possible health effects if water is used for drinking and contact recreation. 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 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 ecological integrity of the Msunduze River has been changed significantly; consequently, the key ecological processes and species composition is probably not comparable to that of natural habitats within the region (RHP, 2002).

The presence of substances that are not removed during the sewage treatment process, such as drugs (e.g., heart and blood medication, hormonal treatments, oral contraceptives), domestic cleaners and various industrial chemicals, all of which may have subtle, but significant effects on an ecosystem. No data is available on these potential Endocrine Disrupting Compounds (EDC's).

The effects of discharging treated sewage into freshwater ecosystems depend on the quality and quantity of the effluent, and on the condition, type, size, and resilience of the receiving ecosystems (Luger & Brown, 2002). Any discharge will result in some change in a receiving aquatic system, but different systems display different sensitivities and thus priority should be given to setting appropriate target effluent quality and quantity at each sewage works, based on an understanding of the resilience of, and the extent and relevance of impacts on the specific receiving environment. Phosphorus concentrations in streams generally show a sequential decrease with increasing distance from municipal WWTP effluent discharge (Haggard *et al.*, 2004).

The nutrient concentrations in the lower Msunduze River are also very high and contribute significantly to the eutrophication process in the lower Mgeni River.

Source reduction technologies are the only effective way of reducing water pollution from the many non-point sources such as agricultural run-off. The primary step in the reduction of eutrophication of a water body is to limit, divert or treat inputs of nutrients and associated particles (UNP, 2000). Source Reduction is the least costly way of managing pollution as it saves the cost of treating polluted discharge waters or cleaning up polluted natural waters. These technologies can be grouped under three broad categories, namely i) efficiency, ii) recycling, and iii) substitution.

7 INANDA RESOURCE UNIT

7.1 INTRODUCTION

Inanda Dam was completed in 1988 at a site 32 km from the Mgeni River mouth. The dam receives the polluted runoff from the Msunduze River. Apart from farmlands around the Msunduze, this resource unit is dominated by the rural Valley of the Thousand Hills, a vigorously undulating landscape with hills and valleys (Figure 32 and Figure 33).

Water quality of the entire Mgeni catchment's rivers and dams is monitored using water quality indices developed by Mgeni Water. Data received for February 2000 shows that water quality in the Inanda Dam is unsatisfactory due to high total algal and *Anabaena* sp. (blue-green algae) counts (Todd & Claasen, 2000). High algal concentrations were also recorded in the upper part of the dam during a recent field trip (June 2007; Figure 34).

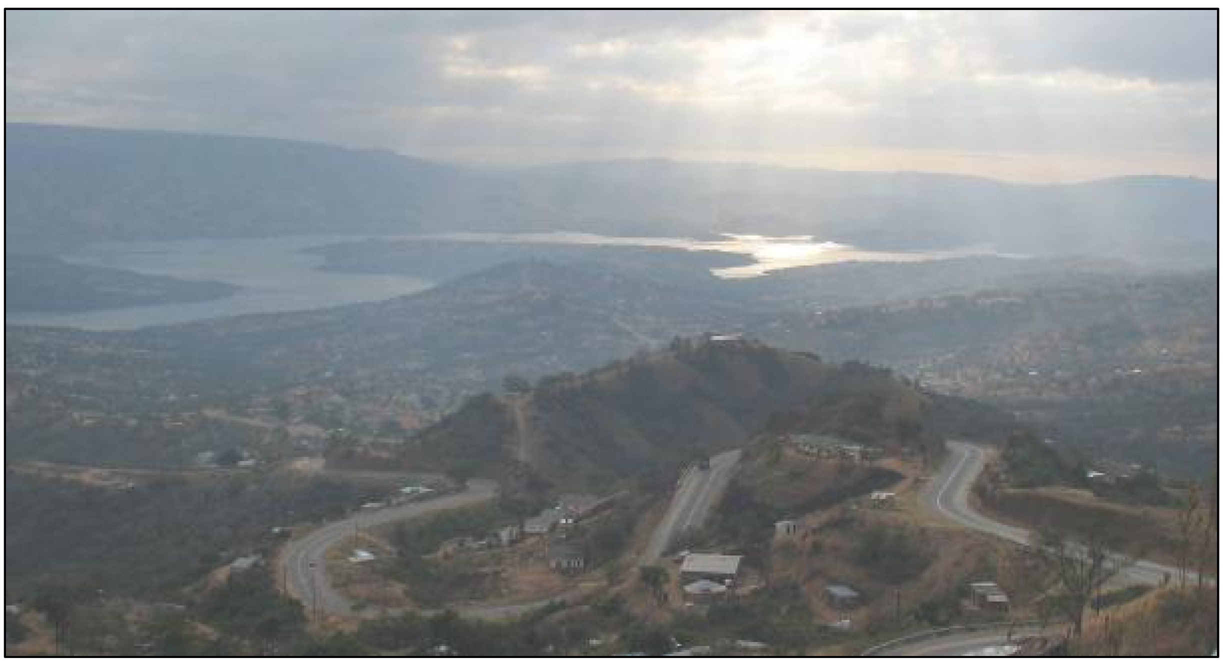


Figure 32: Inanda Dam in the Valley of a Thousand Hills

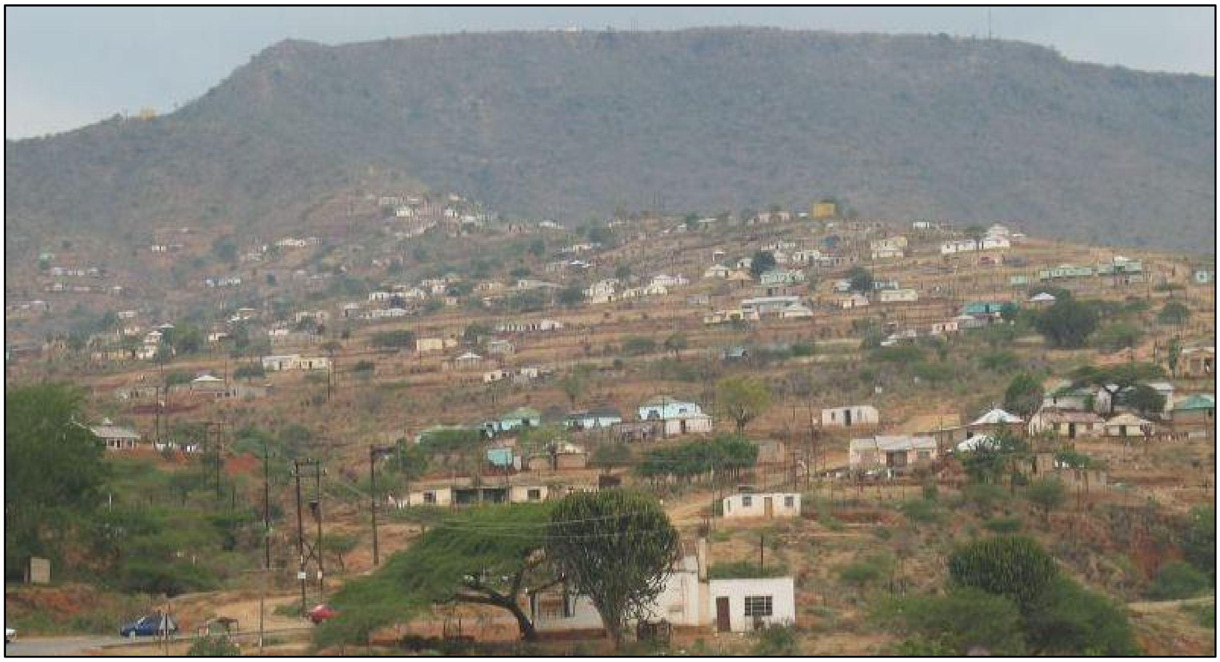


Figure 33: Rural Valley of a Thousand Hills (June, 2007)

Figure 34: Cyanobacterial (*Microcystis* sp.) bloom in Inanda Dam (13/06/2007)

Below Nagle Dam, the Mgeni River is joined by the Msunduze tributary and continues in an easterly direction towards Inanda Dam. A large rural population lives here, and many are directly dependent on the Mgeni River (Figure 35). The total population of the area is 152 000 (RHP, 2002).

Figure 35: Clothes washing in Inanda Dam and fire wood collection (June, 2007)

Within the Mgeni catchment, Inanda Dam and the Mgeni River upstream from the dam suffer the highest incidence of aquatic plant invasion (Figure 36).

Figure 36: Water hyacinth infestation on Inanda Dam (13/06/2007)

These alien plants (Water hyacinth) clog the water surface, deplete oxygen, foster mosquitoes, disrupt rivers' self-purification processes and may lead to a loss of aquatic species, with an associated loss in resource use and value. They also evapotranspire large volumes of water. Water supplied from water bodies covered with alien plants often requires sophisticated, expensive treatment (RHP, 2002).

However, water quality problems were anticipated at Inanda Dam, which is the receptacle for runoff and point source discharges from the upstream urban/industrial complexes of Pietermaritzburg and Cato Ridge (Archibald, 1996).

From Inanda Dam, the Mgeni River flows from the valley of a Thousand Hills with a gentle gradient for 24 km before it flows out to sea at Durban. The water quality in Lower Mgeni Resource Unit is fair, due mainly to the purification of the water in Inanda Dam (RHP, 2002).

The locations of the monitoring stations in the Inanda resource unit are shown in Figure 37.

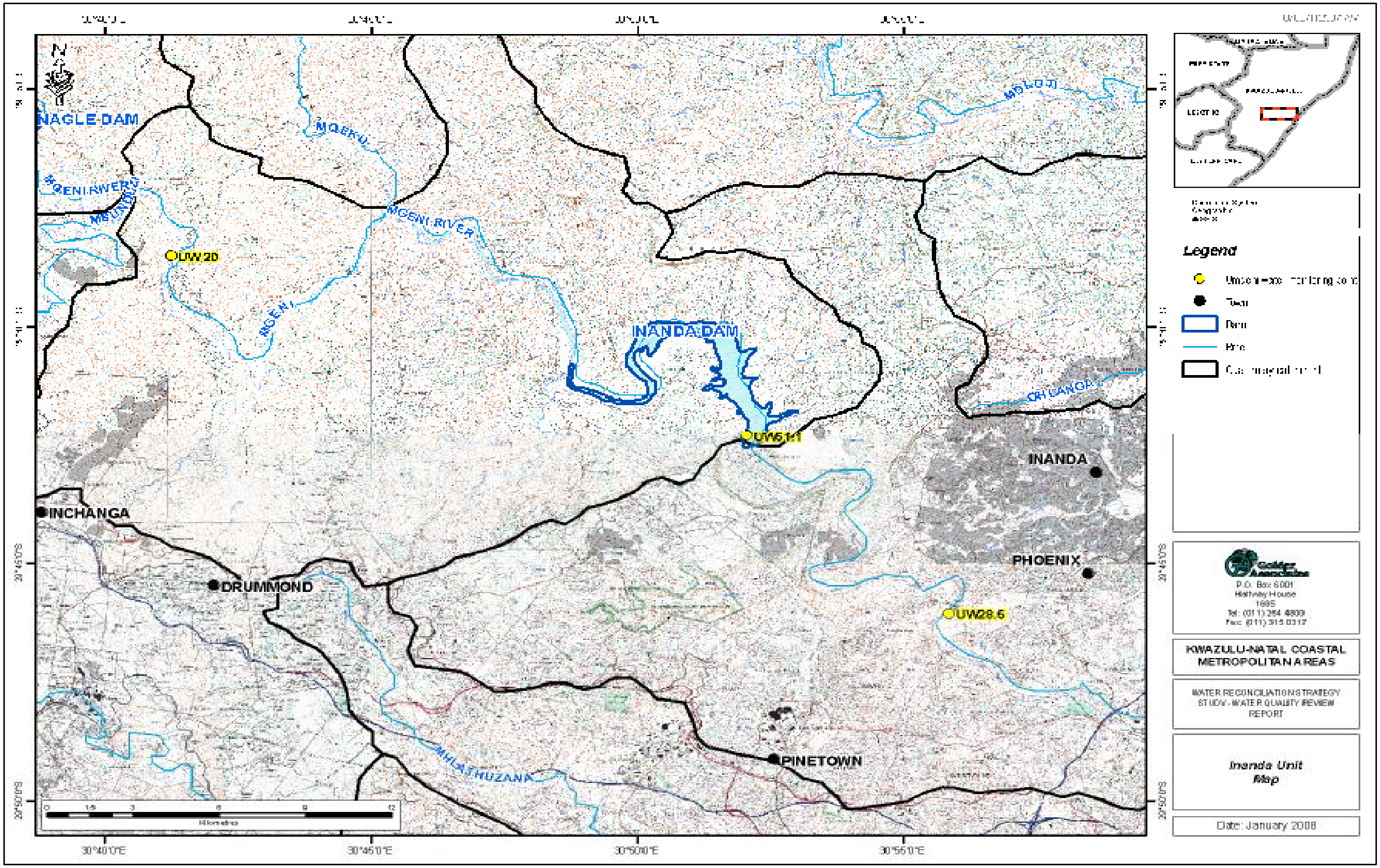


Figure 37: Location of water quality monitoring points in the Inanda Resource Unit

7.2 MGENI – NEW INANDA WEIR (UW 20)

The water quality in the Mgeni River measured at the new Inanda weir between Nagle and Inanda Dam was poor when compared to the upstream Nagle Dam ande Albert Falls Dam. That is high conductivity (mean, 25.25 mS/m, i.e. approx 160 mg TDS/L), very high faecal contamination (mean, 5 265 cfu/100ml); indicating sewage pollution, very high nitrate concentrations (mean, 1.254 mg/L), high ammonium (mean, 0.080 mg/l), high phosphorus (mean TP, 140 µg/L) and high turbidity (mean, 66 NTU) (Figure 38).

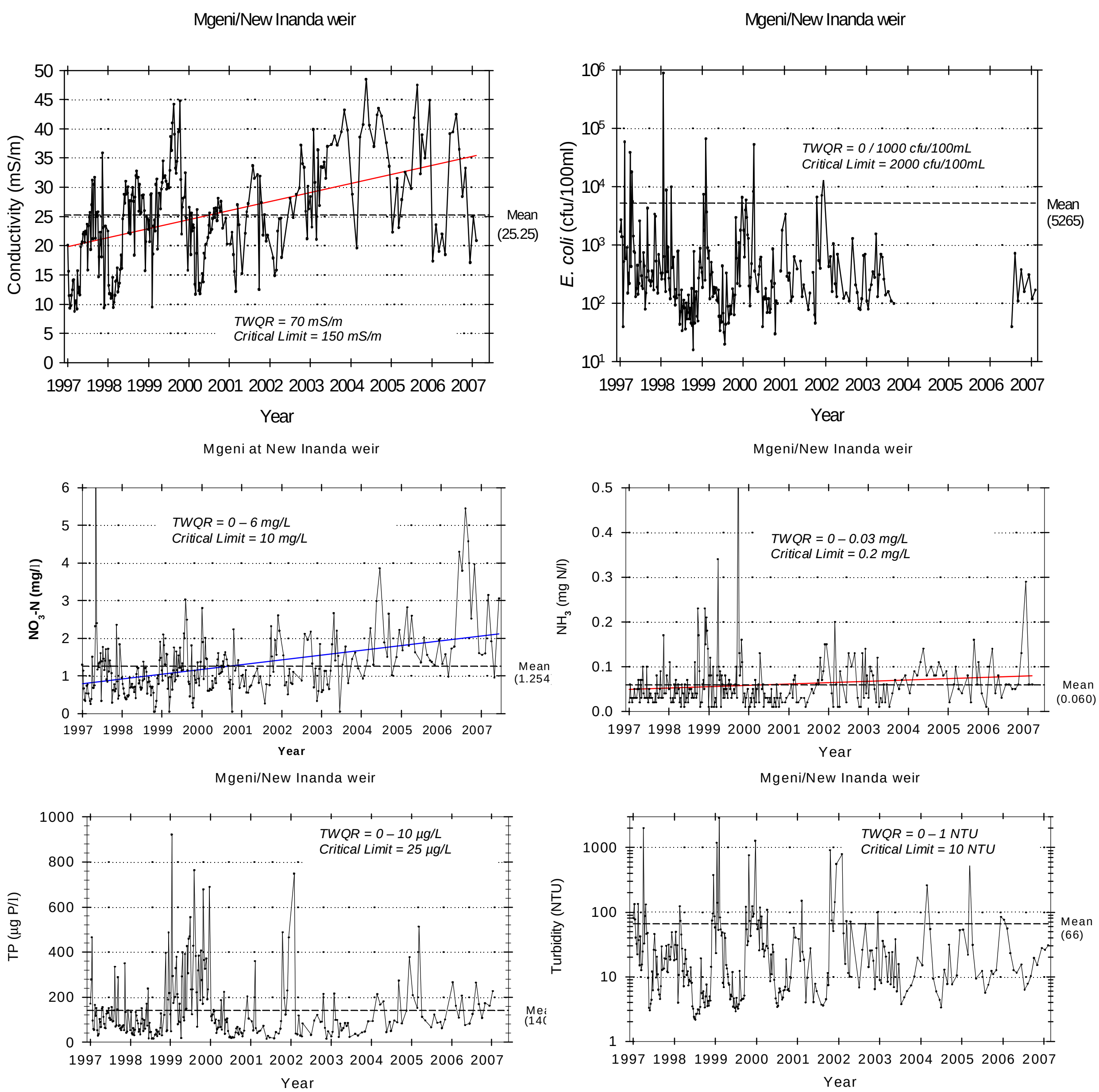


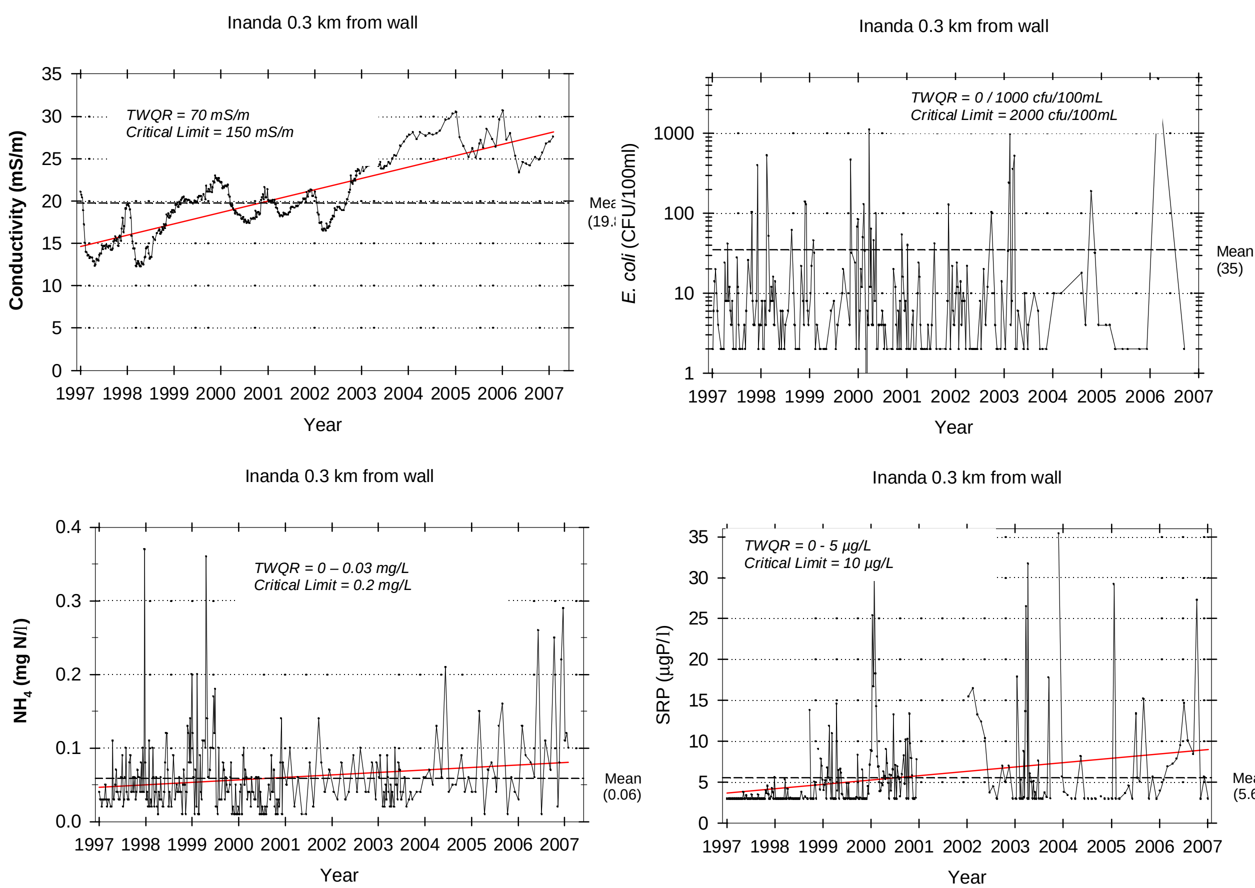
Figure 38: Variation in important variables in Mgeni at new Inanda weir during the ten years period (1997 – 2007)

7.3 INANDA DAM WALL (UW 51.1)

The available water quality data collected at a point 300 m from the dam wall was analysed. The resulting plots are shown in Figure 39. The plots highlight the increasing trend in the salinity (an increase of approx. 85 %) during the past 10 years (i.e. from about 15 to 28 mS/m, mean, 19.8 mS/m). The ammonium and phosphates concentrations also show an increasing trend.

The turbidity in the dam was low (mean, 6 NTU), but displays a clear seasonal pattern with peak turbidities during the rainy season (summer, January to March). Retention of sediment behind the dam wall had led to reduction in available downstream sediment (Garland & Moleko, 2000). It was calculated that during 1988 and 1990, the dam lost 2.7 % of its capacity to sedimentation, the rate of accumulation being equal to approximately 6.8 million tonnes per year (Garland & Moleko, 2000). However, the turbidity shows a decreasing trend during the past 10 years, which could be ascribed to the increasing salinity. Higher salt concentrations in the Vaal River have been associated with higher sedimentation and clearer water (Roos & Pieterse, 1995).

The average phosphate concentration in Inanda Dam was relatively low, which could be ascribed to biogenic uptake by the high concentration of algae and macrophytes in the dam, especially at upstream areas. Nevertheless, the SRP concentration shows an increasing trend. The dam is well within the mesotrophic range.



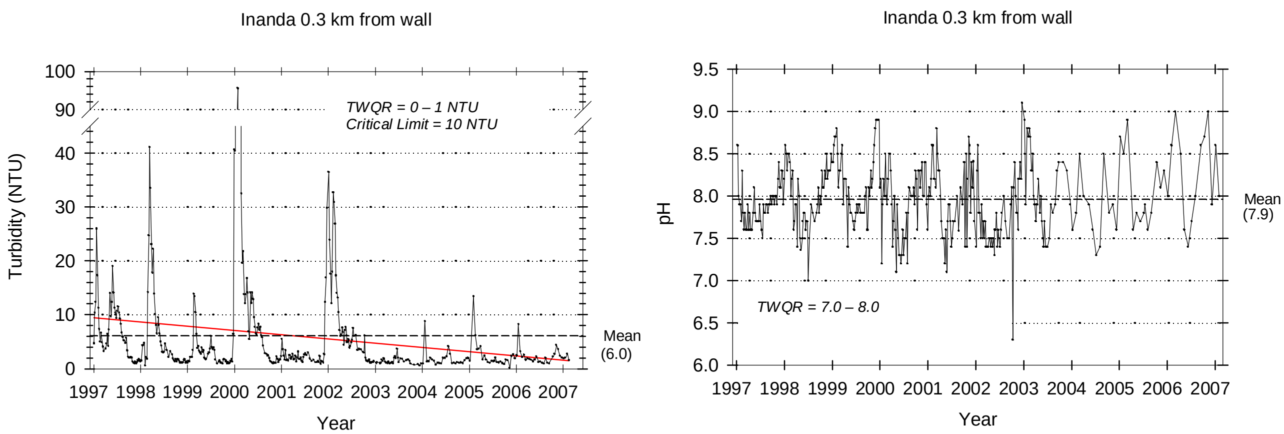


Figure 39: Variation in important variables in Inanda Dam (0.3 km from dam wall) during the ten years period (1997 – 2007)

7.4 MGENI DOWNSTREAM OF KWADABEKA WWW (UW 28.5)

The impact of the Kwadabeka waste water treatment works on the downstream Mgeni River is clearly illustrated in the high *E. coli* counts (mean, 828 cfu/100 ml) and high ammonium concentrations (mean, 0.120 mg/L). Unfortunately, the monitoring was terminated during 1999.

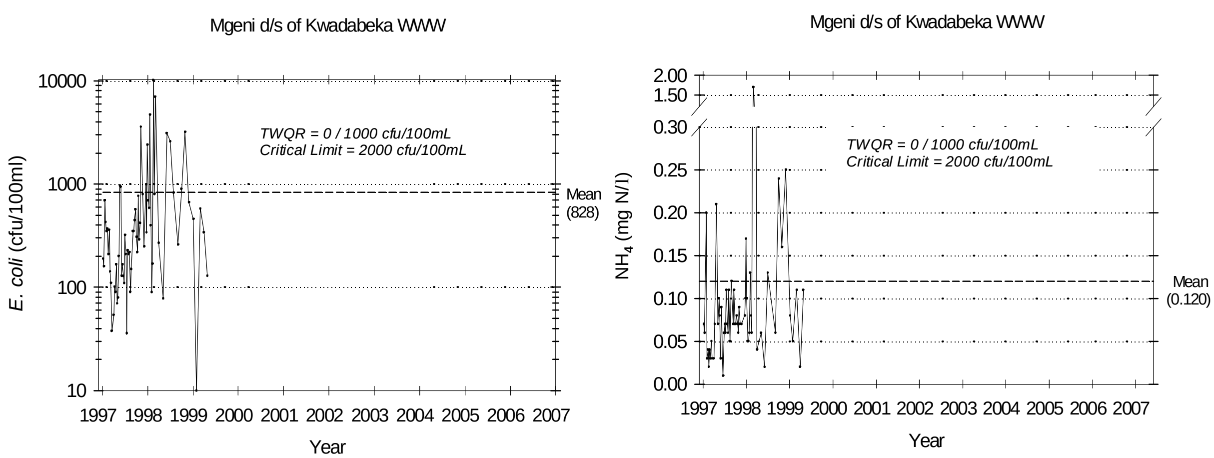


Figure 40: Variation in some variables in Mgeni at Kwadabeka water works, period (1997 – 1999)

8 MOOI RIVER RESOURCE UNIT

8.1 INTRODUCTION

The Mgeni River serves the Pietermaritzburg-Durban region, which is controlled by the four dams and is augmented by inter-basin transfer from the Mooi River in the Tugela Basin. Further augmentation of the Mgeni system is urgently required in order to ensure the levels of assurance are maintained in the long-term to meet the sustained increases in water requirements (Umgeni Water, 2006). Water is currently being transferred from the Mearns weir to the Midmar Dam catchment. One of the options to increase the volumes transferred to Midmar Dam is the construction of the Spring Grove Dam on the Mooi River.

The locations of the monitoring stations in the Mooi River resource unit are shown in Figure 41.

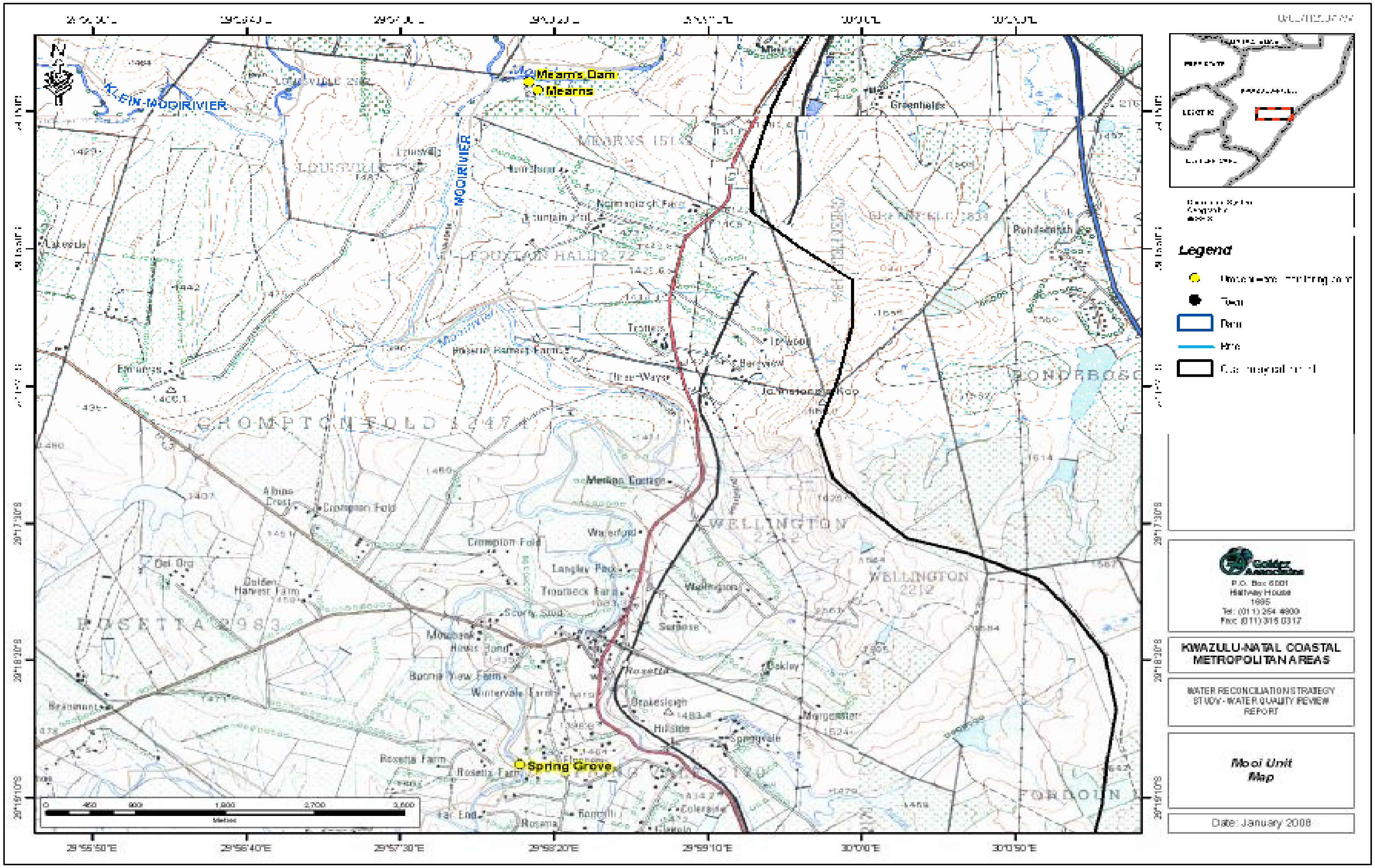


Figure 41: Location of water quality monitoring points in the Mooi River Resource Unit

8.2 MOOI RIVER AT SPRING GROVE

The water quality in the Mooi River at Spring Grove was good with very low conductivity and low dissolved phosphates (Figure 42). However, the *E. coli* counts were high (mean, 1 010 cfu/100 ml) and the turbidity was also relatively high (mean, 17.4 NTU). Unfortunately, the database was incomplete. The transfers of water from Spring Grove to Midmar Dam could impact on the microbiological status of the receiving stream.

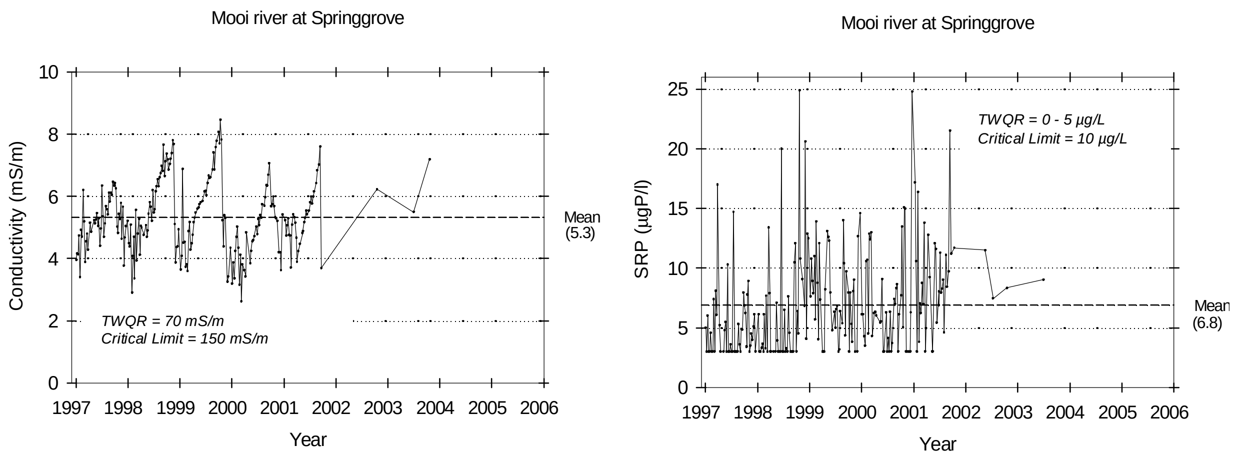


Figure 42: Variation in important variables in Mooi River at the site of the proposed Spring Grove Dam during the ten year period (1997 – 2007)

8.3 MOOI RIVER AT MEARNS

The water quality in the Mooi River at Mearns, based on the relatively old data, was fairly good, i.e. low dissolved salts and low nutrients. The *E. coli* was also high (mean, 510 cfu/100 ml), indicating faecal pollution. The time series plot of the available data is shown in Figure 43.

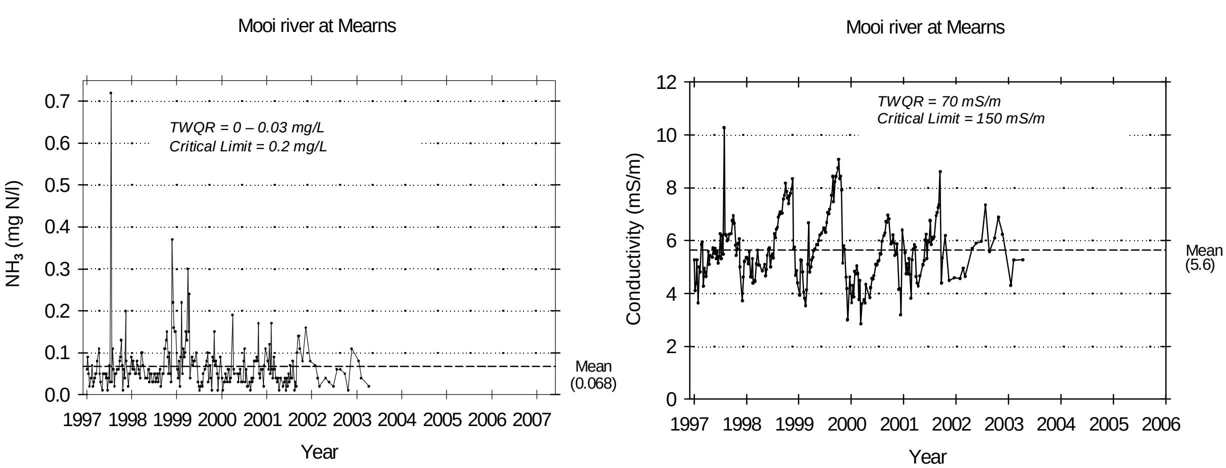


Figure 43: Variation in important variables in Mooi at Mearns weir during the ten years period (1997 – 2007)

8.4 MEARNS DAM

The general water quality in Mearns Dam was fairly good. Characterised by low conductivity (mean, 6.4 mS/m), low bacterial counts (mean, 71 cfu/100 ml), low nitrates (mean, 0.116 mg/L) and low phosphate concentrations (mean, 9.8 µg/L). However, the ammonium concentration in Mearns Dam is increasing drastically (Figure 44). High ammonia usually indicates a high organic load to the system.

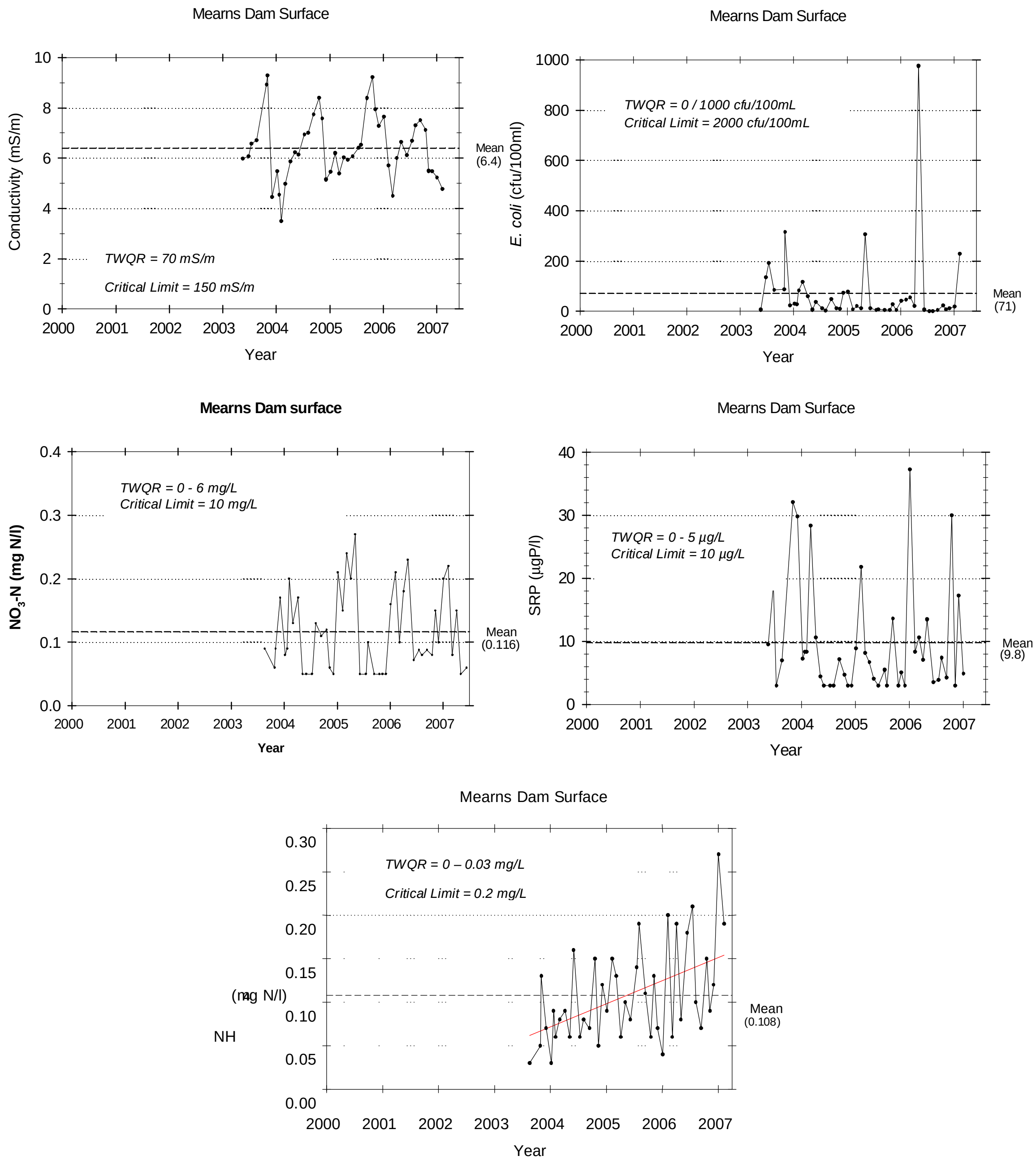


Figure 44: Variation in important variables in Mearns Dam during the ten years period (1997 – 2007)

8.5 CONCLUSIONS

The chemical data from the Mooi River system indicate generally good water quality, with no significant changes during the past four years (2003 – 2007) for most of the parameters. However, the high *E. coli* counts upstream in the river (at Spring Grove and Mearns) and the significant increase in the ammonium concentration in Mearns Dam is a matter of concern.

Umgeni Water (2006) also reported that water quality assessment of Mearns in the Mooi River system showed increased trends in nutrient levels. Analysis showed highly intensive agriculture to be the cause of the eutrophication. A Water User Association was established for the Mooi River by DWAF in 2006 and this, together with the upper Mgeni catchment management forum will provide mechanisms for input into management strategies for the system (Umgeni Water, 2006).

9 MDLOTI RESOURCE UNIT

9.1 INTRODUCTION

The Mdloti River drains a catchment of 376 km^2 in which there is no industrial development. Most of the catchment remains undeveloped grassland but sugar cane cultivation is the dominant agricultural interest (Archibald et al., 1980). Heavy fertilization of the lands at certain times of the year could lead to rapid enrichment of the system runoff from the steep hill slopes.

During the year (2005/2006), complaints were received from the Hazelmere Water Works regarding sand mining impacts (increased sedimentation) on the raw water resource; follow up with the Department of Minerals & Energy was made to address these (Umgeni Water, 2006).

The locations of the monitoring stations in the resource unit are shown in Figure 45.

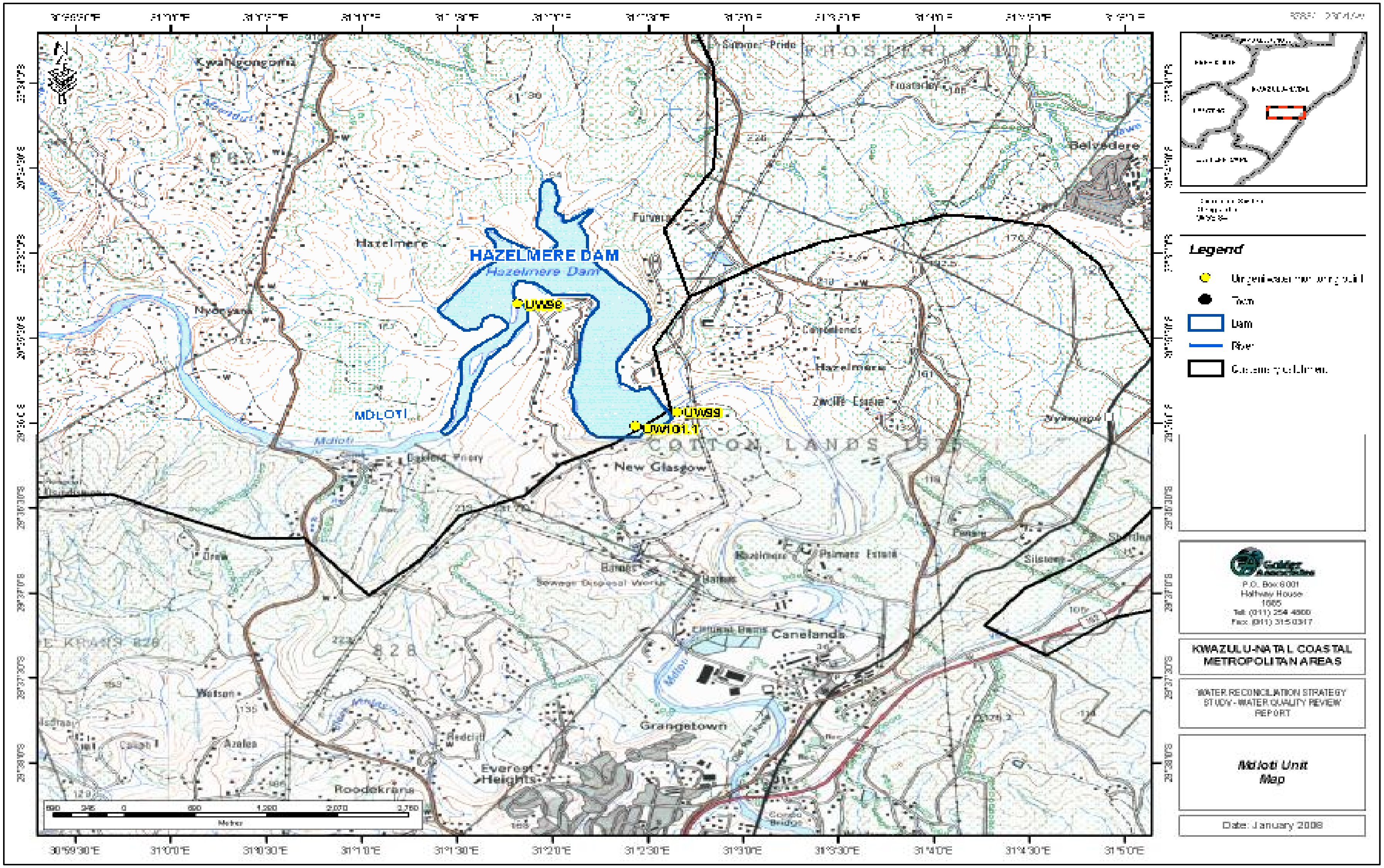


Figure 45: Location of water quality monitoring points in the Mdloti Resource Unit

9.2 MDLOTI HAZELMERE INFLOW (UW 98)

The average conductivity in the Mdloti River (approx. 16 mS/m) is higher than in the upper reaches of the Mgeni River system (mean, approx. 10 mS/m), but fairly stable over the past 10 years (Figure 46). The turbidity was very high (mean, 50 NTU), indicating a high silt load in the water that can contribute to a high siltation rate. However, the turbidity has decreased significantly over the past 10 years (Figure 46).

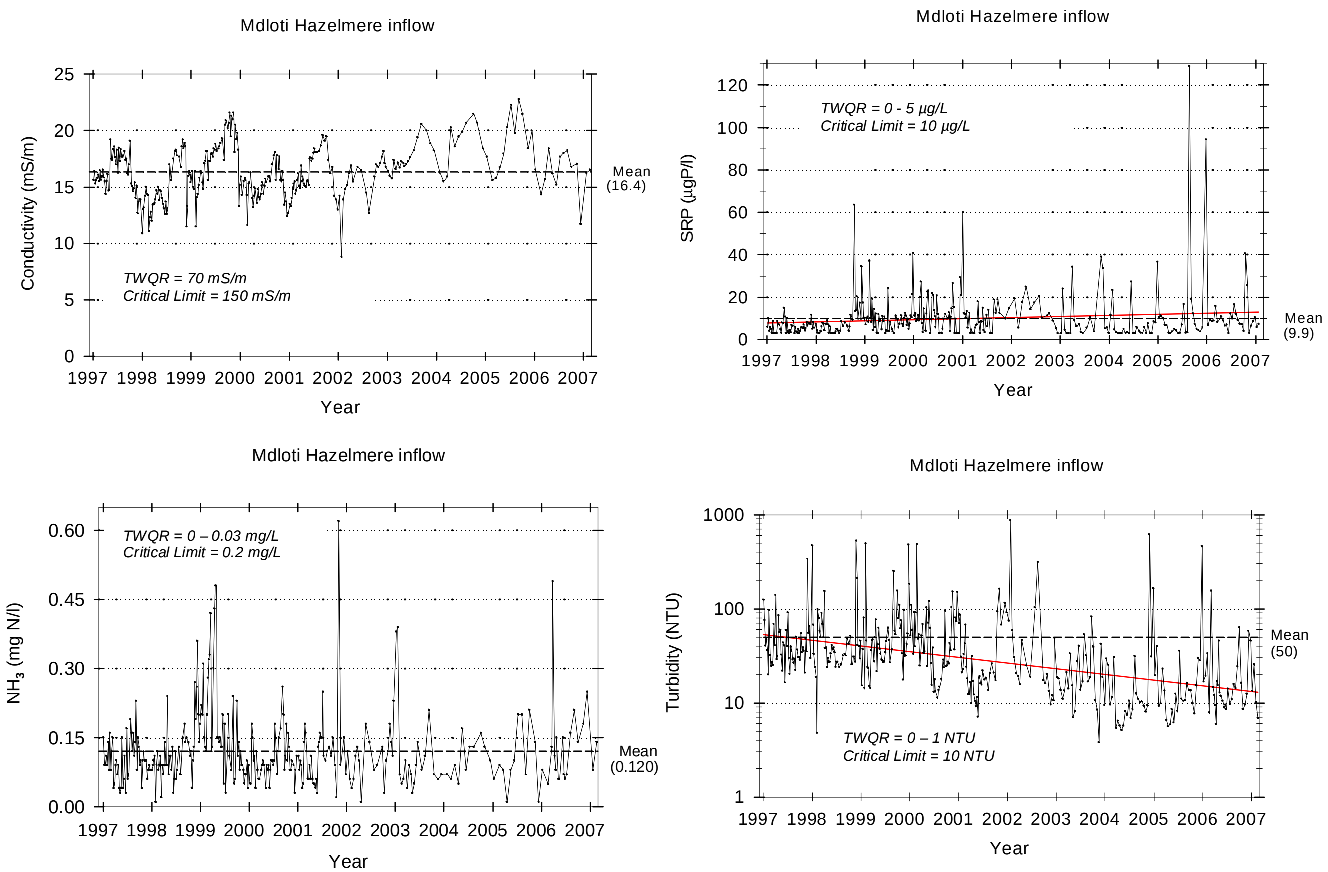


Figure 46: Variation in important variables in Hazelmere weir during the ten years period (1997 – 2007)

9.3 HAZELMERE DAM MAIN BASIN (UW 101.1)

Hazelmere Dam (completed in 1977) is one of the few large coastal reservoirs situated in a catchment dominated by sugar cane cultivation (Figure 47). The Mdloti River is the only major input to the dam and therefore greatly influences the chemical composition of the Dam system.

Figure 47: Hazelmere Dam in the Mdloti River (June, 2007)

The nutrient input to the dam via the Mdloti River increased considerably when silt loads were high (high turbidity) after heavy rains resulted in flow maxima (Figure 48). Hazelmere Dam was a turbid system for most of the year (mean, 47.4 NTU), with very high turbidity values during the rainy season (December to March) (Figure 48). It is one of the most turbid systems in KwaZulu-Natal and therefore has probably a high siltation rate.

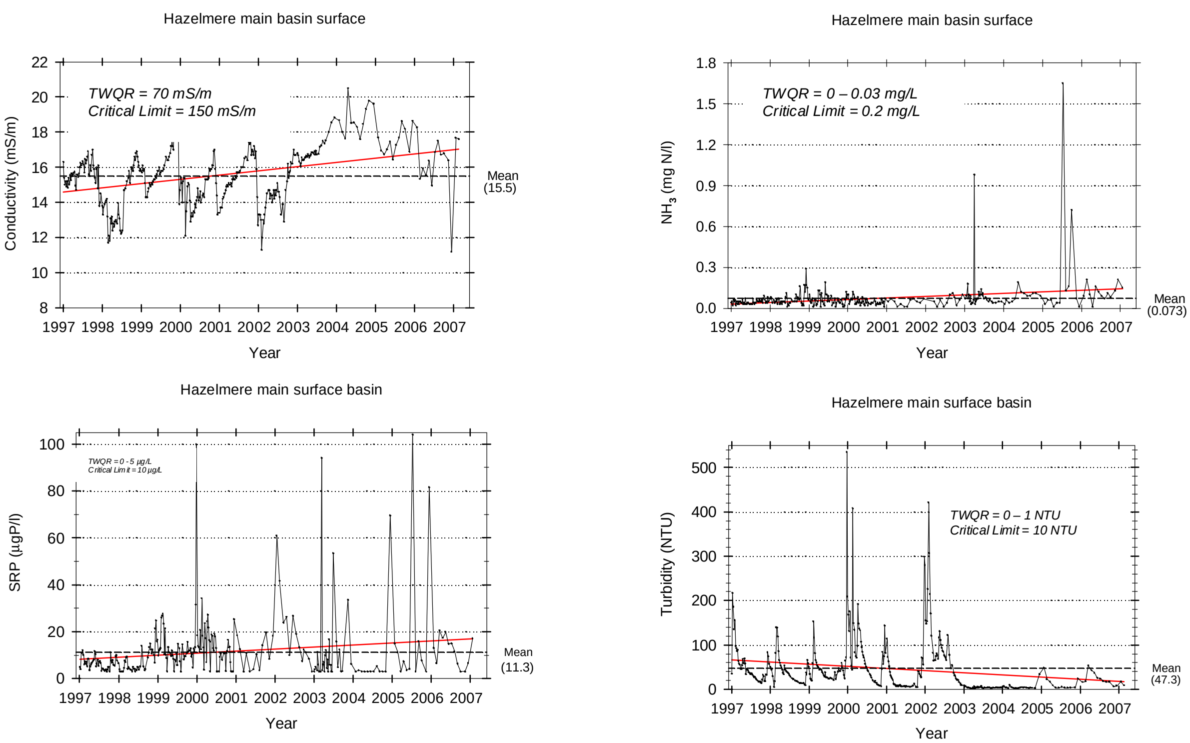


Figure 48: Variation in important variables in Hazelmere Dam during the ten years period (1997 – 2007)

9.4 MDLOTI HAZELMERE OUTFLOW (UW 99)

The water quality at the outflow was, as expected, very similar to the quality in the dam. It is only the ammonium concentration that was significantly higher (Figure 49), which indicates that the water was released from lower layers of the water column where higher ammonium concentrations accumulated because of decomposition.

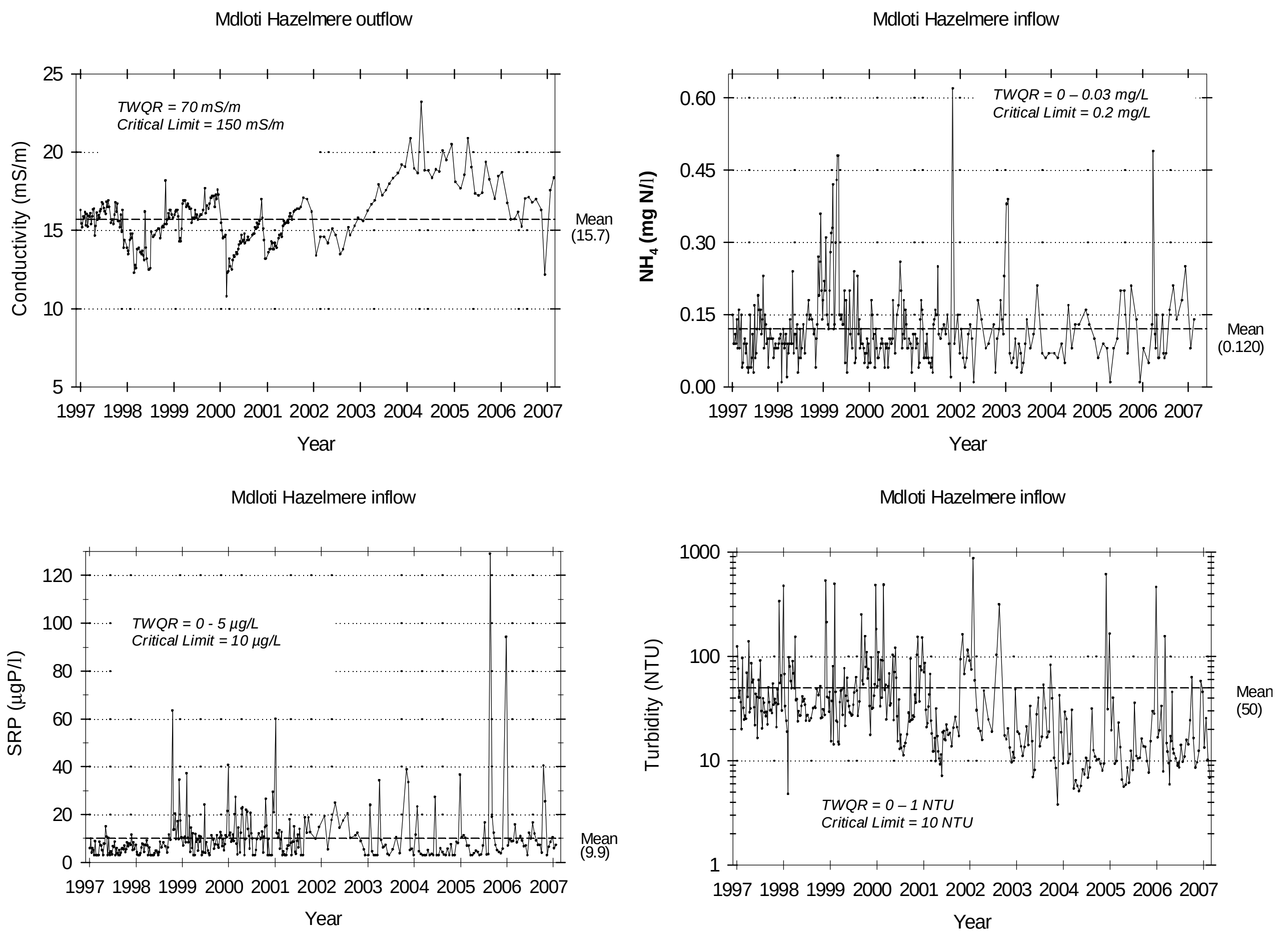


Figure 49: Variation in important variables in Hazelmere (Mdloti) during the ten years period (1997 – 2007)

9.5 WATER WEEDS IN THE TONGATI CATCHMENT

During a field visit to the area, we noticed a weir in the Wewe River totally covered with, *Pistia stratiotes* (water lettuce), a free floating, exotic species and declared weed (Figure 50). The excessive growth of water weeds has a significant impact on river health and reduces the benefits that people could derive from a healthier river ecosystem.

Van Wilgen *et al.* (2007) describe a method that will allow managers and policy makers to prioritize areas for action in terms of invasive alien plant clearing programmes. However, the most successful operations in the history of invasive alien plant control have been those that have targeted species rather than geographical areas. Successful alien plant control operations must be based on a sound understanding of the biology and ecology of the plants (Van Wilgen *et al.*, 2007).

Figure 50: Water lettuce (*Pistia stratiotes*) in the Wewe River (12/06/2007) – close-up on the right

10 MVOTI RESOURCE UNIT

10.1 INTRODUCTION

The Mvoti River is approximately 197 km long with a catchment area of 2730 km^2. This resource unit is the furthest north of all the resource units assessed in this study.

Sugar cane, forestry and banana plantations are the dominant agricultural activities. The town of Stanger falls in this resource unit. The Sappi Stanger pulp and paper mill and the Gledhow sugar mill are located in the lower reaches of the Mvoti River. The pulp and paper mill uses bagasse obtained from the sugar mill in the paper making process. The pulp and paper mill has a licence to discharge treated effluent into the Mvoti River.

The locations of the monitoring stations in the resource unit are shown in Figure 51.

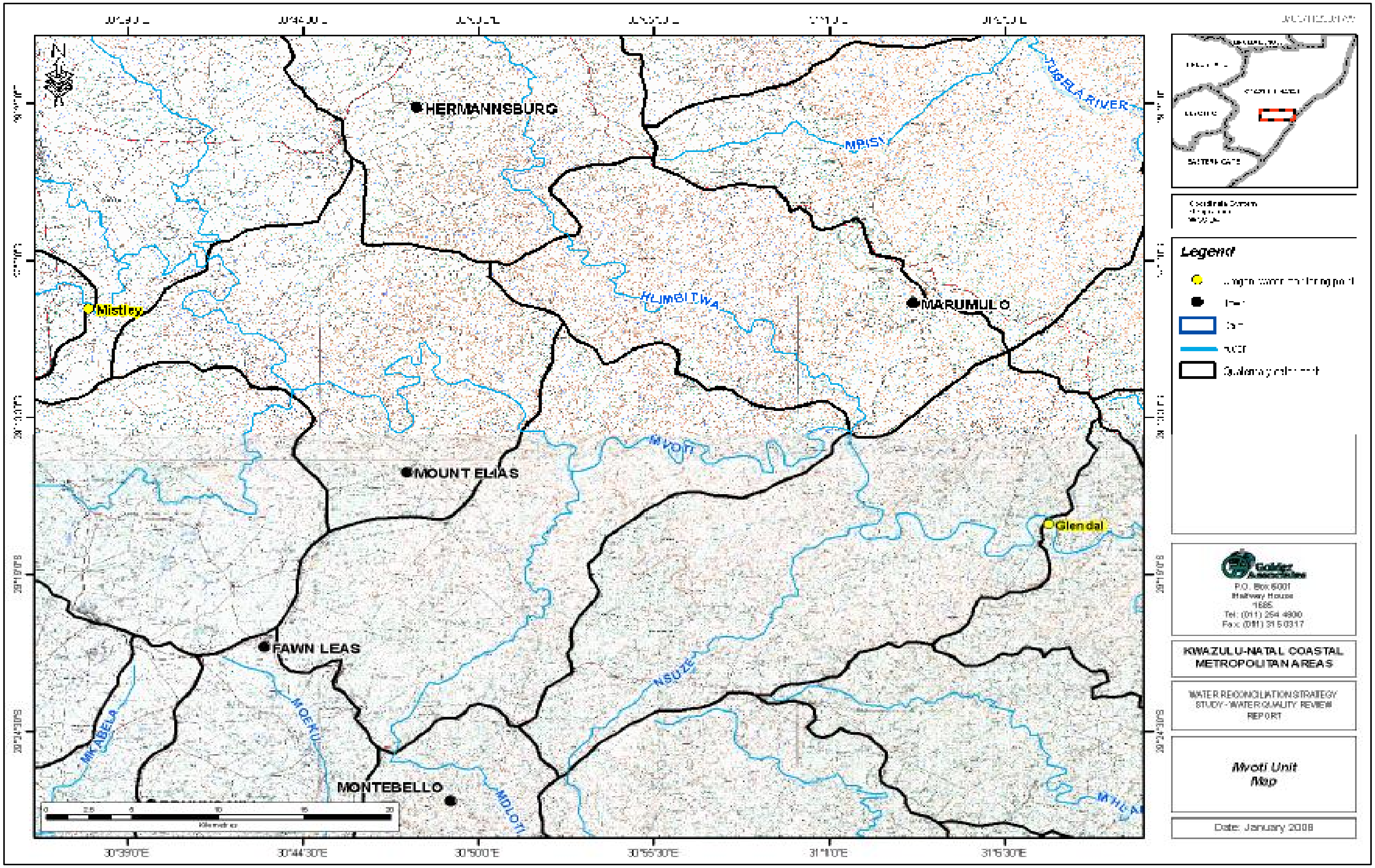


Figure 51 : Location of monitoring stations in the Mvoti Resource Unit

10.2 MVOTI RIVER AT MISTLEY

The upstream water quality of the Mvoti River has been good over the 10 year period analysed. The water has low conductivity, SRP and nitrates. Plots of the time series of concentrations for selected water quality variables are shown in Figure 52.

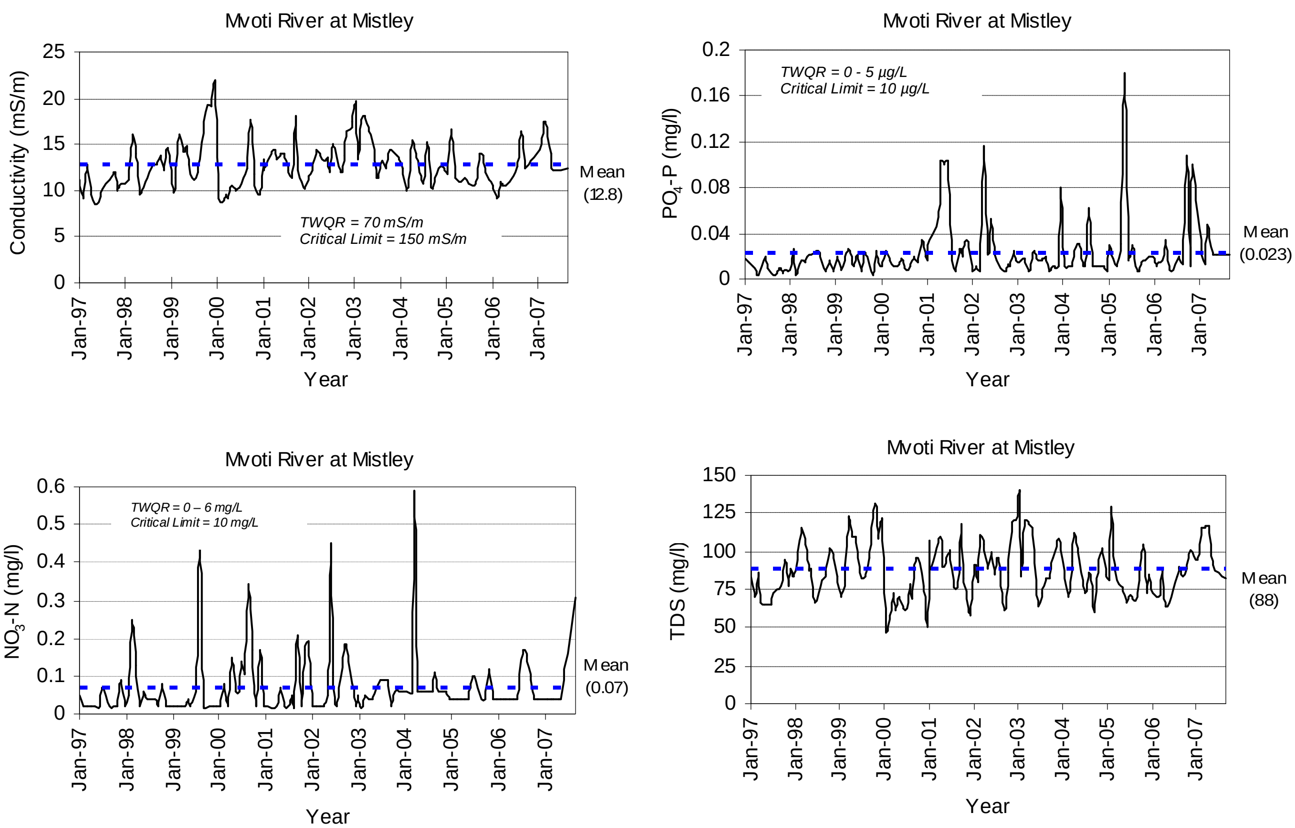


Figure 52 : Time Series plots of selected water quality variables measured at Mistley on the Mvoti River

10.3 CANAL FROM MVOTI AT HLANZANE/GLENDAL

The water quality as measured at the canal from the Mvoti River at Glendal is poorer that at Mistley. The conductivity (mean of 24.6 mS/m) and nutrient concentrations (mean SRP of 0.03 mg/L; mean nitrates 0.44 mg/L)) increased. The time series plots are shown in Figure 53.

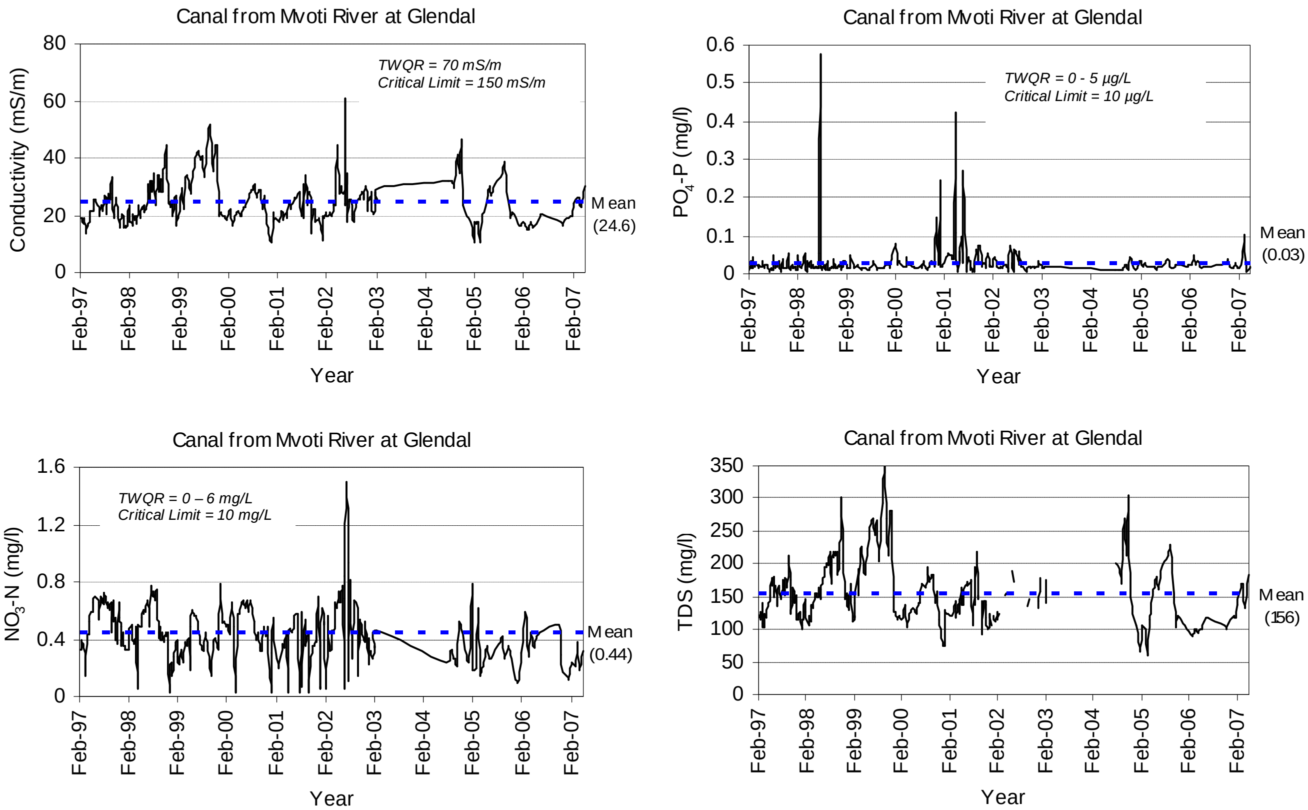


Figure 53 : Time Series plots of selected water quality variables measured at Glendal on the Mvoti River

10.4 CONCLUSIONS

The available data does show a deterioration in water quality further downstream on the Mvoti River due to runoff and return flows from agriculture, return flows from urban areas and industrial discharges. The water quality overall is still good when compared to the fitness for use water quality requirements.

11 MKOMAZI RESOURCE UNIT

11.1 INTRODUCTION

The Mkomazi River rises in the southern Drakensburg and flows in south easterly direction. It is approximately 298 km long with a catchment area of 4310 km^2. The majority of the catchment is comprised of bushland, grassland and forests. The commercial forests are located in the headwaters of the resource unit. There is very little urban development in the Mkomazi catchment and most of the development comprises residential and industrial development associated with the towns of Umkomaas on the coast and Ixopo and Richmond inland.

The locations of the water quality monitoring points in the Mkomazi Resource Unit are shown in Figure 54.

Figure 54 : Locations of water quality monitoring points in the Mkomazi Resource Unit

11.2 MKOMAZI RIVER AT CAMDEN

The time series plots of the nutrient concentrations and salinity as measured at Camden on the Mkomazi River are shown in Figure 55. The time series plots show that the TDS and SRP concentrations are low. There are also no visible trends in the water quality data at the monitoring station.

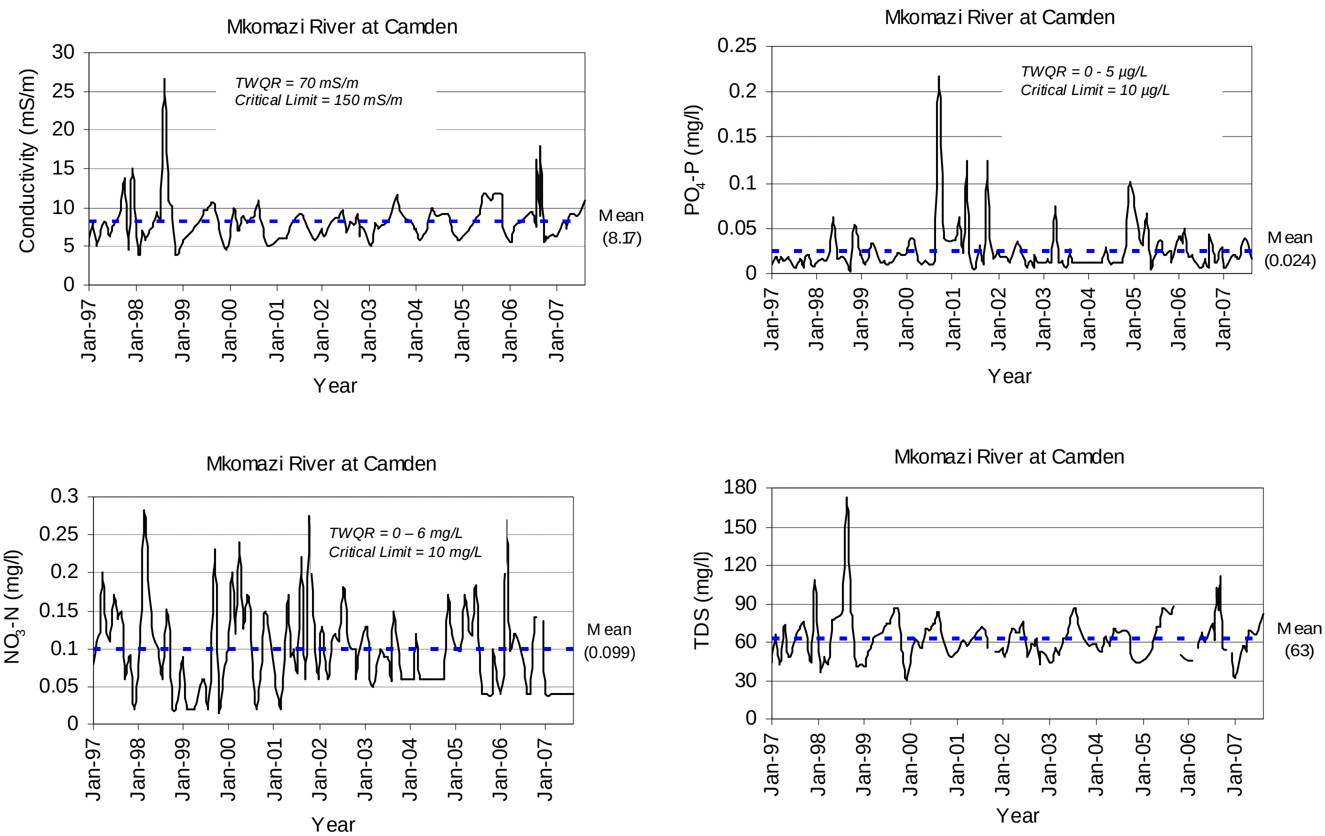


Figure 55 : Time series plots of selected variables measured at Camden

11.3 MKOMAZI RIVER AT SHOZI

The time series plot of the water quality data of selected water quality variables measured at this point are shown in Figure 56. Except for an unusually high SRP concentration during 2001, the water quality data plots show a stable water quality profile over time. The high SRP value at 1.5 mg/L is an outlier in the data set.

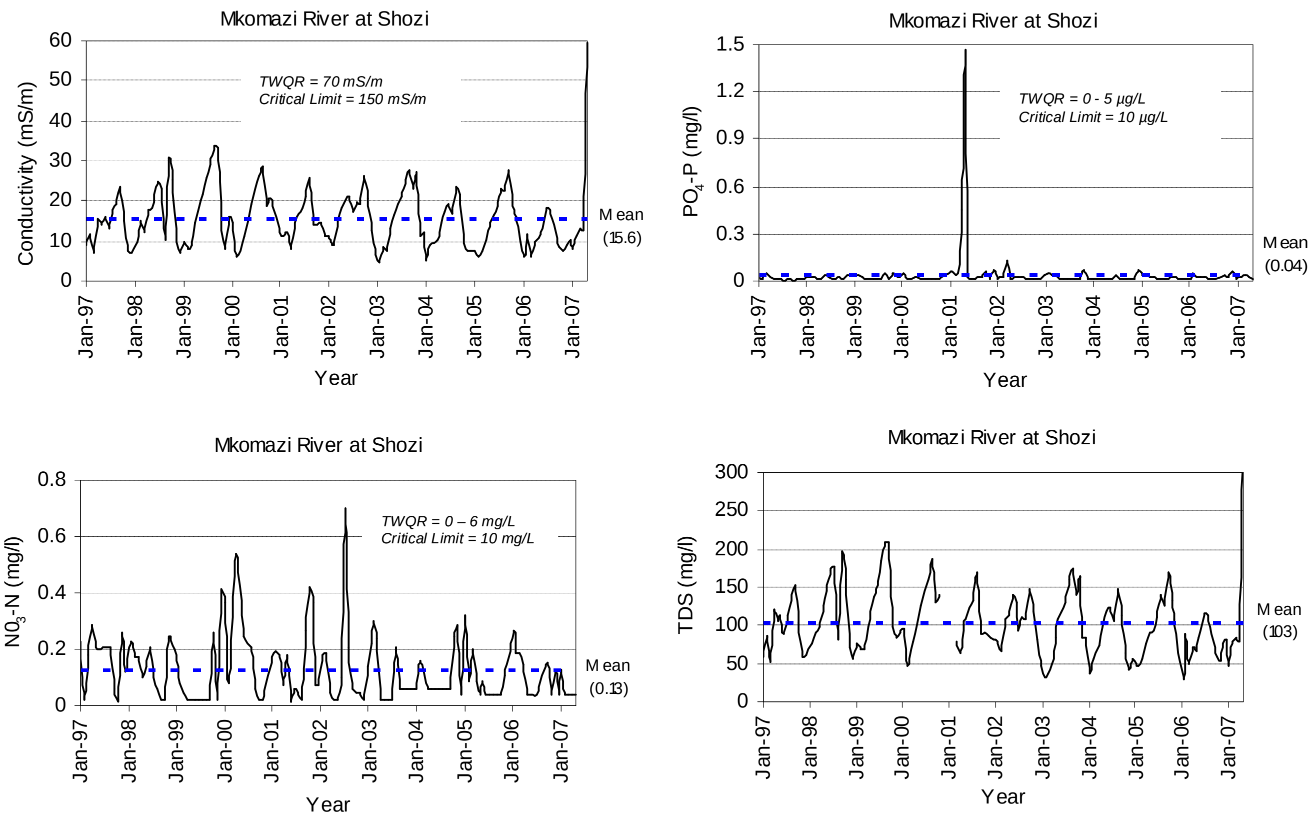


Figure 56 : Time series plots of selected water quality variables measured at Shozi on the Mkomazi River

12 CONCLUSIONS

The following conclusions can be made as a result of the water quality review:-

- The water quality in terms of salinity is good when compared to the guidelines. There is however a trend of increasing conductivity in the Msunduze and Inanda Dam. The spatial changes along the Mgeni Catchment are shown in Figure 57.
- The microbiological water quality is of concern exceeding the guidelines in a number of places. The spatial distribution in the Mgeni Catchment is shown in Figure 58. Of particular concern is the Msunduze Resource Unit. Standard water treatment processes can remove the risk opposed by microbiological pollution.
- The trophic status of the impoundments and rivers are currently oligotrophic to mesotrophic. Some hyacinth and blooms of blue-green algal were found in the major supply dams. If indirect re-use of treated sewage effluent is proposed as a reconciliation option, then the further removal of phosphorus will have to be undertaken before discharge to the

dams can be considered. The spatial variation of the SRP in the Mgeni Catchment is shown in Figure 59.

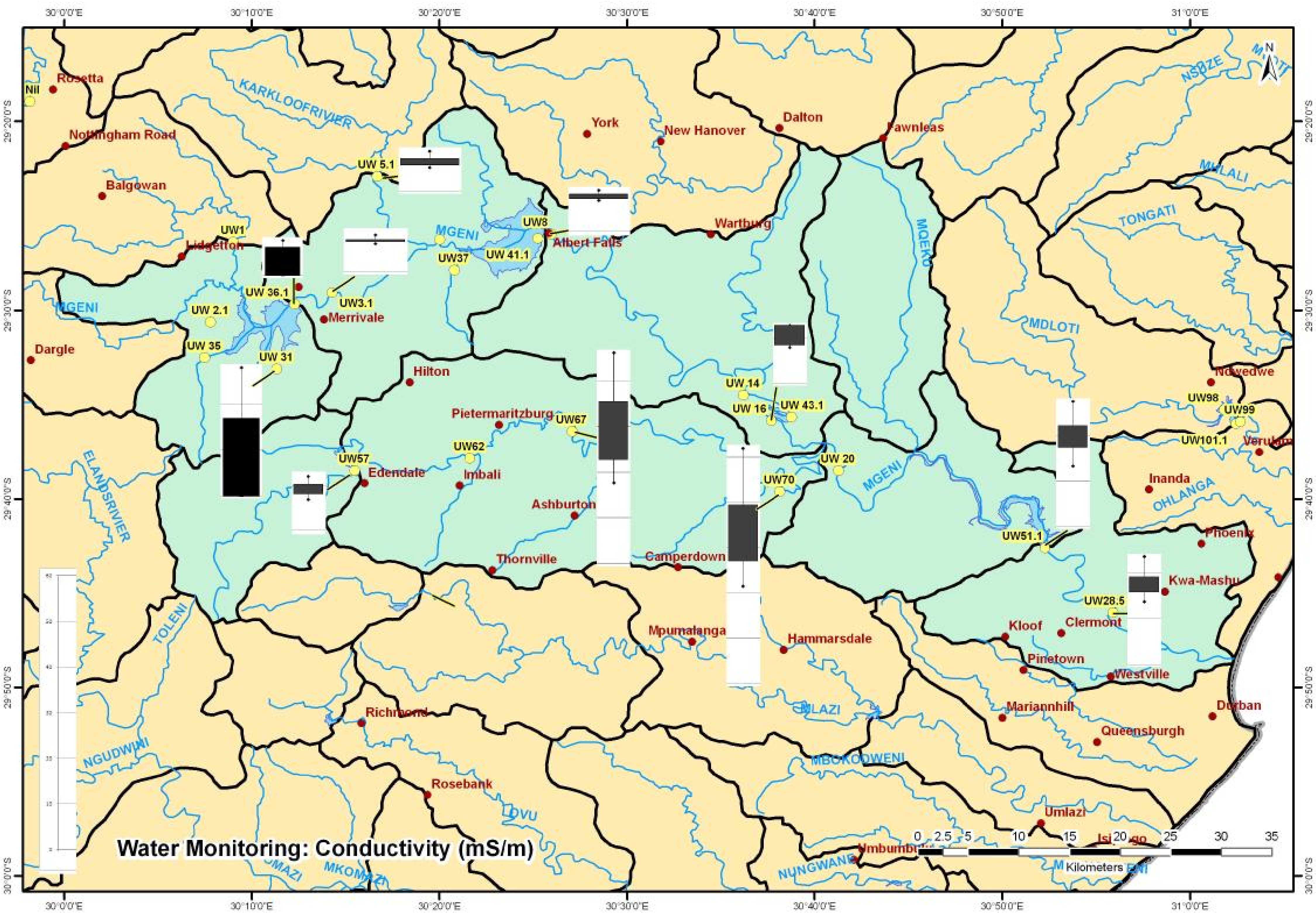


Figure 57: Water Monitoring: Conductivity

Figure 58: Water Monitoring: Ecoli

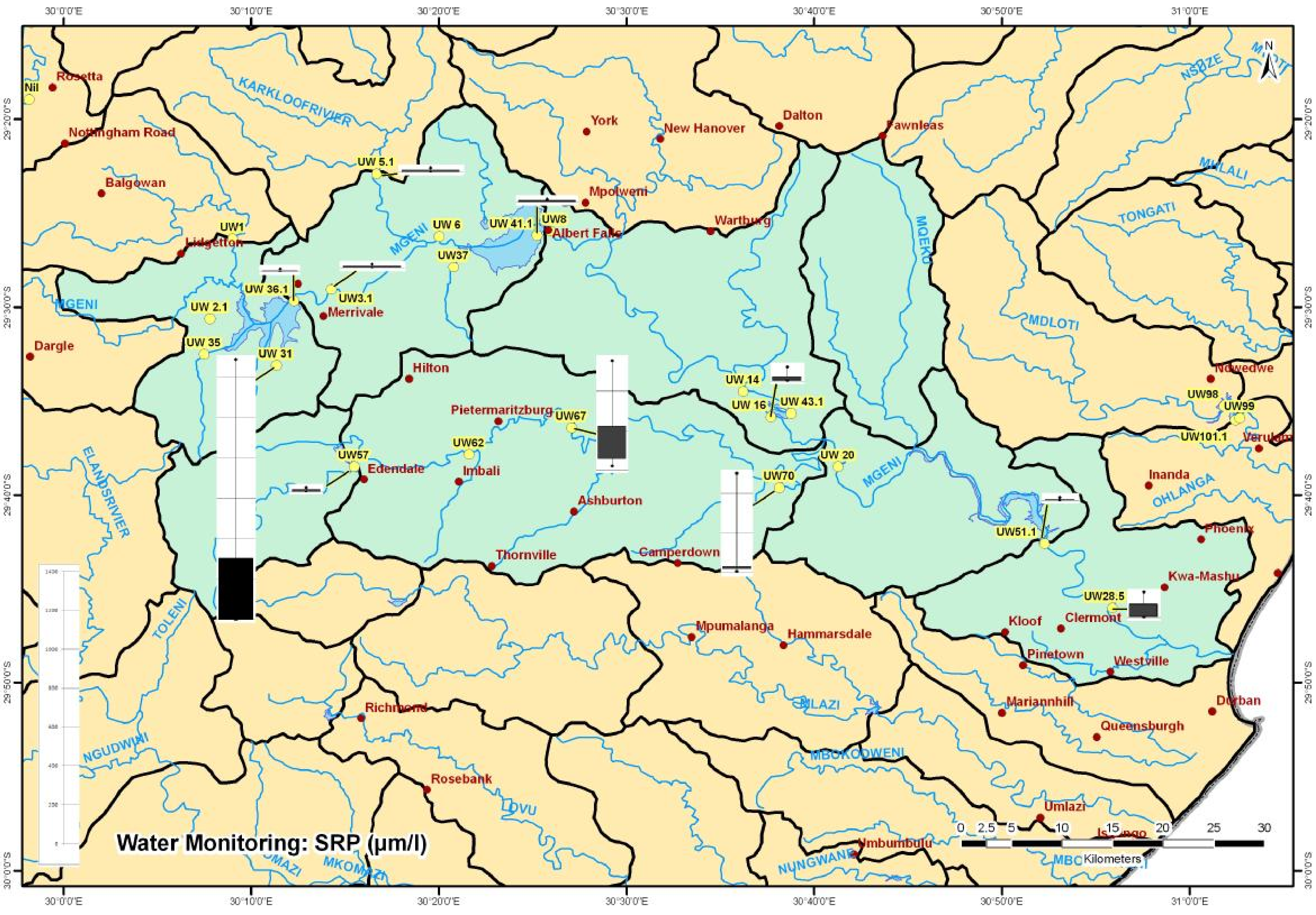


Figure 59: Water Monitoring: SRP

13 REFERENCES

Archibald, C.G.M., Warwick, R.J., Fowles, B.K., Muller, M.S. and Butler, A.C. (1980). Nagle Dam. In: Walmsley, R.D. & Butty, M. *The Limnology of some selected South African impoundments.* V&R Printing Works (Pty) Limited, Pretoria.

Archibald, C. (1996). Freshwater, Chapter 4 of the State of the Environment Report, Durban, South Africa.

DWAF (1994). Mgeni River System Analysis Study : Water quality study – Phase 1 water quality statement – Volume 1. DWAF Report no PB U000/00/0892, Report for DWAF done by BKS and Ninham Shand.

Garland, G. and Moleko, L. (2000). Geomorphological impacts of Inanda Dam on the Mgeni estuary, north of Durban, South Africa. *Bull Eng Geol Env.*, **59:** 119 – 126.

Jewitt, G.P.W. and Kotze, D.C. (1999). Wetland conservation and rehabilitation as components of integrated catchment management in the Mgeni Catchment, KwaZulu-Natal, South Africa. In: Ramsar (1999) Integrating wetland conservation and wise use into river basin management, Handbook 4. URL: http://www.ramsar.org/wurc/wurchbk4cs6.doc

Luger, M.K. and Brown, C. (2002). *The impact of treated sewage effluent on urban rivers – an ecological, social and economic perspective.* Paper presented at the Integrated Urban Water Management Symposium, University of the Western Cape, 2002, 9 pp.

NSoER (1999). National State of the Environment Report.

Ninham Shand, (1996). Mgeni Catchment Management Plan–Technical Report. Final Draft Report.

RHP (2002). South African River Health Programme. State of the Rivers Report – uMngeni River and Neighbouring Rivers and Streams. Electronic version available on Website: http://www.csir.co.za/rhp/state_of_rivers/umgeni_02.pdf.

Roos, J.C. and Pieterse, A.J.H. (1995). Salinity and dissolved substances in the Vaal River at Balkfontein, South Africa. *Hydrobiologia*, **306**: 41 – 51.

Todd, C. and Claasen, M. (2000). Strategic Assessment of the Baseline Environmental Context in Cato Manor: water resources. LEAD Programme in Technology for Enhanced Environmental Management. Durban, March, 2000.

Umgeni Water (2006). *Annual Report 2005/2006.* Electronic version of report available on Website: http://www.umgeni.co.za.

Van Wilgen, B.W., Nel, J.L. and Rouget, M. (2007). Invasive alien plants and South African rivers: a proposed approach to the prioritization of control operations. *Freshwater Biology,* **52:** 711 – 723.

APPENDIX A

Variable	Midmar Resource Unit - Percentiles																
	UW 36.1			UW 2.1			UW35			UW31			UW 1			Guidelines	
	5%	50%	95%	5%	50%	95%	5%	50%	95%	5%	50%	95%	5%	50%	95%	Target Range 1994 study	Target range from 1996 guidelines
Al (T) (ug/l)	17.3	91.2	287				43.5	91.4	365	72.6	94.1	234	82.8	167	356	-	10 – Aquatic 15 – Domestic
Alkalinity (mg CaCO3/l)	22.5	25.8	30.6	17.3	40	47	40.1	54.3	83.5	42.4	62.2	83.4	22.5	31.2	49.5		
Ca (mg/l)	4.02	4.52	5.23	3.19	6.51	7.6	7.30	9.6	12.7	10.3	13.9	19.6	4.2	5.23	6.89	10 - 50	0-32 Domestic Class 0 0-80 Domestic Class 1
Cl mg/l	3.98	4.55	5.23	2.24	3.77	5.39	5.79	7.69	10.9	12.7	18.3	30.4	4.09	5.19	6.92	0-50	0-20 Industry 0-100 Domestic Class 0
Conductivity (mS/m)	6.12	6.6	7.55	3.97	7.62	10.6	10.1	12.7	16.9	13.6	19.8	28	5.97	7.37	11.1	0-70	0-40 Irrigation salt sensitive crops 0-450 Domestic
E.coli (/100ml)	0	2	63.6	21.7	784.5	6300	54	380	2680	203	855	7850	111	410	5900	0 (1000)	130 for full contact recreation
F (ug/l)	100	100	100	50	100	100	76.6	102	126	50	50	77.45	50	100	100		
Fe (T) (mg/l)	0.08	0.22	0.658	0.15	0.808	2.84	0.37	0.62	1.205	0.43	0.86	1.464	0.36	0.7	1.405	0-0.1	0.1-Industry 0.5-Domestic Class 0
K (mg/l)	1.1	2.6	2.947	1	1.295	1.6	1	1.1	1.8	2.37	3.725	5.12	1.1	1.4	1.9		
Mg (mg/l)	2.36	2.6	2.947	1.6	3.1	3.9	4.11	5.6	7.29	5.66	6.93	7.95	2.42	3	3.9	0-20	0-70 Domestic Class 0 0-100 Domestic Class 1
Mn (T) (mg/l)	0.01	0.01	0.02	0.01	0.05	0.34	0.01	0.03	0.09	0.03	0.05	0.08	0.01	0.03	0.089	0-0.05	0.05-Industry 0.1-Domestic Class 0
NH3 (mg N/l) Ammonia / Ammonium	0.01	0.05	0.199	0.01	0.162	0.5	0.01	0.05	0.14	0.03	0.08	0.31	0.02	0.06	0.17	0-0.03	0.007 as NH3 as N-Aquatic 0.58 as NH4 as N-Aquatic

Variable	Midmar Resource Unit - Percentiles																
	UW 36.1			UW 2.1			UW35			UW31			UW 1			Guidelines	
Na (mg/l)	3.76	4.51	5.23	2.82	5.1	5.7	7.3	8.8	10.98	12.1	17.6	21.55	4.1	5	6.3	0-100	0-70 Irrigation 0-100 Domestic Class 0
SO4 (mg SO4/l)	1.432	1.77	2.136	0.62	1.58	2.66	1.29	2.13	3.69	3.88	5.38	9.31	1.01	1.41	2.04	0-200	0-30 Industry 0-200 Domestic Class 0
SRP (ugP/l)	3	3.78	11.16	3	13.64	64.8	3	10.2	176	134	463	1287	3	8.5	19.98	0-20 µg/L – River 0-5 µg/L – Impoundment	0-5 µg/L Oligotrophic 5-255 µg/L Mesotrophic
TDS (mg/l)	5.372	48.2	74.28	28.5	52.8	52.8	51	98	125.3	97.8	128.7	161.2	41.8	53.8	70	0-300	0-260 Irrigation salt sensitive crops 0-70 Domestic
TP (ug P/l)	15	17.8	62.18	15	73.08	794	15	41.8	299	259	745	2070	15.1	39.8	99.1	0-40 River 0-10 Impoundment	-
Turbidity (NTU)	1.668	4.82	16.4	1.7	30.27	251	6.77	19.85	57.48	8.48	26.7	121.5	3.5	13.5	58.12	0-1 (10)	0-0.1 Domestic Class 0 0-1.0 Domestic Class 1
pH	7.2	7.6	8.065	7.1	7.919	8.4	7.3	7.7	8.1	7.5	7.8	8.08	7.1	7.5	7.9	7-8	6.5-8.5
Chla (µg/l)	0.699	1.68	2.652													0-5	0-30

Variable	Albert Falls Resource Unit - Percentiles																			
	UW 3.1			UW 6			UW 41.1			UW 37			UW 5.1			UW 8			Guidelines	
	5%	50%	95%	5%	50%	95%	5%	50%	95%	5%	50%	95%	5%	50%	95%	5%	50%	95%	Target Range 1994 study	Target range from 1996 guidelines
Al (T) (ug/l)	43	114	290	32.7	114.5	310.3	27.8	71.9	295.4	38.1	112	371.1	34.9	110.5	296.3	31.7	101	311.5	-	10 – Aquatic 15 – Domestic
Alkalinity (mg CaCO3/l)	23.9	27.8	34.65	22	29.5	37.53	23.8	26.95	31.93	39.8	52.8	79.51	17.3	25.3	41.22	23.2	27.9	32.38		
Ca (mg/l)	4.37	5	6.22	4.1	5.5	6.86	4.2	4.65	5.78	6.77	8	12.21	3.29	4.4	6.1	43.1	5	6.37	10 - 50	0-32 Domestic Class 0 0-80 Domestic Class 1
Cl mg/l	4.44	5.07	6.32	4.78	6.07	7.66	5.35	6.14	7.21	10.6	11.4	16.58	3.95	4.8	6.384	5.41	6.06	7.256	0-50	0-20 Industry 0-100 Domestic Class 0
Conductivity (mS/m)	6.33	6.92	8.29	6.32	7.9	9.83	6.7	7.46	9.033	11.7	12.7	18.58	5.27	6.53	8.915	6.81	7.51	8.92	0-70	0-40 Irrigation salt sensitive crops 0-450 Domestic
E.coli (/100ml)	108	480	8800	49.2	190	1472	0	2	22	20	180	1360	44	326	1900	10	42	350	0 (1000)	130 for full contact recreation
F (ug/l)	57.7	100	104.5	100	100	100	100	100	114.4	68.1	100	202.6	50	100	100	100	100	105.4		
Fe (T) (mg/l)	0.27	0.55	1.25	0.29	0.52	1.02	0.06	0.11	0.29	0.29	0.42	0.831	0.49	0.74	1.17	0.16	0.45	2.182	0-0.1	0.1-Industry 0.5-Domestic Class 0
K (mg/l)	1.1	1.3	1.5	1	1.4	2.09	1.19	1.34	1.92	1	1	1.804	1	1	1.68	1.2	1.4	1.996		
Mg (mg/l)	2.4	2.7	3.2	2.47	3.24	3.81	1.74	2.92	3.548	4.93	5.8	8.81	2.01	2.8	4.36	2.7	3.08	3.806	0-20	0-70 Domestic Class 0 0-100 Domestic Class 1
Mn (T) (mg/l)	0.02	0.09	0.11	0.01	0.03	0.08	0.01	0.01	2.375	0.02	0.04	0.107	0.01	0.03	0.05	0.03	0.07	0.306	0-0.05	0.05-Industry 0.1-Domestic Class 0
NH3 (mg N/l)	0.01	0.05	0.19	0.01	0.05	0.13	0.01	0.06	0.162	0.01	0.04	0.07	0.01	0.05	0.17	0.02	0.06	0.2	0-0.03	0.007 as NH3 as N-Aquatic 0.58 as NH4 as N-Aquatic
Na (mg/l)	4.2	4.7	5.1	4.5	5.66	7.59	4.81	5.68	6.629	9.19	10.5	15.5	3.5	4.5	5.509	4.78	5.69	6.65	0-100	0-70 Irrigation 0-100 Domestic Class 0

Variable	Albert Falls Resource Unit - Percentiles																			
	UW 3.1			**UW 6**			**UW 41.1**			**UW 37**			**UW 5.1**			**UW 8**			**Guidelines**	
SO4 (mg SO4/l)	1.46	1.83	2.39	1.81	2.35	3.61	2.68	3.16	4.336	2.77	3.42	5.518	1.51	1.87	2.675	2.29	2.99	4.061	0-200	0-30 Industry 0-200 Domestic Class 0
SRP (ugP/l)	3	5.19	21.13	3	14.5	70.43	3	3.37	12.67	3	7.2	22.42	3	6.77	17.48	3	4.785	14.63	0-20 µg/L – River 0-5 µg/L – Impoundment	0-5 µg/L Oligotrophic 5-255 µg/L Mesotrophic
TDS (mg/l)	42.4	54.4	67.68	38.1	58	70.3	38.8	52.7	66.72	74.7	94.8	111	38.6	49.8	66.84	38	51	63.35	0-300	0-260 Irrigation salt sensitive crops 0-70 Domestic
TP (ug P/l)	15	27.45	71.25	19	46.6	127	15	18.6	65.28	15	23.25	76.65	15	32.4	90.22	15	27.05	72.89	0-40 River 0-10 Impoundment	-
Turbidity (NTU)	5.56	13.35	30.83	3.82	11.9	52.95	1.65	3.51	11.2	3.3	12.05	45.8	5.85	17.45	68.1	4.49	11.6	40.55		0-0.1 Domestic Class 0 0-1.0 Domestic Class 1
pH	7.1	7.5	8	7.1	7.5	8	7.1	7.6	8.1	7.3	7.6	8	6.77	7.4	7.9	7.1	7.5	7.9		6.5-8.5
Chla (µg/l)				0.67	0.67	0.67	0.97	2.63	4.286											0-30

Variable	Nagle Resource Unit - Percentiles										
	UW 14			UW 43.1			UW 16			Guidelines	
	5%	**50%**	**95%**	**5%**	**50%**	**95%**	**5%**	**50%**	**95%**	**Target Range 1994 study**	**Target range from 1996 guidelines**
Al (T) (ug/l)	35.76	121	359.4	18.76	69.15	287.55	28.08	114	344.8	-	10 – Aquatic 15 – Domestic
Alkalinity (mg CaCO3/l)	26.1	29.3	34.92	26.4	29.7	34.92	27.1	31.15	40.345		
Ca (mg/l)	4.565	5.105	6.445	4.8	5.47	6.298	4.924	5.875	7.8995	10 - 50	0-32 Domestic Class 0 0-80 Domestic Class 1
Cl mg/l	6.32	7.71	13.2	6.43	7.98	11.62	6.51	8.01	12.23	0-50	0-20 Industry 0-100 Domestic Class 0
Conductivity (mS/m)	7.743	8.77	11.73	7.782	8.94	11.656	8.05	9.27	13.0225	0-70	0-40 Irrigation salt sensitive crops 0-450 Domestic
E.coli (/100ml)	18	74	528	0	4	34.7	16	76	1004	0 (1000)	130 for full contact recreation
F (ug/l)	100	100	104.4	100	100	136.45	100	100	121.55		
Fe (T) (mg/l)	0.256	0.58	1.284	0.08	0.21	0.4545	0.24	0.5	1.243	0-0.1	0.1-Industry 0.5-Domestic Class 0
K (mg/l)	1.2	1.4	1.7	1.285	1.56	2.375	1.2	1.54	2.4095		
Mg (mg/l)	3	3.3	4.28	3.1	3.5	4.2775	3.2	3.7	5.152	0-20	0-70 Domestic Class 0 0-100 Domestic Class 1
Mn (T) (mg/l)	0.02	0.06	0.15	0.01	0.01	0.03	0.0295	0.06	0.21	0-0.05	0.05-Industry 0.1-Domestic Class 0
NH3 (mg N/l)	0.01	0.04	0.11	0.01	0.04	0.18	0.01	0.04	0.14	0-0.03	0.007 as NH3 as N-Aquatic 0.58 as NH4 as N-Aquatic
Na (mg/l)	5.788	6.6	9.7	5.778	7.055	8.7075	5.8	7.3	10.3995	0-100	0-70 Irrigation 0-100 Domestic Class 0
SO4 (mg SO4/l)	3.03	3.59	5.34	3.086	3.735	5.092	3.014	3.7	5.42	0-200	0-30 Industry

Variable	Nagle Resource Unit - Percentiles										
	UW 14			UW 43.1			UW 16			Guidelines	
											0-200 Domestic Class 0
SRP (ugP/l)	3	5.41	21.46	3	3.62	13.476	3	5.01	22.2	0-20 µg/L – River 0-5 µg/L – Impoundment	0-5 µg/L Oligotrophic 5-255 µg/L Mesotrophic
TDS (mg/l)	46.8	67	104.7	48.2	61	99	40.12	59.6	107.96	0-300	0-260 Irrigation salt sensitive crops 0-70 Domestic
TP (ug P/l)	15	28.15	86.66	15	19.25	83	15	30.2	124	0-40 River 0-10 Impoundment	-
Turbidity (NTU)	4.827	13.05	53.59	1.962	4.985	15.845	5.606	14	61.9		0-0.1 Domestic Class 0 0-1.0 Domestic Class 1
pH	7.4	7.8	8.2	7.3	7.7	8.575	7.5	8	8.4		6.5-8.5
Chla (µg/l)											0-30

Variable	Msunduze Resource Unit - Percentiles													
	UW 57			UW 62			UW 67			UW70			Guidelines	
	5%	50%	95%	5%	50%	95%	5%	50%	95%	5%	50%	95%	Target Range 1994 study	Target range from 1996 guidelines
Al (T) (ug/l)	50.9	210.5	966	44.95	192	1015	66.25	262	1049	35.52	194	1214	-	10 – Aquatic 15 – Domestic
Alkalinity (mg CaCO3/l)	20.8	31.95	50.25	28.94	44.05	65.9	38.82	58.8	87.3	48.2	70.4	99.33		
Ca (mg/l)	4.359	6	8.407	5.9	8.1	11.73	11.18	17	24.26	11.4	17	24	10 - 50	0-32 Domestic Class 0 0-80 Domestic Class 1
Cl mg/l	5.786	7.06	10.17	9.931	14.1	24.62	17.64	28.79	46.24	221	38	60.08	0-50	0-20 Industry 0-100 Domestic Class 0
Conductivity (mS/m)	7.023	9.01	12.23	10.4	13.75	20.93	17.72	28.9	46.19	21.6	33.2	52.02	0-70	0-40 Irrigation salt sensitive crops 0-450 Domestic
E.coli (/100ml)	80	480	4225	405	2800	27550	111.2	2200	51955	42	295	11125	0 (1000)	130 for full contact recreation
F (ug/l)	100	100	100	62.23	100	575.9	100	113	191.1	124	164	215		
Fe (T) (mg/l)	0.378	0.645	1.495	0.29	0.52	1.515	0.241	0.58	1.78	0.13	0.45	2.034	0-0.1	0.1-Industry 0.5-Domestic Class 0
K (mg/l)	1	1.09	1.784	1	1.2	1.53	1.9	3.6	5.664	2.2	3.1	6.2		
Mg (mg/l)	2.697	3.8	4.832	3.78	5.3	7.17	4.888	6	7.018	5.95	7.8	9.8	0-20	0-70 Domestic Class 0 0-100 Domestic Class 1
Mn (T) (mg/l)	0.01	0.025	0.1	0.02	0.05	0.17	0.07	0.11	0.2	0.01	0.06	0.258	0-0.05	0.05-Industry 0.1-Domestic Class 0

Variable	Msunduze Resource Unit - Percentiles													
	UW 57			UW 62			UW 67			UW70			Guidelines	
NH3 (mg N/l)	0.01	0.05	0.14	0.02	0.07	0.24	0.05	0.235	2.753	0.01	0.05	0.198	0-0.03	0.007 as NH3 as N-Aquatic 0.58 as NH4 as N-Aquatic
Na (mg/l)	5.383	7.17	9.1	8.48	12.1	17	16.75	32	56.83	19.7	33	60.85	0-100	0-70 Irrigation 0-100 Domestic Class 0
SO4 (mg SO4/l)	1.14	1.63	3.011	3.28	4.78	8.68	11.88	20.85	57.33	11.9	22.1	51.2	0-200	0-30 Industry 0-200 Domestic Class 0
SRP (ugP/l)	3	7.92	23.33	3	12.5	42.6	24.06	108	555	6.3	76	503	0-20 µg/L – River 0-5 µg/L – Impoundment	0-5 µg/L Oligotrophic 5-255 µg/L Mesotrophic
TDS (mg/l)	52.2	80.45	143.4	49.34	94.35	133.8	114.4	173.1	233.8	116	216	313.9	0-300	0-260 Irrigation salt sensitive crops 0-70 Domestic
TP (ug P/l)	15	39.6	164.2	16.63	54.4	213.4	82.6	226	899.6	39.2	169	850.4	0-40 River 0-10 Impoundment	-
Turbidity (NTU)	7.408	24.9	231.5	6.394	23.7	207	5.096	23.55	206.5	3.44	18.8	264	0-1 (10)	0-0.1 Domestic Class 0 0-1.0 Domestic Class 1
pH	7.1	7.6	8.1	7.2	7.7	8.34	7.235	7.7	8.1	7.5	8	8.6	7-8	6.5-8.5
Chla (µg/l)													0-5	0-30

Variable	Inanda Resource Unit - Percentiles										
	UW 20			UW 51.1			UW 28.5			Guidelines	
	5 %	50 %	95 %	5 %	50 %	95 %	5 %	50 %	95 %	Target Range 1994 study	Target range from 1996 guidelines
Al (T) (ug/l)	34.47	145.5	1077	13.9	75.3	275.1	34.6	141	320.9	-	10 – Aquatic 15 – Domestic
Alkalinity (mg CaCO3/l)	34.03	59.2	86.5	38	49.4	66.72	37.7	45.7	58.9		
Ca (mg/l)	7.28	15	21.7	8.1	11.6	14.8	7.96	8.8	11.92	10 - 50	0-32 Domestic Class 0 0-80 Domestic Class 1
Cl mg/l	11.43	31.73	51.48	14.5	23.2	33.6	15.9	22.1	28.32	0-50	0-20 Industry 0-100 Domestic Class 0
Conductivity (mS/m)	11.51	25.1	39.89	13.3	19.6	27.49	13.8	17.2	23.65	0-70	0-40 Irrigation salt sensitive crops 0-450 Domestic
E.coli (/100ml)	45.1	220	6645	0	2	68	61.2	315	3420	0 (1000)	130 for full contact recreation
F (ug/l)	100	159	235	103	171.5	218.7	90.6	134	158.6		
Fe (T) (mg/l)	0.14	0.445	1.427	0.02	0.1	0.46	0.22	0.495	0.998	0-0.1	0.1-Industry 0.5-Domestic Class 0
K (mg/l)	1.688	2.81	4.754	1.9	2.745	3.256	1.9	2.1	2.73		
Mg (mg/l)	4.41	6.95	8.84	4.7	6.225	7.433	4.7	5.4	6.836	0-20	0-70 Domestic Class 0 0-100 Domestic Class 1
Mn (T) (mg/l)	0.01	0.04	0.2	0.01	0.01	0.13	0.04	0.09	0.301	0-0.05	0.05-Industry 0.1-Domestic Class 0
NH3 (mg N/l)	0.01	0.04	0.148	0.01	0.04	0.14	0.02	0.07	0.236	0-0.03	0.007 as NH3 as N-Aquatic 0.58 as NH4 as N-Aquatic
Na (mg/l)	10.98	30	52	13.8	24	31.69	13.8	17	23.1	0-100	0-70 Irrigation 0-100 Domestic Class 0

Variable	Inanda Resource Unit - Percentiles										
	UW 20			UW 51.1			UW 28.5			Guidelines	
SO4 (mg SO4/l)	6.075	17	40.7	7.45	10.9	18.8	7.46	9.53	13.05	0-200	0-30 Industry 0-200 Domestic Class 0
SRP (ugP/l)	4.527	36	210.6	3	3.115	14.88	3	27.3	136.4	0-20 µg/L – River 0-5 µg/L – Impoundment	0-5 µg/L Oligotrophic 5-255 µg/L Mesotrophic
TDS (mg/l)	81.74	163	275	72	117.5	154.9	97.8	111.2	139.7	0-300	0-260 Irrigation salt sensitive crops 0-70 Domestic
TP (ug P/l)	22.72	93.4	437.3	15	15.6	53.02	16.1	67.3	222.1	0-40 River 0-10 Impoundment	-
Turbidity (NTU)	3.324	14.2	133.8	1	2.22	22.08	4.45	10.4	38.78	0-1 (10)	0-0.1 Domestic Class 0 0-1.0 Domestic Class 1
pH	7.435	8.1	8.7	7.4	7.9	8.7	7.35	7.7	7.9	7-8	6.5-8.5
Chla (µg/l)				4.9	5.29	5.668				0-5	0-30

Variable	Mooi Resource Unit - Percentiles										
	Spring Grove			Mearns			Mearns Dam			Guidelines	
	5 %	50 %	95 %	5 %	50 %	95 %	5 %	50 %	95 %	Target Range 1994 study	Target range from 1996 guidelines
Al (T) (ug/l)				47.3	168.5	357.5				-	10 – Aquatic 15 – Domestic
Alkalinity (mg CaCO3/l)				17	24.7	38.25					
Ca (mg/l)				3.4	4.5	6.1				10 - 50	0-32 Domestic Class 0 0-80 Domestic Class 1
Cl mg/l				1.76	2.93	4.83				0-50	0-20 Industry 0-100 Domestic Class 0
Conductivity (mS/m)	3.62	5.26	7.41	3.83	5.485	7.934	4.52	6.175	8.8	0-70	0-40 Irrigation salt sensitive crops 0-450 Domestic
E.coli (/100ml)	40.3	220	2367	38.2	200	1800	2.5	23	286.5	0 (1000)	130 for full contact recreation
F (ug/l)				78.4	100	100					
Fe (T) (mg/l)	0.31	0.52	1.17	0.41	0.75	1.22	0.32	0.72	1.18	0-0.1	0.1-Industry 0.5-Domestic Class 0
K (mg/l)				1	1	1.403					
Mg (mg/l)				1.5	2.32	3.01				0-20	0-70 Domestic Class 0 0-100 Domestic Class 1
Mn (T) (mg/l)	0.01	0.02	0.132	0.02	0.04	0.1	0.03	0.05	0.2	0-0.05	0.05-Industry 0.1-Domestic Class 0
NH3 (mg N/l)	0.01	0.04	0.14	0.06	0.05	0.154	0.04	0.09	0.199	0-0.03	0.007 as NH3 as N-Aquatic 0.58 as NH4 as N-Aquatic
Na (mg/l)				2.4	3.2	4.205				0-100	0-70 Irrigation 0-100 Domestic Class 0
SO4 (mg SO4/l)				0.46	0.8	1.639				0-200	0-30 Industry 0-200 Domestic Class 0

Variable	Mooi Resource Unit - Percentiles										
	Spring Grove			Mearns			Mearns Dam			Guidelines	
SRP (ugP/l)	3	6.1	14.62	3	6.95	17.55	3	7.03	29.97	0-20 µg/L – River 0-5 µg/L – Impoundment	0-5 µg/L Oligotrophic 5-255 µg/L Mesotrophic
TDS (mg/l)				32.2	47.45	57.97				0-300	0-260 Irrigation salt sensitive crops 0-70 Domestic
TP (ug P/l)	15	24.8	79.36	15	27.1	89.3	16	39	99.21	0-40 River 0-10 Impoundment	-
Turbidity (NTU)	3.423	8.02	56.43	4.52	9.92	51.18	1.51	4.12	22.24	0-1 (10)	0-0.1 Domestic Class 0 0-1.0 Domestic Class 1
pH	7.1	7.6	8.1	7	7.6	8	6.75	7.4	8.175	7-8	6.5-8.5
Chla (µg/l)				47.2	168.5	357.5				0-5	0-30

Variable	Mdloti Resource Unit - Percentiles										
	UW 98			UW 101.1			UW 99			Guidelines	
	5 %	50 %	95 %	5 %	50 %	95 %	5 %	50 %	95 %	Target Range 1994 study	Target range from 1996 guidelines
Al (T) (ug/l)	49.73	257	1194.1	103.7	253	831.5	97.49	275	1397.75	-	10 – Aquatic 15 – Domestic
Alkalinity (mg CaCO3/l)	25.58	40.85	56.575	26.49	37.6	48.63	27.3	38.175	52.325		
Ca (mg/l)	4.481	6.065	8.086	4.3	5.615	6.613	4.45	5.855	7.3725	10 - 50	0-32 Domestic Class 0 0-80 Domestic Class 1
Cl mg/l	20.43	24.6	30.385	19.769	24.05	27.521	19.767	23.7	27.4958	0-50	0-20 Industry 0-100 Domestic Class 0
Conductivity (mS/m)	12.86	16.2	20.3	12.88	15.6	18.206	13.185	15.705	18.779	0-70	0-40 Irrigation salt sensitive crops 0-450 Domestic
E.coli (/100ml)	20	445	3515	2	20	305	6	39	290.5	0 (1000)	130 for full contact recreation
F (ug/l)	100	140	191.95	100	142	207.4	100	150	212.25		
Fe (T) (mg/l)	0.798	1.21	2.09	0.226	0.98	1.904	0.581	1.12	2.269	0-0.1	0.1-Industry 0.5-Domestic Class 0
K (mg/l)	1.2	1.6	2.2	1.348	1.7	2.165	1.4	1.7	2.0475		
Mg (mg/l)	4.118	5.05	6.164	4.2	4.9	5.526	4.33	5	5.9575	0-20	0-70 Domestic Class 0 0-100 Domestic Class 1
Mn (T) (mg/l)	0.038	0.09	0.162	0.01	0.02	0.05	0.02	0.06	0.659	0-0.05	0.05-Industry 0.1-Domestic Class 0
NH3 (mg N/l)	0.04	0.1	0.26	0.0135	0.05	0.15	0.01	0.06	0.2655	0-0.03	0.007 as NH3 as N-Aquatic 0.58 as NH4 as N-Aquatic

Variable	Mdloti Resource Unit - Percentiles										
	UW 98			UW 101.1			UW 99			Guidelines	
Na (mg/l)	16	20	23.9	16	19	21.565	16	19	22.15	0-100	0-70 Irrigation 0-100 Domestic Class 0
SO4 (mg SO4/l)	2.76	4.19	7.09	3.842	4.825	7.214	3.672	5.1	7.08	0-200	0-30 Industry 0-200 Domestic Class 0
SRP (ugP/l)	3	7.245	25.005	3	8.1	26.62	3	8.74	23.67	0-20 µg/L – River 0-5 µg/L – Impoundment	0-5 µg/L Oligotrophic 5-255 µg/L Mesotrophic
TDS (mg/l)	88.04	110	153	91.535	127	162.19	82.35	128	197.95	0-300	0-260 Irrigation salt sensitive crops 0-70 Domestic
TP (ug P/l)	15	34.6	91.36	15	33	79.515	15	34.9	95.78	0-40 River 0-10 Impoundment	-
Turbidity (NTU)	7.907	28.25	152.7	3.2175	30.6	151.6	5.692	38	183	0-1 (10)	0-0.1 Domestic Class 0 0-1.0 Domestic Class 1
pH	7	7.5	7.975	7.1	7.6	8.1	7.2	7.7	8	7-8	6.5-8.5
Chla (µg/l)										0-5	0-30

	Mvoti Resource Unit							
Variable	**Mistley**			**Hlanzane/Glendal**			**Guidelines**	
	5%	**50%**	**95%**	**5%**	**50%**	**95%**	**Target Range 1994 study**	**Target range from 1996 guidelines**
Al (T) (ug/l)							-	10 – Aquatic 15 – Domestic
Alkalinity (mg CaCO3/l)	8.15	33	62.85	33	61	107		
Ca (mg/l)	4	6	15.8	6	10	17.5	10 - 50	0-32 Domestic Class 0 0-80 Domestic Class 1
Cl mg/l	4	7	13	15	27	63	0-50	0-20 Industry 0-100 Domestic Class 0
Conductivity (mS/m)	7.9	10.9	19.2	15.9	24	44.4	0-70	0-40 Irrigation salt sensitive crops 0-450 Domestic
E.coli (/100ml)							0 (1000)	130 for full contact recreation
F (ug/l)	100	100	200	200	200	400		
Fe (T) (mg/l)							0-0.1	0.1-Industry 0.5-Domestic Class 0
K (mg/l)	0.4	1.1	3.19	1.4	2	3.75		
Mg (mg/l)	3	4	7	4	6	11	0-20	0-70 Domestic Class 0 0-100 Domestic Class 1
Mn (T) (mg/l)							0-0.05	0.05-Industry 0.1-Domestic Class 0
NH3 (mg N/l)	0.02	0.02	0.09	0.02	0.02	0.08	0-0.03	0.007 as NH3 as N-Aquatic 0.58 as NH4 as N-Aquatic
Na (mg/l)	5	7	11.9	14	25	55	0-100	0-70 Irrigation 0-100 Domestic Class 0

	Mvoti Resource Unit							
Variable	**Mistley**			**Hlanzane/Glendal**			**Guidelines**	
SO4 (mg SO4/l)	2	6	49.9	5	10	19.55	0-200	0-30 Industry 0-200 Domestic Class 0
SRP (ugP/l)	0	15	60	10	19	60	0-20 µg/L – River 0-5 µg/L – Impoundment	0-5 µg/L Oligotrophic 5-255 µg/L Mesotrophic
TDS (mg/l)	53	77	129.8	101	152	293.7	0-300	0-260 Irrigation salt sensitive crops 0-70 Domestic
TP (ug P/l)							0-40 River 0-10 Impoundment	-
Turbidity (NTU)								0-0.1 Domestic Class 0 0-1.0 Domestic Class 1
pH	5.66	7.29	7.95	7.42	7.97	8.33		6.5-8.5
Chla (µg/l)								0-30

Variable	Mkomazi Resource Unit - Percentiles							
	Camden			Shozi			Guidelines	
	5%	50%	95%	5%	50%	95%	Target Range 1994 study	Target range from 1996 guidelines
Al (T) (ug/l)							-	10 – Aquatic 15 – Domestic
Alkalinity (mg CaCO3/l)	15	30	47	21.45	44	73.55		
Ca (mg/l)	3	6	10	4	9	17	10 - 50	0-32 Domestic Class 0 0-80 Domestic Class 1
Cl mg/l	2	4	7	4	14	38.6	0-50	0-20 Industry 0-100 Domestic Class 0
Conductivity (mS/m)	4.4	7.3	10.88	5	14.7	35.2	0-70	0-40 Irrigation salt sensitive crops 0-450 Domestic
E.coli (/100ml)							0 (1000)	130 for full contact recreation
F (ug/l)	100	100	200	100	100	300		
Fe (T) (mg/l)							0-0.1	0.1-Industry 0.5-Domestic Class 0
K (mg/l)	0.2	0.6	1.6	0.5	0.8	2.4		
Mg (mg/l)	1.5	3	4	2	5	9	0-20	0-70 Domestic Class 0 0-100 Domestic Class 1
Mn (T) (mg/l)							0-0.05	0.05-Industry 0.1-Domestic Class 0
NH3 (mg N/l)	0.02	0.04	0.11	0.02	0.02	0.11	0-0.03	0.007 as NH3 as N-Aquatic 0.58 as NH4 as N-Aquatic
Na (mg/l)	1	4	5.5	4	13	31	0-100	0-70 Irrigation 0-100 Domestic Class 0
SO4 (mg SO4/l)	2	2	10	2	8.5	20	0-200	0-30 Industry

Variable	Mkomazi Resource Unit - Percentiles							
	Camden			Shozi			Guidelines	
								0-200 Domestic Class 0
SRP (ugP/l)	0	0.01	0.07	0	0.02	0.07	0-20 µg/L – River 0-5 µg/L – Impoundment	0-5 µg/L Oligotrophic 5-255 µg/L Mesotrophic
TDS (mg/l)	35	57	87.9	47	104	204	0-300	0-260 Irrigation salt sensitive crops 0-70 Domestic
TP (ug P/l)							0-40 River 0-10 Impoundment	-
Turbidity (NTU)								0-0.1 Domestic Class 0 0-1.0 Domestic Class 1
pH	6.34	7.3	7.98	6.23	7.52	8.16		6.5-8.5
Chla (µg/l)								0-30

Umgeni & DWAF Sampling Stations				
Umgeni No.	**DWAF No.**	**Location (River)**	**KZN Data**	**KZN Data**
Midmar				
UW 1	U2H007	Mpofana/Lions	RLN001	Lions River at Weltevreden
UW 2.1	U2H013	Mgeni	RGM001	Mgeni at Petrus Stroom
UW 35	U2H046	Kwagqishi	RGD001	Gqishi Midmar inflow
UW 31	U2H044	Umthinzi on Midmar Dam	RMT006	Mthinzima Midmar outflow
UW 36.1	U2R00101	Midmar Dam	DMM001	Midmar main basin surface
Albert Falls				
UW 3.1	U2H048	Mgeni	RGM006	Mgeni at Howick
UW 6	U2H040	Mgeni	RGM008	Mgeni at Mortons Drift
UW 5.1	U2H006	Karkloof	RKKD02	Karkloof at Shafton
UW 37	U2H039	Doringspruit	RDR001	Doringspruit Albert Falls inflow
UW 41.1	U2R00301	Albert Falls Dam	DAF001	Albert Falls main basin surface
UW8	U2H014	Outflow Albert Falls Dam	RGM010	Mgeni Albert Falls outflow
Nagle				
UW 14	U2H005	Mgeni	RMG013	Mgeni weir u/s of Nagle Dam
UW 43.1	U2R00201	Nagle Dam	DNG002	Nagle main basin surface
UW 16	U2H043	Mgeni	RMG016	Mgeni weir d/s of Nagle dam
Msunduze				
UW57	U2H011	Msunduze	RMD003	Duzi Henley weir
UW62		Msunduze	RMD008	Duzi at Edendale weir bh Pris
UW67	U2H041	Msunduze	RMD019	Duzi at Motorcross
UW70	U2H022	Msunduze	RMD024	Duzi at Eddy Hagan Dr
Inanda Dam				

Umgeni & DWAF Sampling Stations				
Umgeni No.	**DWAF No.**	**Location (River)**	**KZN Data**	**KZN Data**
UW51.1	U2R00401	Mgeni	DIN001	Inanda surface 0.3km from wall
UW28.5		Mgeni	RMG024	Mgeni d/s Kwadabeka WWW
UW 20	U2H055	Mgeni	RMG017	New Inanda weir
Mooi				
		Mearns on Mooi	DMR001	Mearns Dam Surface
		Mooi	RMO001	Mooi river at Springgrove
		Mooi	RMO002	Mooi river at Mearns
Mdloti				
UW98	U3H003	Mdloti		Mdloti Hazelmere inflow
UW101.1	U3R00101	Mdloti		Hazelmere main basin
UW99	U3H005	Mdloti		Mdloti Hazelmere outflow
Mvoti				
	U4H002	Mvoti		Mvoti river at Mistley
	U4H008	Mvoti		Canal from Mvoti at Glendal
Mkomazi				
	U1H005	Mkomazi		Lot 931821 at Camden
	U1H006	Mkomazi		Shozi on Mkomazi