Annual Resource Quality Status Report

Inkomati-Usuthu Water Management Area
2022/23 Financial Year

VISION

Sufficient, equitable and quality water resources for all in the Inkomati-Usuthu Water Management Area

MISSION

To efficiently manage water resources by empowering our stakeholders in our quest to contribute towards transformation by promoting equal access to water and protecting the environment

VALUES

Integrity

Batho Pele (Stakeholders Orientation)

Accountability

Diversity

Transparency

SLOGAN:

“Inkomati-Usuthu CMA, your partner in water management”

ANNUAL RESOURCE QUALITY STATUS REPORT WITHIN INKOMATI-USUTHU WMA

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INKOMATI USUTHU CATCHMENT MANAGEMENT AGENCY (IUCMA)
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EXECUTIVE SUMMARY

Chapter 3 of the National Water Act (1998) prescribes the protection of water resources through resource-directed measures including the determination of the management classification, Resource Quality Objectives, and the Reserve of significant water resources. These are measures which together are intended to ensure the protection of the water resource whereas the Source Directed Control measures are intended to regulate and control the impacts of land-based activities by ensuring pollution prevention and remedying the effects of pollution on water resources. It is further required that the protection of water resources is balanced with the use of water as a factor of production to enable socio-economic growth and development.

Ecological Water Requirements (EWR) compliance for flow and water quality is always poor during dry seasons in river systems where riverflow levels are not supplemented by upstream dam release augmentations. During the 2022/23 financial year, the surface water quality in the Inkomati-Usuthu Water Management Area (WMA) complied with the Resource Quality Objectives (RQOs), South African Target Water Quality Guideline limits (SATWQG) and International Water Quality Guideline limits (IWQG) for most of the monitored points and this showed that the water quality within the WMA is in a relatively fair to good state. The challenges affecting water quality in the Inkomati-Usuthu WMA have always been mainly due to industrial and mining activities and the poor state of Water Services Authorities' sewage infrastructure. Pollution of the resource is caused due to sewage contamination (e.g., from overflows, spills and leakages or by discharge of untreated/partially treated sewage into the resource) and decanting of mining effluents or leachate as well as solid waste especially nappies.

The microbial pollution remains a human health risk, especially to the vulnerable rural communities that at times use the river water for domestic, religious, cultural, and recreational purposes. Deteriorating water quality on certain Ecological Water Requirements sites especially microbiological quality has largely been attributed to inadequate compliance, monitoring and enforcement, weak co-operative governance, absence of regulation and delays in the implementation of the waste discharge charge.

The overall integrated ecostatus for each of the four catchments within the WMA was calculated as category C, which is consistent with the integrated ecostatus calculated from previous results. This indicates that despite the site-specific issues, the overall biotic condition for each of the four catchments has remained constant at Category C (moderately modified), with loss and change of natural habitat and biota in terms of frequency of occurrence and abundance. The resilience of the system to recover from human impacts has not been lost and its ability to recover to a moderately modified state following disturbance has been maintained.

All biophysical nodes and components (water quantity, water quality and aquatic biota) within the integrated Units of Analysis (IUA) should comply with the set Targeted Ecologic al Category (TEC) in order to meet the management class. In this report only EWR sites were considered to ensure that the management class is met within the IUA. Assumption was made that if all components are met at an EWR site, then all biophysical nodes are met within the IUA.

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ACRONYMS AND ABBREVIATIONS

NWA	National Water Act, Act 36 of 1998
IUCMA	Inkomati-Usuthu Catchment Management Agency.
IUWMA	Inkomati-Usuthu Water Management Area
RQOs	Resource Quality Objectives
RSA	Republic of South Africa
RDM	Resource Directed Measures
DWS	Department of Water and Sanitation.
WWTWs	Wastewater Treatment Works.
CFU	Colony-forming unit.
E. coli	*Escherichia coli*.
KNP	Kruger National Park.
EWR	Ecological Water Requirements
CME	Compliance Monitoring and Enforcement
SANAS	South African National Accreditation System
SDC	Source Directed Control
U/S	Up Stream
D/S	Down Stream
EC	Electrical Conductivity
mS/m	Milli Siemens per meter
µS/cm	Micro Siemens per centimetre
mg/l	milli-grams per liter
TWQG	Target Water Quality Guide
WMA	Water Management Area
SATWQG	South African Target Water Quality Guidelines
IWQG	International Water Quality Guidelines
PO_4	Phosphate
NO_3+NO_2	Nitrates and nitrites
pH	Acid base relation
SO_4	Sulphate
Sal	Salinity
NH_3	Ammonia
FRAI	Fish Response Assessment Index
IHI	Index of Habitat Integrity
m.a.s.l.	metres above sea level
PES	Present Ecological State
MIRAI	Macro-invertebrate Response Assessment
MTPA	Mpumalanga Tourism and Parks Agency
PAI	Physico-chemical driver Assessment Index
PES	Present Ecological State
RC	Reference Condition
REC	Recommended Ecological Category

REMP	River Ecostatus Monitoring Programme
RHP	River Health Programme
RIVDINT	River Data Integration
REC	Recommended Ecological Category
REMP	River Ecostatus Monitoring Programme
SASS5	South African Scoring System, Version 5
SQR	Sub-quaternary Reach
TEC	Target Ecological Category
VEGRAI	Riparian Vegetation Response Assessment Index

CHAPTER 1 INTRODUCTION AND BACKGROUND

1.1 Introduction

The Inkomati-Usuthu Catchment Management Agency (IUCMA) is the responsible authority within the jurisdiction of the Inkomati-Usuthu Water Management Area (WMA). The WMA is in the eastern part of the country and falls wholly within the Mpumalanga Provincial boundary depicted in Figure 1 below as WMA three (3) of the nine (9) demarcated WMAs. The Inkomati-Usuthu WMA comprises of four catchments namely Sabie Sand, Crocodile, Komati and Usuthu and is also part of two international basins called the Incomati River Basin and Maputo River Basin. The water resources in the area are strategically important for international obligations as well as inter-basin transfers for power generation. As an authority, the IUCMA is responsible for managing, controlling, protecting, and monitoring water resources in its area of responsibility.

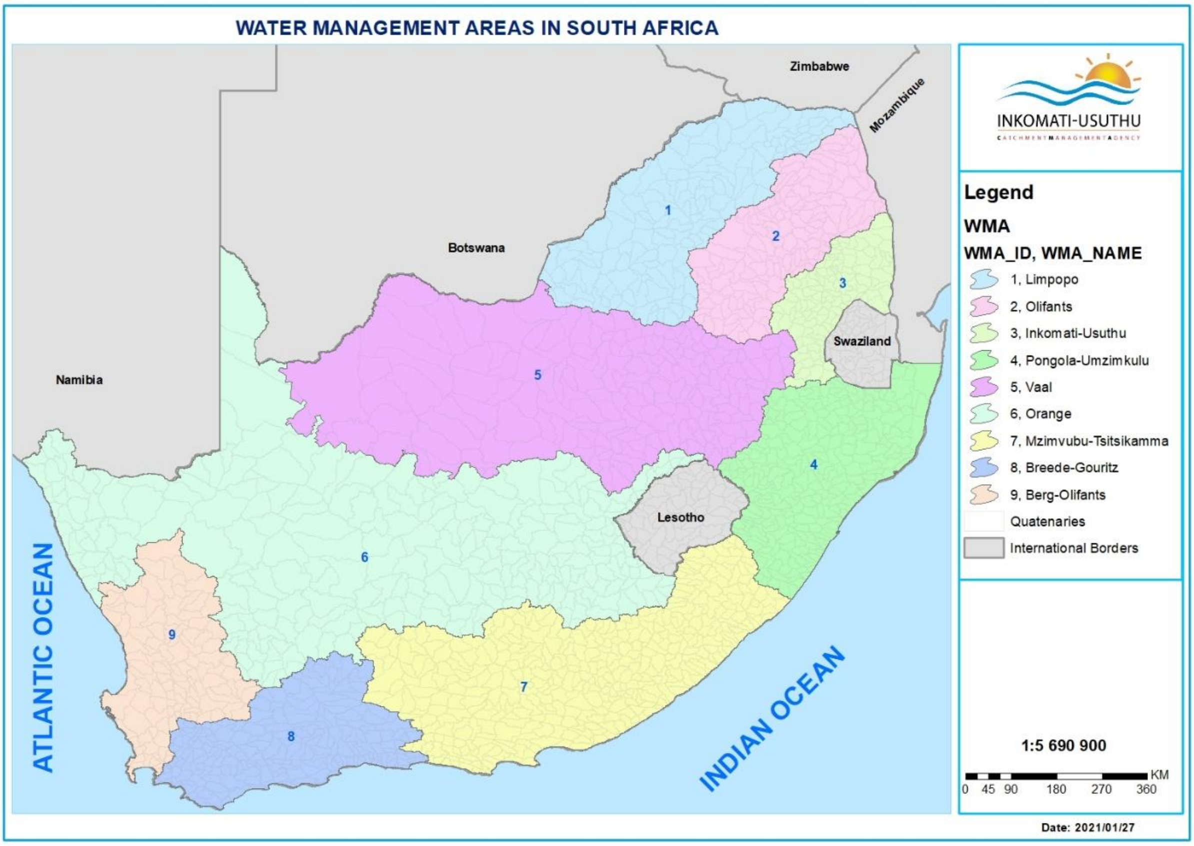


Figure 1: Map of South Africa indicating the nine WMAs.

1.2 Background

The National Water Act, Act 36 of 1998 (NWA) of South Africa Chapter 14 requires the Minister to establish national monitoring systems for the collection of appropriate data and information that is adequate and responsive to the present and future challenges of efficient management of the country's water resources. The Inkomati-Usuthu Catchment Management Agency (IUCMA) conducts resource quality monitoring in the Inkomati-Usuthu WMA which feeds into the national monitoring system.

The WMA is marked with seasonality of rainfall with wet summers and dry winters. This is also variable over longer periods with changes in rainfall seen from year to year and longer time scales. Most of the water demand is in the lower, drier, and hotter parts of the WMA where there is little rainfall and runoff. These factors create complexity and an unstable situation for the economy of the region, which is reliant on the availability of water and makes the proper management of the river flows very important. To adequately manage the high variable rainfall and scarce water resource in the WMA, the IUCMA has installed 25 near real-time rainfall gauges and 31 river flow gauges.

Water quality is vital as it determines fitness for use, the protection of the health and integrity of aquatic ecosystems and is described as chemical, physical, and biological characteristics of water (DWS, 1996). Surface water quality within the Inkomati-Usuthu WMA is measured by means of physio-chemical, microbiological and eutrophication monitoring programme(s) conducted monthly through grab sampling, field measurements and continuous monitoring technique(s) respectively. The samples are then submitted to a South African National Accreditation System (SANAS) accredited laboratory for analysis. The variables of concern differ from catchment to catchment and are based on the types of activities occurring within a specific catchment. Eutrophication monitoring is conducted only in major dams within the WMA through National Eutrophication Monitoring Programme (NEMP). Eutrophication is the process of excessive nutrient enrichment of waters that typically results in problems associated with macrophyte, algal or cyanobacterial growth.

The health of the aquatic ecosystem is monitored through a programme called the River Eco-status Monitoring Programme (REMP). Approaches to water resource management that focus mainly on quantity and quality of the resource and do not consider aspects such as aquatic habitats and ecological integrity are not adequate to protect and maintain the aquatic ecosystems. The REMP complements the surface water chemical and bacteriological monitoring program and provides the state of the river's ecology, considering the various indices used to measure the community attributes of fish, aquatic invertebrates and riparian vegetation and their response to changes in water quality and flow.

Water quality is linked with water quantity, instream and riparian habitat and aquatic biota integrity, which are collectively referred to as “resource quality” in terms of the NWA. Resource quality needs to be maintained within certain pre-determined parameters to enable continuous sustainable economic growth and social development. The pre-determined parameters are Resource Directed Measures (RDMs) represented by the Resource Management Class, Resources Quality Objectives (RQOs) and the Reserve.

The RDMs have been determined and gazetted for the Crocodile, Sabie-Sand and Komati catchments within the Inkomati-Usuthu WMA, except for the Usuthu catchment. The comprehensive ecological Reserve determination study was completed in February 2006; however, it was gazetted into law only in July 2019 through government notice No. 998. The classification and setting of the RQOs studies were completed in April 2015 and gazetted into law in December 2016 by government notice No. 1616. The resource quality status and compliance within the WMA was evaluated against RQOs and where not available the Target Water Quality Guideline limits (TWQG) were used. RQOs are intended to give effect to the management class and the ecological needs determined in the reserve to assist resource managers in the protection of the resource.

The major watercourses within the Inkomati-Usuthu WMA form part of the Incomati and Maputo River Basins. Water quantity and quality conditions of the ten (10) major watercourses within Inkomati-Usuthu WMA were assessed as part of information and data sharing in terms of Interim Inco-Maputo Basin Agreement (IIMA) for co-operation on the protection and sustainable utilisation of these shared watercourses. Water quantity and quality compliance status of international obligation sites were evaluated against the water quality guidelines resolution of the Tripartite Permanent Technical Committee (TPTC) on exchange of information and water quality.

The purpose of the report is to report on the resource quality status, trends and compliance with the set standards/objectives in the water resource, in a manner that supports balanced decision making and planning to support sustainable development within the Inkomati Usuthu WMA.

1.3 Objectives

- To provide information on the status and trends in terms surface water resources quantity (River levels and Dams) within the Inkomati Usuthu WMA.
- To provide information on the status and trends in terms of the physio-chemical and microbial quality of surface water resources within the Inkomati Usuthu WMA.
- To provide information on the trophic status of major dams within the Inkomati Usuthu Water Management Area.
- To determine the present ecological status (PES) of the rivers within the Inkomati Usuthu WMA by using biological indicators (i.e., macro-invertebrates, fish, and riparian vegetation) and Eco status Models.
- To determine compliance status of applicable variables at Ecological Water Requirements (EWR) sites and water quality priority Resource Units (RU) with Resource Quality Objectives (RQOs).
- To determine compliance to the Target Ecological Category (TEC) for water quantity, water quality and aquatic Biota at Ecological Water Requirements (EWR) sites within the Inkomati River basin, and
- To determine water quantity and quality compliance status at International Obligation sites with the set limits in terms of the Interim Inco-Maputo Agreement (IIMA, 2002).

CHAPTER 2 METHODOLOGY

2.1 Study Area

The resource quality monitoring takes place within the jurisdiction of the Inkomati-Usuthu WMA (IUWMA) which comprises of Sabie/Sand, Crocodile, Komati and Usuthu Catchments as illustrated in Figure 2 below. The IUWMA is situated in the north-eastern part of South Africa in the Mpumalanga Province, borders on Mozambique in the east and on eSwatini in the south-east. The WMA extends over several parallel river catchments that drain in a general easterly direction, and flow together at the border with Mozambique or within Mozambique, to form the Incomati River which discharges into the Indian Ocean immediately North of Maputo at Villa Laisa. The Usuthu River confluences with the Pongola River to form the Maputo River which discharges into the Indian Ocean south of Maputo and is called the Maputo basin.

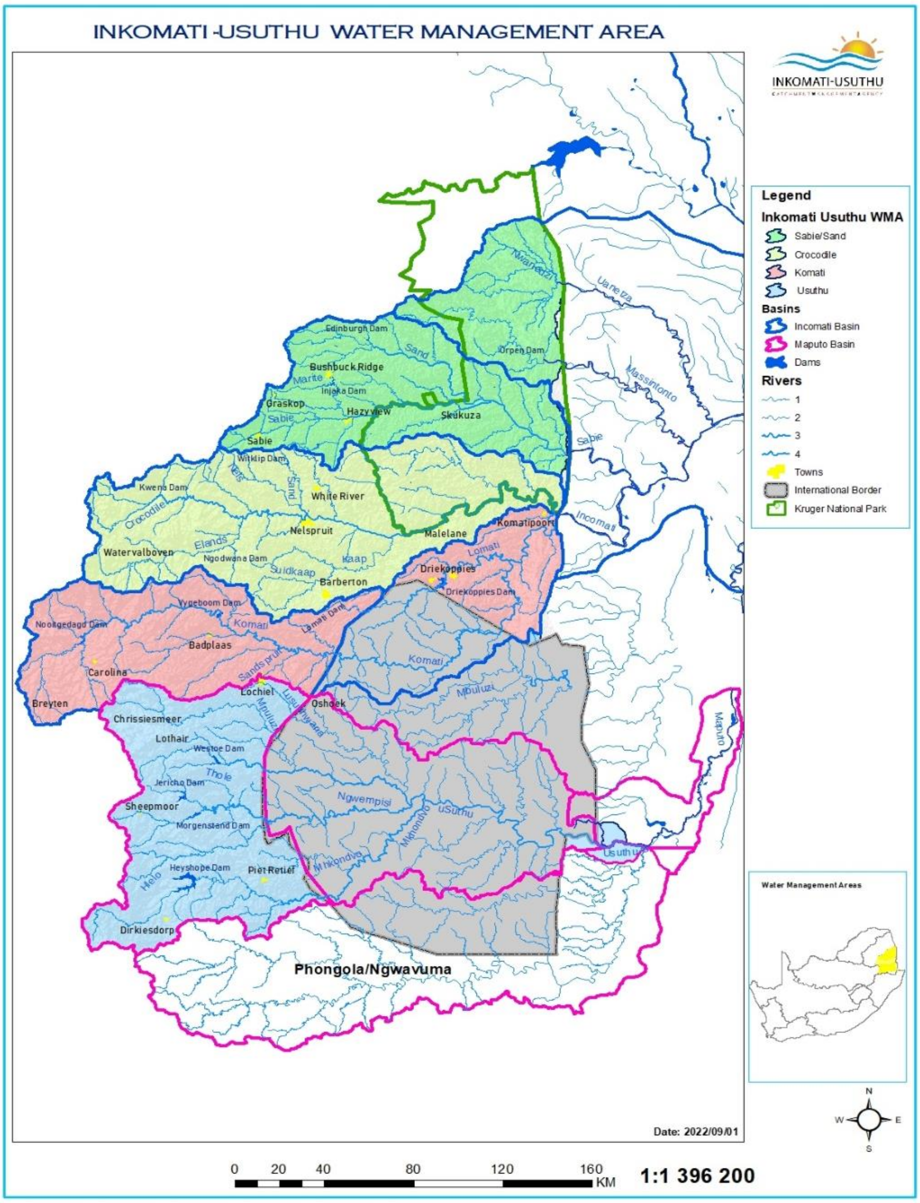


Figure 2: Inkomati-Usuthu Water Management Area.

2.2 Materials and Methods

3.2.1. Water Quantity

The water monitoring networks support a wide range of values and uses within the WMA. These entail the use of water from the rivers, streams, and dams for ensuring that the Reserve (Ecological and Basic Human Needs), International Obligations, strategic use (transfers out of the catchments) is guaranteed. The Inkomati Usuthu CMA monitoring network includes **31** riverflow gauging stations and **25** rainfall stations.

2.2.1.1. Rainfall

The rainfall gauges are automatic tipping buckets that transmit real time precipitation data. The rainfall gauge works by funnelling collected rain to land on the pivot-point of a two-sided "bucket." When one side fills, it pivots down - causing the "bucket-tip" to be recorded, emptying the bucket and bringing the empty side under the collection point. Each bucket - tip occurs when 0.2 mm of rain has been collected.

The IUCMA has two types of rainfall stations: 18 iMETOS eco d2 rain gauges supplied by iMetos-Pessl Instruments, and 7 Adcon's RG1 rain gauges. The iMETOS rain gauge measure rainfall permanently by iMetos ® rain and sent to the internet climate data base of Pessl Instruments GmbH.

The Adcon's RG1 rain gauge measures rainfall using sensors. Each tipping action triggers a pulse of a debounced reed switch with a lifetime of 1 million pulses. The body of the rain gauge, the funnel and the protective filter are made of aluminium, with a precision tipping bucket of plastic.

2.2.1.2. Riverflows

All the riverflow stations are real-time. Continuous flow monitoring involves using electronic equipment to measure and record the riverflow level. A programmable data logger operates a pressure sensor, measure the river level. The data logger is used to convert the pressure to recorded level values, which are recorded at set time intervals. Through ZEDNET software the water levels are converted to discharges and both the levels and discharges are published on ZEDNET and RiverOpWebsite (http://riverops.inkomaticma.co.za/).

The data loggers (Cello) are fully integrated with wireless using GSM (SMS/GPRS) for both network and environmental monitoring, having sophisticated profile alarm dial out regimes. Cello has a variation of inputs such as pressure & flow variations, universal eight channel recorder, offering optional dual 4-20mA self-powered version for remote level monitoring.

2.2.1.3. Dam Levels

The IUCMA does not have instrumentation installed in the dams located within the Inkomati Usuthu WMA. The IUCMA relies on the DWS data for dam monitoring, and uses the data provided by DWS to manage and implement operating rules for dams within Inkomati Usuthu WMA.

3.2.2. Water Quality

2.2.2.1. Grab sampling.

Monthly physio-chemical and microbiological samples were taken using the grab sample technique. Sampling bottles were marked with the site code, date and time of collection using a permanent marker. Some of the samples were taken on bridges using a bucket and bailer. The bucket was rinsed before collecting the sample and filling the sampling bottles.

One (1) litre physio-chemical sample bottles were rinsed three times before they were filled. The 300ml microbial sample collecting bottles were not rinsed since they were sterilized, ample air space was left in the sample bottle to facilitate mixing by shaking.

Both physio-chemical and microbial water quality samples were stored in two separate cooler boxes and preserved with ice packs or cubes. The samples were then submitted to a SANAS accredited laboratory for analysis and microbiological samples were delivered within 12 hours to the Laboratory.

Figure 3: Water quality samples taken at Komati River using the bailer and the bucket.

Figure 4: IUCMA official taking water quality chemical sample at tributary of Seekoeispruit.

2.2.2.2. Continuous monitoring

Five water quality probes are installed within the WMA for continuous water quality monitoring. The parameters measured in continuous monitoring stations are actual conductivity (µS/cm), temperature (˚C) and salinity (PSU) after every 3 hours. Actual conductivity data is transmitted to Zednet via network and other variables are downloaded through Win-Situ software.

Figure 5: IUCMA official downloading data from probe trough Win-Situ software.

2.2.2.3. Field measurements

These comprise measurements that are taken and recorded on site such as temperature and Dissolved Oxygen measured on a monthly basis. Field measurements were taken on 23 Ecological Water Requirements sites and 10 international Obligation site(s) using the handheld EcoSense DO200A Dissolved Oxygen Meter.

2.2.2.4. Eutrophication monitoring

Sampling protocol for eutrophication monitoring dated November 2004 was used for NEMP of major Dams within the WMA.

Macro samples were taken by decanting water from the integrated sample or subsurface grab sample into the blue-top bottle washed with phosphate free soap and the samples were stored in cooler box with ice cubes.

Figure 6: Filling of Macro sample.

Samples for **identification of algae** were taken by decanting water from the integrated sample or subsurface grab sample into a small glass bottle with 2-4 drops of lugol preservative.

Figure 7: Filling of Algae identification sample.

The **chlorophyll-a** samples were conducted using a filter unit, by unscrewing the top of the rinsed filter and carefully placing the filter paper inside the unit and screwing the top back. 250ml of the water from the integrated sample or subsurface grab sample was poured into the unit and water was drawn through the filter using a vacuum pump up to 500ml if possible. The total amount of water filtered was recorded. The filter was then opened gently, then the filter paper was carefully lifted and stored into a glass tube with ethanol.

Total suspended solids samples were taken using the same method as conducted for the Chlorophyll-a samples, but a weighed filter paper marked with a black dot was used and then stored in a petri dish.

Figure 8: Filtration of Suspended solids or chlorophyll-a sample(s).

All samples were clearly marked on a tag with the sample description, date, time, dam ID code, name of the resource and volume filtered. The samples were stored in a dark container. The samples and onsite monitoring report sheets were then submitted to the Department of Water and Sanitation laboratory at Resource Quality Information Services (RQIS) for analysis.

Figure 9: Clearly marked samples for Eutrophication taken at Injaka Dam.

<u>The following onsite visual monitoring and measurements were conducted:</u>

- Estimated visual area on the total surface area covered by algal blooms or invasive water plants.
- Other observation potentially related to eutrophication i.e., Odour problems, fish kill, wind speed and direction.
- The secchi disc is used to determine the clarity by lowering the disc into the water until it is out of sight and record the depth reading on the marked rope.

Figure 10: Secchi disc used to measure clarity.

The HydroNet system and Microsoft Excel were used to display (average) and interpret the 12 months (January 2022- December 2022) water quality data for the sites monitored.

The PAI model as of March 2008 was used to determine the present ecological category for water quality components. Five (5) years data from Jan 2018 to December 2022 was used to run the PAI model with number of samples ranging from 28-59. Therefore, the assessment was completed with a moderate confidence. TEACHA was not used to produced aggregated salts, instead the electrical conductivity was used as surrogate. The benchmark boundary tables were used for the PAI model analysis (DWAF, 2008) since the reference conditions were not determined. Water quality data below detection limits (denoted by a "<") was statistically analysed by converting the data to half the detection limit value (Palmer et.al, 2005), for example, ammonia was <0.20 and replaced with 0.10, as a statistically approved method of manipulating water quality data below quantification levels.

The water quality status for compliance is represented by colour green and for non-compliance is represented by colour red throughout the report unless indicated otherwise.

3.2.3. Aquatic Biota

2.2.3.1. Macro-invertebrates

Aquatic macro-invertebrates were sampled according to the South African Scoring System, Version 5 (SASS5) method. The method provides an assessment of the presence, diversity, and abundance of macroinvertebrates families at a site (Dickens and Graham 2002). The SASS 5 results are expressed as SASS score and ASPT. Each family of aquatic macroinvertebrates is allocated a value between 1 and 15 based on the perceived sensitivity to water quality changes (Murray 1999). The family's sensitivity is classified as having high tolerance (1–5), moderate tolerance (6–10) and very low tolerance (11–15) to water quality changes and pollution (Gerber and Gabriel 2002). Three biotopes were sampled at each site following the sampling method outlined by SASS 5 (Dickens and Graham 2002). The SASS 5 method identifies, and groups three biotopes inhabited by macroinvertebrates. The biotopes are stones (comprising of stones in and out of current and bedrock); vegetation (comprising of both instream and marginal vegetation) and GSM (comprising of gravel, sand, and mud). All the macro-invertebrate samples were collected using a kick-net of 30cm x 30cm and 1mm mesh size. The following time and length limitations were adhered to, as they are required by the SASS 5 method to ensure standardization:

- Stones (and bedrock)-in-current was sampled for 2 minutes.
- Stones (and bedrock)-out-of-current was sampled for 1 minute.
- Marginal vegetation (both in- and out-of-current) was swept with a net for a total length of 2m.
- Aquatic vegetation (where present) was swept with a net for an area of $1m^2$.
- Gravel, sand, and mud was stirred and swept with a net for 1 minute.

The collected samples were placed in three trays for each biotope grouping (i.e., stones, vegetation, and GSM). A total of 15 minutes was allowed for identification per tray. Macro-invertebrate field guides were used for correct identification of the macro-invertebrates sampled (Gerber and Gabriel 2002). The abundance of identified families was rated as 1 if only 1 specimen was found, A if between 2 and 10 specimens were found, B if between 10 and 100 were found, C if between 100 and 1000, and D if more than 1000, as outlined on the SASS 5 data sheet (Dickens and Graham 2002).

The Macro-Invertebrate Response Assessment Index (MIRAI) was used to interpret the Ecological State of the river (Thirion, 2008). The MIRAI is a rule-based model developed by DWS and it integrates the environmental requirements of the invertebrates in a community or assemblage to their response to modified habitat conditions, water quality and changes in the flow (Thirion, 2008). The MIRAI ratings considers both the abundance and frequency of occurrence of macroinvertebrates within a reach. In some reaches, only one site was monitored and as a result, only abundances were considered for comparison with the reference condition.

2.2.3.2. Fish

Fish were sampled at each site using an electric shocker. The data was collected in different velocity depth classes, and for each flow depth class the presence of features that provide cover for fish were considered. Information on the general habitat and cover preferences of fish species was obtained from the available literature and personal experience. Fish data collected in different velocity depth was kept separate for analysis and the results were recorded as a number of fish caught per time unit.

A Fish Response Assessment Index (FRAI) was used to analyse the fish data to get the Present Ecological State of the river (Kleynhans, 2008). The FRAI is a rule-based model recently developed by DWS and is based on the environment intolerances and preference of the reference fish assemblage and the response of a constituent species of the assemblage to a group of environmental determinants or drivers (Kleynhans, 2008). These intolerance and preference attributes are categorized into metric groups with constituents' metric that relates to the environmental requirements and preferences of individual species.

2.2.3.3. Riparian Vegetation

The riparian vegetation was assessed in order to determine the present ecological state. The riparian vegetation was assessed using the Riparian Vegetation Response Assessment Index (VEGRAI), Level 3, technique (Kleynhans et al., 2007), along the 100m upstream and 100m downstream. When the vegetation species were different from either side of the riverbank, the river banks were treated as different sites and the two would be assessed separate from one another. The current data was obtained by recording all the important and dominant plant species in a riverine reach on a VEGRAI Level 3 data sheet. The VEGRAI technique comprises of many metrics (cover, abundance and species composition) and metric groups (marginal and non-marginal zones) that are considered in the in-situ assessment. The status of the indigenous vegetation species (woody and non-woody) for the present and reference states are described in each metric and the difference between the two states compared to measure the vegetation responses to the surrounding disturbances. The alien/exotic species are assessed separately from the indigenous species (Kleynhans et al., 2007). The VEGRAI was used to analyse the riparian vegetation data collected to get the Present Ecological State of the river (Kleynhans et al., 2007).

2.2.3.4. Present Ecological Status

The Present Ecological State (PES) of a river is expressed in terms of various abiotic and biotic factors which are then integrated to provide the Ecostatus of the river. The biotic factors (*i.e.,* macro-invertebrates, fish, and riparian vegetation) provide an indication of biological responses to the changes in the abiotic factors (*i.e.,* physico-chemical, geomorphology, and hydrology), which serve as drivers. Figure 11 provides a simplified integration of influence of land use on physical driver determinants, habitats, and the associated biological responses. Data compilation was done according to models that were developed by DWS to determine the Ecostatus (Kleynhans, 2008). The River Data Integration Application (RIVDINT) was also utilised during the data compilation and analysis process.

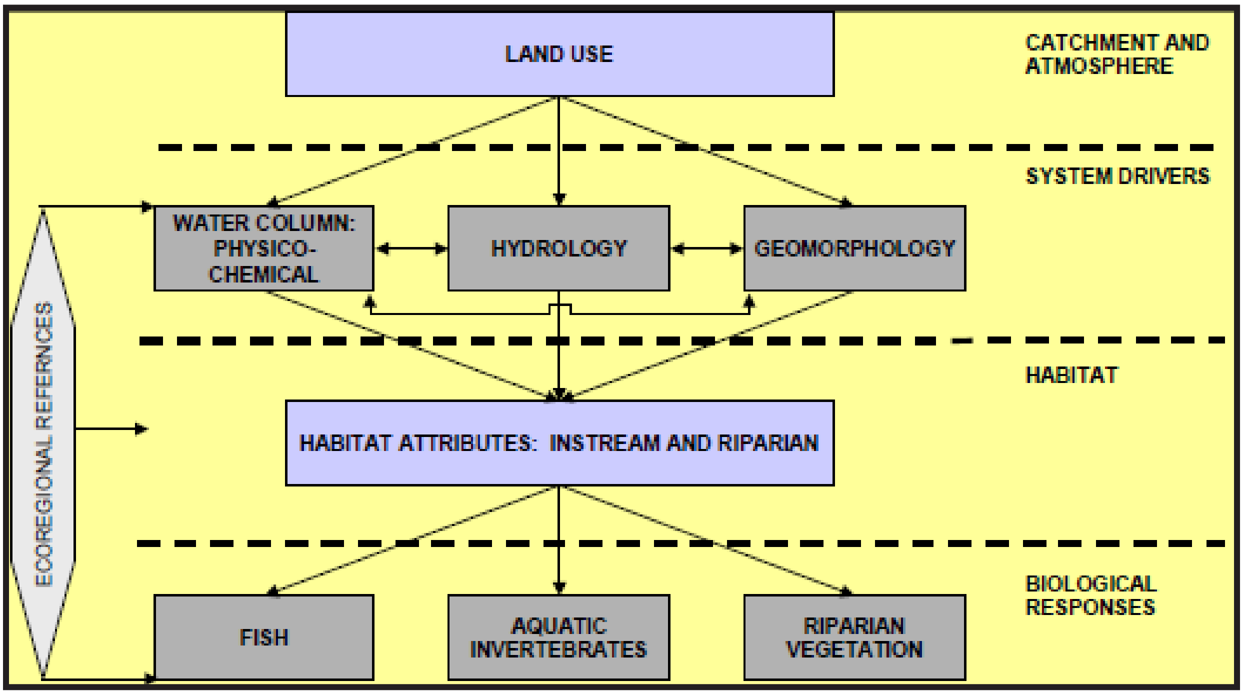


Figure 11: A simplified integration of influence of land use on physical driver determinants, habitats, and the associated biological responses (Kleynhans and Louw, 2008).

The Present Ecological State of the Crocodile Catchment was determined per Sub-Quaternary Reach (SQR) using fish, macro-invertebrates, and vegetation as biological indicators. Table 1 provides a description of the main Ecological Categories (*i.e.,* A – F).

Table 1: The Generic ecological categories for Ecostatus components.

ECOLOGICAL CATEGORY	GENERIC DESCRIPTION OF ECOLOGICAL CONDITIONS	ARBITRARY GUIDELINE SCORE (% OF MAXIMUM THEORETICAL TOTAL)
A	The river is in a natural and undisturbed condition.	>92 – 100
AB	The system and its components are in a close to natural condition most of the time. Conditions may rarely and temporarily decrease below the upper boundary of a B category.	>88 - <= 92
B	Largely natural with few modifications. A small change in the attributes of natural habitats and biota may have taken place in terms of frequencies of occurrence and abundance.	>82 - <=88
BC	Close to largely natural most of the time. Conditions may rarely and temporarily decrease below the upper boundary of a C category.	>78 - <=82
C	Moderately modified. Loss and change of natural habitat and biota have occurred in terms of frequencies of occurrence and abundance. Basic ecosystem functions are still predominantly unchanged.	>62 - <=78
CD	The system is in a close to moderately modified condition most of the time. Conditions may rarely and temporarily decrease below the upper boundary of a D category.	>58 - <=62
D	Largely modified. A large change or loss of natural habitat, biota and basic ecosystem functions have occurred.	>42 - <=58
DE	The system is in a close to largely modified condition most of the time. Conditions may rarely and temporarily decrease below the upper boundary of an E category.	>38 - <=42
E	Seriously modified. The change in the natural habitat template, biota and basic ecosystem functions are extensive.	20 - <=38
F	The river is in a critically or extremely modified state and ecosystem functions are completely lost. The natural habitat and biota are almost completely lost.	<20

CHAPTER 3 WATER QUANTITY STATUS

3.1. Introduction

Knowledge of hydrological patterns, trends, and water quality condition is critical for successful long-term water resource management. All of the rivers in the Inkomati Usuthu WMA flow into the Indian Ocean via Mozambique. Because of the limited rainfall throughout the coastal plains east of the WMA, the southern portion of Mozambique relies heavily on water flowing from the South African territory. This has a substantial impact on the management of the Inkomati WMA's water resources, as South Africa is committed to meeting its international water requirement obligations.

There are two significant dams in the Upper Komati, the Nooitgedacht and Vygeboom dams. These dams account for the majority of the available yield in this sub-area, with transfers from these dams to the Olifants WMA constituting the dominant water usage of this sub-area's water resources. This sub-region has a huge, afforested area, which has a considerable impact on the available yield. Irrigation is another substantial water usage, and while domestic water use is now regulated, demand is fast increasing. The Driekoppies Dam is located in the Lower Komati while the Maguga Dam is in eSwatini. The Lower Komati sub-area is considered extremely stressed, with significant irrigation and domestic water demand.

The Crocodile catchment is dominated by irrigation and forestry, two activities that are also the primary users of water in the catchment. The catchment's industrial water consumption is limited to the Sappi paper mill in Ngodwana and the sugar mills in Malelane and Komatipoort. The catchment is not well developed in terms of water resources, with only one significant dam, the Kwena Dam, in the upper catchment. The catchment is considered highly stressed since the water requirements exceed the available resources.

The Sabie River and its main tributary, the Sand River, are located upstream of the Kruger National Park, which has high ecological flow requirements. This important factor, coupled with rural development and improved service delivery to the rural sector, necessitated the construction of the Inyaka Dam which was completed in 2000. The Sabie system is currently in balance.

The Usuthu catchment has a small surplus (based on current allocations and water usage), while domestic water demands are increasing due to population growth and expanding economic activity. This is offset by Eskom's declining water use, which transfers water out of the catchment to cool coal-fired power plants in the Olifants and Vaal catchments.

3.2. Rainfall status within the WMA

In general, rainfall has been averaged since the start of the 2022 hydrological year, but rainfall received in the Inkomati Usuthu Water Management Area (WMA) due to the cut off low in February 2023 resulted in widespread heavy rains, causing severe flooding in the Sabie-Sand, Crocodile, and Komati Catchments. Cut-off lows, according to SAWS, are known for generating severe weather over South Africa, such as heavy rain and flooding. Due to the slow movement of this cut-off low, continuous rain over many days normally causes significant flooding in the country's central, southern, and eastern areas.

3.2.1. Sabie Sand Catchment

The historical average rainfall total for the Sabie-Sand catchment is 733 mm, the received rainfall from the start of the 2022-2023 hydrological year was is 1262 mm which is above the historical average and is second highest average rainfall total for the catchment receive since 1973 (Figure 12). The rainfall received throughout the current hydrological year was generally average; however, the rainfall received in February 2023 varied between 300 mm and 500 mm across the catchment and was above average; hence, the rainfall received during the 2022-2023 hydrological year was also above average.

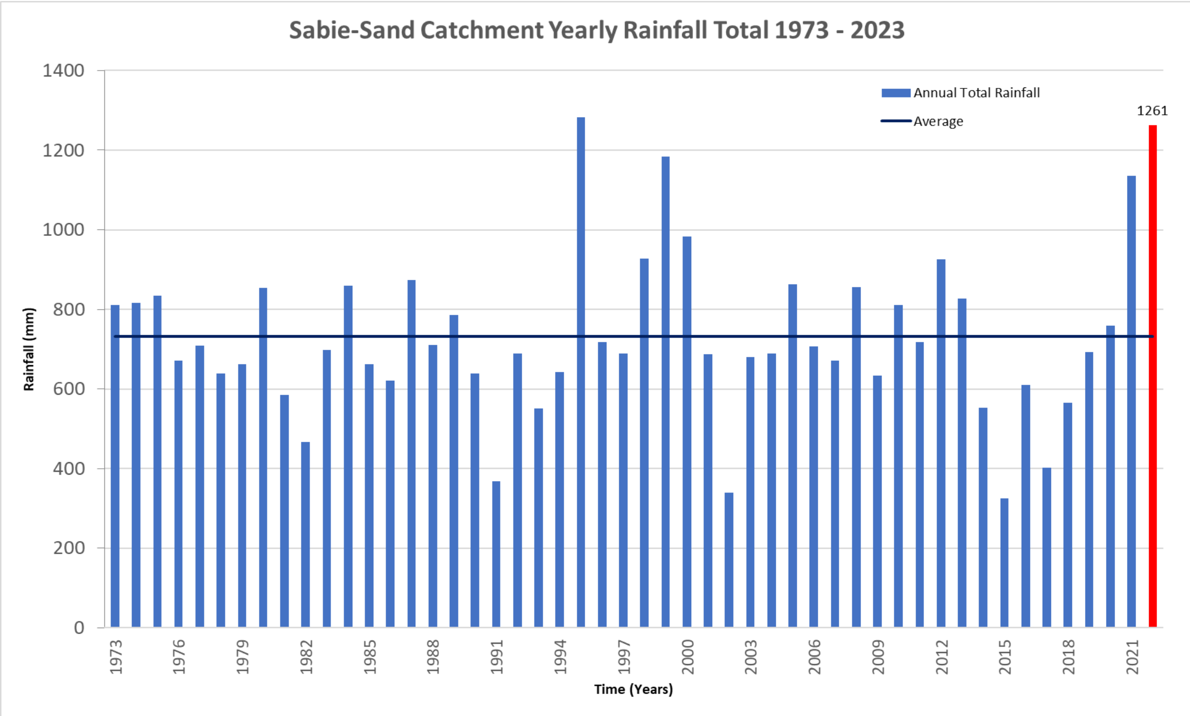


Figure 12: Sabie-Sand Catchment historical rainfall total since 1973.

3.2.2. Crocodile Catchment

The historical total average rainfall for the Crocodile catchment is 848 mm, the received rainfall from the start of the 2022-2023 hydrological year was 1109 mm which is above the historical average and is fifth highest total average rainfall for the catchment received since 1973 (Figure 13).

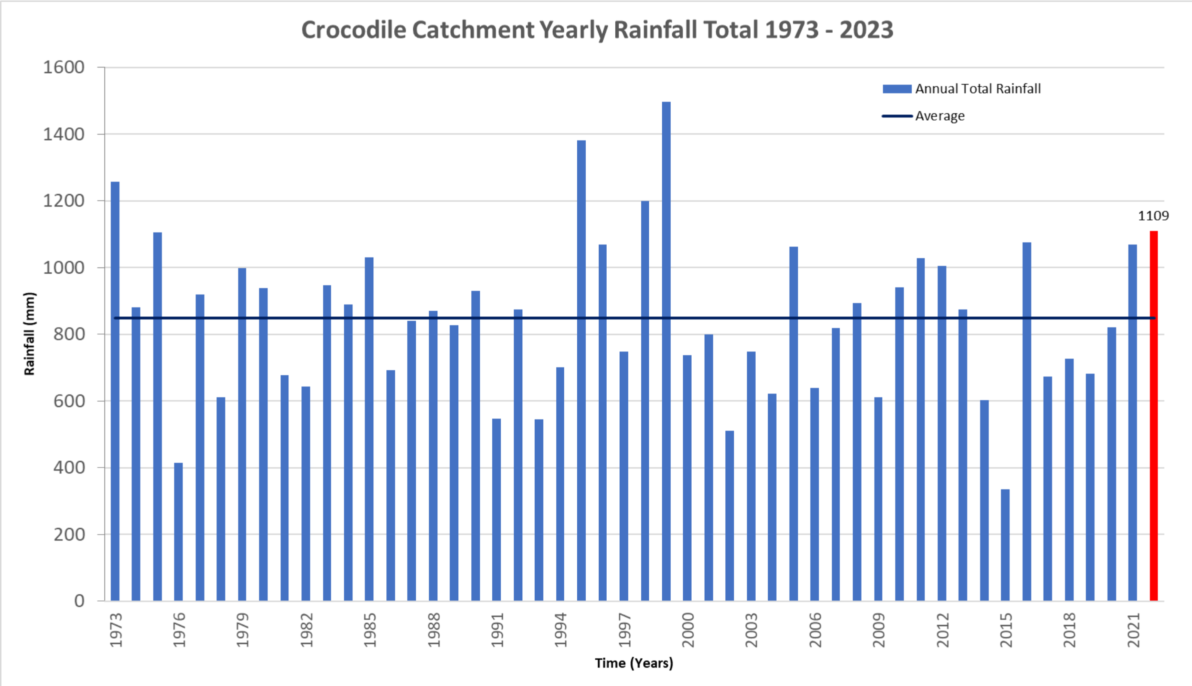


Figure 13: Crocodile Catchment historical total rainfall since 1973.

3.2.3. Komati catchment

The historical total average rainfall for the Komati catchment is 744 mm, the received rainfall from the start of the 2022-2023 hydrological year was 1126 mm which is above the historical average and is the highest total average rainfall for the catchment received since 1973 (Figure 14). The rainfall received throughout the current hydrological year was generally average; however, the rainfall received in February 2023 varied between 300 mm and 450 mm across the catchment and was above average; hence, the rainfall received during the 2022-2023 hydrological year was also above average.

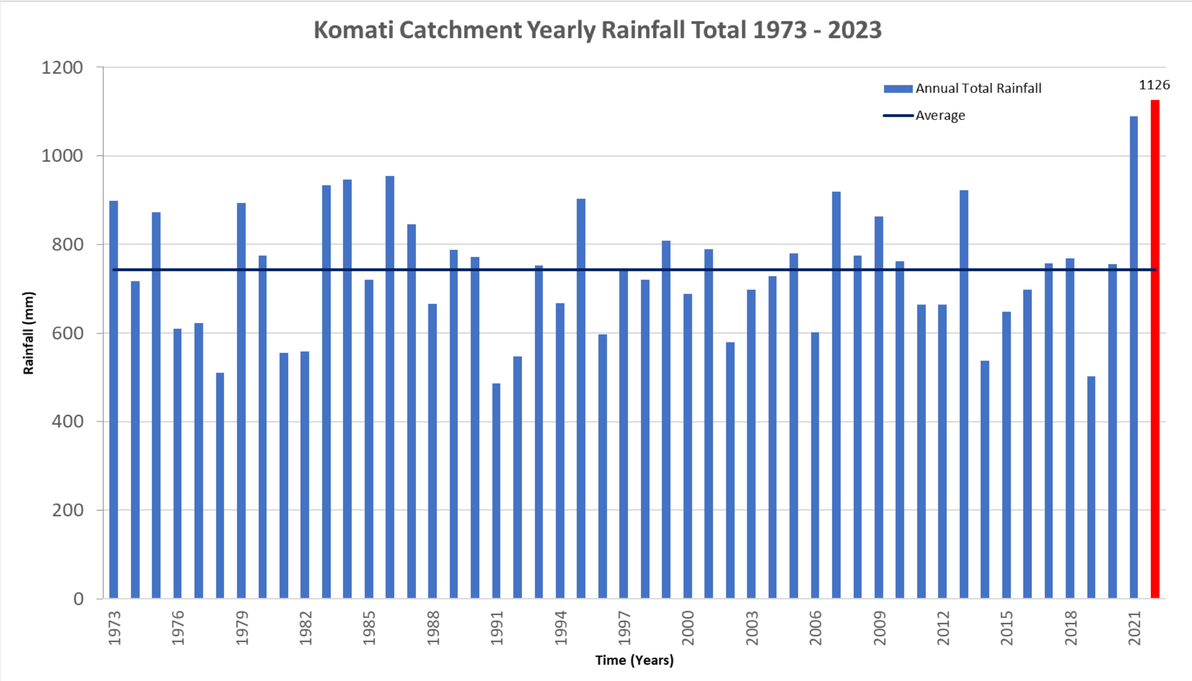


Figure 14: Komati Catchment historical rainfall total since 1973.

3.2.4. Usuthu catchment

The historical total average rainfall for the Komati catchment is 865 mm, the received rainfall from the start of the 2022-2023 hydrological year was 846 mm which is slightly below the historical average received since 1973 (Figure 15).

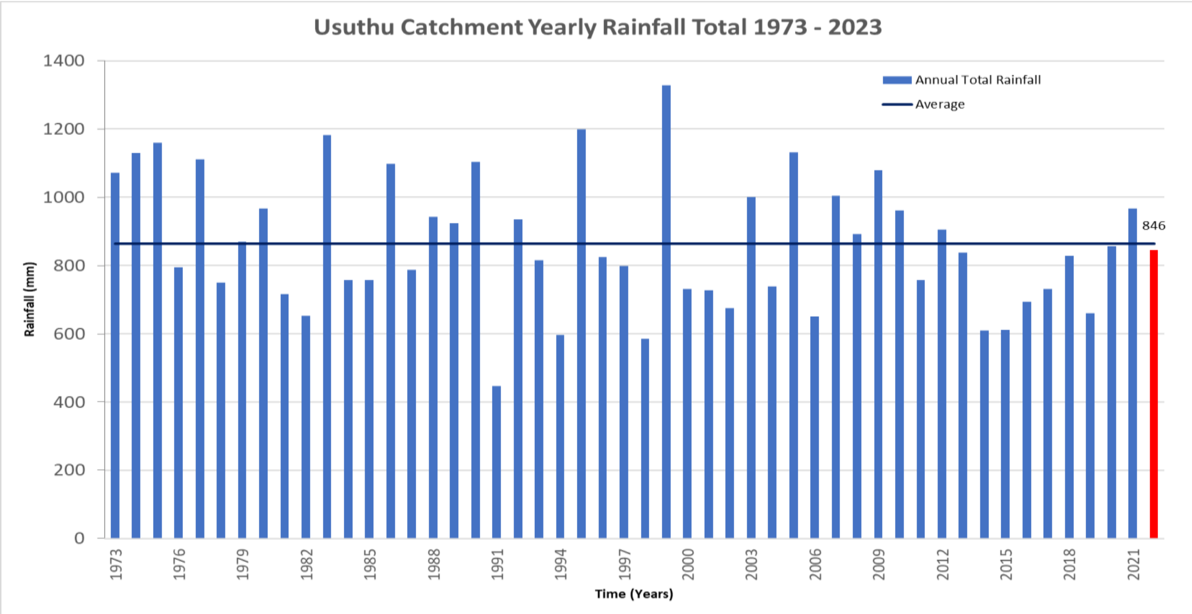


Figure 15: Usuthu Catchment historical rainfall total since 1973.

3.3. Riverflow status within the WMA

The summer rainfall received from the start of the 2022 hydrological year caused the riverflow levels in the Inkomati Usuthu WMA to increase. The Inkomati Usuthu WMA water resource status was high compared to the three previous hydrological years.

During the February 2023 floods, the highest recorded discharges from the Sand River at Exeter reached 950 m^3/s on 10 February 2023 while at Lower Sabie discharge volumes reached 2600 m^3/s, on 09 February 2023. The Crocodile River at Tenbosch reached 2300 m^3/s, and the Komati River at Komatipoort reached 4700 m^3/s, both on 09 February 2023.

The riverflow stations listed below were chosen as indicator stations to offer information on the catchments' overall riverflow status levels. In the Sabie-Sand, two stations were chosen: Sand River @ Exeter and Sabie River @ Emmet; in the Crocodile, the station at Karino; in the Komati, the station at Hooggenoeg; and in the Usuthu, the station Assegaai River at Zandbank.

3.3.1. Sabie Sand Catchment

The observed mean discharge from the Sand River at Exeter was very high for most of the reporting period. There was no specific trend followed when compared with the previous hydrological year (Figure 16), while the station's Jan – March 2023 flow statistics are shown in Table 2.

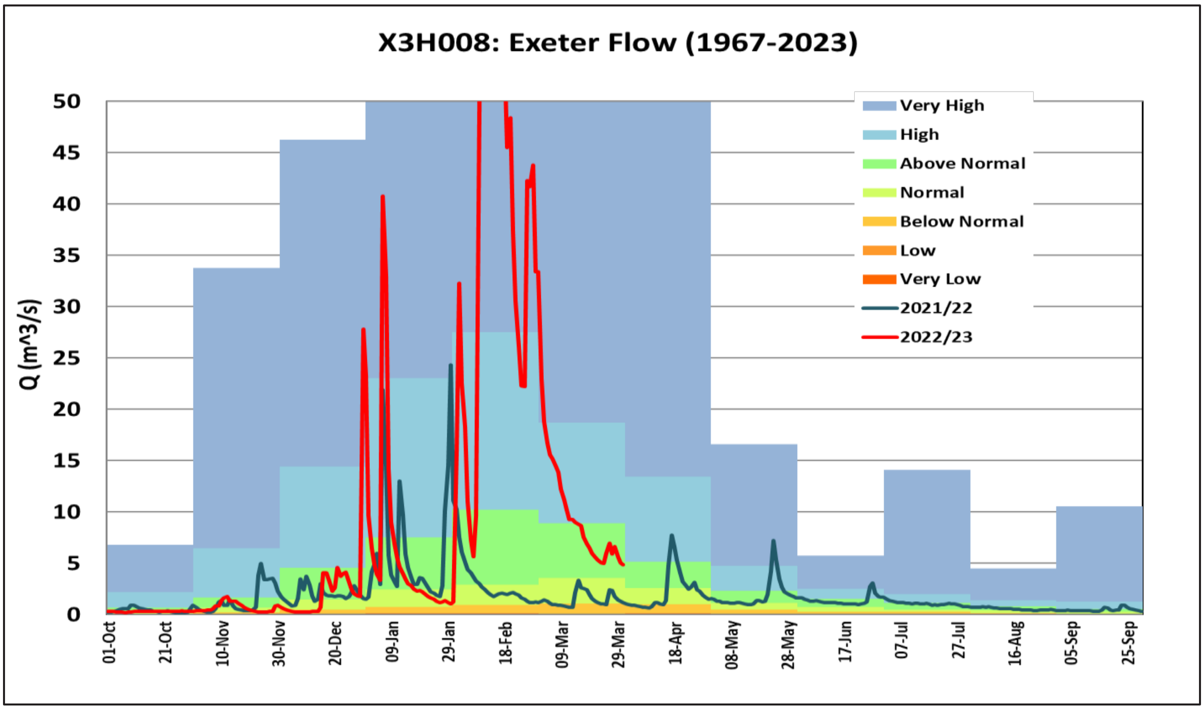


Figure 16: Sand River at Exeter- riverflow level historical analysis.

Table 2: Waterbody: Sand River at Exeter – X3H008: Daily mean discharge (m^3/s)

Jan-23		Long-term January	
Mean	**5.89**	Mean	7.396
Minimum	1.063	Q95	56.47
Maximum	40.786	Q5	1.80
Feb-23		Long-term February	
Mean	**62.162**	Mean	19.818
Minimum	5.650	Q95	26.65
Maximum	262.553	Q5	1.70
Mar-23		Long-term March	
Mean	**10.271**	Mean	9.004
Minimum	4.827	Q95	12.51
Maximum	33.429	Q5	1.86

The observed mean discharge from Sabie River at Emmet was very high for most of the reporting period. The rainfall received during February had a significant contribution to the high flows at this weir. Flows have been higher than the previous hydrological year for almost the entire reporting period (Figure 17), while the station's Jan – March 2023 flow statistics are shown in Table 3.

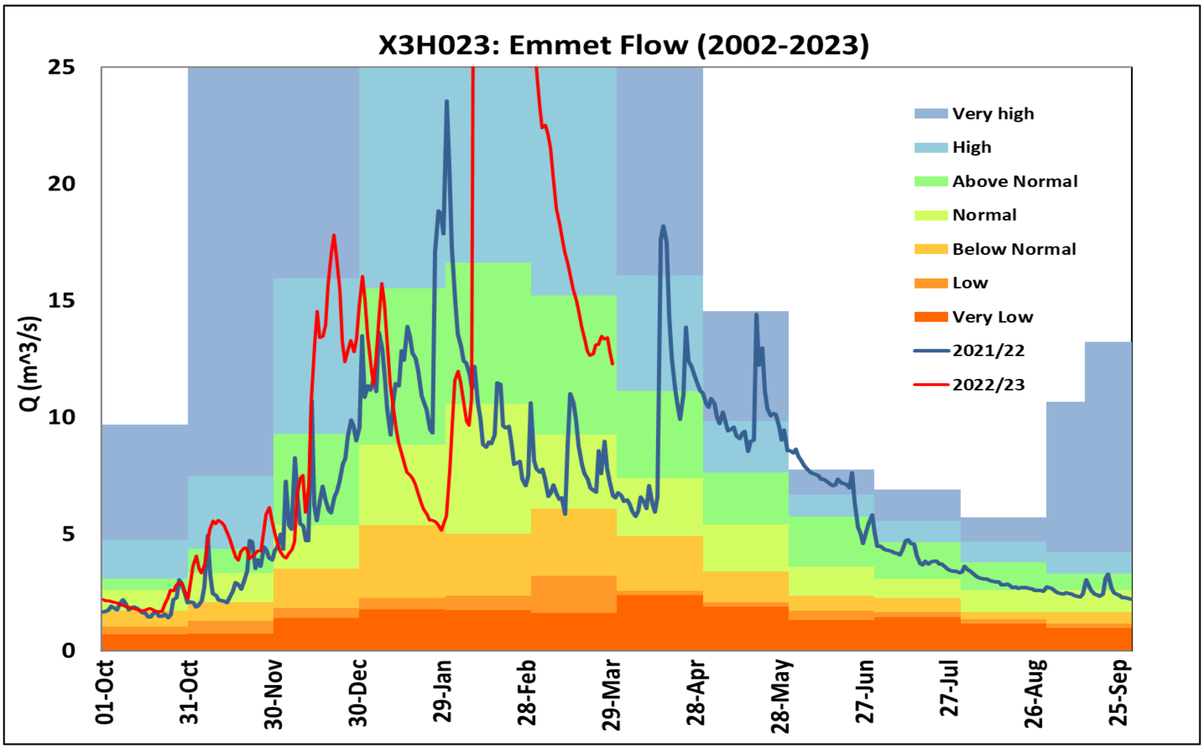


Figure 17: Sabie River at Emmet- riverflow level historical analysis.

Table 3: Water body: Sabie River at Emmet – X3H023: Daily mean discharge (m³/s).

Jan-23		Long-term January	
Mean	8.963	Mean	12.513
Minimum	5.020	Q95	57.28
Maximum	15.132	Q5	2.00
Feb-23		**Long-term February**	
Mean	55.025	Mean	14.604
Minimum	9.275	Q95	23.79
Maximum	142.250	Q5	1.84
Mar-23		**Long-term March**	
Mean	17.096	Mean	11.119
Minimum	12.096	Q95	25.62
Maximum	28.658	Q5	3.77

3.3.2. Crocodile Catchment

The observed daily average flow at Crocodile River at Karino was above normal for the entire duration of the reporting period. The same trend was observed, although a bit higher when compared with the previous hydrological year. These flow statistics can be seen in Figure 18, while the station's Jan – March 2023 flow statistics are shown in Table 4.

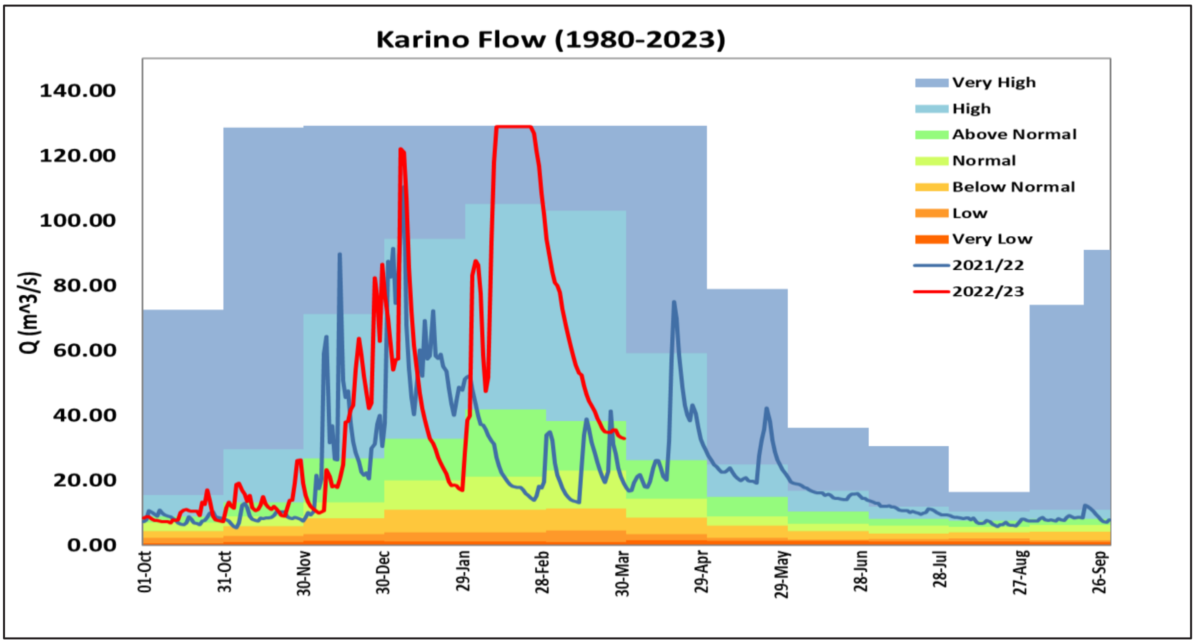


Figure 18: Crocodile River at Karino- riverflow level historical analysis.

Table 4: Water body: Crocodile River at Karino – X2H006: Daily mean discharge (m^3/s).

Jan-23		Long-term January	
Mean	**46.88**	Mean	27.24
Minimum	16.90	Q95	129.22
Maximum	122.07	Q5	5.09
Feb-23		**Long-term February**	
Mean	**107.98**	Mean	32.85
Minimum	39.85	Q95	90.81
Maximum	129	Q5	5.77
Mar-23		**Long-term March**	
Mean	**55.81**	Mean	28.74
Minimum	33.24	Q95	109.15
Maximum	102.04	Q5	6.25

3.3.3. Komati catchment

Observed average flow conditions have been above normal in the Komati River at Hooggenoeg for the entire reporting period. The same trend was followed when compared with the previous hydrological year. Flows have been a bit higher than the previous hydrological year for the later parts of the reporting period (Figure 19), while the station's Jan – March 2023 flow statistics are shown in Table 5.

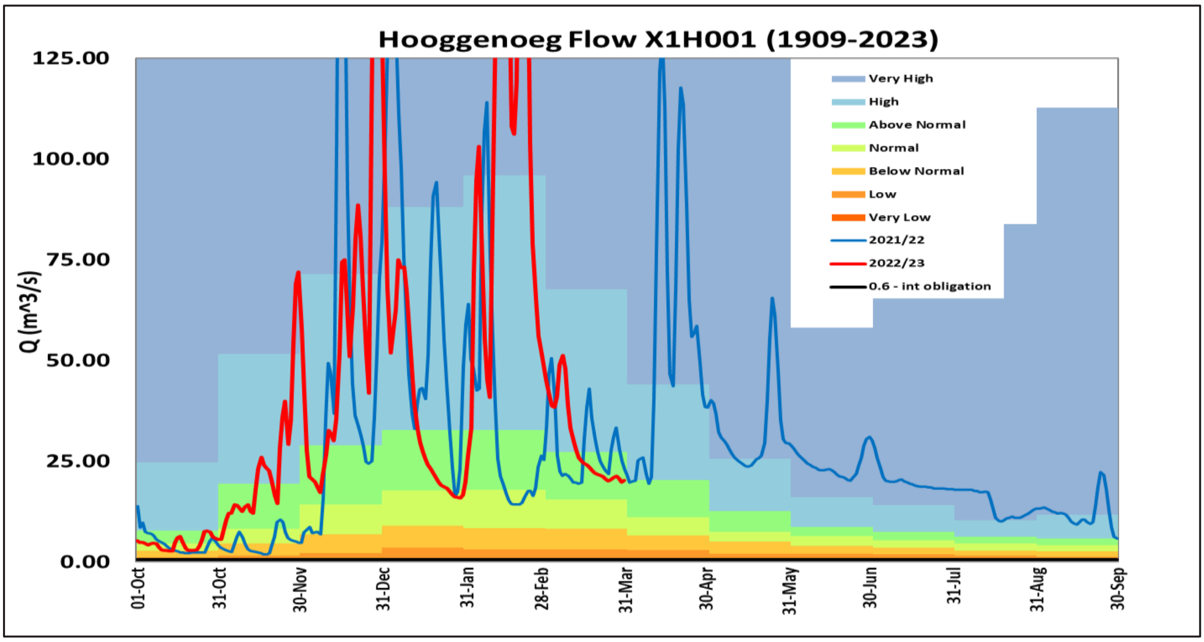


Figure 19: Komati River at Hooggenoeg riverflow level historical analysis.

Table 5: Water body: Komati River at Hooggenoeg – X1H001: Daily mean discharge (m^3/s).

Jan-23		Long-term January	
Mean	**35.139**	Mean	28.255
Minimum	15.568	Q95	88.67
Maximum	65.692	Q5	3.62
Feb-23		Long-term February	
Mean	**122.086**	Mean	30.619
Minimum	33.654	Q95	52.40
Maximum	371.078	Q5	2.99
Mar-23		Long-term March	
Mean	**36.286**	Mean	23.171
Minimum	24.551	Q95	40.20
Maximum	59.849	Q5	3.85

3.3.4. Usuthu catchment

The observed daily average flow at Assegaai was normal to above normal for the entire duration of the reporting period. The same trend was observed, although a bit higher when comparing with the previous hydrological year. These flow statistics are presented in Figure 20, while the station's Jan – March 2023 flow statistics are shown in Table 6.

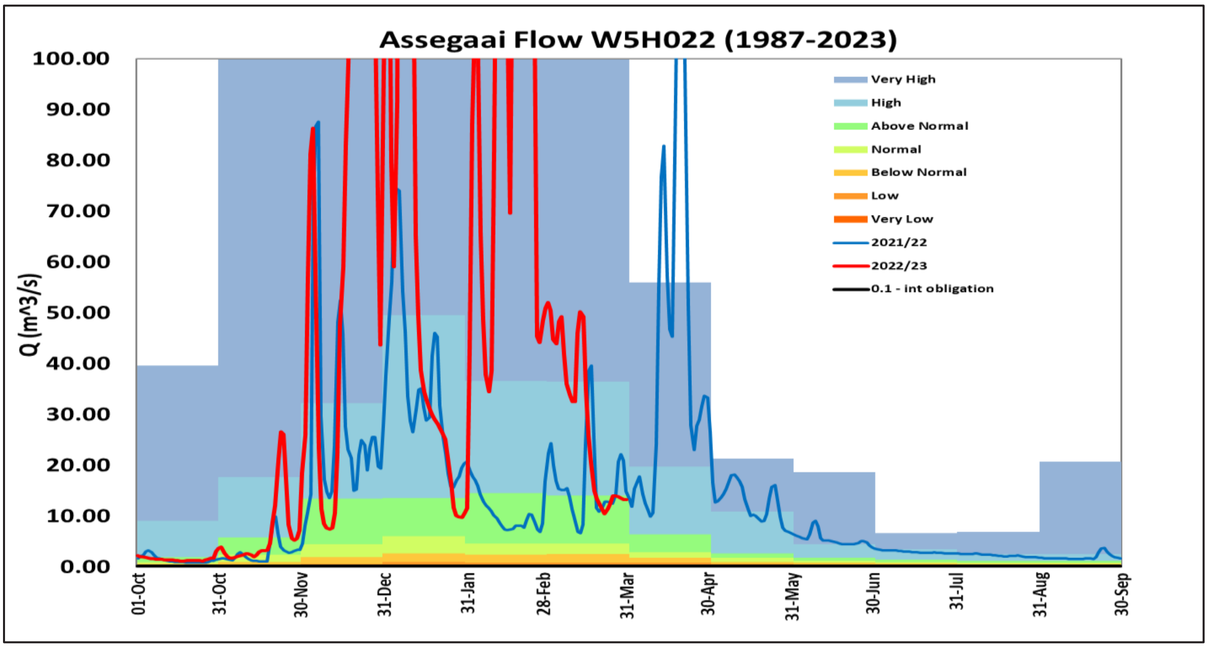


Figure 20: Assegaai River at Zandbank riverflow level historical analysis.

Table 6: Water body: Assegaai River at Zandbank – W5H022: Daily mean discharge (m^3/s).

Jan-23		Long-term January	
Mean	90.02	Mean	6.05
Minimum	9.495	Q95	49.50
Maximum	528.274	Q5	0.95
Feb-23		Long-term February	
Mean	175.95	Mean	4.52
Minimum	30.149	Q95	36.60
Maximum	753.594	Q5	0.88
Mar-23		Long-term March	
Mean	29.93	Mean	4.62
Minimum	9.572	Q95	36.43
Maximum	72.653	Q5	0.81

3.4. Dam Level Status with the WMA

The water level status in most dams within the WMA (which supply the major towns, irrigation, and strategic water users) since the start of the current hydrological year varied between high and very high. All dam levels significantly increased from December 2022 to February 2023, because of the above normal rainfall received in February 2023, and all major dam levels went above 100%. The 2022/23 hydrological year has been the first time since 2016 where all the major dams in the WMA increased to above 100% as illustrated below (Figure 21).

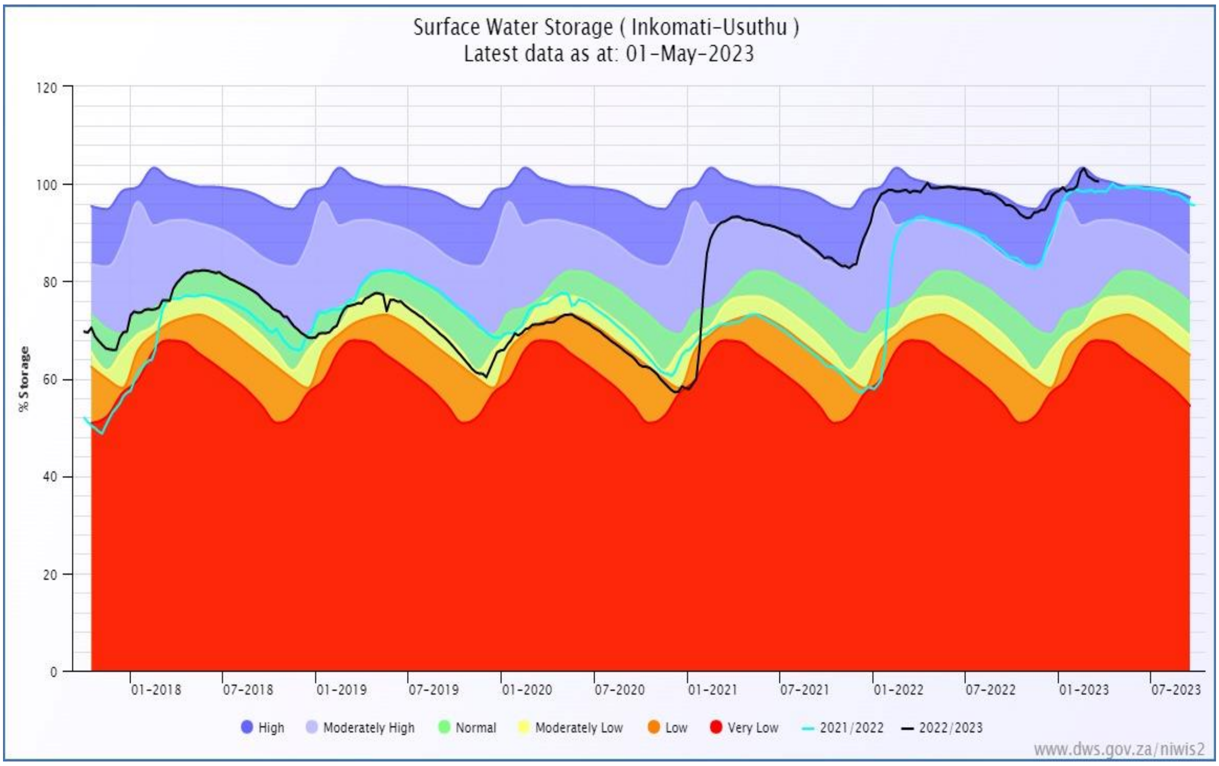


Figure 21: Inkomati – Usuthu WMA dams' storage historical analysis.

CHAPTER 4 WATER QUALITY STATUS

4.1. Introduction

Much of the importance in water resource management has revolved around quantity ensuring that users have enough water, however, as water gets used and re-used, water quantity also becomes scarce and feedback loops become even tighter. As such, it is the quality aspect that begins to assume an even more important characteristic. Importantly, both quantity and quality need to be considered at the same level of detail, and this can mean that at times they should be considered with similar emphasis and expenditure of resources. Water quality describes the condition of the water, including chemical, physical, and biological characteristics, usually with respect to its fitness to use.

Surface water quality within the WMA is affected mainly by land use activities including sediment and erosion. Water quality impacts of the resource is due to contamination from sewage (e.g., from overflows, spills, and leakages or by discharge of untreated/partially treated sewage into the resource), agricultural activities and decanting of mining effluents or leachate into the water resources as well as landfill sites and illegal solid waste dumping. Industrial waste and sewage discharges are the easiest to authorise and control, but this does not mean that this is problem-free. There is a problem of compliance regarding the local authorities and private operators responsible for waste management systems. The IUCMA has found that the quality of sewage discharges often far exceeded the standards and conditions demanded by authorisation.

Poor water quality impacts negatively on human health, threatens downstream water users, increases /industrial costs and raw water treatment costs arising from removing pollutants, reduces income generated from recreation and ecotourism, destroys ecosystems, and affects biodiversity. IUCMA is moving towards the integrated reporting of quantity and quality and its impact on the aquatic biota. To ensure that the quality of water resources remains fit for recognised water uses and that the viability of aquatic ecosystems is maintained and protected. The water quality compliance status will be presented by maps and trends chart per Catchment using the HydroNet application or Microsoft Excel. Maps indicate an average water quality status from January –December 2022 and trends chart indicate data ranging from January 2016 to December 2022.

4.2. Water Quality Status within WMA

4.2.1. Sabie Sand Catchment

The Sabie River originates in the upper reaches of the Sabie Town and passes through industries such as York Timber Sawmill and the defunct underground gold mines of the Transvaal Gold Mine Estate (TGME) are situated. The Sabie River further flows through Hazyview and Mkhuhlu and other residential areas before it enters the Kruger National Park, Mozambique, and the Indian Ocean respectively. The main tributaries of the Sabie River are Mac-Mac River, Klein Sabie River, Noord-Sand River, Bega River, Sand River and Marite River. The Sand River confluences with the Sabie River inside the Kruger National Park. There are four main dams in the Sabie Sand Catchment, namely: Inyaka Dam, Da-Gama Dam, Eidenburg Dam and Mahleve Dam. The catchment is dominated by trout farming, forestry at the upper reaches of the catchment and housing development such as guest houses, lodges and hotels. There are several wastewater treatments works, the majority of which are operated by municipalities. The middle reaches from Hazyview to the Kruger National Park are affected mostly by agriculture, eco-adventure tourism, irrigation, water abstraction and urban development while the lower reaches of the catchment are located within the Kruger National Park which is a protected area as shown in Figure 22.

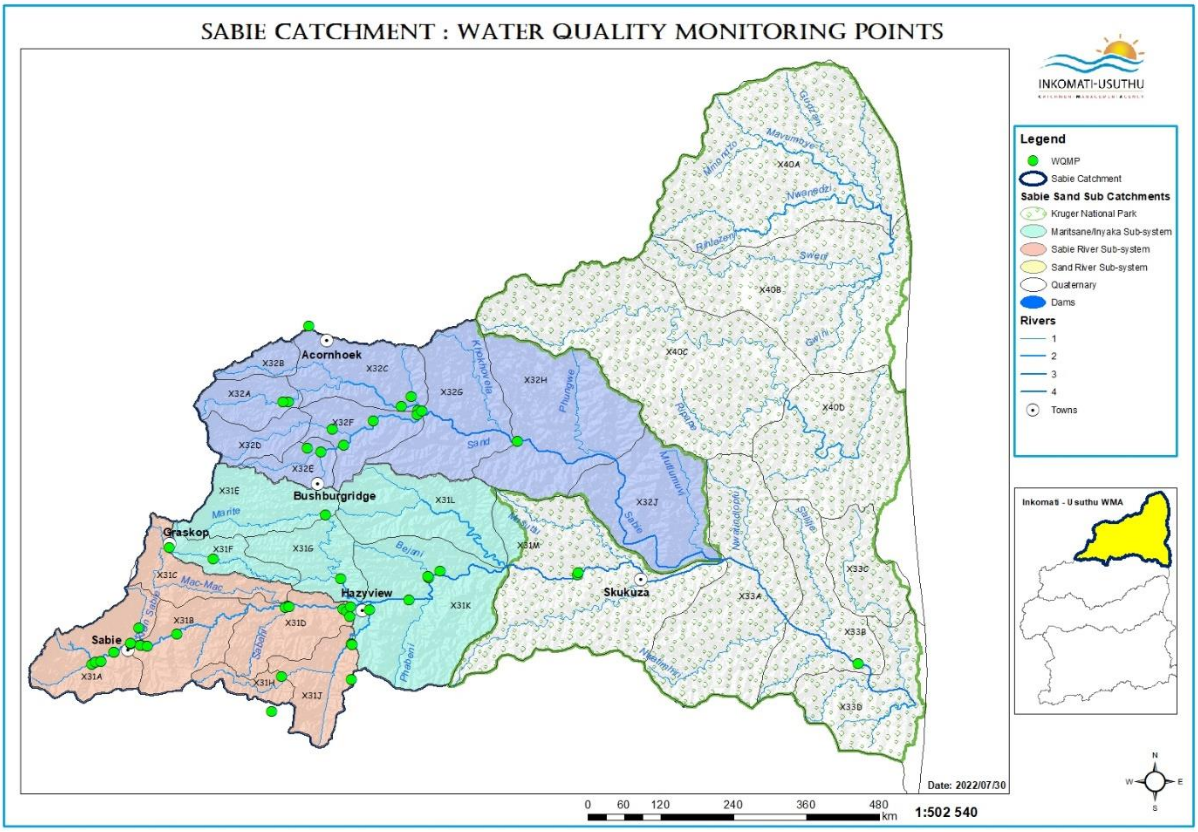


Figure 22: Water quality monitoring points in the Sabie Catchment.

The water quality status and trends of the indicator parameters is compared with the Resource Quality Objectives (RQOs) published in a Government Gazette dated 30 December 2016 or the Target Water Quality Guideline limits (TWQG) where the RQOs were not available or set as tabulated below.

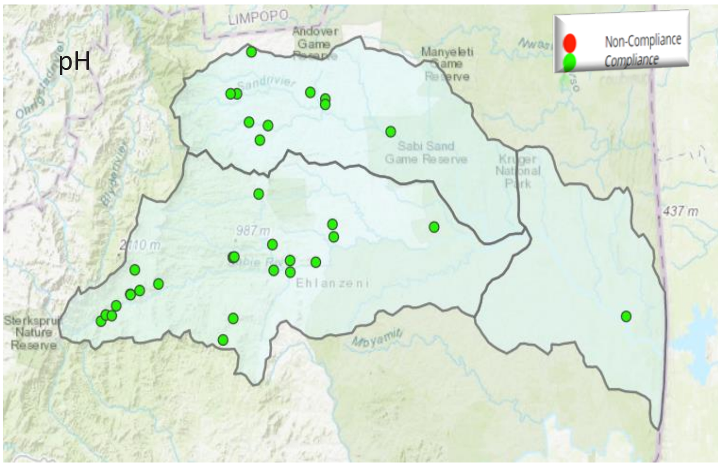
Table 7: TWQG and RQOs within Sabie/Sand Catchment.

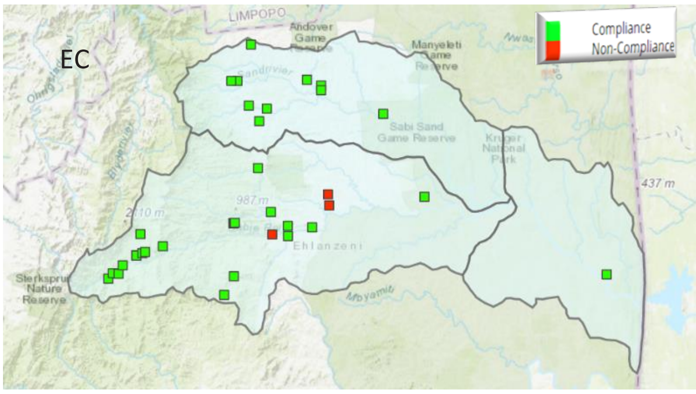
Variables/Parameters	**Resource Quality Objectives**		**TWQG**
	Sabie System	**Sand System**	
pH	6.5 - 8.0	6.5 – 8.8	6.5-8.5 (Recreation)
Electrical Conductivity (EC) in mS/m	30	55	40
Phosphate (PO_4) in mg/l	0.015	0.125	N/A
Nitrates/Nitrites (NO_3 + NO_2) in mg/l)	N/A	N/A	6 (Domestic)
(E. coli) in cfu/100ml	130	130	0
Total ammonia (NH_3+ NH_4^+) in mg/l	-	-	1 (Domestic)

N/A=Not available

System Variable and Salts

pH is a vital indicator of water that is changing chemically and measures how acidic/or basic the water is, ranging from 0 to 14. **pH** levels complied with the TWQG throughout the Sabie Sand catchment.





Electrical Conductivity (EC) complied with RQOs except Langspruit (Hazyview), the Bega River and Ngwenyameni River (Mkhuhlu).

Figure 23: Water quality status within Sabie/Sand Catchment showing pH and EC concentrations.

Electrical Conductivity

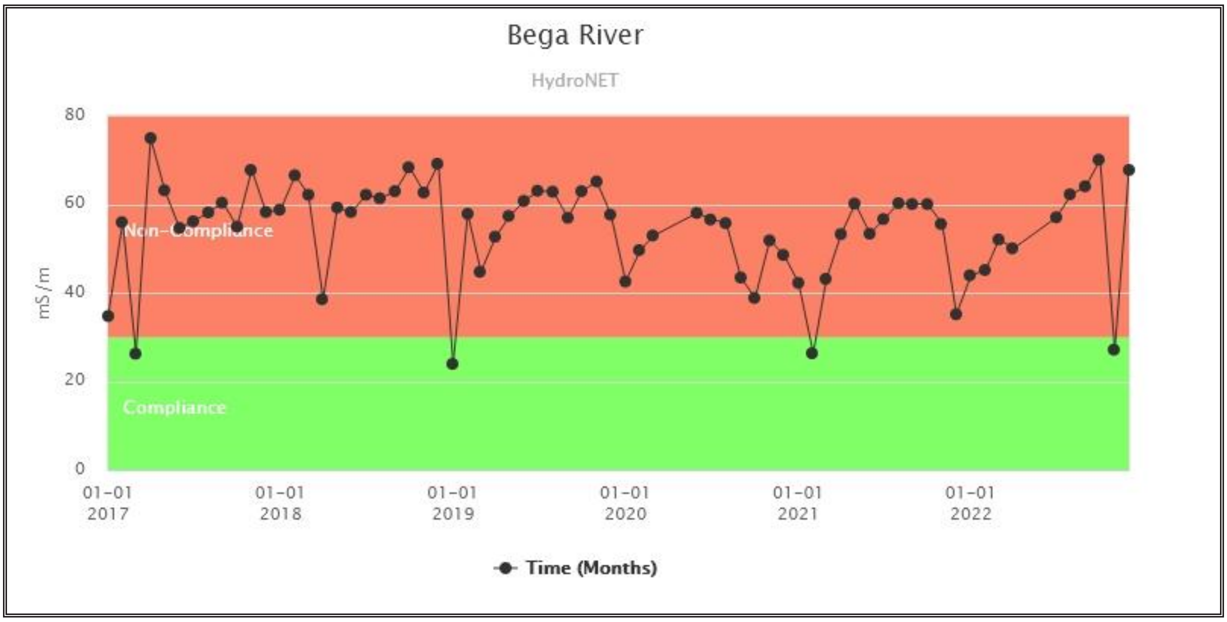
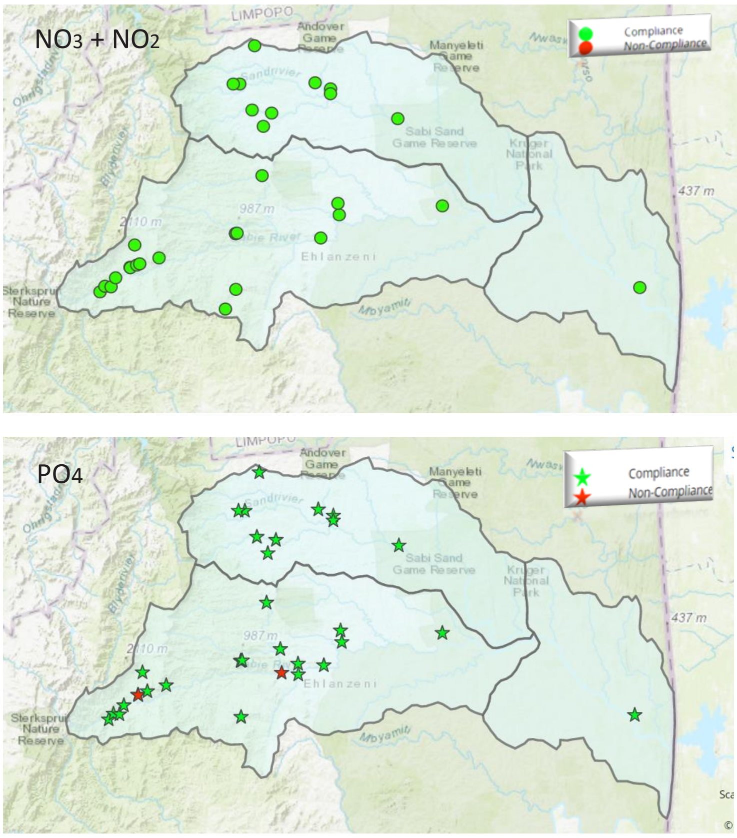


Figure 24: Chart indicating Electrical conductivity concentrations trends at Bega River (Mkhuhlu Area).

Nutrients



Nitrates/Nitrites concentrations complied with the TWQG throughout the sites monitored in the catchment.

Phosphate indicated compliance with the RQOs for most sites within the Catchment except for Klein Sabie (Sabie Town) and Langspruit River (Hazyview) which indicated non-compliance.

Nutrients are required in water resource; however excessive amount can lead to eutrophication process which is harmful to fish and other aquatic life.

Figure 25: Water quality status within Sabie/Sand Catchment NO_3+NO_2 and PO_4) concentrations.

Phosphate

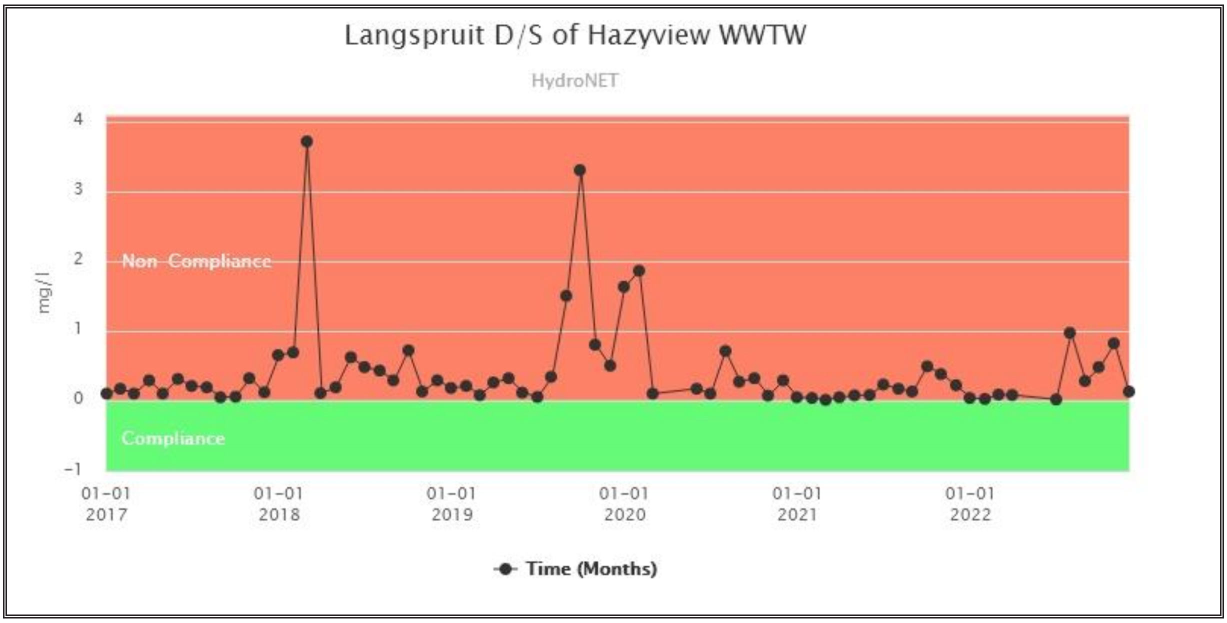


Figure 26: Chart indicating Phosphate concentrations trends at Langspruit D/S of Hazyview WWTW.

Microbial

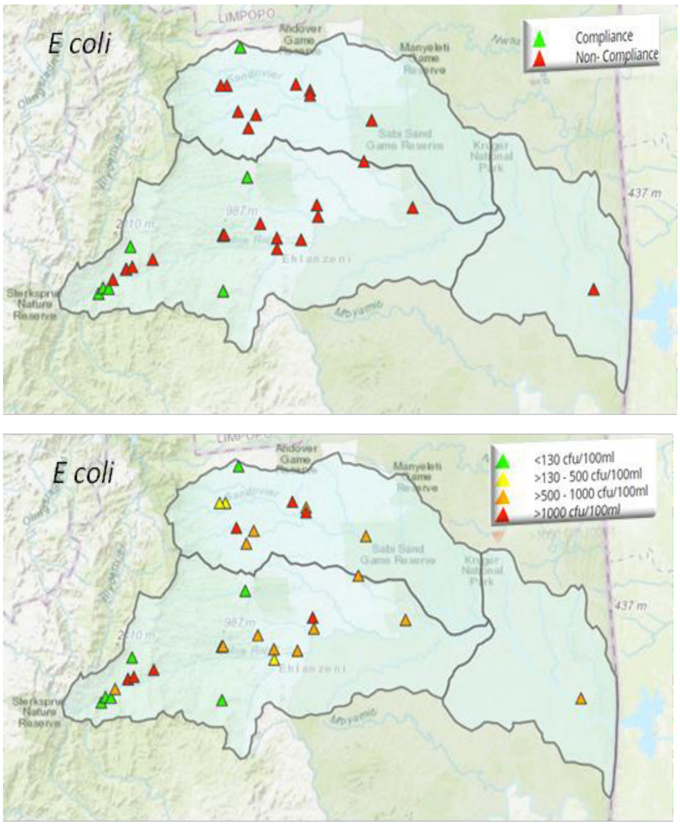


Figure 27: Water quality status within Sabie/Sand Catchment showing E coli concentrations.

E. coli counts in the Sabie/Sand Catchment indicated noncompliance with the set RQOs of 130 (cfu/100ml) except for head waters of Sabie River and Klein Sabie River, Lone Greek River, Da-Gama Dam, Injaka Dam and Mahleve Dam which showed compliance with the set RQOs. The second map shows extent of *E coli* counts by showing less than 1 000 cfu/100ml in green, orange and yellow colour while greater than 1 000 cfu/100ml is shown in red. High levels of microbial counts greater than (>) 1 000 (cfu/100ml) arises from urban and rural impacts from the Sabie, Bushbuckridge, Mkhuhlu and Thulamahashe areas including effluent from WWTWs and its associated infrastructure. Whereas other areas have not reached an alarming stage as the coliform counts are below 1000 (cfu/100ml).

E coli

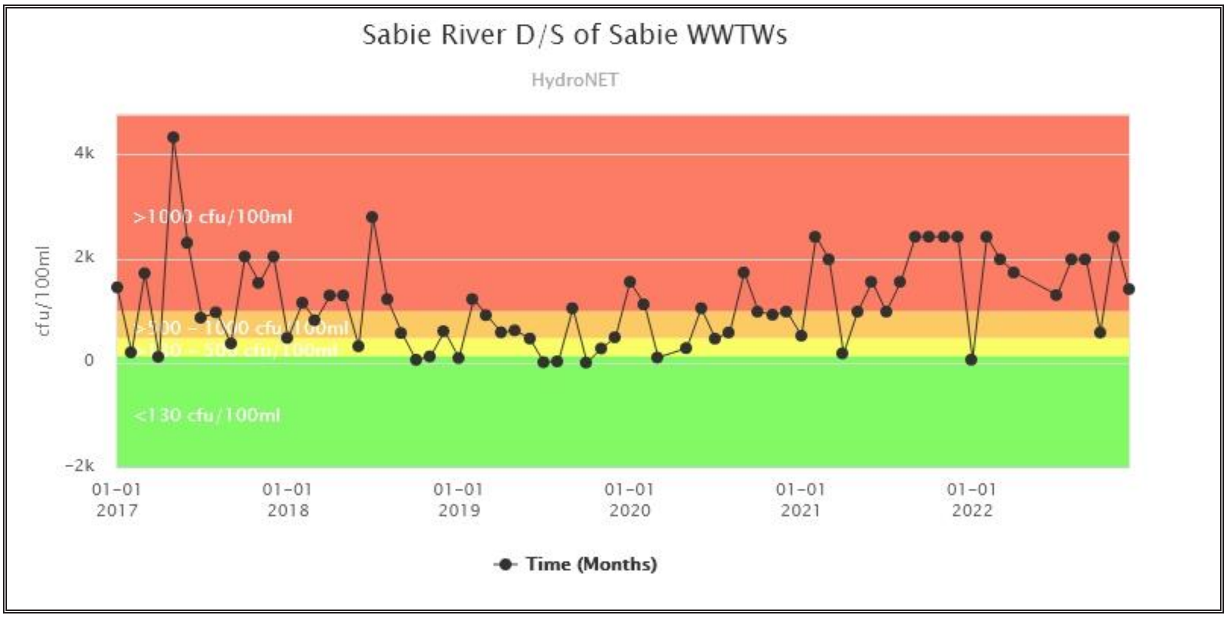
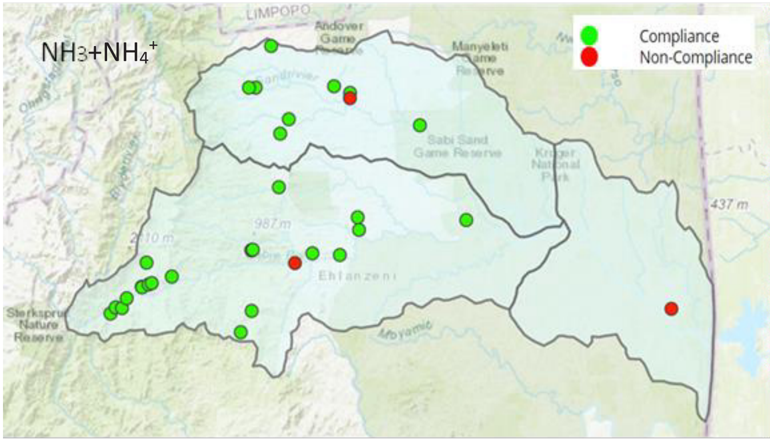


Figure 28: Chart indicating *E coli* concentrations trends at Sabie River downstream of Sabie WWTWs.

Toxic Substances



Total ammonia (NH_3+NH_4^+) within the Sabie Sand Catchment indicated compliance with TWQG (Domestic) of 1 (mg/l), except the Langsruit, Sand River downstream of Hazyview and Thulamahashe WWTWs and Sabie River at KNP downstream of Lower Sabie Rest Camp as illustrated in Figure 29.

Figure 29: Water quality status within Sabie/Sand Catchment showing total ammonia concentrations.

Ammonia is a common toxicant derived from domestic, industrial, or agricultural pollution (fertilizers, organic matter) and natural processes. Total ammonia (NH_3 + NH_4^+ as N) occurs in equilibrium with the ammonium ion and the position of equilibrium is governed by pH and temperature. The un-ionized form ammonia (NH_3) is more toxic than the ionized form ammonium (NH_4^+). As pH and temperature increases, NH_4^+ is converted to NH_3, and the toxicity increases. NH_3 is highly toxic to fish and other aquatic life. The chart (Figure 30) below indicates total ammonia concentrations which indicated non-compliance to TWQG from August to December 2022 in the Langspruit, in October 2022 a fish kill was reported in the Langspruit. Based on the temperature and pH the estimated concentration of un-ionized form ammonia (NH_3) contribution was 0.215 mg/l from August to November 2022 which was above the set TWQG for aquatic ecosystem of 0.007 mg/l.

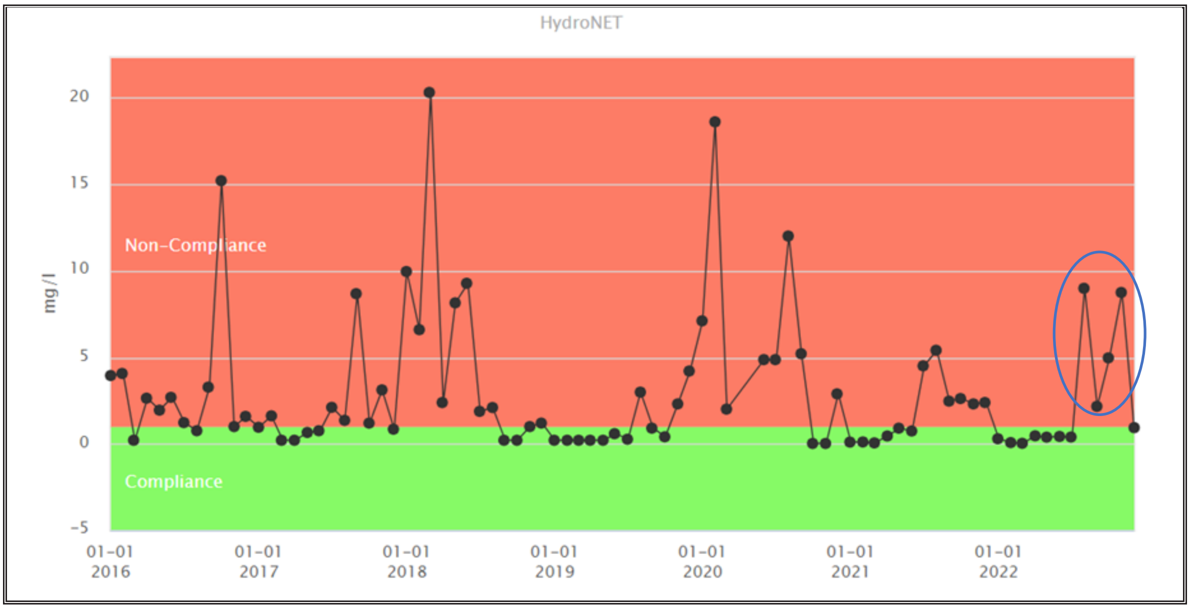


Figure 30: Chart indicating Ammonia concentrations trends at Langspruit D/S of Hazyview WWTWs.

4.2.2. Crocodile Catchment

The Crocodile River catchment originates near Dullstroom as illustrated in figure 31, where it flows into the Kwena Dam and eastwards through Mbombela and confluences with the Komati River before entering Mozambique at the Lebombo Border Gate. The Elands River and Kaap River are two large tributaries of the Crocodile River system. The other smaller tributaries of the Crocodile River include the Lunsklip River, Nels River, Houtbosloop, Gladdespruit, White River and Bestersspruit. The Significant Dams include the Kwena Dam, Ngodwana Dam, Witklip Dam, Klipkoppie Dam, Longmere Dam & Primkop Dam. The Crocodile River Catchment is dominated by agricultural activities (dry land, and irrigated cultivation), forestry, rural and urban settlements. The middle region of the Crocodile River is characterized by increased urbanization. The river flows through the major towns of Mbombela, Kaapmuiden and Malelane as well as commercial farming activities (sugar cane, fruit orchards, and vegetables) which are important characteristics of this catchment. There are also mining activities in the Kaap River and the Sappi Mill in the Elands River sub-catchment. Other activities that existed in the catchment but have since closed are, Manganese Metal Corporation, Papas Quarry and Assmang Chrome. Illegal sand mining is posing a severe water quality problem in the middle regions of the Crocodile River catchment area around Ka-Nyamazane area.

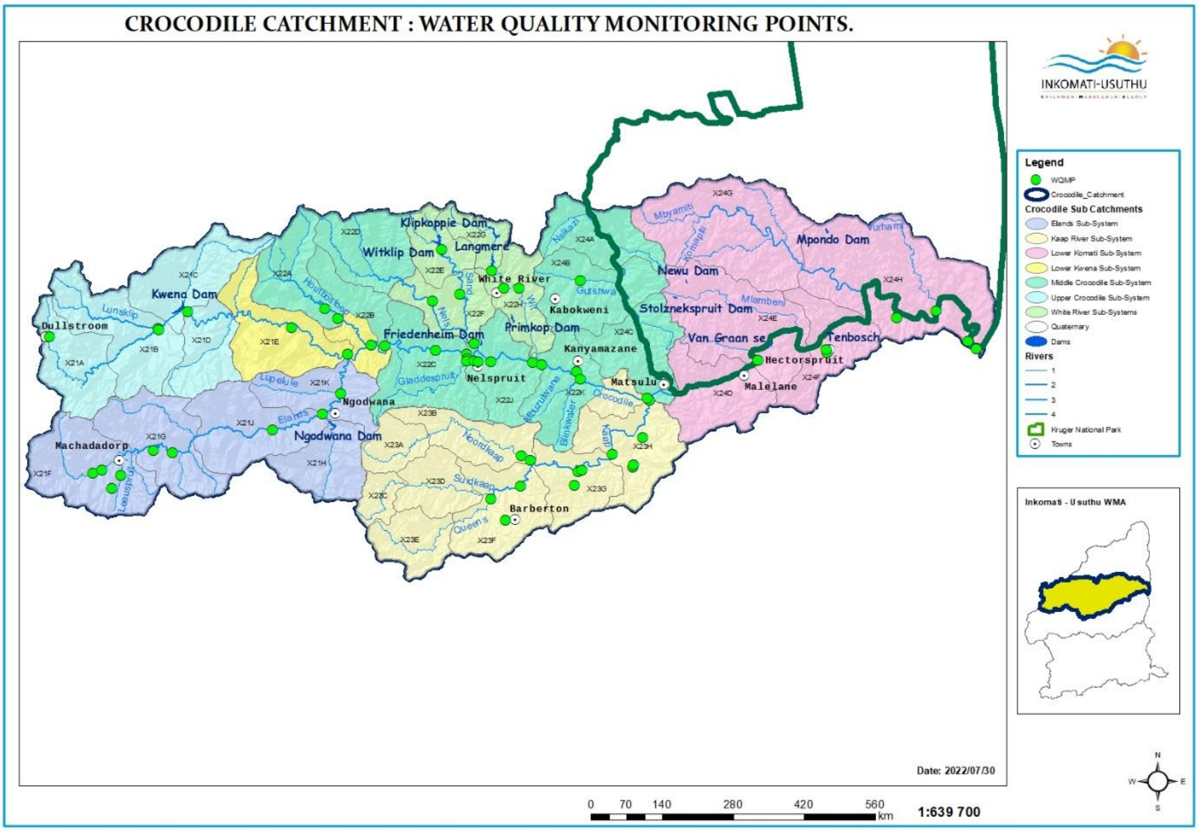


Figure 31: Water quality monitoring points in the Crocodile Catchment.

The compliance of the indicator parameters is compared with the Resource Quality Objectives published in a Government Gazette dated 30 December 2016 or the Target Water Quality Guideline limits (TWQG) where the RQOs were not available or set as tabulated below.

Table 8: TWQG and RQOs within Crocodile Catchment.

Variables/Parameters	RQOS	TWQG
Salinity in % Saturation		
pH	6.5 – 8.0	6.5 - 8.5
Electrical Conductivity (EC) in mS/m	30, 70 & 200	40
Sulphate (SO_4) in mg/l	-	30 (Industry)
Phosphate (PO_4) in mg/l	0.015, 0.025, 0.075 & 0.125	0.025
Nitrates/Nitrites (NO_3 + NO_2) in mg/l)	-	6 (Domestic)
E coli in (cfu/100ml)	120 and 130	130
Total ammonia (NH_3+ NH_4^+) in mg/l	-	1 (Domestic)
Chromium (Cr) VI in mg/l	0.014	-
Arsenic (As) in mg/l	0.02	-
Cyanide (Cn) in mg/l	0.004	-
Iron (Fe) in mg/l	-	0.1 (Domestic)
Manganese (Mn) in mg/l	0.18	-

N/A=Not available

System Variable(s) and Salt(s)

Salinity is a key parameter used to classify bodies of water as fresh, slightly saline (Brackish) moderately saline (Sea water), or highly saline (Brine). Figure 32 indicates the salinity (PSU) concentrations measured through continuous monitoring at Lindenau station on Elands River from 01 January 2022 to 31 December 2022. According to water classes the salinity concentration at Elands River is less than 0.5 (PSU) which is considered fresh water.

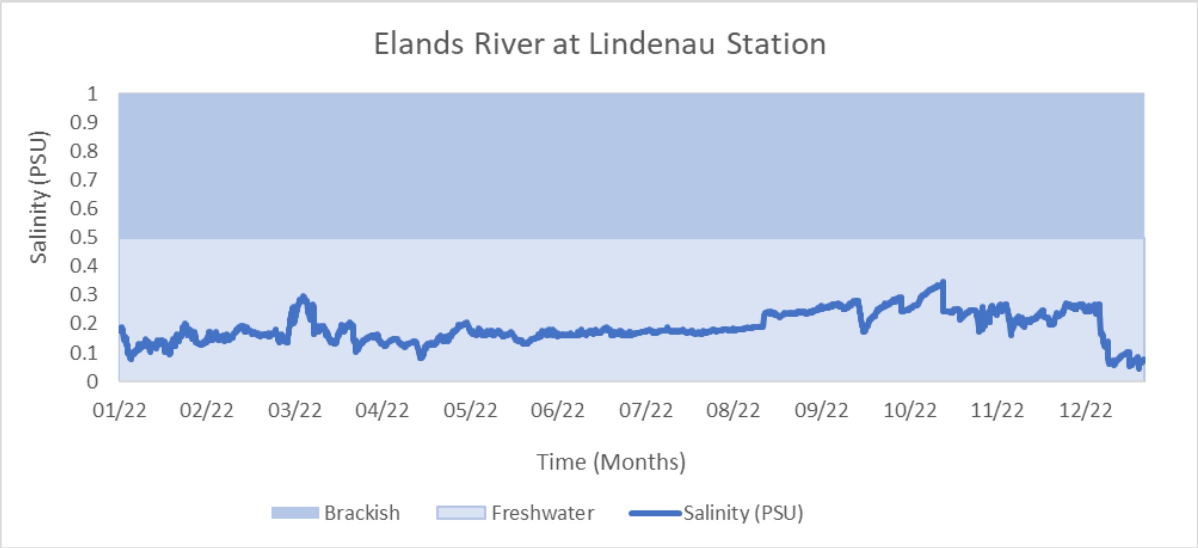


Figure 32: Salinity concentration chart at Elands River (Lindenau station).

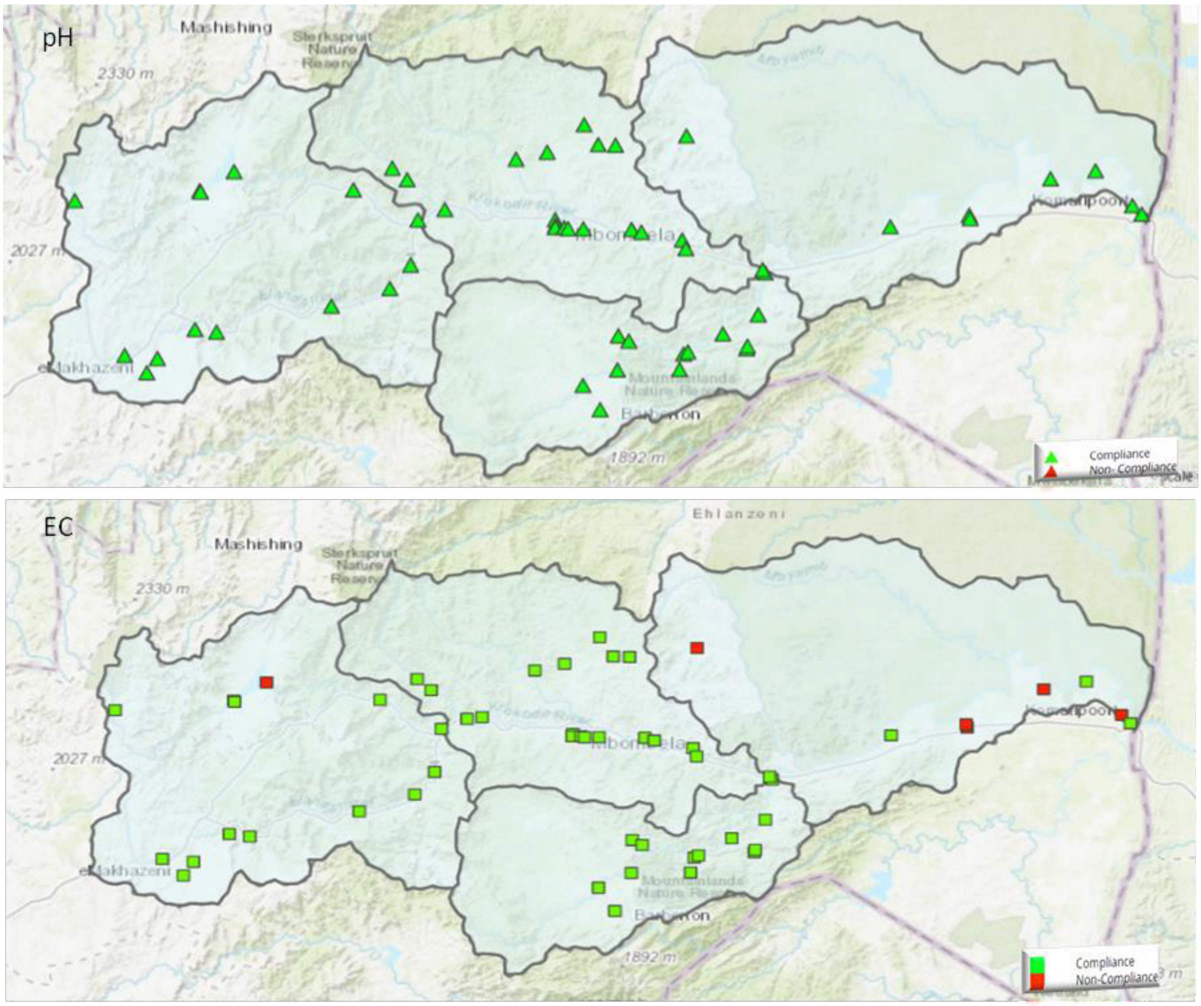


Figure 33: Water quality status within Crocodile Catchment showing pH and EC concentrations.

System Variable(s)

pH is a vital indicator of water that is changing chemically and measures how acidic/or basic the water is, ranging from 0 to 14. The pH levels complied with the TWQG throughout the Crocodile Catchment.

Salts

The electrical conductivity is an indicator of the estimated levels of dissolved salts in water. Electrical Conductivity within the Crocodile Catchment complied with the RQOs (Aquatic Ecosystem drivers), except Kwena Dam due to outlier observerd in July 2022, Gutshwa River downstream of Kabokweni WWTW, tributary of Crocodile River at Tenbosch, Hectorspruit upstream and downstream of Hectorspruit WWTWs and the tributary of Crocodile River downstream of Komati WWTW. The high level of EC may be due to presence of dissolved inorganic solids such as chloride, phosphate, and nitrate arising from industrial effluent, WWTWs, stormwater runoff from formal /informal settlements and agricultural runoff.

There are also challenges with sulphate concentration within the Crocodile Catchment indicating non-compliance with TWQG (Industry: category one) of 30 (mg/l) in the Elands River downstream of Sappi's Ngodwana Mill, Suidkaap River, Kaap River and Low's Creek due to industrial activities (Mill and Mines).

Nutrients

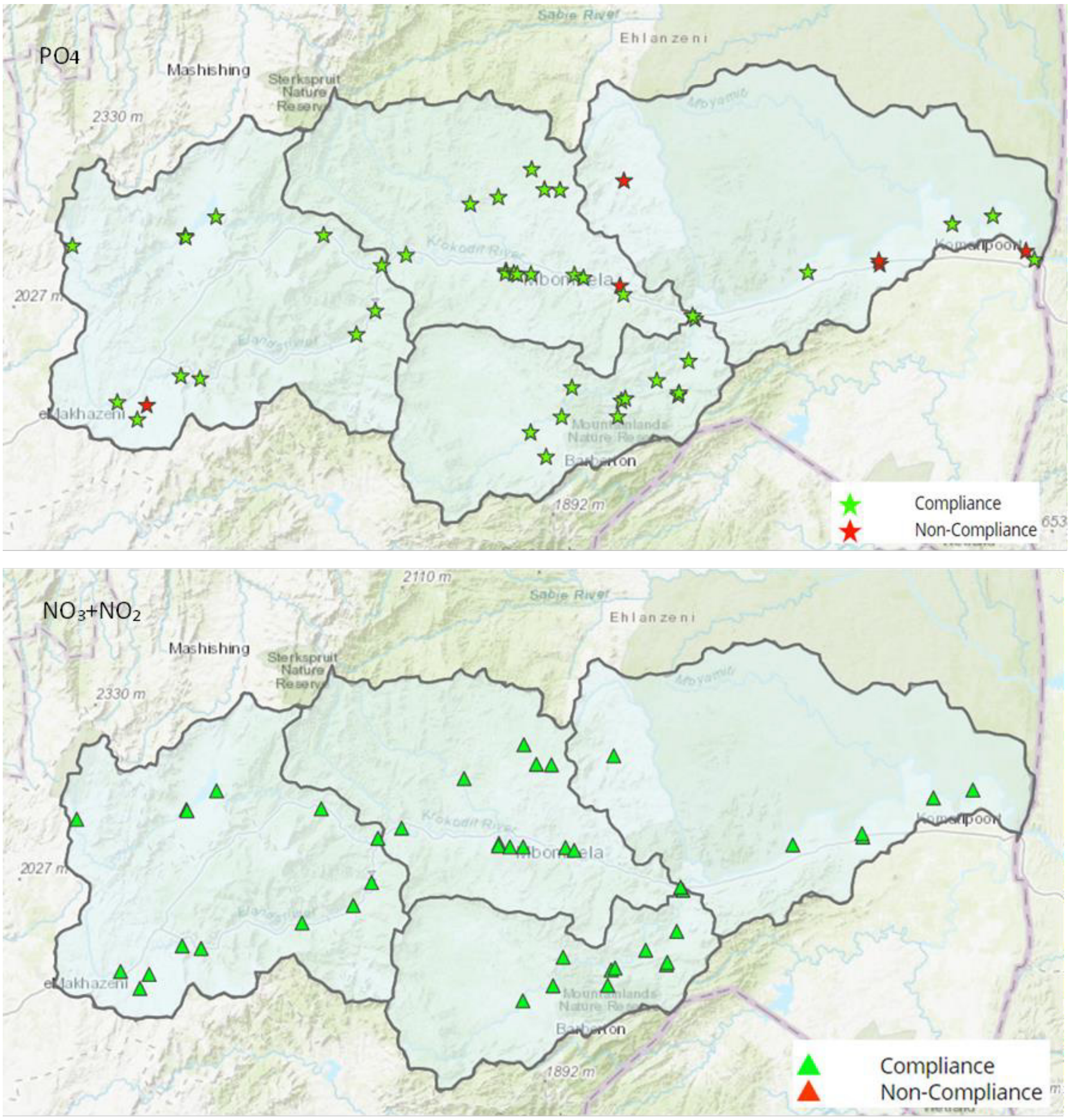


Figure 34: Water quality status within Crocodile Catchment showing PO_4 *and* $NO_3 + NO_2$ *concentrations.*

Phosphates enter surface water from human and animal feacal waste, effluent discharges and fertilizers runoff. Phosphate concentrations in the Crocodile Catchment complied with the RQOs for most of the time except for points downstream of Emthonjeni, Komatipoort and Kabokweni WWTWs, downstream & upstream of Hectorspruit WWTWs as well as the Kanyamazane stream. The impacts are attributed to effluent discharges from WWTWs and illegal dumping of solid waste. The nitrate and nitrite levels complied with the TWQG throughout the Crocodile Catchment.

Microbial

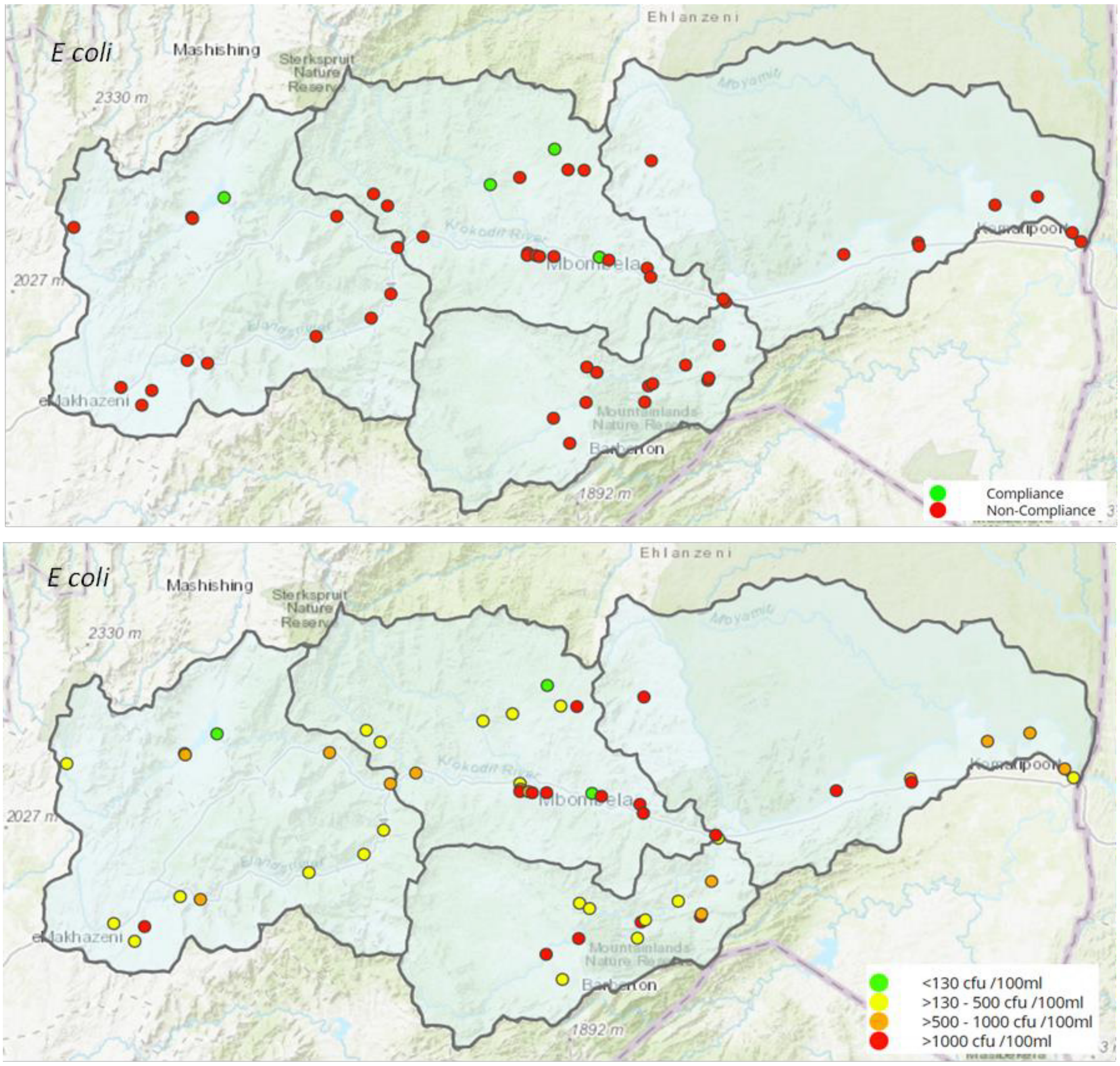


Figure 35: Water quality status within Crocodile Catchment showing E coli concentrations.

The first map shows *E. coli* counts in the Crocodile Catchment with elevated counts which from time to time exceeded the set RQOs of 130 (cfu/100ml). The non-compliance from the upper, middle and lower parts of the Crocodile River and its tributaries are due to contamination from human faecal material and/or animals. Only four (4) points in the catchments complied with the RQO of 130 (cfu/100ml) Kwena Dam, Langmere Dam , Sand River and white River before confluence with Crocodile River at Karino.

This second map shows extent of *E coli* counts by showing less than 1 000 cfu/100ml in green, orange and yellow colour while greater than 1 000 cfu/100ml is shown in red. E. coli counts greater than(>) 1 000 (cfu/100ml) arises from extensive urban and rural impacts from the Nelspruit, White River, Barberton, Malelane, Hectorspruit and Komatipoort including effluent from WWTWs and its associated infrastructure which discharge effluent into the Crocodile River and its tributaries. Meanwhile, the other areas have not reached an alarming stage as the *E. coli* counts are below 1000 (cfu/100ml).

Toxic substances

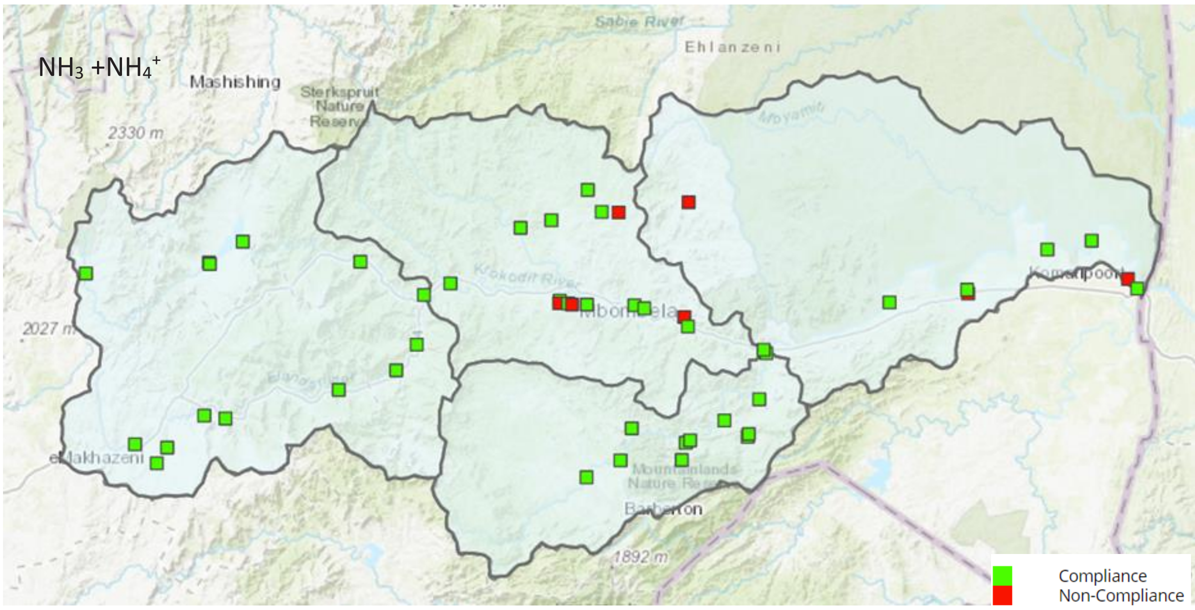


Figure 36: Water quality status within Crocodile Catchment showing total ammonia concentrations.

Total ammonia ($NH_3+NH_4^+$) within the Crocodile Catchment indicated compliance with TWQG (Domestic) of 1 (mg/l), except the tributaries of Crocodile River, namely the Gladdespruit, Besterspruit, KaNyamazane Stream, Hectorspruit as well as unnamed tributary downstream of Komatipoort WWTWs and the tributary of Gutshwa River downstream of Kabokweni WWTW.

Cr (VI) is monitored at Leeuspruit to assess the impact from Assmang Chrome on the water resource. Cr (VI) complied with the RQOs of 0.014 (mg/l) throughout the reporting period (Jan-Dec 2022) as illustrated below in Figure 37.

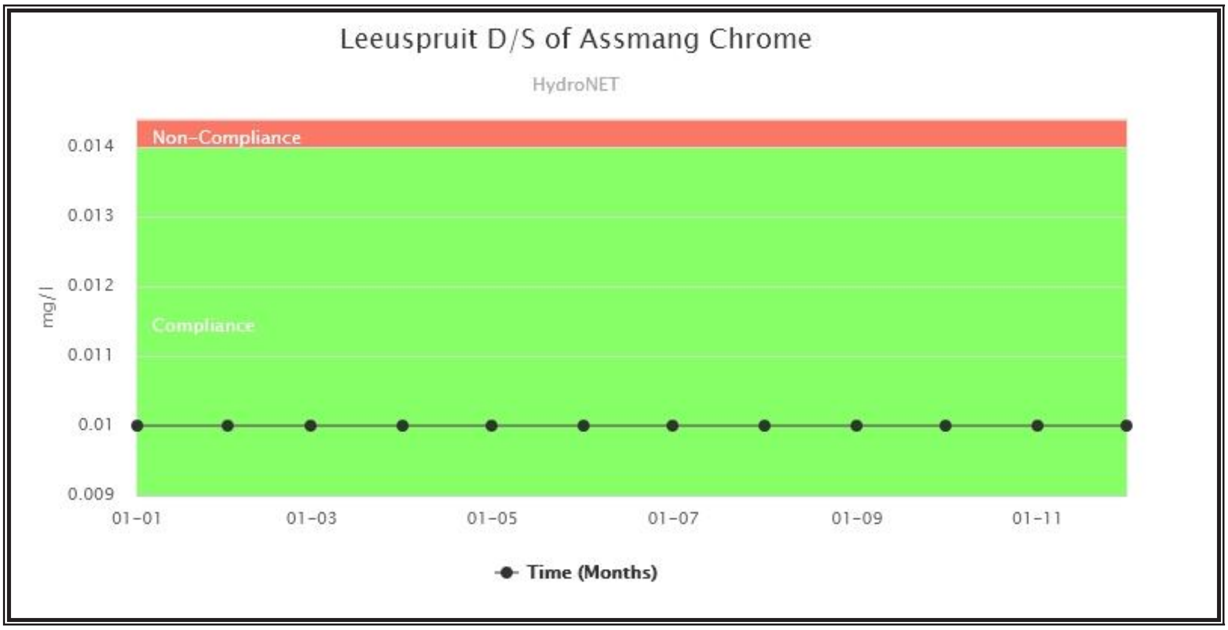


Figure 37: Chromium (VI) trend chart for the Leeuspruit.

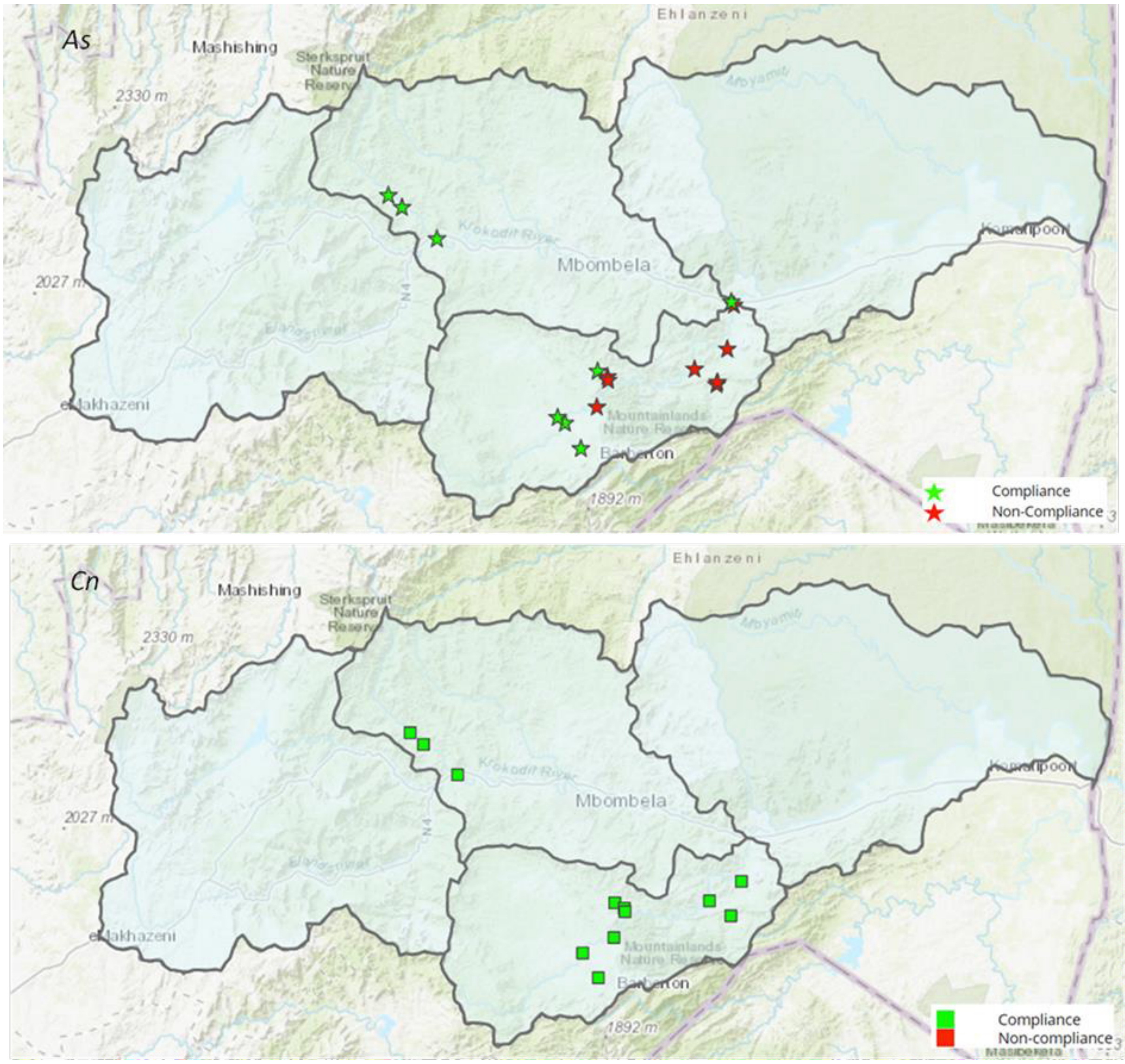


Figure 38: Water quality status within Crocodile Catchment showing As and Cn concentrations.

Arsenic is a toxic metalloid mainly found in gold mining areas and also a naturally occurring element. Arsenic complied with the RQOs of 0.02 (mg/l) within the Houtbosloop, Noordkaap, tributary of Queens, however indicated non-compliance in Suidkaap and Noordkaap downstream of Fairview and Consort Mine, respectively including Louw's Creek and its tributaries as well as Kaap River after confluence with Louws Creek . The impact is attributed to gold mine activities in the area as well as illegal gold mining in the Kaap River system.

The cyanide concentrations within the Crocodile Catchment were <0.07 mg/l through out the reporting period, the RQO is 0.004 mg/l and there is no intruments that can detects below the 0.07 mg/l. Therefore, it will be regarded as compliant due to the detection limit that makes it impossibe to measure the concentration of cyanide in the water resources. The World Health Organisation recommends that people should not consume water with a cyanide concentration above 0.5 mg/l. The cynaide concenrations in the middle Crocodile Catchment and the Kaap River system is below <0.07 mg/l, however communities should drink treated water provided by water service authorities not directly from the resource.

Metals

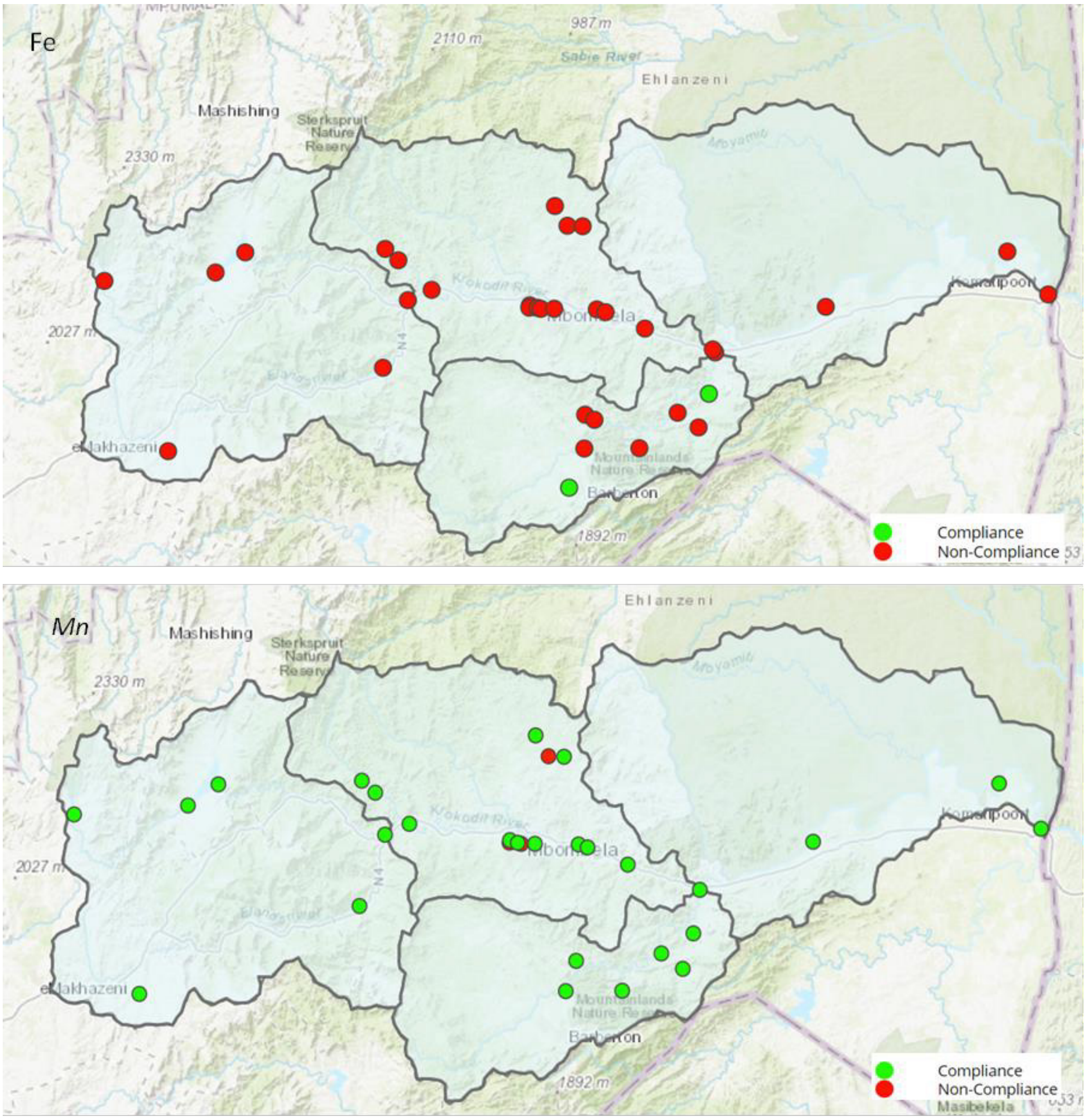


Figure 39: Water quality status within Crocodile Catchment showing Mn and Fe concentrations.

Iron and manganese can affect the colour and taste of water. These minerals can be found naturally in the environment (surface water) or because of land use activities such as mining and industrial discharges. Iron did not comply with the TWQG of 0.1 mg/l (Domestic) except for two points throughout the Catchment. However, there are no known sources of iron and furthermore, noncompliance is recorded in the head waters. It is apparent from the results that the noncompliance is as a result of the background geology.Manganese complied with the RQOs of 0.18 (mg/l) within Crocodile Catchment, except for three points Gladdespruit, Besterspruit (Mbombela area) and White River in middle Crocodile Catchment. The targeted domestic limit for iron in wateris 0.1 mg/l, and is based on taste and appearance rather than on any detrimental health effect. However, communities should drink treated water provided by water service authorities not directly from the resource.

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4.2.3. Komati catchment

The Komati River originates from the outflow of the Nooitgedacht dam next to Carolina, Mpumalanga province. The catchment of the Nooitgedacht dam includes the Boesmanspruit, Vaalwaterspruit and the Witkloofspruit tributaries that feed directly into the dam. The most unique feature of the Komati River is that it starts in South Africa and flows through eSwatini in a North-easterly direction and comes back to South Africa at the Mananga Border Gate. It then confluences with the Crocodile River (one of its main tributaries) at Komatipoort before it enters Mozambique where its confluences with the Sabie River which is another one of its main tributaries. After entering Mozambique, the Komati River is referred to as the Incomati River and flows into the Indian Ocean at Maputo Bay. From the source to the mouth, the length of the Inkomati River is 480 kilometers. The catchment is dominated by coal mining in the upper reaches of the catchment and irrigation agriculture in the lower reaches of the catchment. There are also WWTWs the majority of which are operated by municipalities. For the purposes of this report the Komati River upstream of eSwatini will be referred to as Upper Komati and downstream of eSwatini, will be referred to as Lower Komati as illustrated in figure 40.

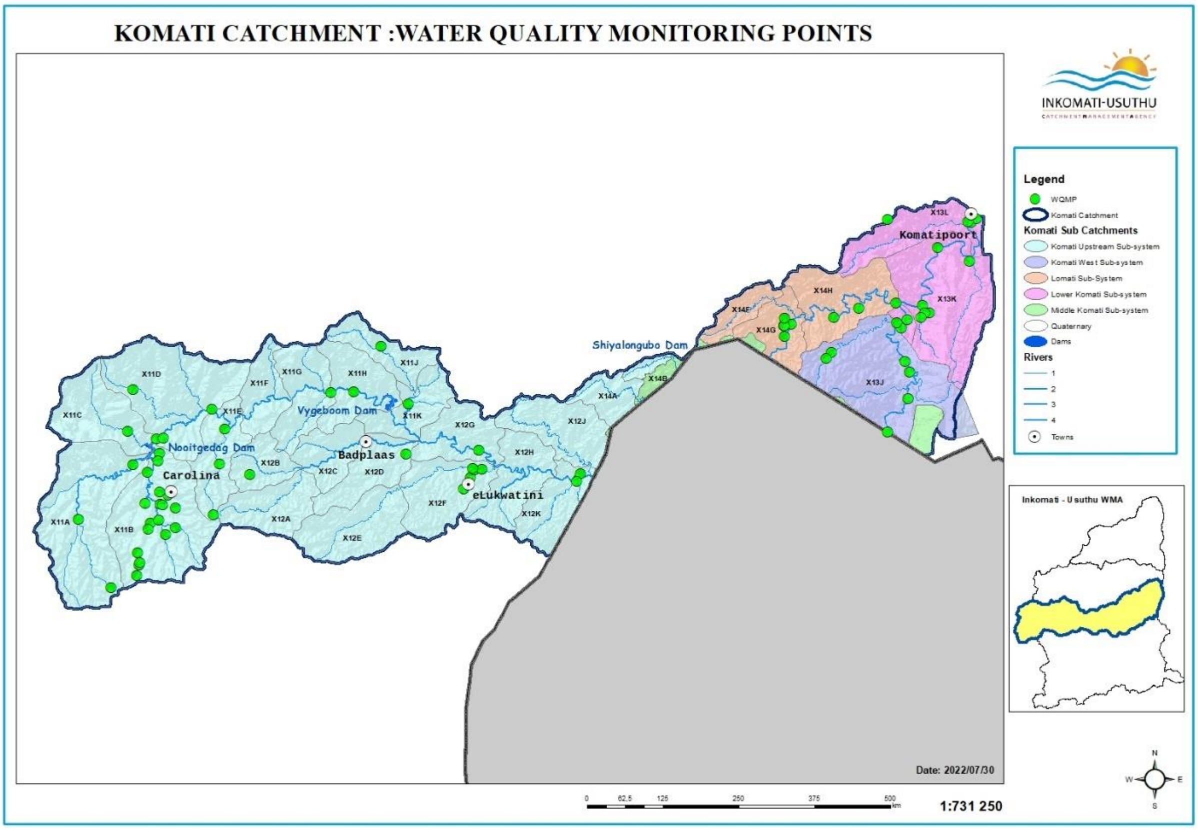


Figure 40: Water quality Monitoring points in the Komati Catchment.

The compliance of the indicator parameters is compared with the Resource Quality Objectives published in a Government Gazette dated 30 December 2016 or the Target Water Quality Guideline limits (TWQG) where the RQOs were not available or set as tabulated below.

Table 9: TWQG and RQOs within Komati Catchment.

Variables/Parameters	RQOs	TWQG
Temperature (Temp) in °C	-	Not vary by more than 2 °C
pH	6.5 - 8.0	6.5 - 8.5
Electrical Conductivity (EC) in mS/m	30, 40, 50, 55 & 85	40
Sulphate (SO_4) in mg/l	30 and 80	30 (Industry category 1)
Phosphate (PO_4) in mg/l	0.02	0.025
Nitrates/Nitrites ($NO_3 + NO_2$) in mg/l)	N/A	6 (Domestic)
E coli (cfu/100ml)	130	130
Total ammonia (NH_3+NH_4^+) in mg/l	-	1 (Domestic)
Nickel (Ni) in mg/l		0.2 (Agriculture-irrigation)

N/A=Not available

System Variable(s)

As illustrated in Figure 41 the annual water temperature ranged between 11.0 – 27.8 °C. A moderate change to stream temperatures should not vary by more than 2 °C from the natural temperature range for each month. The monthly water temperature at Komati River ranges between 11.2 - 26.7 °C calculated using 10th and 90th percentiles for each month, respectively.

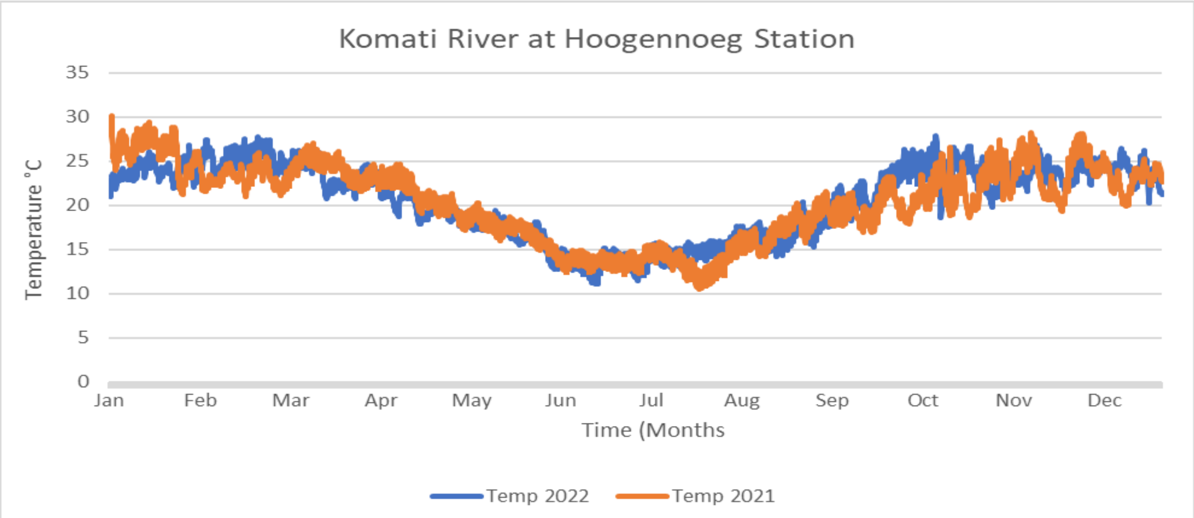
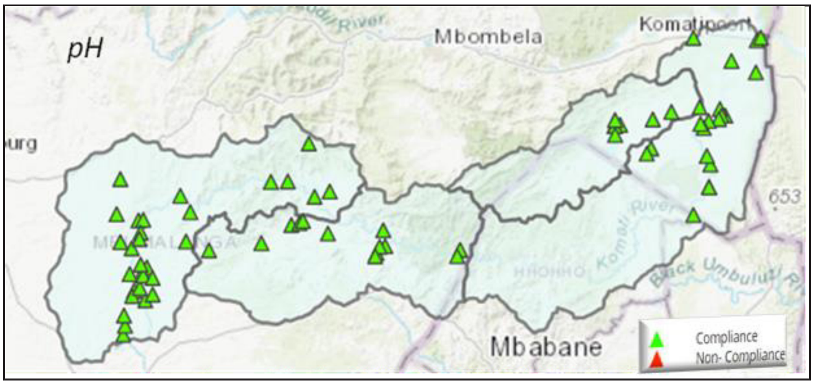


Figure 41: Temperature trend charts at Komati River at Hoogenoog station.



pH is a vital indicator of water that is changing chemically and measures how acidic or basic the water is, ranging from 0 to 14. **pH** levels complied with the TWQG throughout the catchment.

Figure 42: Water quality status within Komati Catchment showing pH concentrations.

Salts

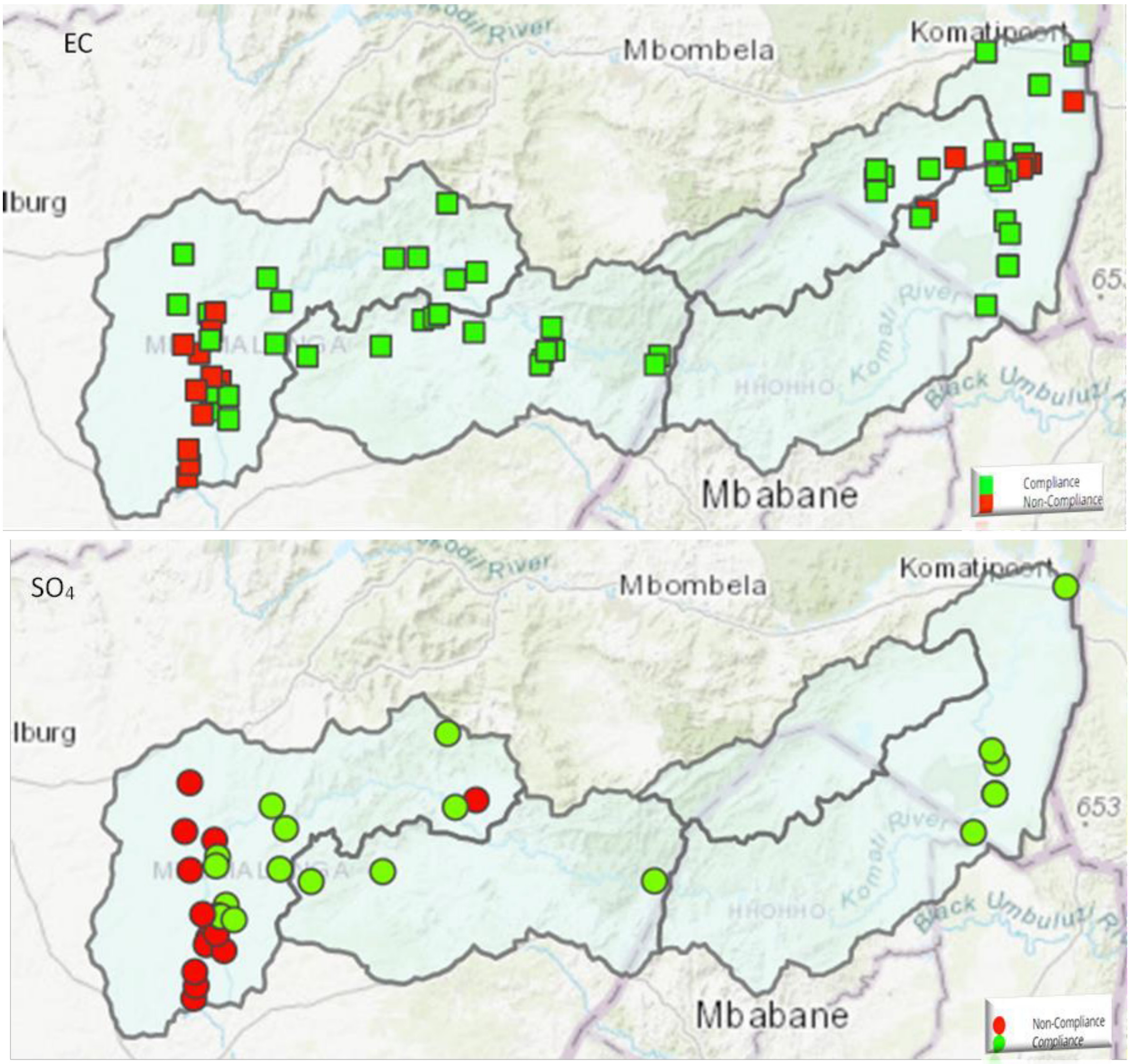


Figure 43: Water quality status within Komati Catchment showing EC and SO_4 concentrations.

Electrical Conductivity was compliant at most monitoring points with the RQOs (Aquatic Ecosystem drivers) set within the Komati Catchment. There were a few points where the EC did not comply with the set RQOs in the Upper Komati sub-catchment, especially on the Boesmanspruit which is dominated by coal mines. In the Lower Komati sub catchment mainly dominated by agricultural activities, there were also a few monitoring points where EC did not comply with the set RQOs. The high level of EC is due to the presence of dissolved solids arising from mining activities, effluent from WWTWs, stormwater runoff from formal /informal settlements areas and agricultural runoff within the Catchment.

Sulphate concentration showed non-compliance with the RQOs limit within priority resource units or the TWQG limits in the Boesmanspruit, Witkloofspruit and Gladdespruit. These priority resource units are dominated by coal mines and the high levels of sulphates are mostly attributed to active mines and defunct mines some of which are decanting.

Nutrients

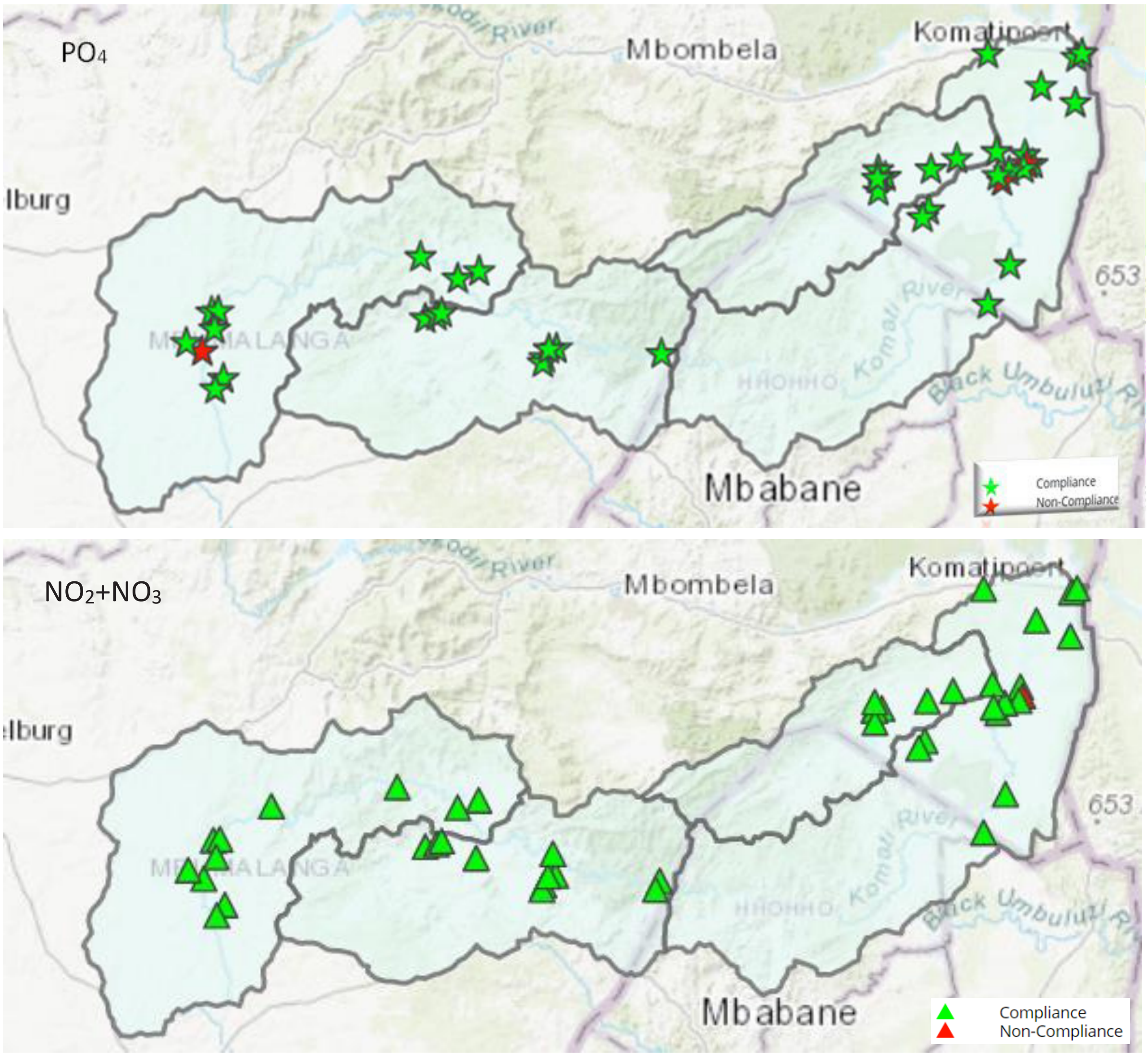


Figure 44: Water quality status within Komati Catchment showing PO_4 and NO_2+NO_3 concentrations.

Phosphate showed compliance with the RQOs for most of the points within Komati Catchment, except for four points. The one point is in upper Komati sub catchment on the tributary of Boesmanspruit downstream of Carolina WWTWs and the other three points are in the lower Komati sub catchment on the tributary of the Komati River downstream of Tonga Hospital WWTWs and Mahorwane stream and its tributary. The impacts are attributed to effluent discharges from WWTWs and illegal dumping of solid waste materials. Nitrates/Nitrites concentrations complied with the TWQG throughout the sites monitored in the Komati Catchment except the Mahorwane stream, which is highly impacted by extensive settlements (KaMaqhekeza).

Microbial

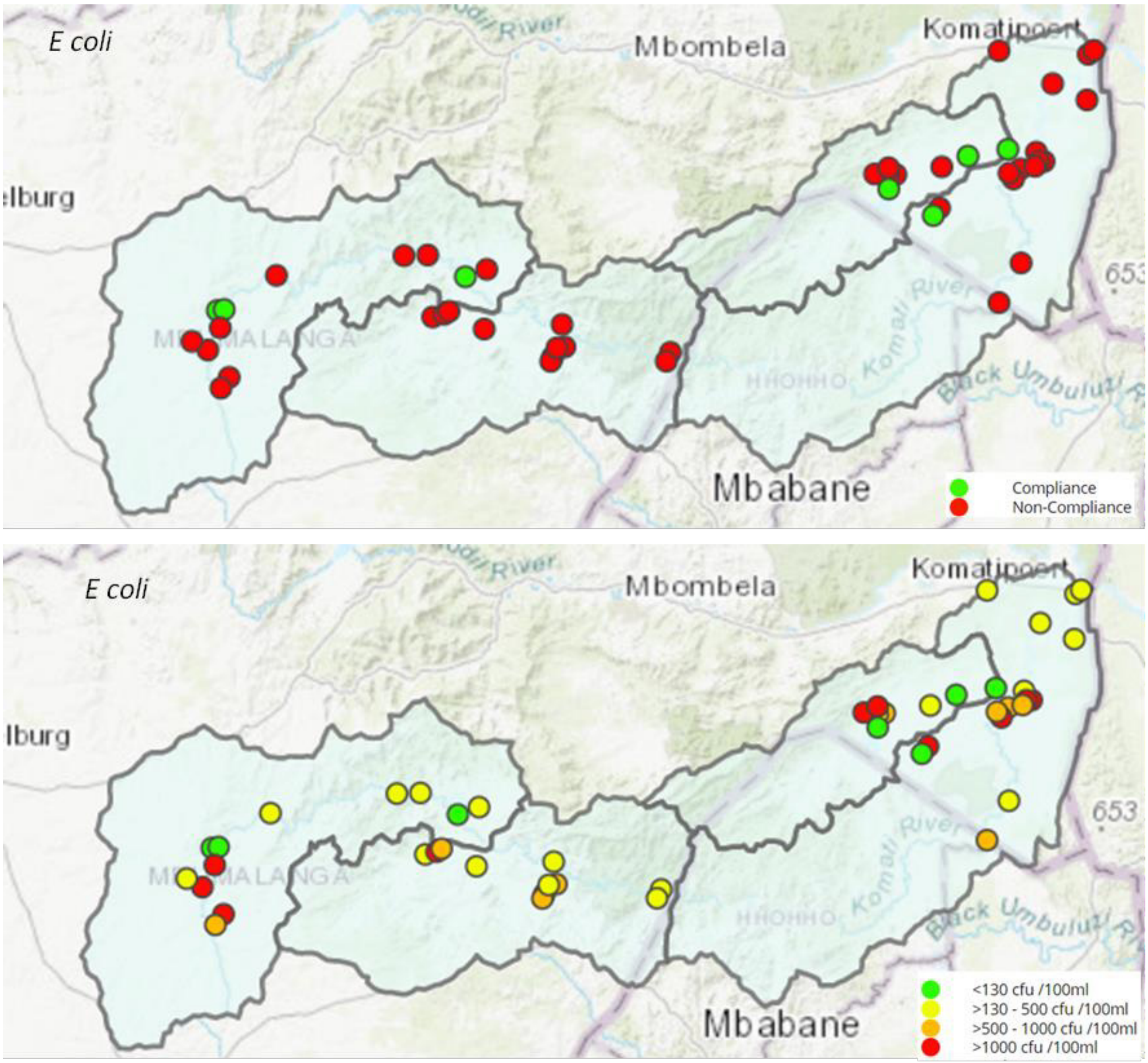


Figure 45: Water quality status within Komati Catchment showing E. coli concentrations.

The. ***E. coli*** counts in the Komati Catchment complied with the RQO of 130 (cfu/100ml) for few points mostly the major dams (Nooitgedacht, Vygeboom, Driekoppies, Magogeni and Vlakbult) and Lomati River at Phiva as illustrated in the first map of Figure 45. The other sites in Carolina, Badplaas and Elukwatini areas within the upper Komati sub catchment and Matsamo, Tonga, Skoonplaas, KaMaqhekeza and Buffelspruit settlement within the lower Komati sub catchment showed elevated *E. coli* counts that did not comply with the set RQOs due to contamination by human faecal material and/or other animals.

The second map shows extent of *E coli* counts recording less than 1 000 cfu/100ml in green, orange and yellow colours, while greater than 1 000 cfu/100ml is shown in red. E coli counts > 1 000 (cfu/100ml) arise from extensive urban and rural impacts from Carolina, Badplaas, Elukwatini, Tonga, Skoonplaas, KaMaqhekeza and Buffelspuit, Driekoppies areas including WWTWs and its associated infrastructure which discharge poorly treated effluent into the Komati River and its tributaries. Meanwhile, other areas have not reached an alarming stage as *E. coli* counts for most of the points were still below 1 000 (cfu/100 ml).

Toxic

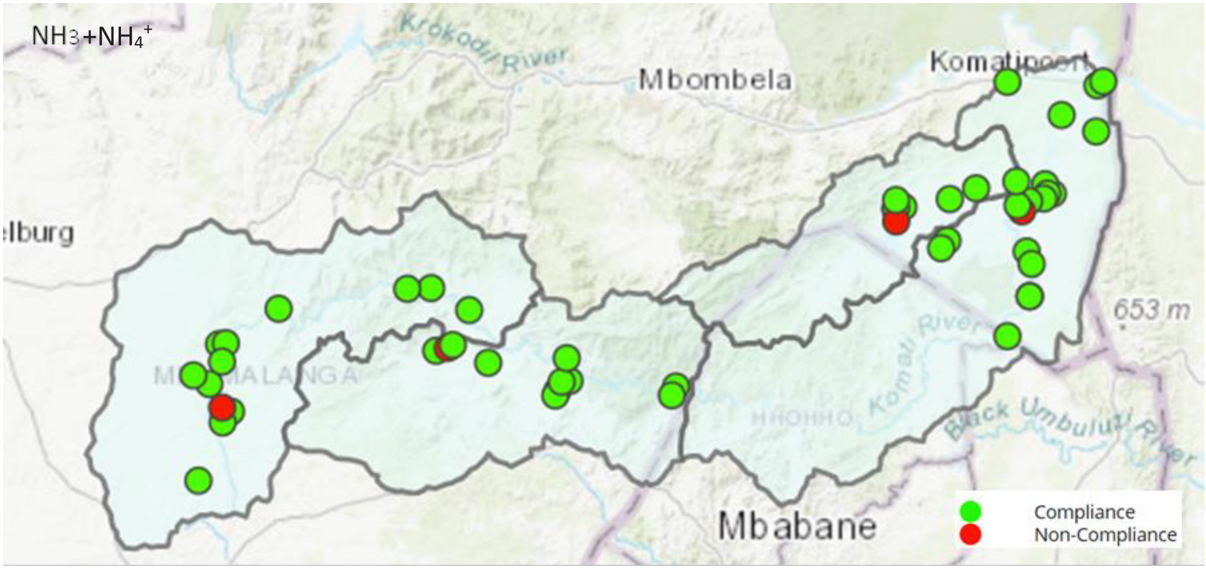


Figure 46: Water quality status within Komati Catchment showing total ammonia concentrations.

Total ammonia within the Komati Catchment indicated compliance with TWQG (Domestic) of 1 (mg/l), except the tributaries of Boesmanspruit downstream of Carolina WWTWs, tributary of Seekoeispruit downstream of sewer pumpstation, tributary of Komati downstream of Tonga WWTWs and Driekoppies Dam.

The chart below indicates that total ammonia concentration at Driekoppies Dam complied with TWQG (Domestic) of 1 (mg/l) from January 2017-December 2022, except in September 2022 where there was an outlier of 12.6 (mg/l) concentration (an outlier is a data point that differs significantly from other observations).

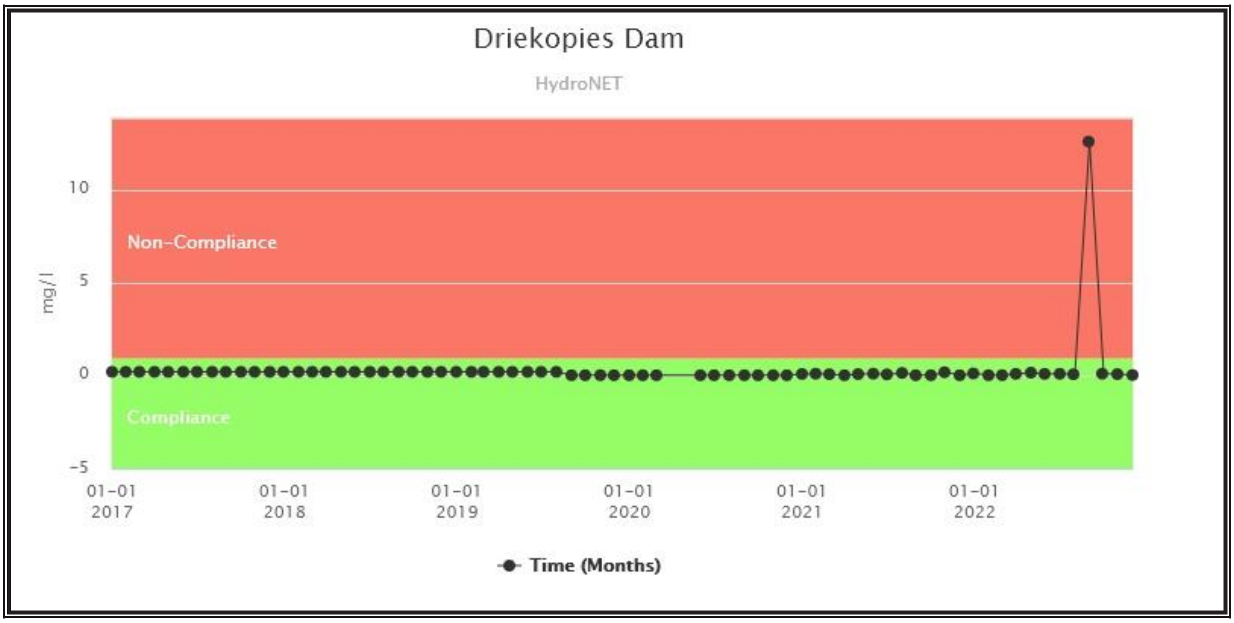


Figure 47: Chart indicating Ammonia concentrations trends at Driekoppies Dam.

The non-compliance in the remaining three sites was due to domestic waste derived from partially treated effluent from WWTWs and overflowing of raw sewer from the pump station and manholes. Figure 48 indicates the total ammonia trends at tributary of Komati River downstream of Tonga WWTWs.

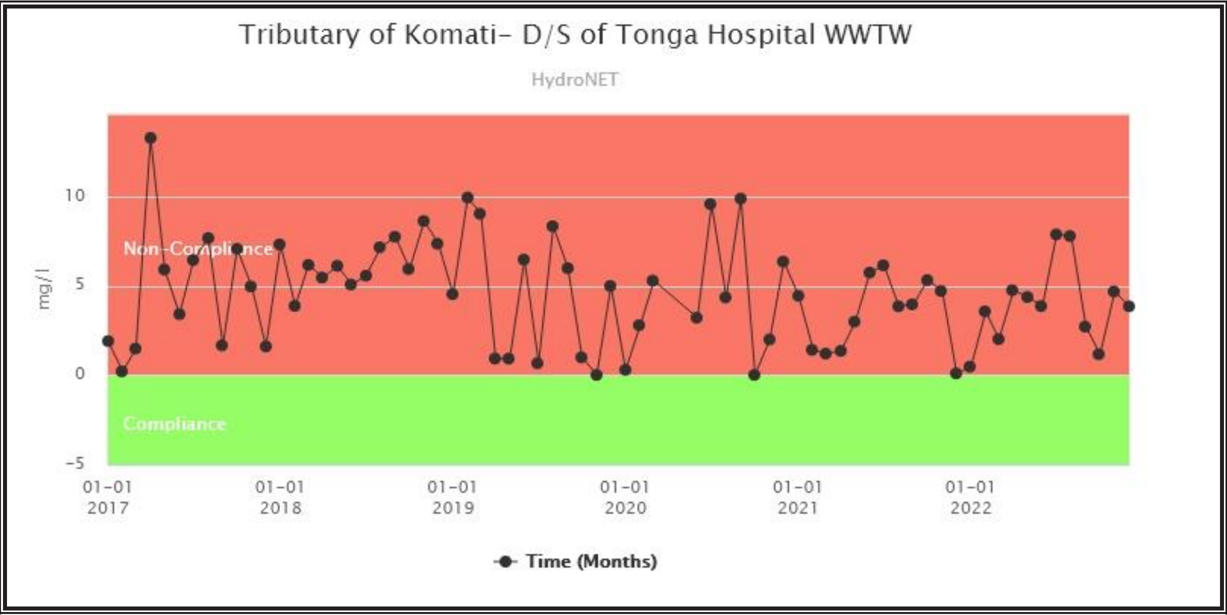


Figure 48:Total ammonia (NH_3+NH_4^+) trend chart at Tributary of Komati River.

Nickel (Ni) is monitored in the Gladderspruit to assess the impact from the Nkomati Mine a joint venture between African Rainbow Minerals (Pty) Ltd and Norilsk Nickel that produces mainly nickel. Ni complied with the RQOs of 0.2 (mg/l) in the water resource throughout the reporting period (Jan-Dec 2022) as illustrated in Figure 49 below.

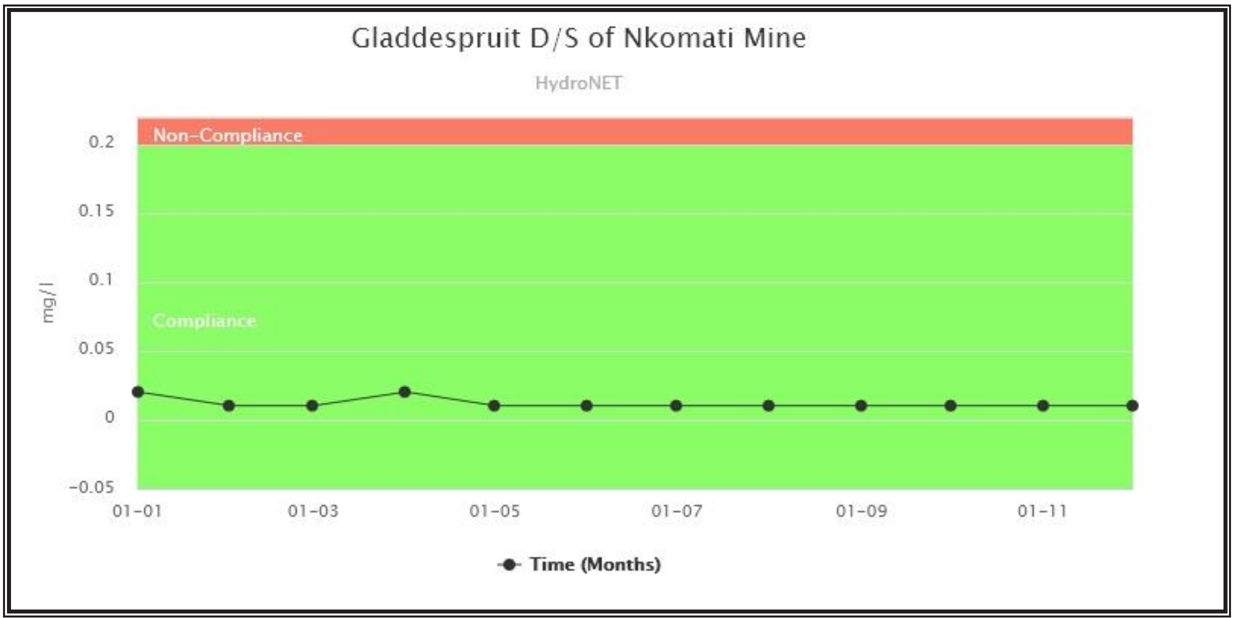


Figure 49: Nickel (Ni) trend chart in the Gladderspruit.

4.2.4. Usuthu catchment

The headwaters of the Usuthu River emerge from the highlands of Amsterdam, Mpumalanga province, flow through the Kingdom of eSwatini and into the Republic of Mozambique before entering the Indian Ocean. The Usuthu Catchment is unique from the other three catchments due to the short distance from the headwaters to the border with eSwatini as illustrated in figure 50.

The major activities in the catchment include forestry, mining, agricultural activities and municipal wastewater treatment works. The Usuthu catchment is characterised by large transfers out of the catchment (and out of the WMA) to the Vaal and Olifants Water Management Areas mainly for cooling purposes at ESKOM power stations but also for other economically important activities. Four large dams in the Usuthu support these transfers, namely, Heyshope, Morgenstond, Westoe and Jericho dams. Pollution of these strategic water resources will significantly impact on power generation and the economy of the country at large.

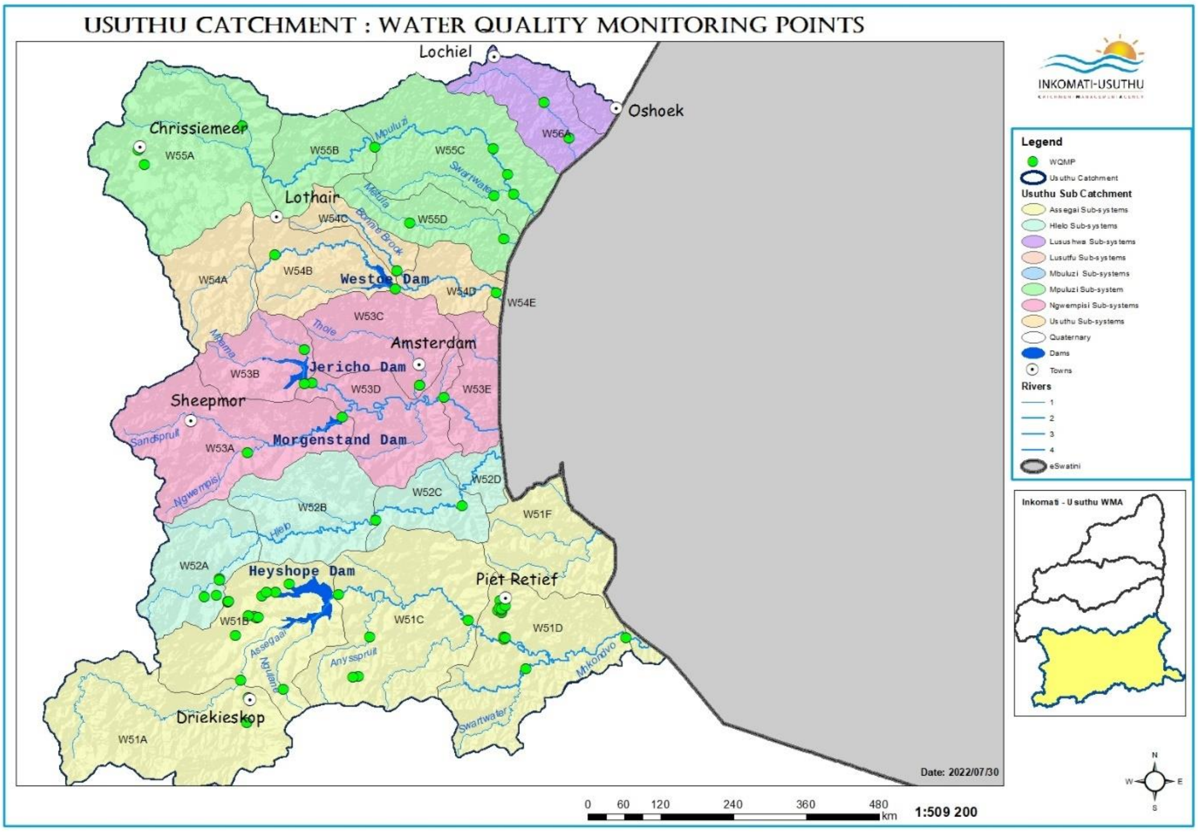


Figure 50: Water quality monitoring points in the Usuthu Catchment.

The RQO are currently not determined for the Usuthu Catchment. Thus, the South African Target Water Quality Guidelines (SATWQG) were used to benchmark the water quality data for all variables. The compliance of the indicator parameters was compared with the Target Water Quality Guideline Limits (TWQG) as indicated in Table 10.

Table 10: Target Water Quality Guideline.

Variables/Parameters	TWQG
pH	6.5-8.5
Dissolve Oxygen (DO) in % Saturation	>80
Electrical Conductivity (EC) in mS/m	40
Sulphate (SO_4) in mg/l	30 (Industry Category 1)
Phosphate (PO_4) in mg/l	0.025
Nitrates/Nitrites (NO_3 + NO_2) in mg/l	6 (Domestic)
E.coli in cfu/100ml	130 (recreation)
Total ammonia (NH_3+NH_4^+) in (mg/l)	1 (Domestic)
Aluminium (Al) in mg/l	0.15 (Domestic)

System Variables

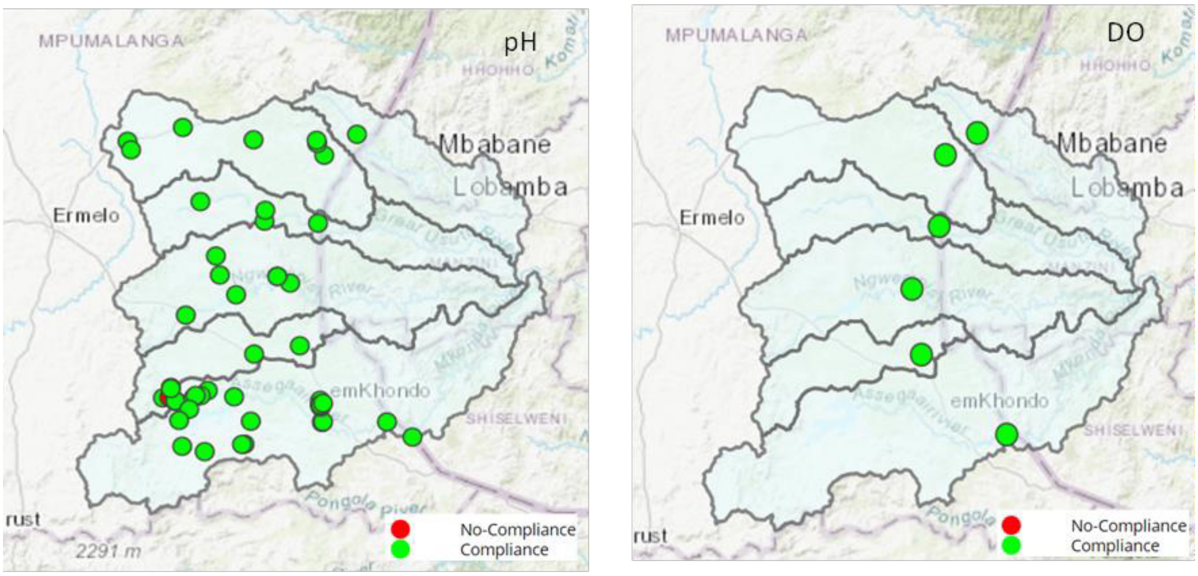


Figure 51: Water quality status within Usuthu Catchment showing pH and DO concentrations.

As shown in Figure 51 the system variables using pH and DO comply with the TWQG limit throughout the reporting period, except for pH at Wokolo stream (Nooitgesein) which was acidic in December 2022 due to mining activities within the area.

Salts

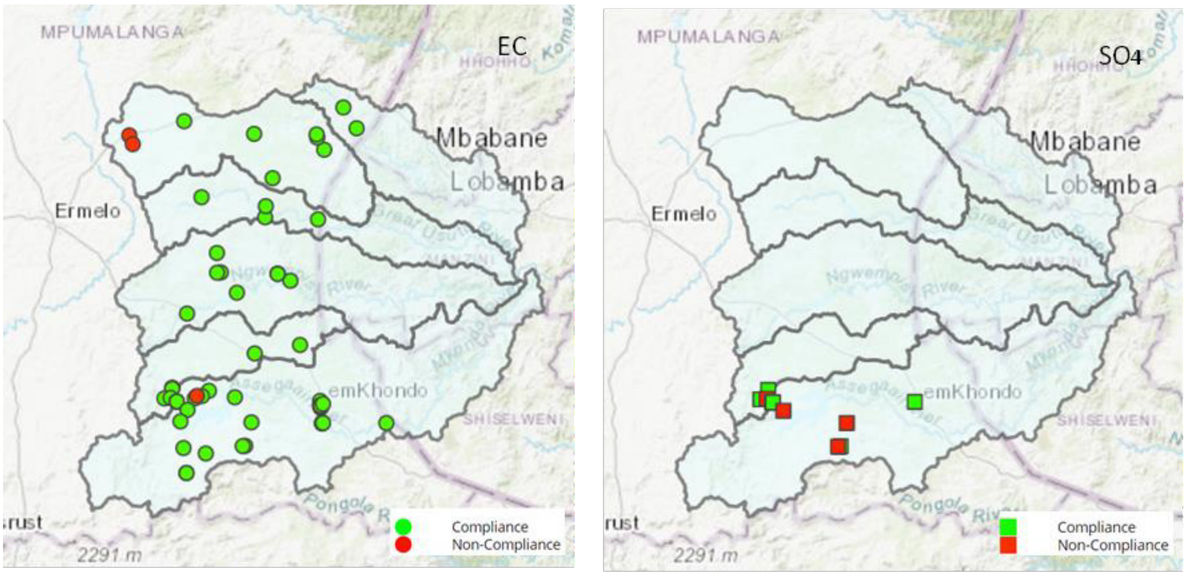


Figure 52 : Water quality status within Usuthu Catchment showing EC and SO_4 concentrations.

EC complied with the TWQG limits within the Usuthu Catchment except for upstream of Chrissiesmeer WWTWs, Chrissiesmeer lake, Egude River, Klipmisselspruit and its tributary downstream of WWTW and industrial area (Umkhonto). Sulphate is monitored to assess the impact of coal mining activities in the upper Assegai River, Annysspruit and Hlelo River sub-systems in the Usuthu Catchment. SO4 indicated compliance with the TWQG for Industry of 30 (mg/l) except for 4 sites that indicated non-compliance as shown in Figure 52.

Nutrients

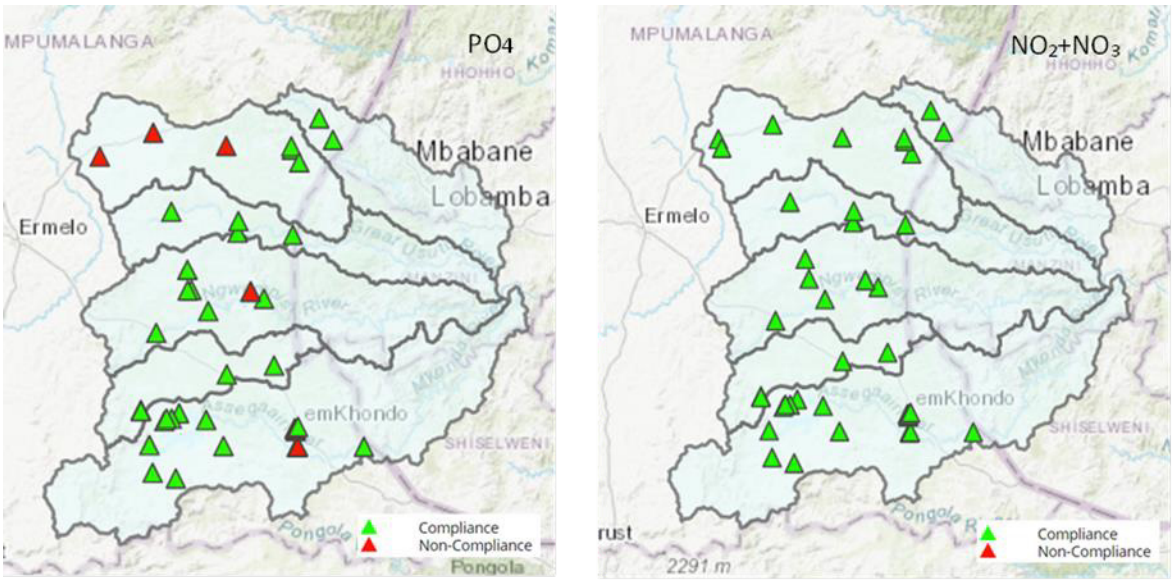


Figure 53 : Water quality status in Usuthu Catchment showing PO_4 and NO_2 +NO_3 concentrations.

As shown in Figure 53 Phosphate and Nitrates/Nitrite concentrations complied with the TWQG throughout the reporting period in the catchment, except for ten (10) points that indicated non-compliance for phosphate which are downstream of the WWTW as well as, Chrissiesmeer lake, upper Mpuluzi River, Klipmisselspruit and its tributaries.

Microbial

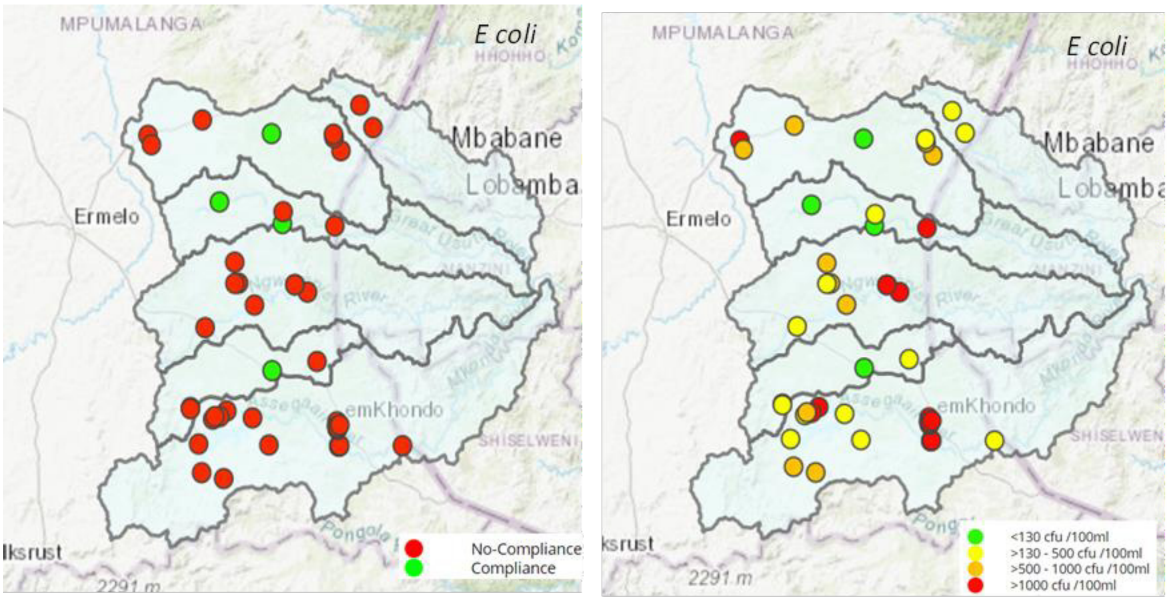


Figure 54 : Water quality status within Usuthu Catchment showing microbial (E coli) concentrations.

The map (left) shows elevated E coli counts which from time to time exceeded the TWQG limits of 130 (cfu/100ml) as illustrated in Figure 54. The non-compliance can mostly be attributed to the WWTWs that discharge untreated or partially treated wastewater into the streams, overflowing sewer pump stations, non-point sources such as illegal waste dumping. In the same figure, the map (right) shows extent of *E coli* counts recording less than 1 000 cfu/100ml in green, orange and yellow colours, while greater than 1 000 cfu/100ml is shown in red. The high level of microbial counts > 1 000 (cfu/100ml) arises from extensive urban and rural impacts from Chrissiesmeer, Empuluzi, eMvelo (Amsterdam), Driefontein and eMKhondo (Piet Retief). Most of the areas have not reached an alarming stage as *E. coli* counts were below 1 000 (cfu/100 ml).

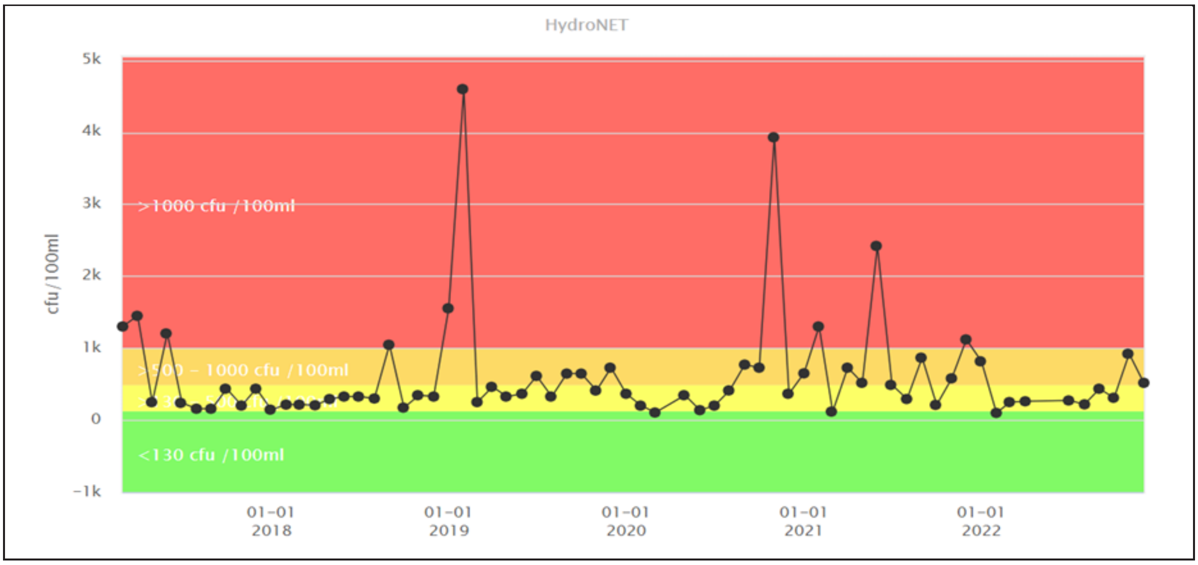


Figure 55: Chart indicating microbial (E coli) concentration trends (Marc 2017-Dec 2022) in the Assegai River.

Toxic Substances

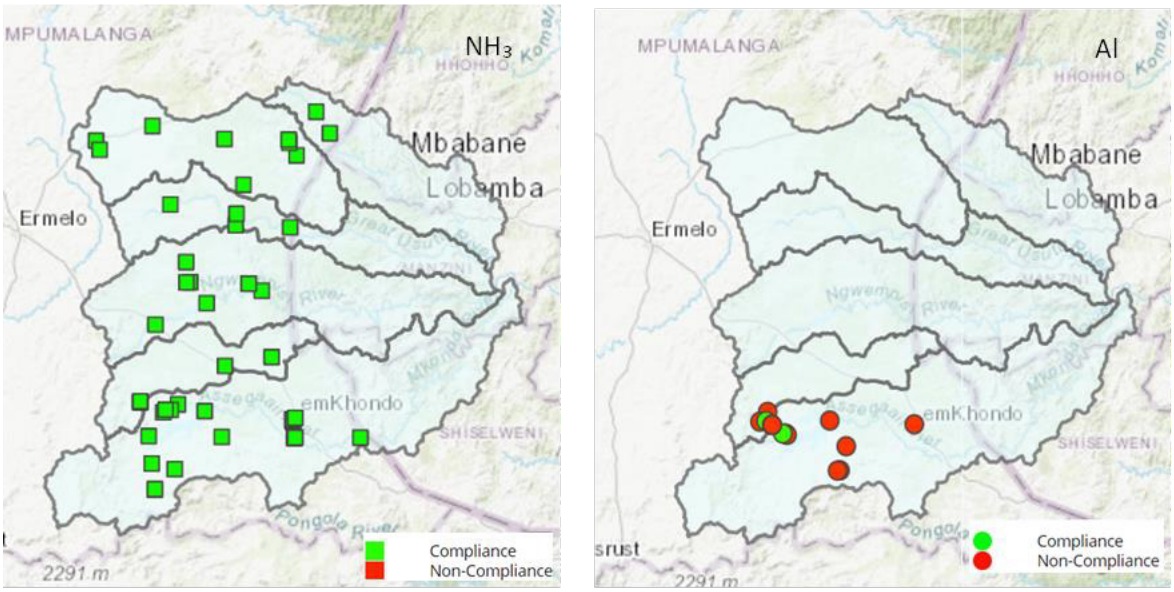


Figure 56 : Water quality status in Usuthu Catchment showing total NH_3 and Al concentrations.

Average concentration of total ammonia within the Usuthu Catchment indicate compliance with domestic targeted water qulity guideline of 1 (mg/l) throughout the catchment. Aluminium is found in soluble forms mainly in acid mine drainage waters. Aluminium indicated non comliance with targeted water quality guideline of 0.15 in ml/g (Domestic) within the Hlelo and Assegai River systems, except for four points. The impacts arise from mining activities within this systems. The chart below shows aluminium trends at Annylspruit downstream of mining activities, and may have pontential risk of mining drainage within the system.

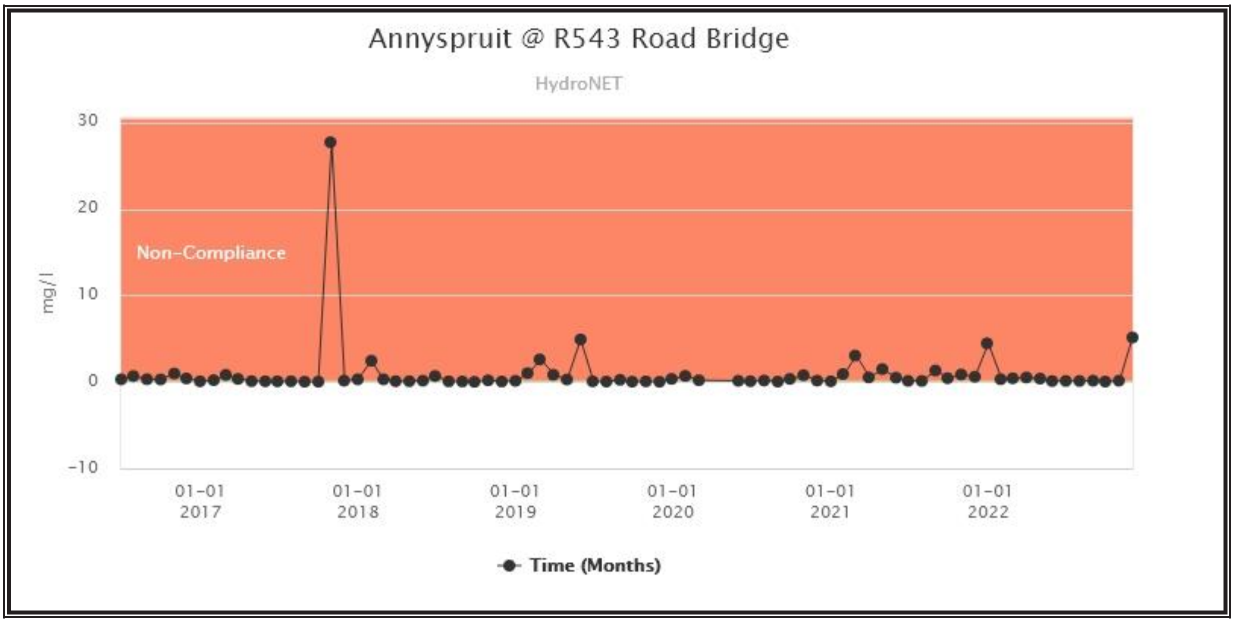


Figure 57: Chart indicating Aluminium concentration trends (March 2017-Dec 2022) in the Annysspruit.

4.3. Water Quality Areas of Concern

Below are the areas of concern in relation to water quality within the WMA per Catchment including the intervention

Catchment	Water Resource and Area	Parameters of concern	Interventi
Sabie/Sand	Klein Sabie at Sabie area (Simile), Langspruit at Hazyview and Bega River and Ngwenyameni River at Mkhuhlu.	EC (Salts) and PO_4 (Nutrients)	i. Conti impr ii. Conti IUCM iii. Conti relati espec and reso (poo it's a mana iv. To strat v. Impl vi. Revi efflu vii. Deve dete takin
Crocodile	Tributary of Crocodile River at Hectorspruit, Komatipoort and Tenbosch and tributary of Gutshwa River at Kabokweni	EC (Salts)	
	Leeuspruit, KaNyamazane stream, tributary of Gutshwa River and tributary of Crocodile River at Hectorspruit and Komatipoort most of these points are down stream of WWTWs. Kaap River system (SuidKaap, NoordKaap and Louw's Creek). Gladder spruit and Bester spruit (Mbombela area)	PO_4 (Nutrients) Arsenic (Toxic) Manganese (Metal)	
Upper Komati	Boesmanspruit and its tributaries, Vaalwaterspruit, Witkloofspruit (Carolina area Upstream of Nooitgedacht Dam) and Gladdespruit (Badplaas area Downstream of Vygeboom Dam)	Sulphates, EC (Salts)	
	Tributary of Boesmaspruit at Carolina and tributary of Komati River downstream of Tonga Hospital WWTWs.	PO_4 (Nutrients)	
Lower Komati	Ntulane River, tributary of Mahorwane stream at Block B, Mahorwane Stream and Sikwakwa River	EC (Salts) PO_4 (Nutrients)	
Usuthu	Chrissiessmeer lake, Egude River and Klipmisselspruit and its tributaries. Nutrients mostly on downstream of the of the WWTWs.	EC (Salts)	
		PO_4 (Nutrients)	
Inkomati-Usuthu WMA	Some of the EWRs indicated non-compliance to the set RQOs with un Unionized- Ammonia. Most of the downstream points of WWTWs indicated high levels concentration of total ammonia above (1 mg/l).	Unionised- Ammonia (Toxic) Total Ammonia	
	All EWRs indicated non-compliance to the set RQOs except for Crocodile at Dullstroom (Headwaters). The presence of *E coli* and *Feacal Coliforms* in water resource is a huge challenge throughout the entire water management area.	*E coli* (Microbial)	

4.4. Eutrophication status within the WMA

Eutrophication is the process of nutrient enrichment of waters which results in the stimulation of an array of symptomatic changes, amongst which increased production of algae and aquatic macrophytes, deterioration of water quality and other symptomatic changes found to be undesirable and to interfere with water users (DWAF, 2002).

Eutrophication is a natural process resulting from the accumulation or overabundance of nutrients in bodies of water, particularly nitrogen and phosphorus compounds (Van Ginkel, 2011; Bol et al., 2018). However, human activities and related water pollution impacts such leaching from fertilized agricultural regions, erosion, nitrogen deposits from atmospheric pollution, sewage and industrial waste have been reported to accelerate the extent of eutrophication (Van Ginkel, 2011). This results in the intense development of eutrophication symptoms including blooms of blue-green algae (i.e. Cyanobacteria), which causes the reduction of water quality and clarity, an outbreak of alien aquatic plants such as water hyacinth (Moran, 2006), degradation of recreational opportunities, health risks to people and animals and thus, an increase in water treatment expenses.

Ten (10) major dams within the WMA were monitored as part of the National Eutrophication Monitoring Programme (NEMP) from April 2021 to December 2022. The list of trophic status classes and criterion used to assign the trophic status are given in Table 11 and Table 12 below.

Table 11: Trophic status classes used for assessment of dams in South Africa.

1. **Oligotrophic**	low in nutrients and not productive in terms of aquatic and animal plant life;
2. **Mesotrophic**	intermediate levels of nutrients, fairly productive in terms of aquatic animal and plant life and showing emerging signs of water quality problems;
3. **Eutrophic**	rich in nutrients, very productive in terms of aquatic animal and plant life and showing increasing signs of water quality problems; and
4. **Hypertrophic**	Very high nutrient concentrations where plant growth is determined by physical factors. Water quality problems are serious and can be continuous.

Table 12: Criterion used to assign trophic status for the dams and lakes in South Africa.

Statistic	**Unit**	**Current trophic status**			
Median annual Chl *a*	µg/l	0<x<10	10<x<20	20<x<30	>30
		Oligotrophic (low)	Mesotrophic (Moderate)	Eutrophic (significant)	Hypertrophic (serious)
		Potential for algal and plant productivity			
Median annual Total Phosphorus (TP)	mg/l	x<0.015	0.015<x<0.047	0.047<x<0.130	>0.130
		Negligible	Moderate	Significant	Serious

4.4.1. Trophic Status and Nutrients Level of Major Dams

The trophic status is the level of eutrophication within the water resource. The trophic status helps us in determining the level of plant and algal growth within the specific resource. Shown below in Table 13 are annual median concentrations of each impoundment monitored through the NEMP from January 2022 to December 2022. All 10 major impoundments monitored fall under the Oligotrophic status based on median annual Chlorophyll-A and Total Phosphorus (TP), thus meaning they are low in nutrients with negligible potential for plant and algal productivity as illustrated in Figure 58 and Figure 59. In 2022 compared to 2021 Chlorophyll-A concentrations improved in five major dams, whereas other five dams indicated decline as illustrated in Figure 58. Eutrophication status of all major dams within the WMA were in an ideal condition.

Table 13 : The trophic status of the impoundments within the Inkomati - Usuthu WMA.

Dam Name	Parameters	
	Chlorophyll-A in (µg/l)	Total Phosphorus in (mg/l)
Inyaka Dam	2.9	0.01
Kwena Dam	3.6	0.01
Nooitgedacht Dam	8.9	0.01
Vygeboom Dam	5.5	0.01
Boesmanspruit Dam	5.1	0.01
Driekoppies Dam	2.4	0.01
Westoe Dam	2.6	0.01
Jericho Dam	7.8	0.01
Morgenstond Dam	1.6	0.01
Heyshope Dam	1.2	0.01

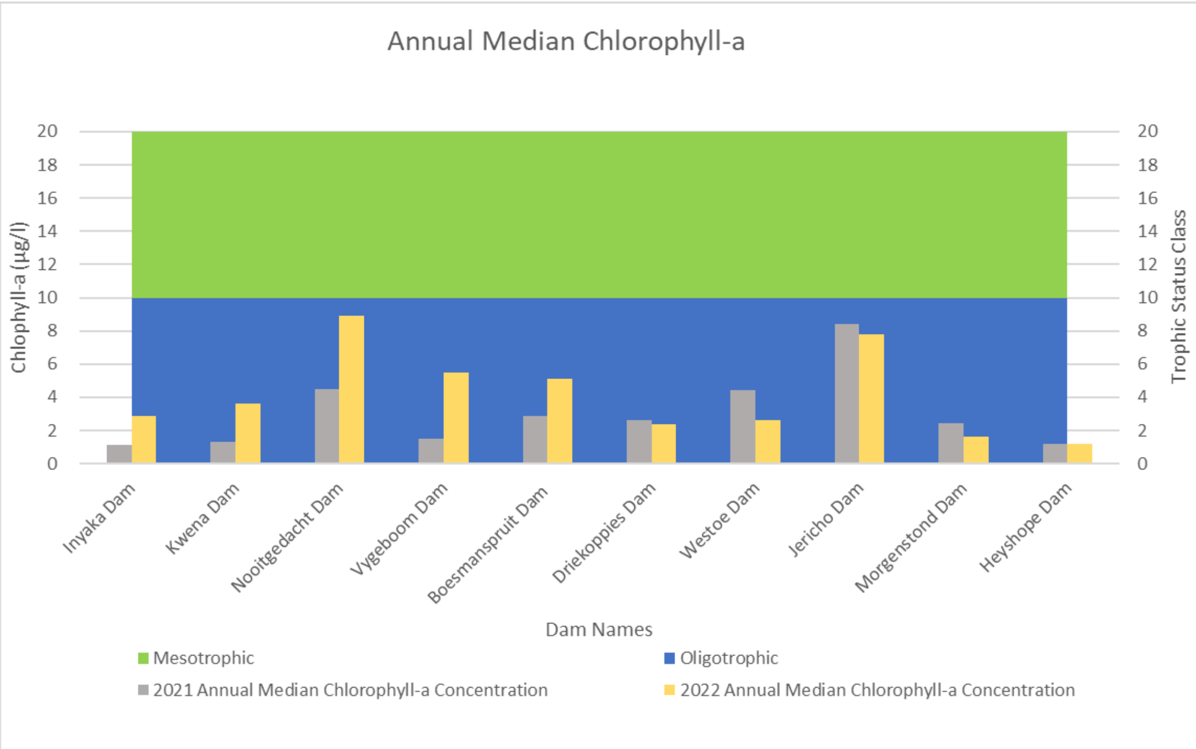


Figure 58: Annual Median Chlorophyll-a Concentration of major dams within WMA.

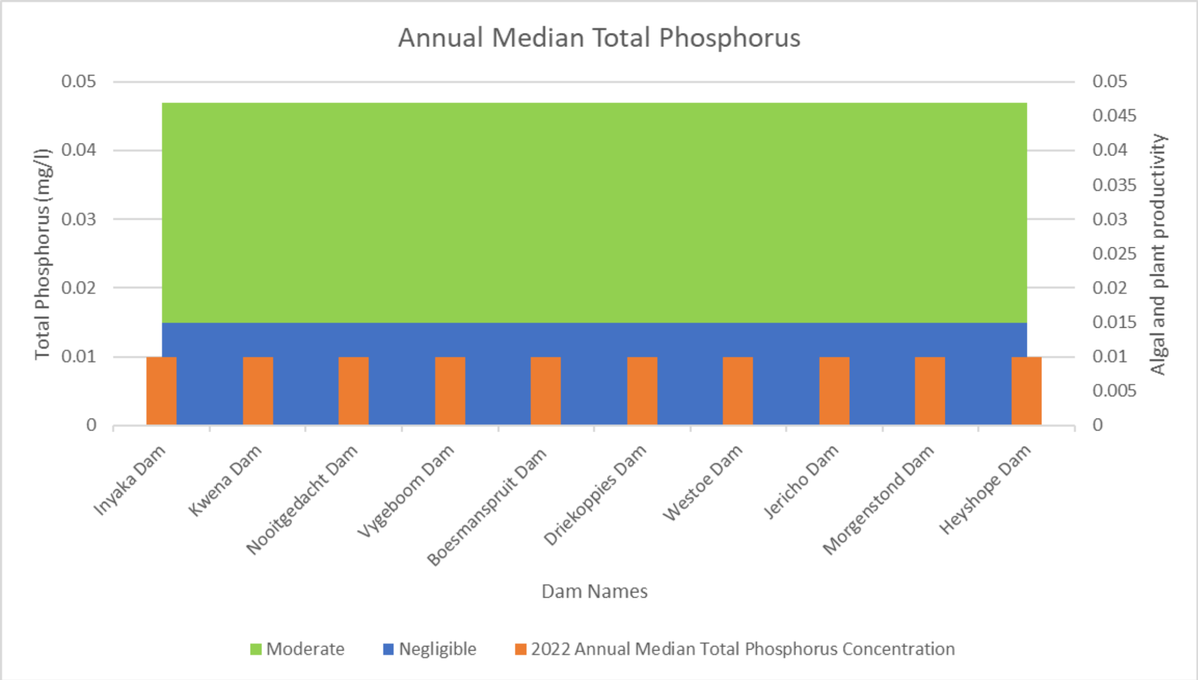


Figure 59: Annual Median Total Phosphorus Concentration of major dams within WMA.

Below is the photo of Kwena Dam as an example in Crocodile Catchment indicating trophic status and nutrients level of the dam which implies low or no productivity in terms of plants (Water hyacinth) and algal growth.

Figure 60: A photo of *Kwena* Dam with low to no algal growth *and* macrophyte *(*Water hyacinth*).*

CHAPTER 5 BIOTA

5.1. Introduction

Aquatic biomonitoring is the science of gathering information of the ecological condition of rivers and streams by examining the types of organisms that live there, such as invertebrates, algae, aquatic vegetation, and fish. The method is based on the principle that different aquatic organisms have different tolerances to pollutants, and that certain organisms will appear under conditions of pollution, while others will disappear. The assessment of biota in freshwater ecosystems is a widely recognized means of determining the condition, or 'health' of the ecosystem.

The health of the aquatic ecosystem is monitored through a programme called the River Eco-status Monitoring Programme (REMP). The REMP complements the surface water chemical and bacteriological monitoring program and provides the state of the river's ecology, considering the various indices used to measure the community attributes of fish, aquatic invertebrates and riparian vegetation and their response to changes in water quality and flow.

The full ecostatus includes combined analysis of vegetation, fish, and macro-invertebrate communities. This provides an integrated and sensitive measurement of environmental problems and represent progress in the assessment of ecological impacts and in the management of aquatic ecosystems.

5.2. Present Ecological Status within the WMA

The present ecological status was determined for the four catchments within the WMA and is presented in the following sections for each catchment.

5.2.1. Sabie Sand Catchment

The survey was conducted on a total of 34 monitoring sites (Figure 61), representative of the Sabie-Sand catchment from the source of the river in the upper reaches to the lower reaches and ending in the lower reaches mainly located in the Kruger National Park and other protected areas.

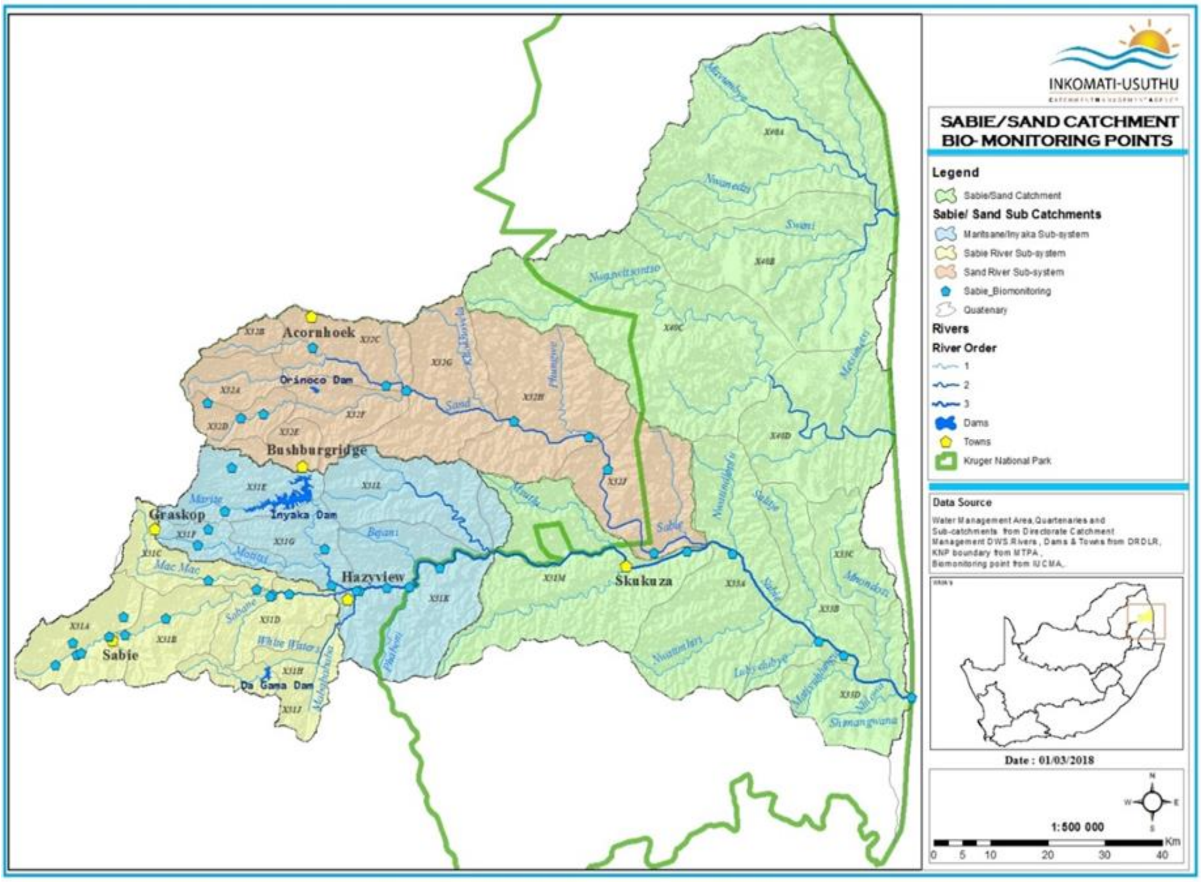


Figure 61: A map showing the sub-catchments in the Sabie-Sand Catchment.

Aquatic macro-invertebrates

The macro-invertebrate assessment results show that the catchment generally falls into an ecological category C, meaning that the catchment is moderately affected by anthropogenic activities (Figure 62). The catchment remained in a similar ecological category (C) as in the previous surveys (e.g., 2021, 2020, 2019 and 2017). There are eight EWR sites in the catchment and during this survey, five sites were sampled while the remaining three sites were not sampled as they are on private land and were not accessible. Alternative sites in the same reach will be identified for sites that were not sampled The results of the survey show that none of the five sampled EWR sites met the requirements for TEC (Table 14).

Sand mining, alien invasive species, eutrophication and waste disposal are some of the emerging environmental issues identified during this study. Physidae were detected at the X3Sand-Rolle and X3Sand-Thula sites, which is a cause for concern as it suggests that effluents containing organic matter may be discharged into the river, creating suitable conditions for gastropod survival. At the time of sampling at the X3Sand-Rolle site, there was an odour of sewage, which could be due to inadequately treated sewage from wastewater treatment plants being discharged into the river. Extensive sand mining activities were observed at the X3Sand-Thula, X3Sabi-Treinb and X3Mari-Sandf sites, which could lead to further ecological degradation of the river as habitat and flow are altered by deep excavations. The removal of sand from the river alters the habitat and this leads to low taxa diversity as a result of low habitat availability.

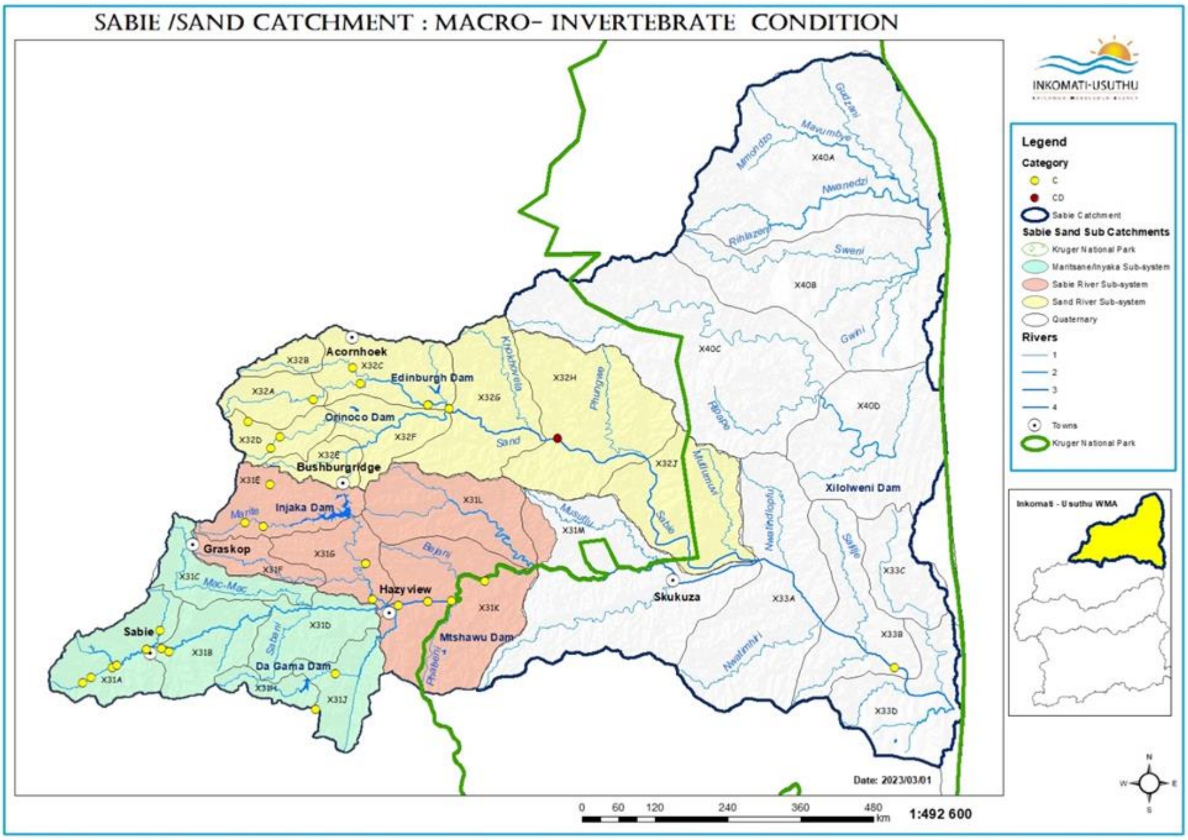


Figure 62: Visual representation of the macro-invertebrate condition in the Sabie-Sand catchment.

Fish

Based on the analysis of the fish results, the present ecological state of the Sabie-Sand catchment was determined as category C (Figure 63). The main stem of the catchment falls into an ecological category CD in the upper catchment due to modifications attributed to limited habitat cover, trout farming and sawmill activities. In the middle catchment, the ecological state of the main stem was determined as category C. The present ecological status of other tributaries of the Sabie-Sand catchment such as Lone Creek, Klein Sabie and Sabana fall within an ecological category C, which is consistent with previous surveys on these tributaries. The absence of other fish species in the Sabie-Sand River catchment was attributed to the presence of alien fish species (*Oncorhynchus mykiss*), flow modification caused by the presence of weirs and dams, and limited habitat cover preference for certain fish species.

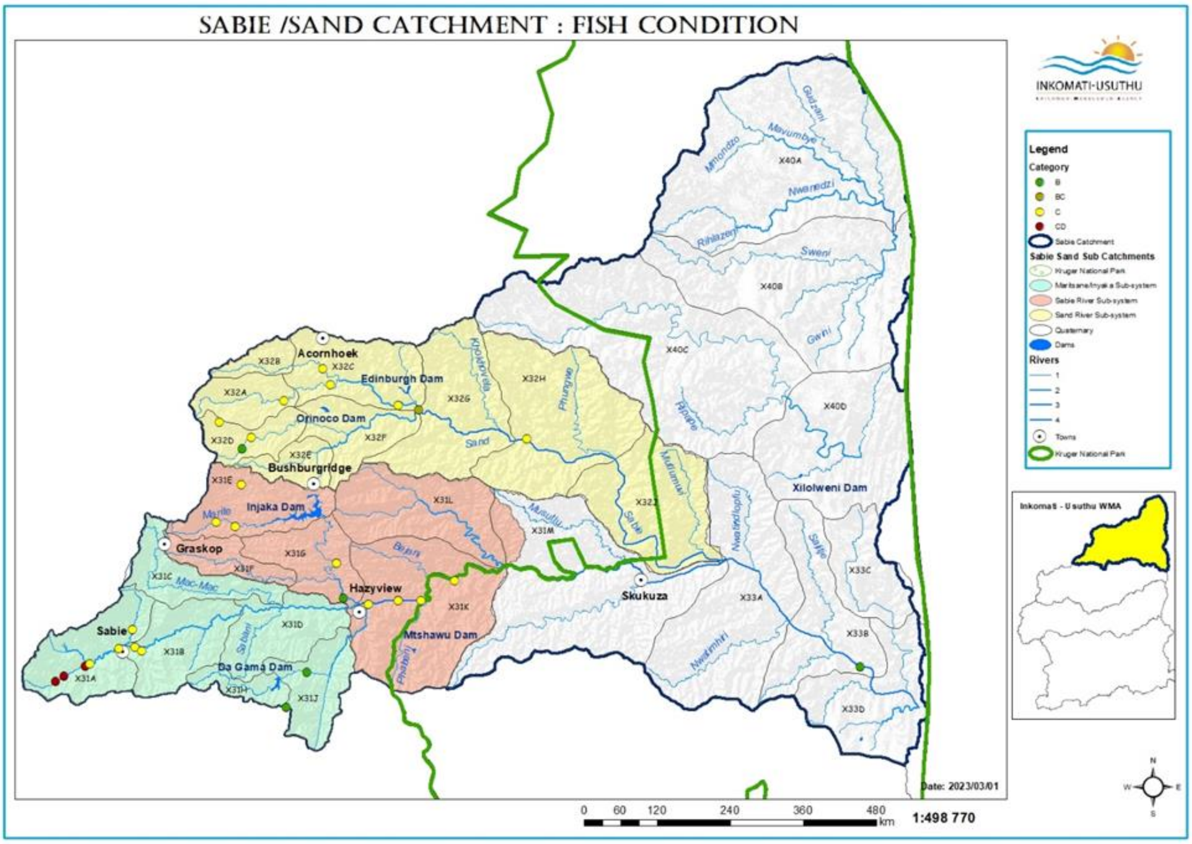


Figure 63 : Visual representation of the fish condition in the Sabie-Sand catchment.

Riparian vegetation

The results of the riparian vegetation assessment are shown in Figure 64. The present ecological status of most of the reaches were determined as ecological category C, which means that the riparian vegetation in these reaches is moderately modified, with loss and alteration of natural habitat and biota, but the basic ecosystem functions are still largely unchanged. Five of the eight EWR sites in the Sabie-Sand catchment were sampled and assessed for their riparian vegetation condition. Only one selected EWR site (X3MUTL-NEWF1) met the ecological target category (TEC). This trend could be due to a combination of different anthropogenic impacts, including afforestation and residential development near the riparian zones around the Sabie-Sand catchment, which are usually noticeable and visible downstream of the river. Common impacts associated with riparian zone degradation include invasion of alien/exotic vegetation, removal of riparian vegetation, water abstraction for various purposes, sand mining, afforestation and dumping of waste and debris in the riparian zone.

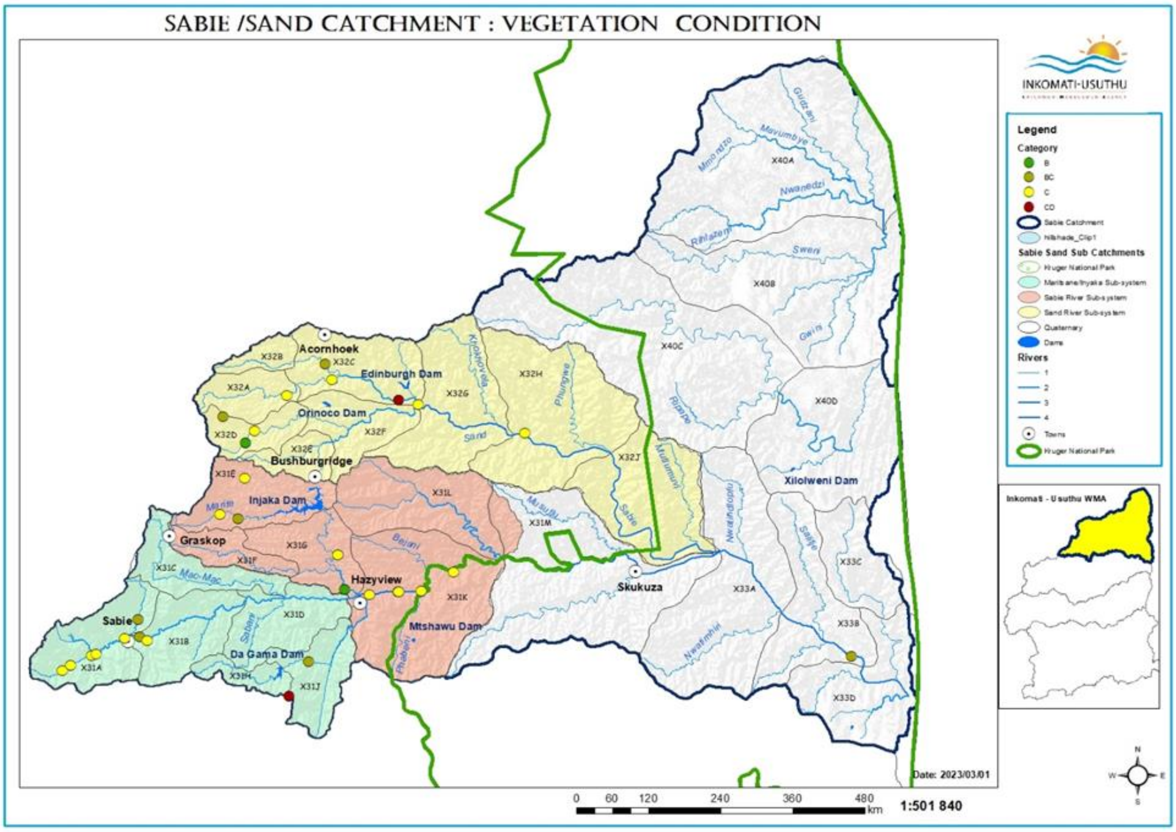


Figure 64: Visual representation of the vegetation condition in the Sabie-Sand catchment.

The summary of the macro-invertebrates results, fish, and riparian vegetation for the EWR sites in comparison to Target Ecological Category (TEC) are shown Table 14.

Table 14: Biomonitoring results of sampled EWR sites in comparison to RQOs for fish, macro-invertebrates, and riparian vegetation in Sabie-Sand River (X3) as published in Government Gazette No 40531, 30 December 2016.

EWR SITE	SQ REACH	SITE NAME	RIPARIAN VEGETATION ECOSTATUS		TEC RIPARIAN	INVERTEBRATES ECOSTATUS		TEC INVERTEBRATES	FISH ECOSTATUS		TEC FISH
			2021	2022		2021	2022		2021	2022	
(EWR S-1)	X31B-00756	X3SABIBRAND	C	BC	B	C	C	B	C	C	B
(EWR S-2)	X31D-00755	X3SABIAANDE	C	C	B	C	C	B	C	C	B
(EWR S-4)	X31C-00683	X3MacM-Picnic	BC	BC	AB	C	C	AB	B	B	BC
(EWR S-5)	X31G-00728	X3MARI-SANDF	CD	C	BC	C	C	BC	C	C	BC
(EWR S-6)	X32F-00597	X3MUTL-NEWF1	C	C	C	C	C	BC	C	BC	C

Based on fish, macroinvertebrate and riparian vegetation surveys, the overall ecological condition of the Sabie-Sand River system was found to be in an ecological category C. This means that the ecological status is moderately altered, with loss and alteration of natural habitat and biota, but the basic ecosystem functions are still mostly unchanged. All EWR sites in the Sabie-Sand catchment must be included in the present monitoring programme to verify compliance with the river's RQOs, and this will be a key tool for tracking changes in aquatic biota and detecting environmental issues before they spread. This will also help determine the necessary mitigation measures for the identified environmental problems.

5.2.2. Crocodile Catchment

The survey was conducted in the Crocodile catchment, one of the four catchments within the IUWMA. The current survey was conducted at a total of 41 monitoring sites. Figure 65 shows a map of the Crocodile Catchment, on which the locations of the monitoring sites are marked. The Elands and Kaap rivers are the two major tributaries of the Crocodile River which were monitored. In addition to the two tributaries, a total of six relatively smaller tributaries were monitored. The tributaries are Lunsklip River, Houtbosloop, Visspruit, Nelsriver, and Gladdespruit. The following tributaries of the Elands River were monitored: Leeuspruit, Swartkoppiespruit and Ngodwana. Noord Kaap, Suid Kaap and Queens rivers are relatively large tributaries of the Kaap River and were also monitored.

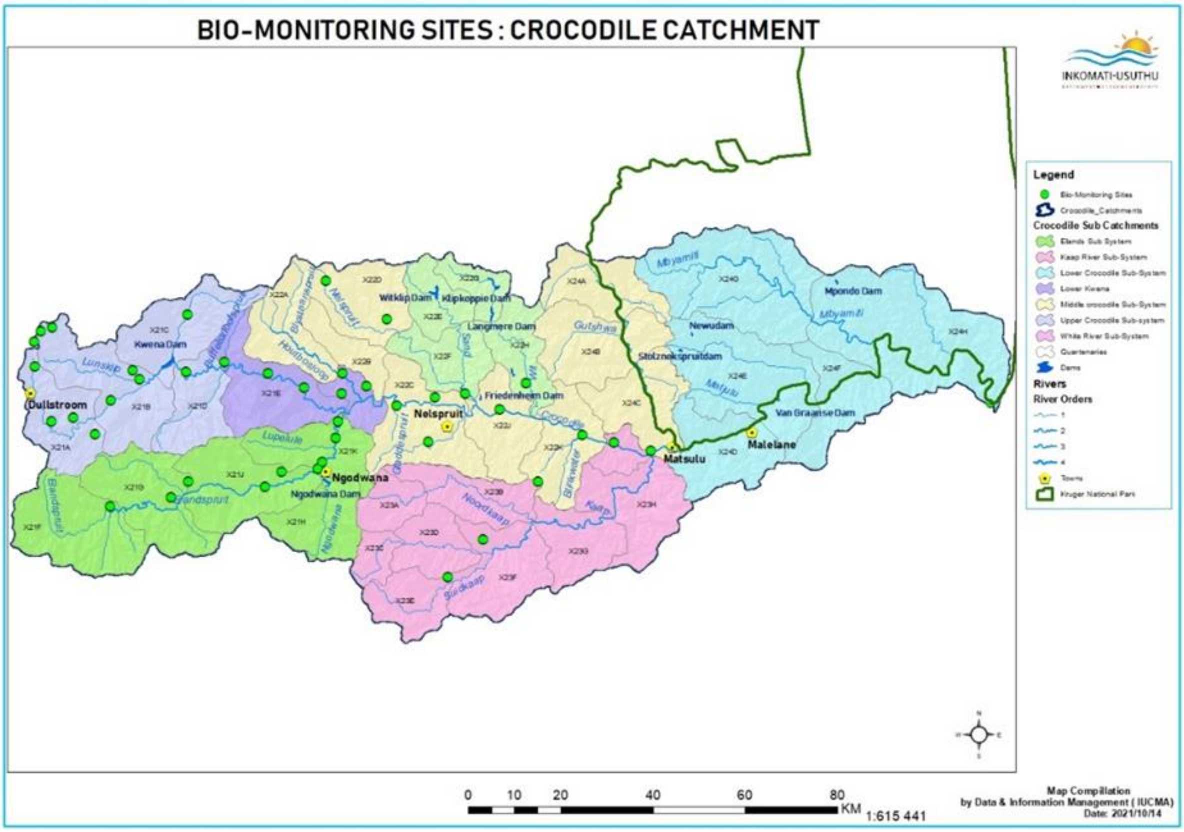


Figure 65: A map showing the biomonitoring sites in the Crocodile Catchment.

Aquatic macro-invertebrates

The Crocodile Catchment is currently in an ecological category C, showing a similar ecological status to previous surveys, although some parts of the catchment are in an ecological category CD (Figure 66), e.g., X2Viss-Alkam, X2Glad-Herma and X2Croc-Rietv, indicating that there are moderate to large modifications in response to anthropogenic activities. Nonetheless, X2Glad-Herma and X2Viss-Alkma sites actually improved compared to the ecological category D obtained in the 2021 survey. Other sites with notable improvements are X2Hout-Sudwa, X2Ngod-Groot and X2Quee-Hilve, which improved from ecological category CD in 2021 to ecological category C in the current survey. In terms of compliance of EWR sites with the set Target ecological Category (TEC), the EWR sites (X2Croc-Goede, X2kaap-Honey, X2Elan-Water, X2Elan-Roode) were in Ecological Category B and site X2Croc-Valy1 were at Ecological Category A. All the monitored EWR sites (X2Croc-Goede, X2kaap-Honey, X2Elan-Water, X2Elan-Roode, X2Croc-Valy1) were in an Ecological Category C for all indices monitored during the current survey and therefore did not comply with the applicable TEC.

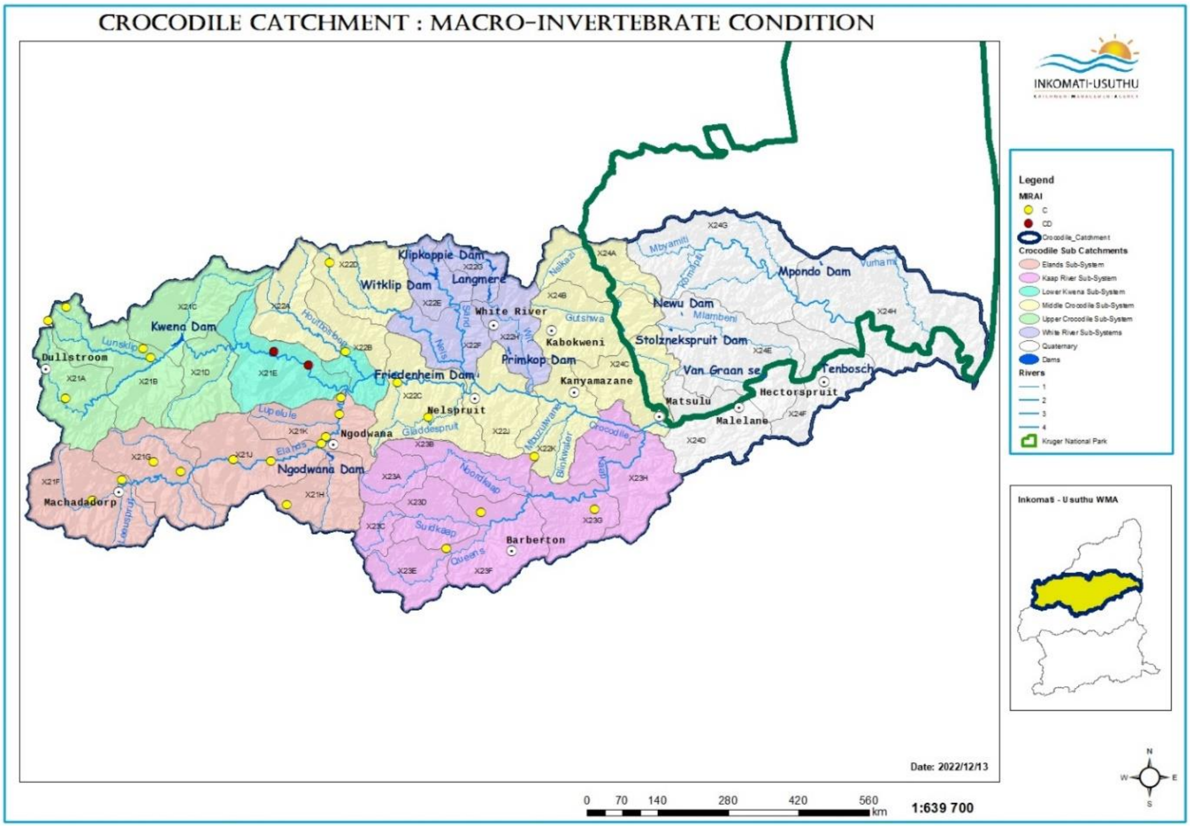


Figure 66: Visual representation of the macro-invertebrate condition in the Crocodile catchment.

Fish

Figure 67 shows the condition of the fish in the Crocodile catchment. Based on the monitoring and analysis of fish data, sites X2Hout-Sudwa, X2Viss-Alkma and X2Glad- Herma were identified as being of concern as shown by the ecological category CD. The sites in the Elands River, the main tributary of the Crocodile River, are in an ecological category C. The other ecological categories in the Crocodile catchment remained unchanged from previous surveys.

Five (5) EWR sites (X2Croc-Valy1, X2Croc-Goede, X2kaap-Honey, X2Elan-Water, X2Elan-Roode) were monitored for fish species status and did not comply with the set Ecological Category. The sites (X2Croc-Goede, X2kaap-Honey, X2Elan-Water, X2Elan-Roode) have been set at Target Ecological Category B while site X2Croc-Valy1 has been set at the Target Ecological Category A. The absence and lower abundance of fish species was observed in the catchment and attributed to changes in water quality, flow modification, and habitat loss.

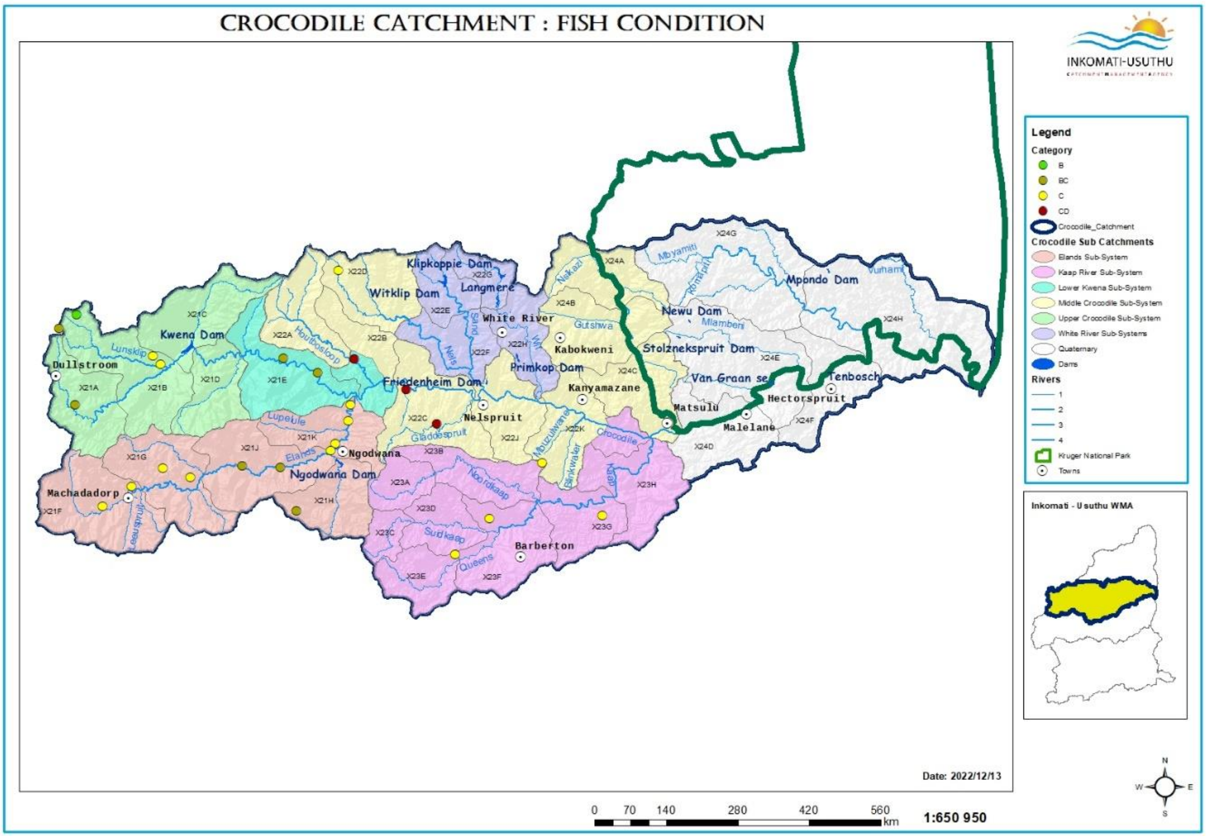


Figure 67: Visual representation of the fish condition in the Crocodile catchment.

Riparian vegetation

Based on the riparian vegetation assessment, the Crocodile Catchment is currently in an ecological category C (Figure 68), although some reaches of the catchment are in an ecological category CD (X2Hout-Sudwa and X2Nels-Rheno, X2Viss-Alkma, X2Elan-Ryton) and D (X2Hout-Sudwa). Sites X2Croc-Kamag and X2Quee-Hilve were in an ecological category BC, indicating a condition that is close to largely natural most of the time. The impacts observed during the current riparian assessment in the Crocodile River catchment include vegetation clearing, alien invasive vegetation in riparian zones. The health of the river system is also threatened by habitat loss and degradation, due to sedimentation and eutrophication, flow modification and the introduction of alien invasive species.

Of the six (6) EWR sites (X2Croc-Valy1, X2Croc-Goede, X2kaap-Honey, X2Elan-Water, X2Elan-Roode and X2Croc-Popla) in the Crocodile catchment assessed for riparian vegetation in 2022 using the VEGRAI method (Level 3), only two (2) sites (X2Croc-Goede and X2Croc-Valy1) showed non-compliance with the set TEC.

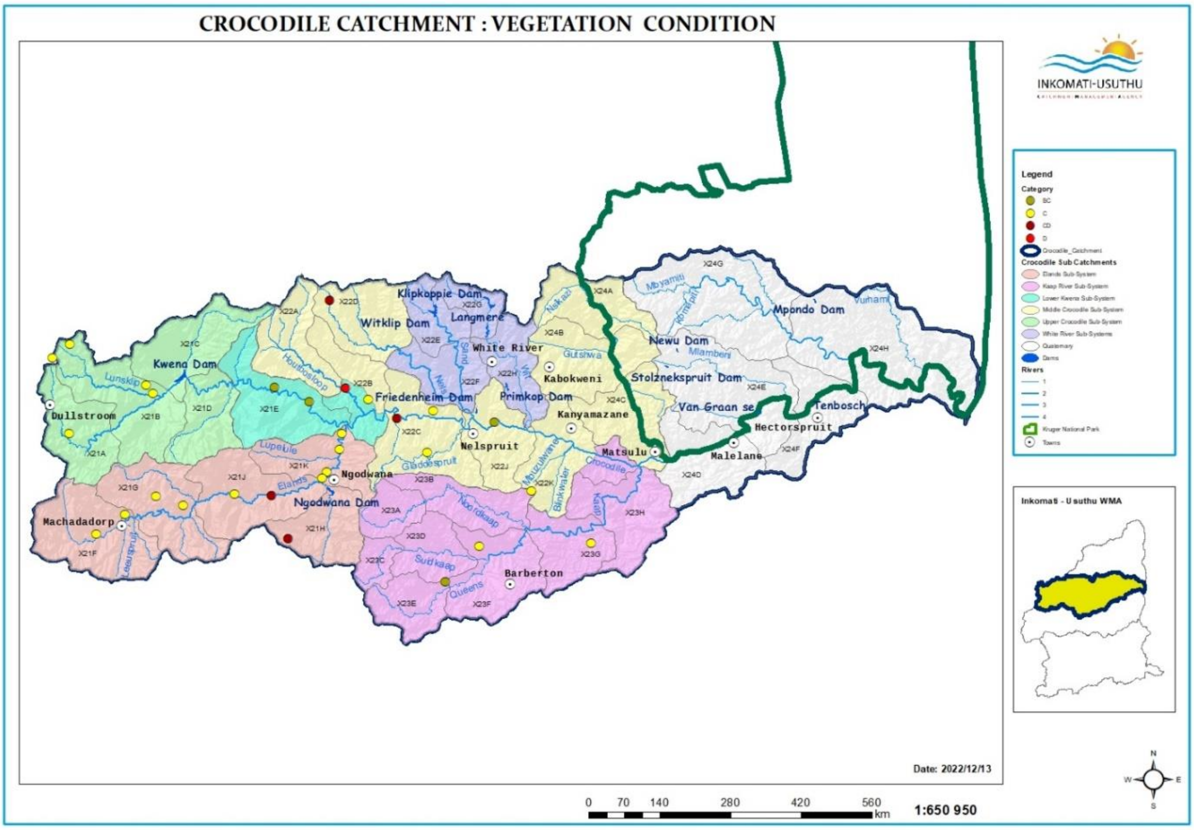


Figure 68: Visual representation of the vegetation condition in the crocodile catchment.

A summary of the biomonitoring results of the EWR sites compared to the ecological target category (TEC) is shown in Table 15.

Table 15: Biomonitoring results of sampled EWR sites in comparison to RQOs for fish, macro-invertebrates, and riparian vegetation as published in Government Gazette No 40531, December 2016.

EWR SITE	SQ REACH	SITE NAME	RIPARIAN VEGETATION ECOSTATUS		TEC RIPARIAN	INVERTEBRATES ECOSTATUS		TEC INVERTEBRATES	FISH ECOSTATUS		TEC FISH
			2017	2022		2021	2022		2021	2022	
EWR C-1	X21A-00930	X2CROC-VALY1	B	B	A	C	C	B	BC	BC	A
EWR C-2	X21B-00962	X2CROC-GOEDE	B	C	AB	C	C	B	C	C	B
EWR C-3	X21E-00943	X2CROC-POPLA	C	BC	C	CD	VA	C	BC	VA	B
EWR C-7	X23G-01057	X2KAAP-HONEY	C	C	CD	C	C	B	C	C	B
EWR E-1	X21G-01037	X2ELAN-WATER	C	C	C	C	C	B	C	C	B
EWR E-2	X21K-01035	X2ELAN-ROODE	C	C	C	C	C	B	C	C	B

VA: Variable Not Analysed

Based on the analysis of biomonitoring data, the overall ecological status of the Crocodile River system was found to be in an ecological category C. This means that the natural habitat and biota are moderately modified in terms of abundance and frequency of occurrence.

5.2.3. Komati Catchment

The survey was conducted in the Komati catchment, one of the four catchments within the IUWMA. The current survey was conducted at the 36 selected monitoring sites sourced from the 2015 Komati Catchment Ecostatus Report. A total of 13 sites are located on the mainstream of the Komati River, while the remaining 23 sites are located on tributaries. Figure 69 shows a map of biomonitoring sites in the Komati catchment and the assigned reach codes. The following tributaries were monitored during the current survey: Vaalwaterspruit, Mtsoli, Lomati, Boesmanspruit, Klein Komati, Swartspruit, Ndubazi, Gladdespruit, Buffelspruit, Seekoeispruit, Teespruit, Sandspruit, Mhlangampepa, Mlondolozi, Ngweti, Mzinti, Ugutugulo and Mhlambanyatsi.

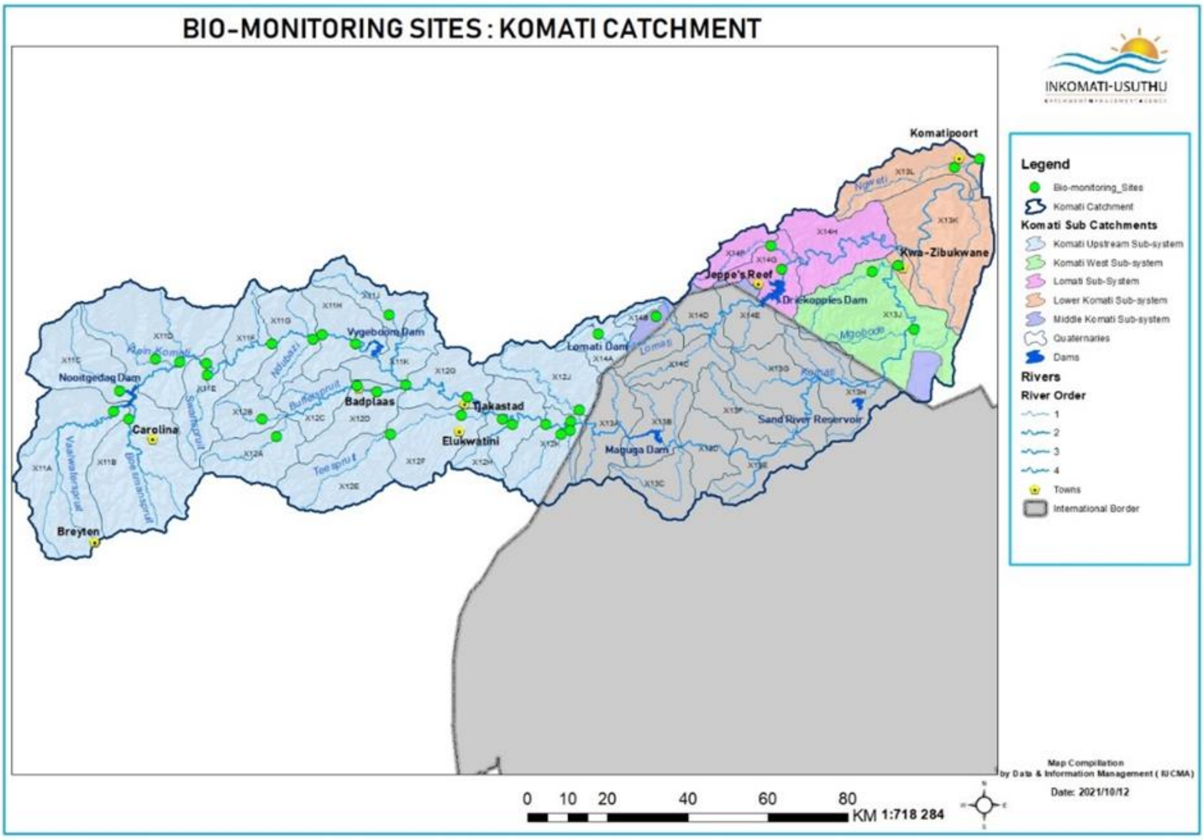


Figure 69: A map showing the biomonitoring sites in the Komati Catchment.

Aquatic macro-invertebrates

Based on the macro-invertebrate assessment results, the catchment is largely in an ecological category C, except for site X1Swar-Hebro which is in an ecological category BC (Figure 70). The results show that the catchment is moderately modified due to the cumulative impacts of anthropogenic activities. Compared to the previous survey, some sites showed improvements in the ecological condition such as X1Mhla-Rusoo, X1Boes-Roode and X1Swar-Hebro which improved from ecological category CD to C, while X1Glad-Vygeb improved from ecological category D to C. From these results, it is evident that anthropogenic activities taking place in the catchment are having a negative impact on the macro-invertebrate community. Land use activities in the catchment include agricultural activities, mining, commercial forestry, residential and associated subsistence farming, and waste disposal. These activities introduce pollutants into rivers, either directly or indirectly. In addition, there are also wastewater treatment works in the catchment area, which pose the risk of eutrophication through the discharge of inadequately treated wastewater.

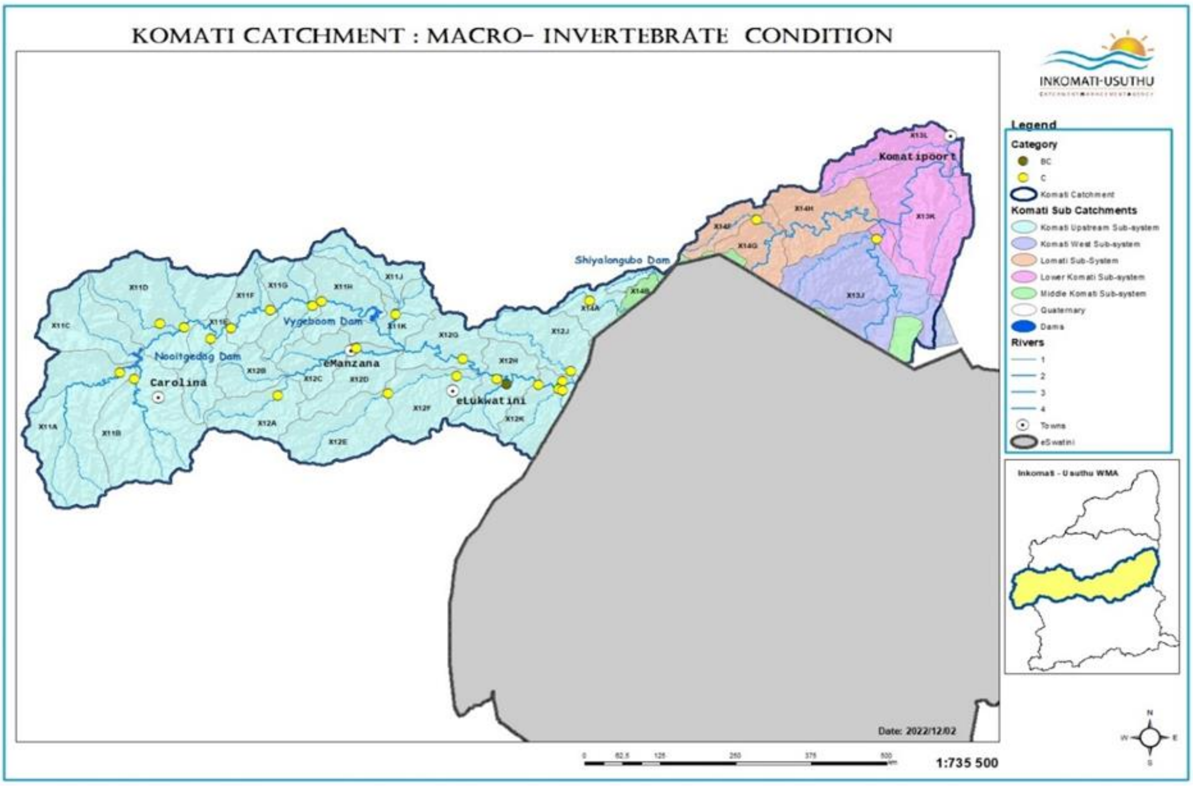


Figure 70: Visual representation of the macro-invertebrate condition in the Komati catchment.

Impoundments, including large dams, farm dams and weirs in the catchment, have a negative impact on the migration of taxa and thereby change the river habitat from flowing to standing water. The catchment is also affected by domestic waste disposal, which has been observed at sites such as X1KKom-Welge, X1Koma-Tjaka and X1Tees-Heuni, while sand mining activities have been observed at X1Koma-IFR04.The results further showed that the ecological status at two Ecological Water Requirements (EWR) sites (X1Koma-IFR04, X1Glad-Vygeb and X1Koma-Hooge and X1Tees-Heuni) complied with the set Target Ecological Category (TEC) while other EWR site (X1Koma-Gevon) did not comply with the set TEC for aquatic macro-invertebrates.

Fish

Figure 71 shows the condition of the fish species for the ecological status in the Komati catchment. These results of the fish survey indicate that the number of fish species available in the catchment has improved compared to the previous survey.

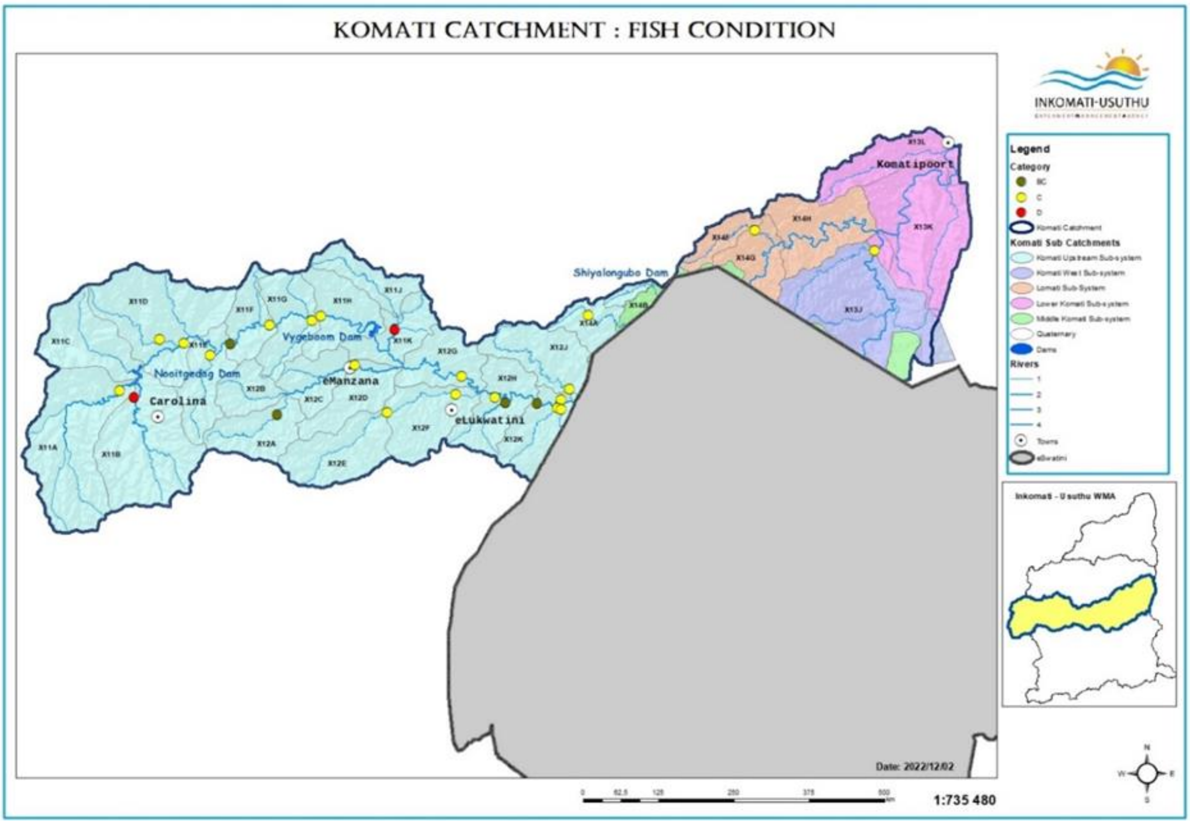


Figure 71: Visual representation of the fish condition in the Komati catchment.

The higher number of species observed in the 2022 survey suggests that the catchment has a high diversity of species. The absence of other expected fish species in the catchment was attributed to the several factors: Flow modification due to weirs, dams, and afforestation; change in water quality due to runoff from agricultural activities and mining; and change in habitat cover due to bank erosion and animals trampling the riverbank. As shown in Figure 71, the ecological status of fish in the catchment was mostly in an ecological category C, indicating moderately modified condition and only a few reaches were in an ecological category BC (Largely natural with few modifications). Reaches of concern in the catchment include X11B-01272 (X1BOES-ROODE), located in the Boesmanspruit, and X11K-01194 (X1GLAD-VYGEB), located in the Gladdespruit, within ecological category D (largely modified). Based on the fish assessment, all the EWR sites sampled during the current survey complied with the TEC for fish. These sites are X1Koma-IFR04, X1Glad-Vygeb, X1Koma-Gevon, X1Koma-Hooge and X1Tees-Heuni.

Riparian Vegetation

The results of the riparian vegetation assessment showed that none of the rivers in the catchment are still in a pristine condition (Figure 72). Most of the reaches in the catchment were found to be in an ecological category C, which means that they have been moderately modified from their historical reference condition. The dominant ecological category C also indicates that some ecological interventions could possibly be undertaken to try to restore the sites to a near-natural state. A few sites had an ecological category/status of ecological category BC, indicating a condition close to a largely natural vegetation compared to the reference condition. Of the six EWR sites assessed for riparian vegetation in 2022 using the VEGRAI method, five sites (X1Koma-IFR04, X1Glad-Vygeb, X1Koma-Gevon, X1Koma-Hooge and X1Tees-Heuni) met the set Ecological Target Category (TEC), while the other site (X1KOMA-LEBOM) did not meet the set TEC, as only an ecological category C ecological status could be achieved during this survey.

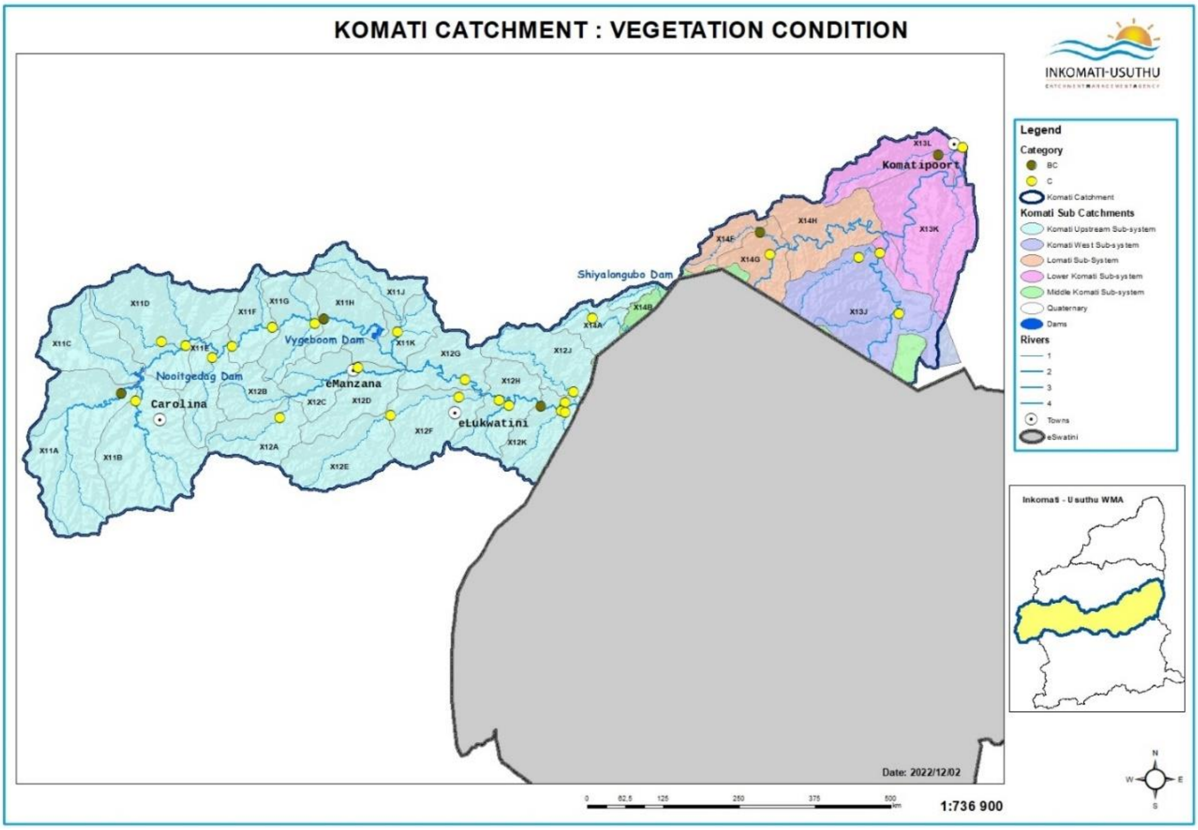


Figure 72: Visual representation of the vegetation condition in the Komati catchment.

A summary of biomonitoring results of the EWR sites in comparison to Target Ecological Category (TEC) is shown Table 16.

Table 16: Biomonitoring results of sampled EWR sites in comparison to RQOs for fish, macro-invertebrates, and riparian vegetation as published in Government Gazette No 40531, December 2016.

EWR SITE	SQ REACH	SITE NAME	RIPARIAN VEGETATION ECOSTATUS		TEC RIPARIAN	INVERTEBRATES ECOSTATUS		TEC INVERTEBRATES	FISH ECOSTATUS		TEC FISH
			2014	2022		2021	2022		2021	2022	
EWR K-1	X11G-01142	X1KOM-GEVON	B	C	C	C	C	BC	C	C	C
EWR G-1	X11J-01106	X1GLAD-VAALK	VA	C	D	D	C	D	C	D	D
EWR T-1	X12E-01287	X1TEES-HEUNI	C	C	C	C	C	C	C	C	C
EWR K-2	X12H-01258	X1KOMA-HOOGE	B	BC	C	C	C	C	BC	BC	C
EWR K-3	X13J-01130	X1KOMA-IRF04	C	CD	D	C	C	D	BC	C	CD
EWR L-1	X13L-00995	X1KOMA-LEBOM	C	C	BC	VA	VA	C	VA	VA	C

VA: Variable Not Analysed

Based on fish, macro-invertebrates, and riparian vegetation assessments, the overall integrated ecostatus for the Komati River system falls into an ecological category C.

Mitigation measures should be developed to address the problems that have resulted in non-compliance with the set TECs as identified during the survey Contributing factors include modified habitat, flow modification, alien invasive species and reduced water quality due to land use practises in the surrounding area.

5.2.4. Usuthu catchment

The current survey was conducted on a total of 38 monitoring sites. Figure 73 shows a map of the six sub-catchments within the Usuthu Catchment as well as the allocated reach codes.

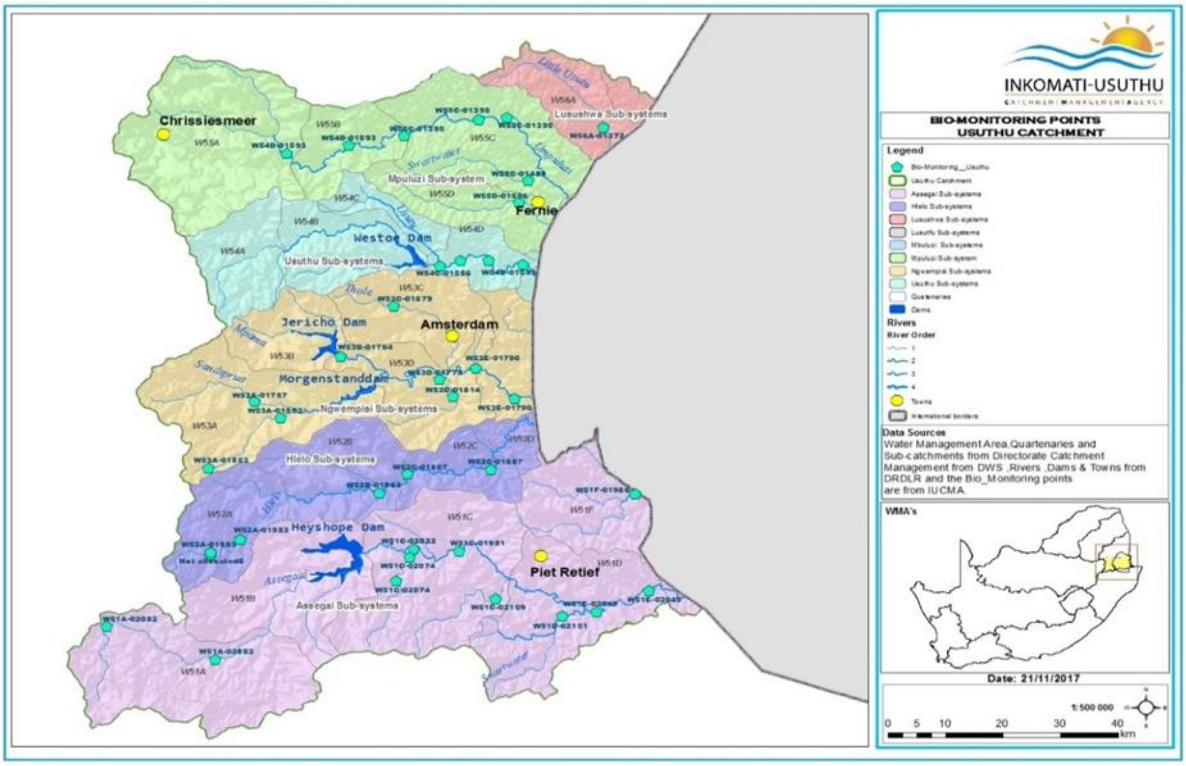


Figure 73: A map showing the six sub-catchments in the Usuthu Catchment.

The current ecological status of macro-invertebrates, fish and riparian vegetation was determined for the Usuthu catchment and is presented in the next sections.

Aquatic macro-invertebrates

Based on the macro-invertebrates results the ecological status of the catchment was in an ecological category C, which means that the catchment has been moderately modified by anthropogenic activities (Figure 74). The results are similar to previous surveys, which showed that the catchment falls into an ecological category C. There were sites that fell within the ecological category CD, and these are: W5Mpul-Hami, W5Mpul-Midde, W5Mpul-Borde, W5Mpul-Busby, W5Usut-Dingl, W5Usut-Staff, W5Swar-Izind, W5Sand-Zands, and W5Lusu-Robin. The presence of more than two species of Baetidae at some of the sampled sites and of sensitive taxa such as Polymitarcyidae, Prosopistomatidae and Heptageniidae indicates that the Usuthu catchment is capable of supporting a diversity of species, including highly sensitive, moderately sensitive and tolerant taxa. The presence of the exotic gastropod Physidae at sites W5Bles-Weeho on Blesbokspruit is of concern as it suggests that pollutants may have been introduced into the river and provide good habitat or environmental conditions for the gastropods to thrive.

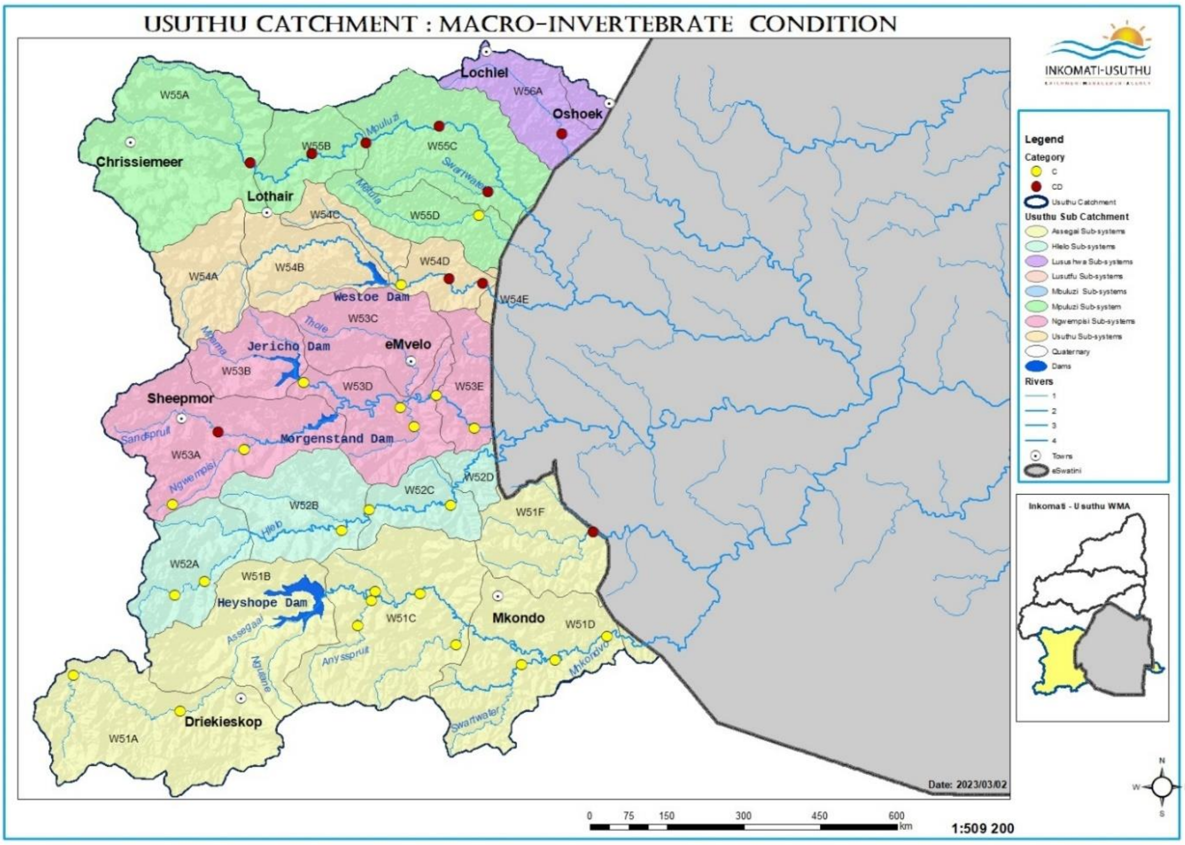


Figure 74: Visual representation of the macro-invertebrate condition in the Usuthu catchment.

Fish

As shown in Figure 75, the ecological status of the catchment was predominantly category C (moderately modified). This status remained unchanged from the previous surveys. The changes in the catchment were attributed to poor habitat cover (sedimentation and absence of aquatic macrophytes), flow modification and water quality. Improvement in the condition of the catchment was observed at SQ in W53D-01773 and W53E-01790. The Usuthu catchment supported a variety of fish species during the survey and although this was the case, no species were captured at site W5ASSE-NAAUW during the survey. The absence of fish species at site W5ASSE-NAAUW is not known as no fish species have been caught at this site since the 2015 survey. The site is located upstream of the Assegaai waterfall, which is a barrier to fish migration in the upper reaches. Exotic fish species such as Largemouth Bass (*Micropterus Salmoides)* were caught at sites W5HLEL- WATER, W5HLEL-HOLDER, W5NGWE- STERK, W5USUT-DINGL, and W5MPAM- GLENE.

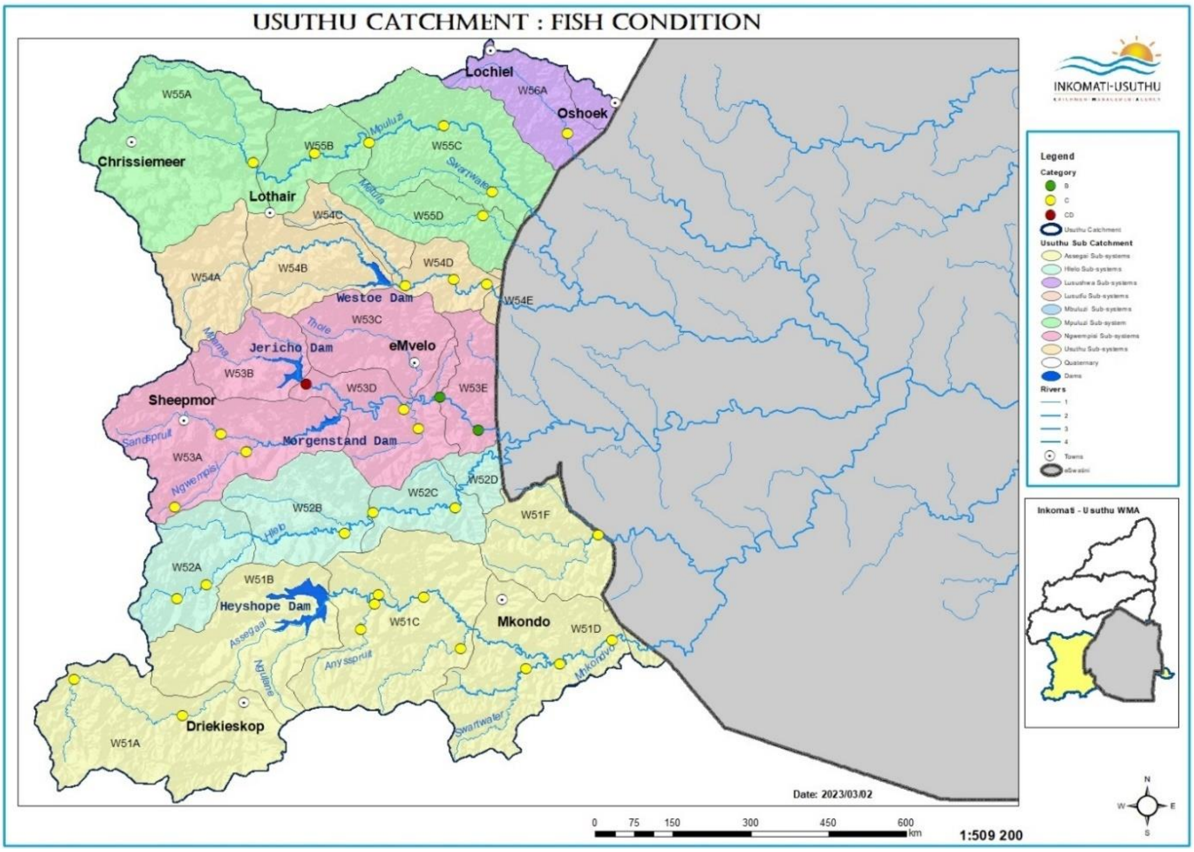


Figure 75: Visual representation of the fish condition in the Usuthu catchment.

Riparian vegetation

Based on the riparian vegetation survey, the ecological status was moderately modified (ecological category C), indicating that the natural habitat and biota have been moderately modified in terms of abundance and frequency of occurrence (Figure 76). It is important to note that the ecological category BC was recorded only in the Ngwempisi sub-catchment, where there was no heavy infestation of invasive wattle (*Acacia mearnsii)* according to field observations during the survey. It is also worth noting that sand mining has been identified as one of the greatest threats to ecological integrity in this catchment. Another notable impact and activity along the riparian zones of the Usuthu catchment is agricultural activities associated with overgrazing of livestock and clearing of vegetation in preparation for cultivation, mainly along the riparian zones.

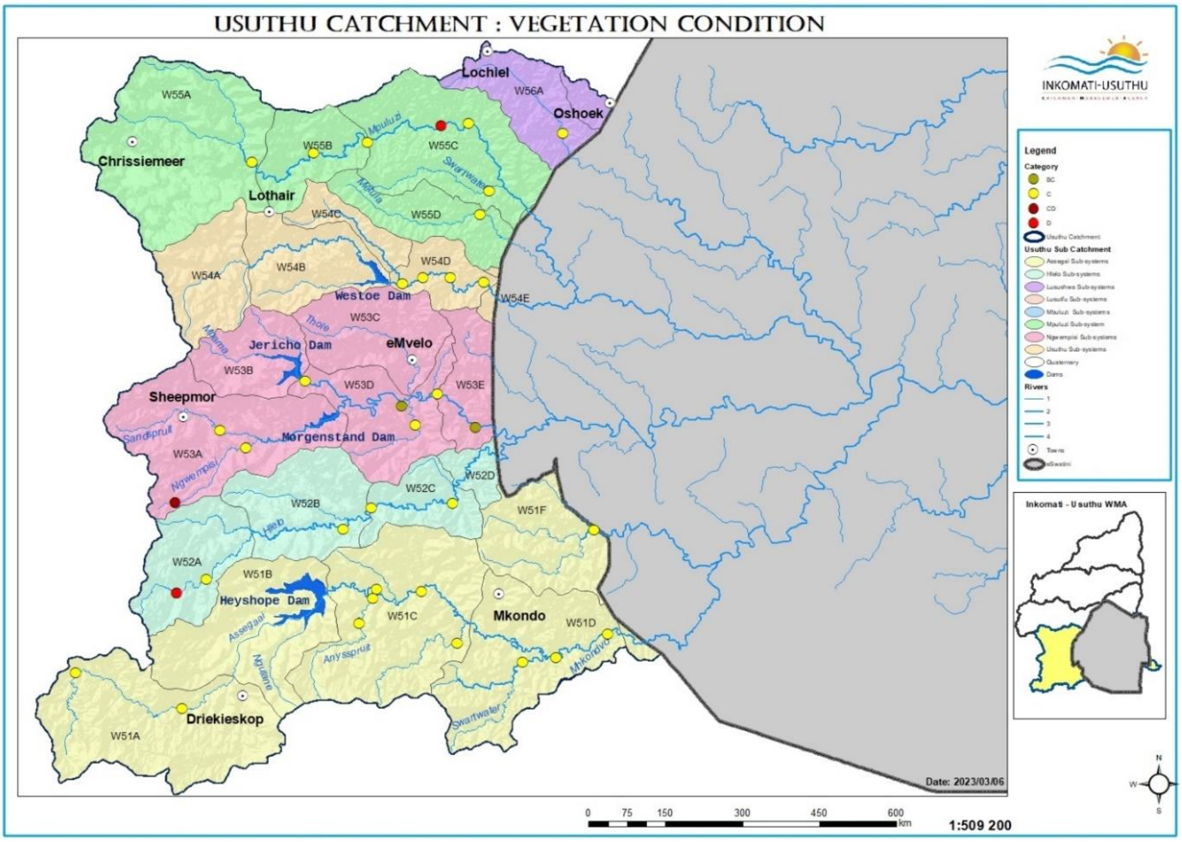


Figure 76: Visual representation of the vegetation condition in the Usuthu catchment.

The ecological status of the Usuthu catchment was found to be in an ecological category C (moderately modified) for fish and macro-invertebrates and for riparian vegetation during the survey. This suggests that the natural habitat and biota have been moderately modified by anthropogenic activities. Extensive sand mining activities, for example, were observed at the W5Metu-Ferni, W5Lusu-Robin, and W5Mpul-Borde sites. Domestic waste was also found at W5Mpam-Glene, W5Metu-Ferni, W5Swar-Izind, W5Hlel-Thoek, W5Lusu-Robin, W5Boes-Anhal, and W5Sand-Zands, either from local communities dumping on the riverbanks or from the rivers being used for cultural or religious purposes.

CHAPTER 6 RESOURCE DIRECTED MEASURES

6.1. Introduction

This chapter focuses on the Resource Directed Measures (RDM) . RDM are tools developed to manage water quality, water quantity and aquatic ecosystems for the protection of water resources by setting objectives for the desired condition of resources. The ecological Reserve is one of the components of Reserve within the framework of resource directed measures which also consist of the Management Class (MC) and Resource Quality Objectives (RQOs) for protection of water resources to ensure sustainable development and use of water resource. RQOs provide descriptive and numerical goals for the state of the resource, while the Source Directed Controls (SDC) specify the criteria for controlling impacts.

Classification process sets a class in which the water resource must be managed (DWS, 2011), while Reserve and RQOs are prescribed based on the management class set. RQOs capture the ecological Reserve into measurable conditions which should be adhered to in the receiving water resource in terms of resource quality. In the Inkomati Usuthu WMA, Classes and RQOs are determined within the X primary drainage region of Komati (X1), Crocodile (X2), Sabie-Sand (X3) and (X4) and gazetted into law in December 2016 by government notice No. 1616. The comprehensive ecological Reserve determination study was also completed in February 2006, however gazetted into law in July 2019 by government notice No. 998.

Resource quality objectives (RQOs) are numerical or narrative descriptors of quality, quantity, habitat, and aquatic biotic conditions that need to be met to achieve the required management scenario and are defined for each resource units (RU) for every integrated Units of Analysis (IUA). RU are the portrayal of catchments using units which are relatively homogenous on an ecological basis and IUAs represent a homogenous catchment area of similar impacts. Every IUA is classed in terms of the extent of permissible utilisation and protection and constitutes respective catchment configuration. The catchment configuration consists of several biophysical nodes representing river reaches. Within these river reaches Ecological water requirements (EWR) sites are established.

The RQOs have four key components of aquatic ecosystem (quality, quantity, habitat, and biota) to ensure that the structure and the function is protected. Monitoring of RQOs is required to determine compliance/or achievement of the numerical or narrative descriptors of resource quality set to achieve the required management class.

Resource quality monitoring is conducted within the WMA, and the purpose of this chapter is to assess compliance/or achievement of RQOs at specified Ecological Water Requirements site(s) and water quality priority resource units within the specified reaches. Note that where there is more than one monitoring site on the same river reach within the water quality (WQ) priority resource units the downstream monitoring site is used for reporting. It should be noted that it is not a single water user responsibility for the achievement/or compliance of the RQO in a resource unit but rather an aggregate impact of all water users within the RU. Consequently, the RQOs do not form part of the licence conditions.

Non-compliance to RQO should not only be seen as a failure to achieve Key Performance Area when moving towards the direction of the RQO and certainly not away from it, then it should still be seen as effective management of water resource. In situations where the RQO is persistently not achieved, it needs to be addressed progressively over realistic period, to allow users to adjust their activities, to allow water resource managers to apply successful SDC that are guided by RDM which may require amendment of regulation(s)/condition(s). For example, attaching appropriate conditions of use to licenses.

6.2. EWR Sites and WQ Priority Resources Units Compliance Status

The data reported was collected over a period of a year from January 2022- December 2022 for water quality and aquatic biota while water quantity data was collected from April 2022 to March 2023 and was analysed as tabulated below in Table 17.

Table 17:Variables analysed and assessed.

Resource Quality Variable	Indicator Variables	Statistical analysis of data/Ecostatus models
System variable(s)	pH, Turbidity (TUR), Temperature (Temp),	5 and 95 percentiles Mean 10 and 90 percentiles
Salt(s)	Electrical Conductivity (EC), Sulphate (SO_4)	95 percentiles
Nutrient(s)	Phosphate (PO_4), Total inorganic nitrogen (TIN)	50 percentiles
Microbial	*Escherichia coli (E coli) and Faecal Coliforms (FC)*	Average
Toxic(s)	Copper (Cu), Arsenic (As), Cyanide (Cn), Manganese (Mn), Chromium IV (Cr IV), Nickel (Ni)	95 percentiles
Water quantity	Flow	90% or 60% 90% or 70%
Aquatic biota	Fish	FRAI
	Macro-invertebrate	MIRAI
	Riparian vegetation	VEGRAI

The hydrological RQOs for Komati and Crocodile River systems were calculated on 90% below normal rainfall and 60% above normal rainfall whereas, Sabie Sand River system was calculated on 90% and 70%, respectively. The hydrological RQOs compliance were implemented using the above normal rainfall percentiles of 60% and 70 %.

Table 18 shows the models/methods used to determine Targeted Ecological Categories for each component (water quantity, water quality, habitat and aquatic biota).

Table 18: Models/methods used to determine Targeted Ecological Categories.

Characteristics of the resource	Models /Methods
Water Quantity	Actual measured values against 90% or 60% and 90% or 70% of RQOs
Water Quality	Physio-chemical driver Assessment Index (PAI)
Aquatic biota	River Data Integration (RIVDINT)

6.2.1. Sabie-Sand Catchment

The Sabie-Sand catchment comprises of eight (8) Ecological Water Requirements (EWR) sites across the catchment as presented in Figure 77.

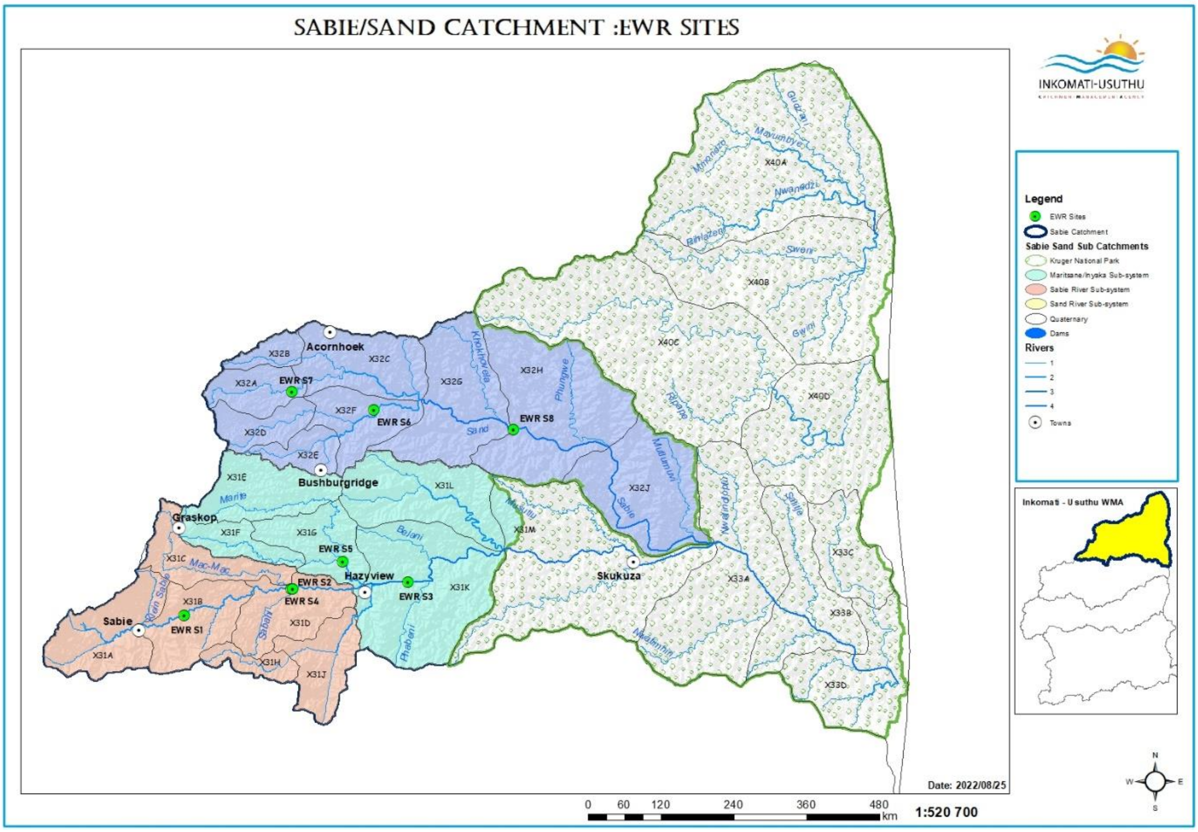


Figure 77 : Map showing Ecological Water Requirement sites within Sabie-Sand Catchment.

The compliance status of each EWR site is indicated by colours: Compliance (Green) or non-compliance (Red) as shown in Table 19 - Table 21 below.

Table 19: EWR Sites compliance status in the Sabie-Sand Catchment.

EWR Site	Turbidity (NTU)		EC (mS/m)		PO_4 (mg/l)		*E coli* (cfu/100ml)		Un-ionized Ammonia (mg/l)		Flow (m^3/s)		Fish		*Macro-invertebrates*		*Riparian vegetation*	
	RQO	Results	RQOs	Results	RQOs	Results	RQOs	Results	RQOs	Results	RQO	Compliance %	RQOs	Results	RQOs	Results	RQOs	Results
EWR S-1	NR	8.8	30	13.3	0.015	0.011	130	1419	0.007	0	1.0	100%	B	C	B	C	B	B/C
EWR S-2	NR	11.0	30	12.0	0.015	<0.010	130	641	0.007	0	0.93	100%	B	C	B	C	B	C
EWR S-3	NA	13.5	30	11.8	0.015	<0.010	130	559	0.007	0.009	3.2	100%	B	VA	B	VA	A/B	VA
EWR S-4	NA	4.1	40*	13.8	0.025*	<0.010	130*	218	*0.007	0		VA	B/C	B	A/B	C	A/B	B/C
EWR S-5	NR	6.1	30	7.7	0.015	<0.010	130	505	0.007	0.009		VA	B/C	C	B/C	C	B/C	C
EWR S-6	NR	33.2	55	18.1	0.015	<0.010	130	493	0.007	0.025		VA	C	B/C	B/C	C	C	C
EWR S-7	NA	6.1	42	10.6	0.125	<0.010	130	512	0.007	0.009		VA	C/D	VA	C	VA	C	VA
EWR S-8	NR	63.7	40*	100.8	0.125	0.016	130	688	*0.007	0.008	0.67	93 %	C	VA	B	VA	B	VA

NA: Not available   NR: Not Required   VA: Variable Not Analysed   TWQR*: Strictest limit from Targeted Water Quality Guideline

Table 20: Water Resource Classes and Targeted Ecological Categories in the Sabie-Sand Catchment.

IUAs	Class for IUAs	Resource Name	EWR Site	Water Quantity			Water Quality			Aquatic Biota		
				TEC	PEC	Target Met	TEC	PEC	Target Met	TEC	PEC	Target Met
X3-2	I	Sabie River	EWR S-1	B	B	√	A/B	B	X	B	C	X
		Sabie River	EWR S-2	B	B	√	B	A/B	√	B	C	X
		Mac Mac River	EWR S-4	B	VA		A/B	A/B	√	B	C	X
X3-3	I	Sabie River	EWR S-3	A/B	A/B	√	B	B	√	A/B	C	X
		Marite River	EWR S-5	B/C	VA		B	B	√	B/C	C	X
X3-7	II	Mutlumuvi River	EWR S-6	C	VA		B	B/C	X	C	C	√
X3-8	II	Tlulandziteka	EWR S-7	C	VA		C	B	√	C	VA	
X3-9	I	Sand River	EWR S-8	B	B (93%)	X	B	B/C	X	B	VA	

NA: Not available VA: Variable Not Analysed

Table 21: Compliance status of monitoring sites per reach within WQ Priority Resources Units: Compliance (Green) or non-compliance (Red).

WQ Priority RU	River reach and Resource Name	Turbidity (NTU)		EC (mS/m)		PO_4 (mg/l)		*E-coli* (cfu/100ml)	
		RQO	Results	RQOs	Results	RQOs	Results	RQOs	Results
RU S6	X31J-00774 (Noorsand River)	NA	**4.3**	30	**32.8**	0.025	**<0.010**	130	**451**
RU S9	X31K-00713 (Bejani River)	NA	**38.3**	30	**68.9**	0.025	**<0.010**	130	**1283**
MRU Sabie C	X33B-00804 (Sabie River)	NA	**19.6**	42	**16.7**	0.125	**0.014**	130	**765**

NA: Not available NR: Not Required TWQR*: Strictest limit from Targeted Water Quality Guideline

Discussion of results within Sabie Sand Catchment

IUA X3-2

This IUA consists of the headwaters of the Sabie River down to the confluence with the Klein Sabie River and Mac-Mac River. The Sabie River rises on the escarpment and drops off steeply through mountainous terrain. There are three (3) EWR sites and no significant dams within the IUA. Land use in this IUA is mostly forestry with some wilderness areas and urban areas. EWR site S1 did not meet the Target Ecological Category (TEC) as gazetted for water quality and in terms of aquatic biota all EWR sites did not meet the TEC. The sites in this IUA ranged between slightly modified (B to B/C PES) to moderately modified (C PES).

The primary impact in this IUA is non-flow related as the TEC for all EWR sites is met within the IUA, while water quality deterioration is evident in the lower Sabie reach of the IUA due to urban runoff, effluent discharge from municipal and private WWTW and Sawmill industries. The aquatic biota did not meet the Target Ecological Category due to water quality impacts and the loss of instream habitat as contributing factors. The variable of concern related to water quality are microbial (*E coli*) which did not comply with the set RQOs. However, *E coli* have no impact on aquatic biota.

IUA X3-3

This IUA consists of the upper reaches of the Marite River down to the Inyaka Dam, Motitsi River and Middle Sabie River. The terrain is mostly steep and mountainous. There are two EWR sites and includes the Inyaka Dam, the largest dam in the Sabie Sand Catchment within the IUA. Land use in the IUA consists mostly of forestry although there are significant wilderness areas, irrigation, and urban/rural development. The set targets were met for water quality at both sites, whereas the set targets were not met for aquatic biota. The sites in this IUA ranged between slightly modified (B to B/C PES) to moderately modified (C PES).

The primary impact in this IUA is non-flow related, while some water quality deterioration is evident in the lower Marite River due to urban runoff (Graskop, Marite and parts of Bushbuckridge), effluent discharge from municipal and private WWTWs. The aquatic biota did not meet the Target Ecological Category due to water quality impact on EWR S- 5 and the loss of instream habitat as contributing factors. The variable of concern related to water quality is *E coli* which did not comply with the set RQOs.

IUA X3-7

This IUA consists of the Mutlumuvi River, a major tributary of the Sand River. The Mutlumuvi River rises on escarpment and drops rapidly to the Lowveld plains. There is one EWR site and no significant dams within the IUA. Land use consists of forestry on the mountain slopes, numerous villages, grazing, limited irrigation, and subsistence dry-land agriculture.

The set targets were not met for water quality at EWR S-6, when comparing with the TEC as per gazette, but aquatic biota indicated compliance with the set TEC. Modified habitat is a concern related to deterioration of the PES from category B (largely natural with few modifications) in 2014 to C (moderately modified) in 2023. This IUA is situated in an area dominated by rural agriculture and urbanizations such as agricultural fields, vegetation removal, overgrazing and trampling, sedimentation, bed and channel disturbance.

IUA X3-8

This IUA consists of the northern tributaries of the Sand River, i.e., the Klein-sand and Thulandziteka Rivers. The terrain is the same as the IUA X3-7 with the rivers rising on the escarpment and falling rapidly to the Lowveld plains. There is one EWR site and no significant dams within the IUA. Land use is grazing, villages, irrigation, and dry-land subsistence agriculture.

The set targets ecological category of C for water quality were met at EWR S-7 with PES of B (Slightly modified) and this indicates an improvement in water quality status from C (moderately modified) in 2014. Water quantity and aquatic biota were not measured/sampled, due to no measuring station and no access, respectively. For aquatic biota alternative sites will be established in the same sub-quaternary reach.

IUA X3-9

This IUA consists of the lower Sand River Catchment. The terrain is flat, and the area falls entirely within wilderness area, either the Sabi Sand Park or the KNP. There is one EWR site and no significant dams within the IUA. Land use includes the settlement of Phungwe and Utlha and tourism and recreational activities.

The set targets ecological category for water quantity and quality were not met at EWR S-8, when comparing with the TEC as per the gazette. Aquatic biota water was not sampled, due to no access. The flows in the Sand sub-catchment are not controlled, because of the lack of infrastructure to implement the sub-catchment operating rules. Water quality variable of concern related to deterioration of the PES from category B (largely natural with few modifications) in 2014 to C (moderate modification) in 2023 is phosphate from upstream. The rivers within this IUA are situated in conservation areas and thus fairly well protected.

WQ Priority Resources Units

Compliance status on water quality priority resource units of analysis presented in Table 21 show that microbial pollution is a major concern as reflected by the non-compliance to the set RQOs of *E. coli*. Electrical conductivity (EC) was non-compliant at Noord-Sand River (Hazyview) and Bejani River (Mkhuhlu) and nutrients complied with the set RQOs for water quality priority resource units of analysis sites.

Management Class

All biophysical nodes (reaches) and components (water quantity, water quality and aquatic biota) within the IUA should comply with the set TEC in order to meet the management class. In this report only EWR sites were considered to ensure that the management class is met within the IUA. Assumption was made that if all components are met at an EWR site, then all biophysical nodes are met within the IUA.

EWR S-1-5 represents all biophysical nodes within IUA (X3-2 and X3-3) and did not meet the management Class I due to either water quality or aquatic biota not complying to the TEC. It was not possible to conclude on other IUAs because not all components were assessed.

WQ Priority Resources Units

Compliance status on water quality priority resource units of analysis in **Table 21** shows that microbial and salt are a major concern as shown by the non-compliance to the set RQOs.

6.2.2. Crocodile Catchment

The Crocodile catchment comprises of nine (9) Ecological Water Requirements (EWR) sites across the catchment as presented in Figure 78.

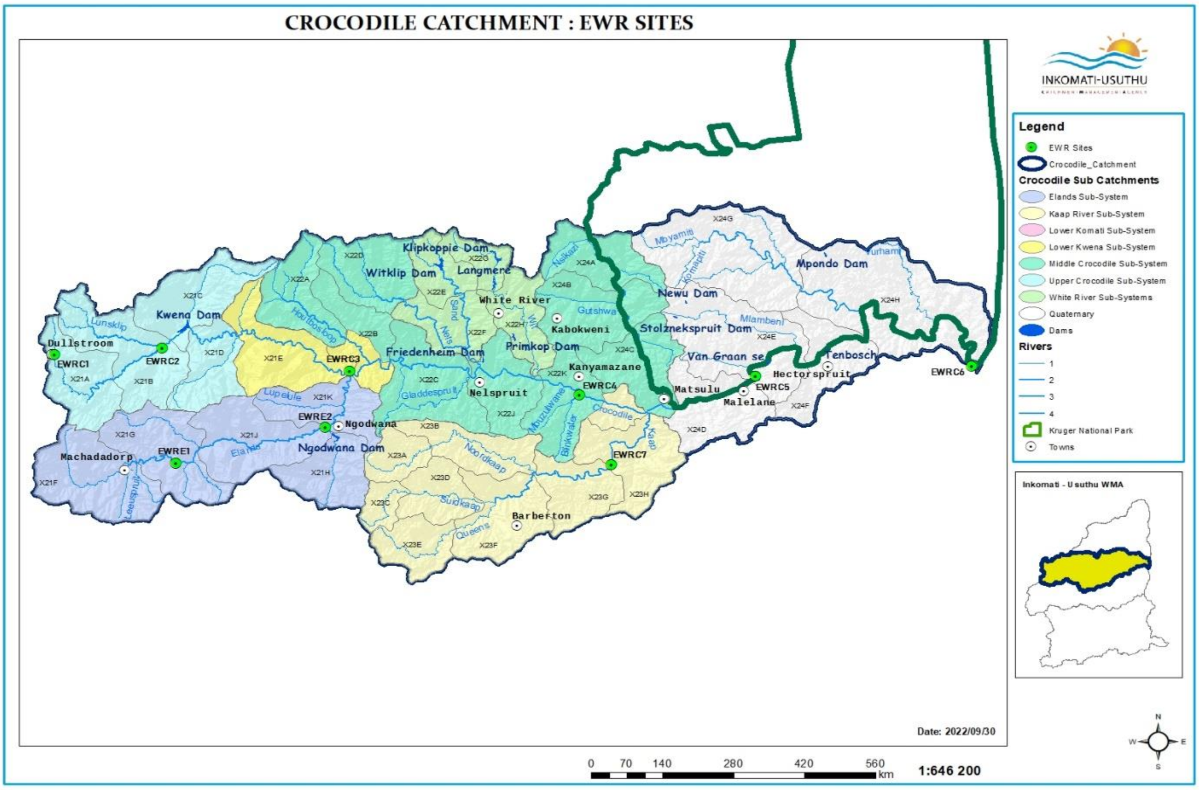


Figure 78: Map showing Ecological Water Requirement sites within Crocodile Catchment.

The compliance status of each EWR site is indicated by colours: Compliance (Green) or non-compliance (Red) as indicated in Table 22 - Table 24 below.

Table 22: EWR Sites compliance status in the Crocodile Catchment.

Variable	Results ROQs Ecospecs	Resources Units								
		MRU CROC A Crocodile River		MRU CROC B Crocodile River	MRU ELAN A Elands River	MRU ELAN B Elands River	MRU CROC D Crocodile River	MRU CROC E Crocodile River		MRU KAAP A Kaap River
		EWR-C1	EWR-C2	EWR-C3	EWR-E1	EWR-E2	EWR-C4	EWR-C5	EWR-C6	EWR-C7
Temp (°C)	RQO	Not more than 2 °C from baseline (Aquatic Ecosystem driver)								
	Results	9.9 - 21.3	11.5 - 21.1	15.0 - 22.7	13.1 - 24.4	15.4 - 24.9	16.3 - 26.2	18.4 - 27.7	18.6 - 29.3	15.7 - 27.3
Turbidity (NTU)	RQO	NA (Aquatic Ecosystems driver)								
	Results	3.0	15.9	28.1	4.6	4.5	27.0	22.9	18.6	33.5
EC (mS/m)	RQO	30	30	30	30	55	70	70	70	200
	Results	7.1	13.8	12.8	8.7	68.4	27.3	41.2	65	52.3
PO_4 (mg/l)	RQO	0.015	0.025	0.015	0.025	0.015	0.125	0.075	0.125	0.125
	Results	<0.010	<0.010	<0.010	<0.010	<0.010	0.066	0.049	0.032	0.045
TIN (mg/l)	RQO	NR	NR	NR	NR	NR	NR	NR	NR	< 4
	Results	NR	NR	NR	NR	NR	NR	NR	NR	0.01
E-coli (cfu/100 ml)	RQO	120	130	130	130	130	130	130	130	130
	Results	223	809	431	719	169	2123	819	398	270
Un-ionized Ammonia (mg/l)	RQO	*0.007	*0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007
	Results	0.002	0.004	0.005	0.006	0.005	0.0216	0.025	0.025	0.032
Cn(mg/l)	RQO	NR	NR	NR	NR	NR	NR	NR	NR	0.004
	Results	NR	NR	NR	NR	NR	NR	NR	VA	<0.07
As (mg/l)	RQO	NR	NR	NR	NR	NR	NR	NR	NR	0.020
	Results	NR	NR	NR	NR	NR	NR	NR	VA	0.040
Flow (m^3/s)	RQO			2.43		0.5	5.47	8.185	4.72	0.99
	Results	VA	VA	100%	100%	100%	100%	91%	99%	93%

Variable	Results ROQs Ecospecs	Resources Units								
		MRU CROC A Crocodile River		MRU CROC B Crocodile River	MRU ELAN A Elands River	MRU ELAN B Elands River	MRU CROC D Crocodile River	MRU CROC E Crocodile River		MRU KAAP A Kaap River
		EWR-C1	EWR-C2	EWR-C3	EWR-E1	EWR-E2	EWR-C4	EWR-C5	EWR-C6	EWR-C7
Fish	RQO	A	B	B	B	B	B	C	C	C
	Results	BC	C	VA	C	C	VA	VA	VA	C
Macro-invertebrates	RQO	B	B	C	B	B	C	C	C	B
	Results	C	C	VA	C	C	VA	VA	VA	C
Riparian Vegetation	RQO	A	A/B	C	C	C	C	C	C	C/D
	Results	B	C	C	C	C	VA	VA	VA	C

NA: Not available NR: Not Required VA: Variable Not Analysed **Detection limit TWQR*: Strictest limit from TWQG

***Table 23**: Water Resource Classes and Targeted Ecological Categories in the Crocodile Catchment.*

IUAs	Class for IUAs	Resource Name	EWR Site	Water Quantity			Water Quality			Aquatic Biota		
				TEC	PEC	Target Met	TEC	PEC	Target Met	TEC	PEC	Target Met
X2-1	II	Crocodile River	EWR C-1	A/B	VA		A	A/B	X	A/B	C	X
		Crocodile River	EWR C-2	B	VA		C	A/B	√	B	C	X
X2-2	II	Crocodile River	EWR C-3	B/C	B/C	√	C	B	√	B/C	C	X
X2-3	I	Elands River	EWR E-1	B	B	√	NA	B	√	B	C	X
X2-5	I	Elands River	EWR E-2	C	C	√	NA	B/C	√	B	C	X
X2-9	II	Crocodile River	EWR C-4	C	C	√	C	C	√	C	VA	
X2-11	II	Crocodile River	EWR C-5	C	C (91%)	X	C	C	√	C	VA	
		Crocodile River	EWR C-6	C	C (99%)	X	C	C	√	C	VA	
X2-10	II	Kaap River	EWR C-7	C	C (93%)	X	B	B/C	X	C	C	√

NA: Not Available VA: Variable Not Analysed

Table 24: Compliance status of monitoring sites per reach within WQ Priority Resources Units: Compliance (Green) or non-compliance (Red).

WQ Priority RU: River reach (Resource Name)	Turbidity		pH		EC (mS/m)		PO_4 (mg/l)		*E. coli* (cfu/100ml)		*Mn(mg/l)*		As(mg/l)		Cn (mg/l)		Cr VI (mg/l)	
	RQO	Results	RQO	Results	RQOs	Results	RQOs	Results	RQOs	Results	RQOs	Results	RQOs	Results	RQOs	Results	RQOs	Results
MRU Elan A: X21F-01046 (Elands River)	NR		6.5 – 8	7.3-7.7	30	14.9	0.025	<0.010	130	193	0.18	<0.010	NR		NR		0.014	<0.010
RU C7: X21F-01100 (Leeuspruit)	NR		6.5 – 8	7.6-8.0	30	24.3	0.025	0.069	130	1674	0.18	<0.010	NR		NR		0.014	<0.010
MRU Elan B: X21J-01013 (Elands River)	NA	20.6	6.5-8.5*	7.5-7.7	55	17.0	0.025	0.011	130*	402	0.18	<0.010	NR		NR		0.014	<0.010
MRU Elan B: X21K-00997 (Elands River)	NA	11.8	6.5-8.5*	7.7-8.4	55	59.5	0.025	<0.010	130*	159	0.18	0.0175	NR		NR		NR	
MRU Croc C: X22B-00888 (Crocodile River)	NA	7.3	6.5-8.5*	7.5-7.8	55	27.2	0.025	<0.010	130	372	0.18	0.019	0.020	0.010	0.004	0.070**	NR	
MRU Croc C: X22J-00993 (Crocodile River)	NA	14.4	6.5-8.5*	7.3-7.8	55	25.0	0.025	0.010	130	607	0.18	0.024	NR		NR		NR	
MRU Croc C: X22J-00958 (Crocodile River)	NA	14.3	6.5-8.5*	7.4-7.7	55	24.0	0.025	0.012	130	1530	0.18	0.044	NR		NR		NR	
MRU Croc C: X22K-00981 (Crocodile River)	NA	14.5	6.5-8.5*	7.3-7.6	55	25.2	0.025	0.059	130	1589	0.18	0.029	NR		NR		NR	
RU C12: X22C-01004 (Gladdespruit)	NA	4.6	6.5-8.5*	7.0-7.6	30*	25.5	0.02*	<0.010	130*	1371	0.18	0.890	NR		NR		NR	
RU C14: X22H-00836 (White River)	NR		6.5-8.5*	7.3-7.6	55	33.0	0.125	0.028	130	50	0.18	0.019	NR		NR		NR	
RU C13 X22F-00886 (Sand River)	NA	4.4	6.5-8.5*	6.7-7.4	30	3.2	0.025	<0.010	130*	3	0.18*	<0.010	NR		NR		NR	

WQ Priority RU: River reach (Resource Name)	Turbidity		pH		EC (mS/m)		PO_4 (mg/l)		*E. coli* (cfu/100ml)		*Mn(mg/l)*		As(mg/l)		Cn (mg/l)		Cr VI (mg/l)	
	RQO	Results	RQO	Results	RQOs	Results	RQOs	Results	RQOs	Results	RQOs	Results	RQOs	Results	RQOs	Results	RQOs	Results
RU C13 **X22F-00977** (Nels River)	NA	26.4	6.5-8.5*	7.3-7.7	30	11.9	0.025	0.020	130*	238	0.18*	0.026	NR		NR		NR	
RU C17: X23C-01098 Suidkaap River)	NR		6.5-8.5*	7.7-8.0	30	18.8	0.075	0.019	130	128	NR		NR		0.004	VA	NR	
RU C17: X23E-01154 (Queens River)	NR		6.5-8.5*	7.5-8.0	30	38.0	0.075	0.015	130	1986	0.18	0.027	0.02	0.010	0.004	0.07**	NR	
RU C17: X23F-01120 (Suidkaap River)	NR		6.5-8.5*	7.5-8.1	30	56.9	0.075	0.100	130	2420	0.18	0.151	0.02	0.068	0.004	0.07**	NR	
MRU Croc D: X24C-01033 (Crocodile River)	NA	7.6	6.5-8.5*	7.6-8.0	85	31.7	0.125	0.061	130	876	0.18*	0.019	0.01*	0.019	NR		NR	
RU C19: X24B-00903 (Gutshwa River)	NA	11.0	6.5-8.5*	7.0-7.4	55	110.2	0.125	1.860	130	1387	NR		NR		NR		NR	

NA: Not available NR: Not Required VA: Variable Not Analysed **Detection limit TWQR*: Strictest limit from TWQG

Discussion of results within Crocodile Catchment

IUA X2-1

This IUA consists of the headwater of the Crocodile River down to the confluence with Lunsklip River and Alexanderspruit. This IUA rises over 2000m on the escarpment and forms increasingly deep valleys moving downstream towards Kwena Dam. There are two (2) EWR sites and Kwena Dam is the largest and most important dam in the Crocodile River System. The Kwena Dam is located at the outlet to this this IUA. Land use consists of forestry, grazing, irrigation and dry-land crops, trout farming.

The set targets were not met for water quality and aquatic biota at EWR C-1. The target for biota was also not met at EWR C-2 but was met for water quality which indicated compliance with the set TEC. Water quantity was not measured, due to no measuring station. The EWR sites in this IUA ranged between slightly modified (A/B PES) to moderately modified (C PES).

The aquatic biota did not meet the Target Ecological due to loss of instream habitat as contributing factors. The variable of concern related to water quality are E coli which did not comply with the set RQOs.

IUA X2-2

This IUA consists of the Crocodile River and tributaries from the Kwena Dam to the confluence of the Elands River. The terrain consists of a deeply incised valley although the valley bottom is sufficiently wide for extensive agricultural lands. There is one (1) EWR site and few small farm dams in the IUA. Land use consists mostly of forestry and agricultural activities (grazing and irrigation) in lower lying areas of this IUA.

The set targets were met for water quantity and quality at EWR C-3 when comparing with the TEC as per the gazette, except for aquatic biota which indicated non-compliance with the set TEC. Due to loss of instream habitat (construction/upgrading of the N4) as contributing factors for the reduced biotic integrity.

IUA X2-3

This IUA consists of the upper reaches of the Elands River catchment. The catchment rises on the escarpment and is generally undulating although becoming increasingly mountainous as the river drops down the escarpment in near Waterval Boven. There is one (1) EWR site and few farm dams and trout dams in the catchment and a small dam which supplies water to Machadodorp. Land uses consist of settlement, forestry, grazing and dry-land crops.

The set targets were met for water quantity and quality at EWR E-1 when comparing with the TEC as per the classification technical report, except for aquatic biota which indicated non-compliance with the set TEC. For water quantity, measured values were estimated using results of EWR E-2 because it is the outlet of EWR E-1. The TEC for water quality is not available (has not been set) and therefore the PES will be regarded as compliant. The aquatic biota did not meet the Target Ecological Category due to the loss of instream habitat as contributing factors. Water quality related impacts are associated with this land-use type (increased nutrients and sediment runoff) as well as the runoff and effluent discharge from WWTWs of Machadodorp and Waterfall Boven towns.

IUA X2-5

This IUA consists of the Elands River and tributaries downstream of Waterval Boven and ending at the confluence with the Ngodwana River and Lupelele River. The landscape consists of a deeply incised but wide-bottom valley. There is one (1) EWR site and small farm dams and Ngodwana dam which supplies water to the SAPPI paper mill. The land use consists of extensive forestry, industrial and agricultural activities (grazing and irrigation with raw water and water containing waste from SAPPI Paper Mill).

The set targets were met for water quantity and quality at EWR E-2 when comparing with the TEC as per the classification technical report, but not met for aquatic biota which indicated non-compliance with the set TEC. In case of water quality, TEC is not available and therefore the PES will be regarded as compliant. The aquatic biota did not meet the Target Ecological Category due to the loss of instream habitat as contributing factors. Water quality deterioration, associated with these land-uses (irrigation return flows, recreation, and upstream towns) is also prevalent.

IUA X2-9

This IUA consists of the main stem of the Crocodile River from Nelspruit down to the confluence with the Kaap River, including the Blinkwater River. The landscape is undulating flat although the Blinkwater River flows through a mountainous area. There is one (1) EWR site and no significant dams within the IUA. The land use consists of extensive settlements (KaNyamazane and Thekwane) and agricultural activities including effluent discharge from WWTWs.

The set targets were met for water quantity and quality at EWR C-4 when comparing with the TEC as per the gazette. The PES of C (moderately modified) was attained for both water quantity and quality, with the primary impact being subject to upstream flow modification and land use activities. The water quantity TEC was estimated using the measured flow values from Karino station. The aquatic biota was not sampled due to access.

IUA X2-11

This IUA consists of the Crocodile River from the confluence with the Kaap River down to the confluence with the Komati River. The landscape in this IUA is very flat. There are two (2) EWR sites and no significant dams within the IUA. The land use consists of extensive irrigation (sugarcane), grazing and game farming as well as settlements (Malelane, Hectorspruit and Komatipoort).

The set targets were not met for water quantity at EWR C-5 and C-6 when comparing with the TEC as per the gazette. However, the target for water quality at EWR C-5 and C-6 indicated compliance with the set TEC. The aquatic biota was not sampled as the sites are located within KNP and is not safe to sample without the rangers. In future the sites will be sampled with the team from KNP accompanied by the rangers.

IUA X2-10

This IUA consists of the Kaap River catchment, a major tributary of the Crocodile River. The Kaap River rises on the escarpment and drops off steeply to a wide valley floor. There is one (1) EWR site and no significant dams within the IUA but there are several farm dams present. Land use in this IUA consists of gold mining, forestry, rural and urban settlement, and agricultural activities (grazing and irrigation).

The set targets were not met for water quantity and quality at EWR C-7 when comparing with the TEC as per the gazette. However, the target for aquatic biota indicated compliance with the set TEC of C. The PES of C (moderately modified) was attained for both water quantity and quality, with the primary impact being subject to upstream flow modification and land use activities. The variables of concern related to water quality deterioration at EWR site C-7 are arsenic which did not comply with the set RQOs. Illegal gold mining is likely contributing to higher levels arsenic within the Kaap sub-catchment.

Management Class

All biophysical nodes and components (water quantity, water quality and aquatic biota) within the IUA should comply with the set TEC in order to meet the management class. In this report only EWR sites were considered to ensure that the management class is met within the IUA. Assumption was made that if all components are met at an EWR site, then all biophysical nodes are met within the IUA.

EWR E-1 and EWR E-2 represents all biophysical nodes within IUA X2-3 and X2-5 respectively and have not met the management Class I due to aquatic biota not complying to the TEC. EWR C3 represents all biophysical nodes of X2-2 and has not met the management Class II due to aquatic biota not complying to the TEC. EWR C7 represents all biophysical nodes of X2-10 and has not met the management Class II due to water quantity and quality not complying to the TEC. It was not possible to conclude on other IUAs because not all components were assessed.

WQ Priority Resources Units

Compliance status on water quality priority resource units of analysis in **Table 24** shows that microbial pollution as a major concern as shown by the non-compliance to the set RQOs of *E. coli*. Salts and nutrients were non-compliant at selected sites using EC and PO_4 as indicator variables. The levels of arsenic exceeded the set RQOs in Suid-Kaap River.

6.2.3. Komati Catchment

The Komati catchment comprises of six (6) Ecological Water Requirements (EWR) sites across the catchment as presented in Figure 79.

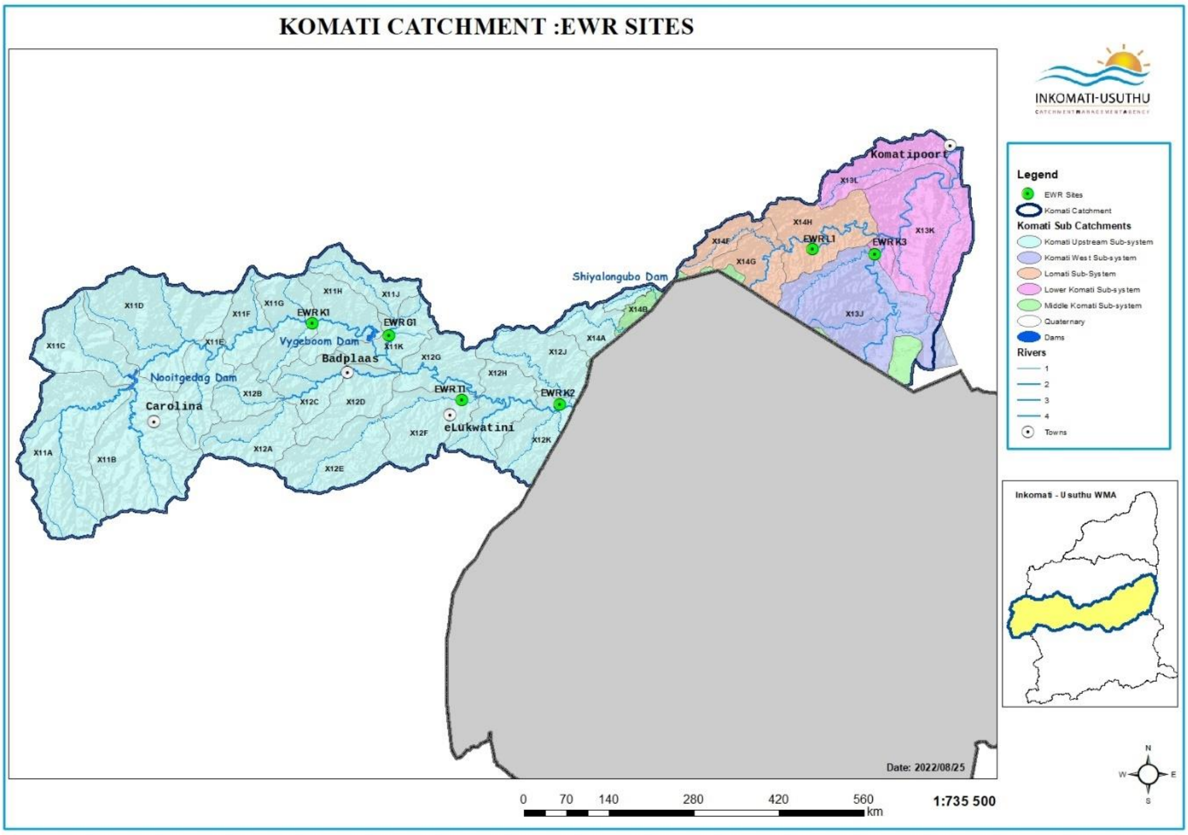


Figure 79 : Map showing Ecological Water Requirement sites within Komati Catchment.

The compliance status of each EWR site is indicated by colours: Compliance (Green) or non-compliance (Red) as indicated in Table 25 - Table 27 below.

Table 25: EWR Sites compliance status in the Komati Catchment.

EWR Site	Turbidity (NTU)		EC (mS/m)		PO_4 (mg/l)		TIN		*E coli* (cfu/100ml)		Un-ionised Ammonia (mg/l)		Flow (m^3/s)		Fish		Macro-invertebrates		Riparian Vegetation	
	RQO	Results	RQOs	Results	RQOs	Results	RQO	Results	RQOs	Results	RQOs	Results	RQOs	Compliance %	RQOs	Results	RQOs	Results	RQOs	Results
EWR K-1	NR	14.7	50	20.8	0.02	<0.010	NR		130*	212	0.007	0.005	0.7	100%	C	C	B/C	C	C	C
EWR G-1	NA	16.6	40*	32.7	0.02	<0.010	NR		130*	329	0.007	0.007			D	D	D	C	D	C
EWR K-2	NA	24.0	55	20.3	0.02	<0.010	NR		130	357	*0.007	0.0078	1.02	100%	C	BC	C	C	C	BC
EWR T-1	NA	16.8	40*	19.0	0.125	<0.014	NR		130	772	*0.007	0.023			C	C	C	C	C	C
EWR L-1	NA	30.9	30	22.5	0.015	<0.010	1	0.010	130	315	0.007	0.008	0.97	100%	C	VA	C	VA	B/C	C
EWR K-3	NR	22.9	85	114.9	0.125	<0.010	1	0.010	130	929	0.007	0.012	1.84	100%	C/D	C	D	C	D	CD

NA: Not available NR: Not Required VA: Variable Not Analysed TWQR*: Strictest limit from Targeted Water Quality Guideline

Table 26: Water Resource Classes and Targeted Ecological Categories in the Komati Catchment.

IUAs	Class for IUAs	Resource Name	EWR Site	Water Quantity			Water Quality			Aquatic Biota		
				TEC	PEC	Target Met	TEC	PEC	Target Met	TEC	PEC	Target Met
X1- 2	II	Komati	EWR K-1	C	C	√	B	B	√	C	C	√
X1- 4	III	Mngubhudle	EWR G-1	D	VA		C	B/C	√	D	C	√
X1- 5	II	Komati	EWR K-2	C	C	√	B/C	B	√	C	C	√
X1- 6	I	Teespruit	EWR T-1	C	VA		B/C	C	X	C	C	√
X1- 8	III	Lomati River	EWR L-1	C	C	√	B/C	B	√	C	VA	VA
X1- 9	III	Komati River	EWR K-3	D	D	√	D	C	√	D	C	√

NA: Not Available VA: Variable Not Analysed

Table 27: Compliance status of monitoring sites per reach within WQ Priority Resources Units: Compliance (Green) or non-compliance (Red).

WQ Priority RU	River reach and Resource Name	pH		Temperature		Turbidity (NTU)		Sulphate (mg/l)		EC (mS/m)		PO_4 (mg/l)		*E-coli* (cfu/100ml)	
		RQO	Results	RQO	Results	RQOs	Results	RQOS	Results	RQOs	Results	RQOs	Results	RQOs	Results
RU K1	X11A-01248 (Vaalwaterspruit)	8.0-8.8	7.1-8.1	NR		NR		30	202.1	30	65.6	0.025	<0.010	130	249
	X11A-01295 (Vaalwaterspruit)	8.0-8.8	6.9-7.9	NR		NR		30	438.6	30	102.7	0.025	<0.010	130	633
RU K2	X11B-01370 (Boesmanspruit)	8.0-8.8	6.5-7.6	NR		NR		80	403.8	30	70.7	0.025	<0.010	130	270
	X11B-01361 (Tributory of Boesmanspruit)	8.0-8.8	6.7-7.8	NR		NR		80	15.1	30	29.5	0.025	0.012	130	186
	X11B-01272 (Boesmanspruit)	8.0-8.8	5.0-7.7	NR		NR		80	175.9	30	64.2	0.025	0.021	130	892
RU-K3	X11C-00147 (Witkloofspruit)	8.0-8.8	6.8-7.7	NR		NR		30	100.6	30	37.4	NR		NR	
	X11D-01129 (Klein Komati River)	8.0-8.8	6.7-7.7	NR		NR		30	123.2	30	30.7	NR		NR	
RU-K4	X11E-01237 (Swartspruit)	6.5-8.5*	6.9-8.0	NR		NA	6.8	30	21.6	40*	15.2	0.020*	<0.010	NR	
MRU Komati E	X13K-01038 (Komati River)	6.5-8.5*	7.4-8.2	Not more than 2 °C from baseline.	25.8-26.1	NA	4.8	NR		85	50.3	0.125	<0.010	130	205
	X13L-00995 (Komati River)	6.5-8.5*	7.2-8.2		19.1-27.6	NA	56.2	30*	27.3	85	63.1	0.125	00.011	130	197

NA: Not available NR: Not Required VA: Variable Not Analysed TWQR*: Limit from Targeted Water Quality Guideline

Discussion of results within Komati Catchment

IUA X1-2

This IUA consists of the main stem of the Komati River commencing immediately downstream of the Nooitgedacht dam and ending with the Vygeboom Dam. This IUA is relatively flat in the upper reaches but becomes increasingly incised progressing downstream, although the catchment flattens out again in the vicinity of the Vygeboom Dam. There is one (1) EWR site and the Vygeboom Dam. Land use is forestry and agricultural activities (grazing, dry land crops and limited irrigation).

The set targets were met for water quantity, water quality and aquatic biota at EWR K-1 when compared with the TEC as per the gazette. The PES ranges between B (slightly modified) to C (moderately modified). The Komati River is dominated by changes in flow largely due to the operation of Nooitgedacht Dam. There is a weir located on the river between the two dams from which water is pumped by Eskom for transfer to the Olifants system. The other significant abstraction is from the Vygeboom Dam, also for transfer to the Olifants.

IUA X1-4

This IUA consists of the Gladdespruit tributary. The catchment is mountainous with the river rising on the Highveld escarpment and descending over 800 m to the low-lying plateau on which the Vygeboom Dam is located. There is one (1) EWR site and no significant dams. Land use is forestry, nickel mining, and agricultural activities (grazing, dry land crops and limited irrigation).

The set targets were met for water quality and aquatic biota at EWR G-1 when comparing with the TEC as per the gazette. The PES for both water quality and aquatic biota is B/C to C (slightly to moderately modified). The TEC for biota was exceeded at EWR G-1, indicating that improvement of the target is possible with appropriate management. It also shows that the ecological category for these reaches can be managed as ecological category C. Water quantity was not measured, due to the lack of a measuring station.

IUA X1-5

This IUA consists of the main stem of the Komati River from the outlet of the Vygeboom Dam down to the Eswatini border. This stretch of river is relatively flat but flows through a deeply incised valley. There is one (1) EWR site and no significant dams. Land use in this IUA is mainly agricultural activities (grazing with limited dryland crops), settlement and conservation areas.

The set targets were met for water quantity, water quality and aquatic biota at EWR K-2 when comparing with the TEC as per the gazette. The PES ranged between B (slightly modified) to C (moderately modified). The river was still in a reasonable condition, mostly as it is situated in some protected areas such as Songimvelo Nature Reserve.

IUA X1-6

This IUA consists of three tributaries flowing into the Komati River, mainly the Seekoeispruit, Sandspruit and Mlondolozi River. The terrain is flat, high-lying escarpment area with tributaries flowing steeply to the Komati through deeply incised valleys. There is one (1) EWR site and no significant dams in this IUA. Land use consists mostly of forestry, settlement, and agriculture activities (grazing with limited dryland crops).

The set targets were met for aquatic biota at EWR T-1 when comparing with the TEC as per the gazette. The PES is C (moderately modified) for both water quality and aquatic biota. However, the water quality exceeded the set TEC of B/C due the overflow of effluent from the Elukwatini oxidation ponds and storm water impacts from Elukwatini. The water quality variables of concern identified are microbial pollution (*E. coli*) and toxic substance (NH_3). Water quantity was not measured, due to no measuring station.

IUA X1-8

This IUA consists of the Lomati River downstream of the eSwatini border and down to the confluence with the Komati River. The area is mostly very flat although bordered by mountains in the Northwest. There is one (1) EWR site and a large dam (Driekoppies Dam) in this IUA although there are also numerous farm dams as well. Land use consists mostly of numerous settlements, and agriculture activities (extensive irrigated crops and some livestock grazing).

The set target was met for water quantity at EWR L-1 when compared with the TEC as per the gazette. The PES is B (slightly modified) for water quality. Aquatic biota was not sampled due to no access an alternative site will be established in the same sub-quaternary reach.

IUA X1-9

This IUA consists of the Lower Komati River from the Swaziland border to the confluence with the Lomati River. The area is flat. There is one (1) EWR site and two small dams in this IUA, the Mbambiso and Masibikela dams. Land use consist of settlements, and dominated by irrigated crops, mostly sugar cane although there is also extensive stock grazing taking place.

The set targets were met for water quantity, water quality and aquatic biota at EWR K-3 when comparing with the TEC as per the gazette. The PES was C (moderately modified) for water quality and aquatic biota. EWR K-3 exceeded the TEC for water quality and aquatic biota, indicating that improvement of the target is possible with appropriate management. It also shows that the ecological category for these reaches can be managed as ecological category C.

Management Class

All biophysical nodes and components (water quantity, water quality and aquatic biota) within the IUA should comply with the set TEC in order to meet the management class. In this report only EWR sites were considered to ensure that the management class is met within the IUA. Assumption was made that if all components are met at an EWR site, then all biophysical nodes are met within the IUA.

EWR K-1 and EWR K-2 are the only biophysical nodes within IUA X1-2 and X1-3 respectively and have met Management Class II. This means the IUA X1-2 is moderately used. EWR K-3 is representing all biophysical nodes within IUA X1-9 and has met the management Class III, indicating that the IUA heavily used. It was not possible to conclude on other IUAs because not all components were assessed.

WQ Priority Resources Units

Compliance status on water quality priority resource units of analysis in Table 27 shows that microbial pollution is a major concern as shown by the non-compliance to the set RQOs of *E. coli*. System variable and nutrients complied at all sites using pH and PO_4 as indicator variables. There are challenges with salts, the levels of EC and sulphate exceeded the set RQOs due to coal mines within the Upper Komati Catchment and return flow from irrigation in the lower Komati.

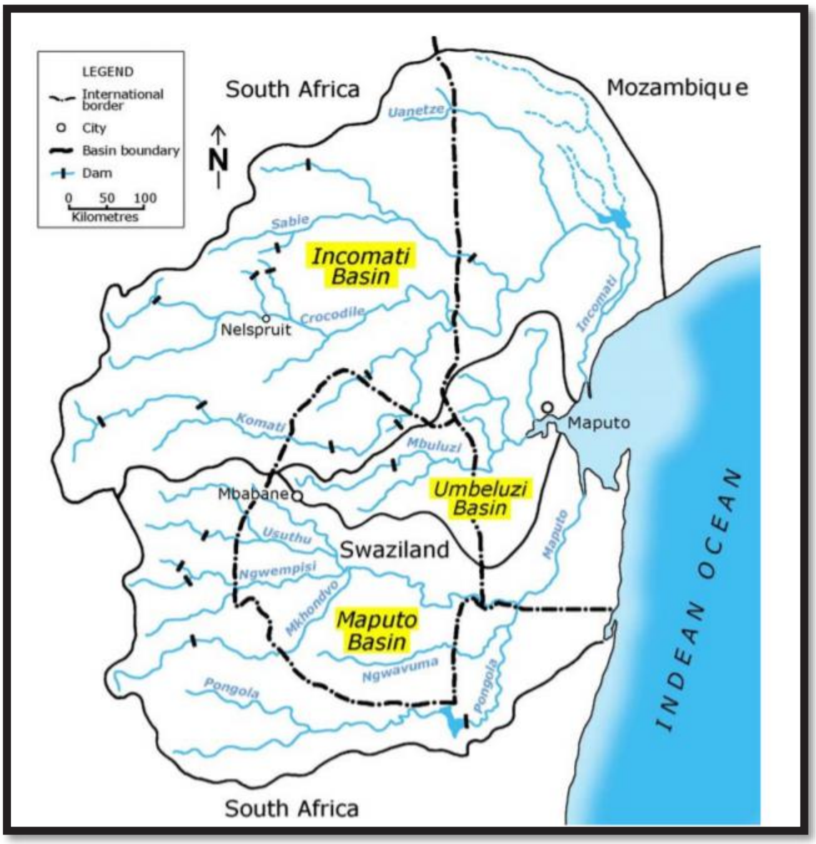
The un-ionised ammonia contribution was calculated from total ammonia based on the pH and water temperature using the South African water quality guideline (aquatic ecosystem). However, it should be noted that most of the data were recorded as <0.2 because of the detection limit. As a result, the data was manipulated by removing the "<" signs and haling the value, e.g., replace <0.04 with 0.02, as a statistically approved method of manipulating water quality data below quantification levels. Therefore, the results might not reflect the exact concentration of total ammonia as the detection limit was above the set RQO. From April 2023, the laboratory can analyse ammonia up to the value of 0.010 mg/l and this will reflect the exact concentration which will assist us in determining the compliance with set RQOs.

CHAPTER 7: COMPLIANCE TO INTERNATIONAL OBLIGATIONS FOR WATER QUALITY AND FLOW REQUIREMENTS

7.1. Introduction

The governments of the Republic of Moçambique, the Republic of South Africa (RSA) and the Kingdom of eSwatini have been collaborating in the exchange of information, agreements on sharing of water, and in joint studies that are of mutual interest and benefit. These initiatives have been done through the Tripartite Permanent Technical Committee (TPTC), which was formally established on 17 February 1983. The TPTC is responsible for providing advice to the shared watercourse States on equitable utilisation and management of the shared waters. It was identified in the Interim IncoMaputo Agreement (IIMA), (August 2002) that a "Comprehensive Agreement" is required for the watercourse states to participate more effectively in the utilisation, development and protection of the shared waters.

The Incomati River Basin is located in the eastern region of southern Africa and is shared by South Africa, eSwatini and Mozambique. The basin is 480 kilometres long, with drainage basin 50,000 square kilometres in size. The headwater of Maputo River Basin originates in South Africa, Usuthu River in Mpumalanga province, and flow easterly through eSwatini and the River is called Great Usuthu or Lusutfu, where it enters the Republic of Mozambique after confluence with Pongola River and it is called Maputo River flowing into the estuary in Maputo Bay. The 13 km gorge (Valley) forms the boundary between Kingdom of eSwatini and Republic of South Africa and approximately twenty kilometres forms the border between South Africa (province of KwaZulu-Natal) and the Republic of Mozambique. The land area of the Maputo River basin is about 30 000 km^2.



The purpose of this chapter is to share water quality compliance status and flow of the major watercourses within the basins which falls within the Inkomati Usuthu WMA, South Africa.

7.2. International Water Quality Monitoring Points

There are ten (10) international obligation (IO) sites across the WMA as presented in Figure 80.

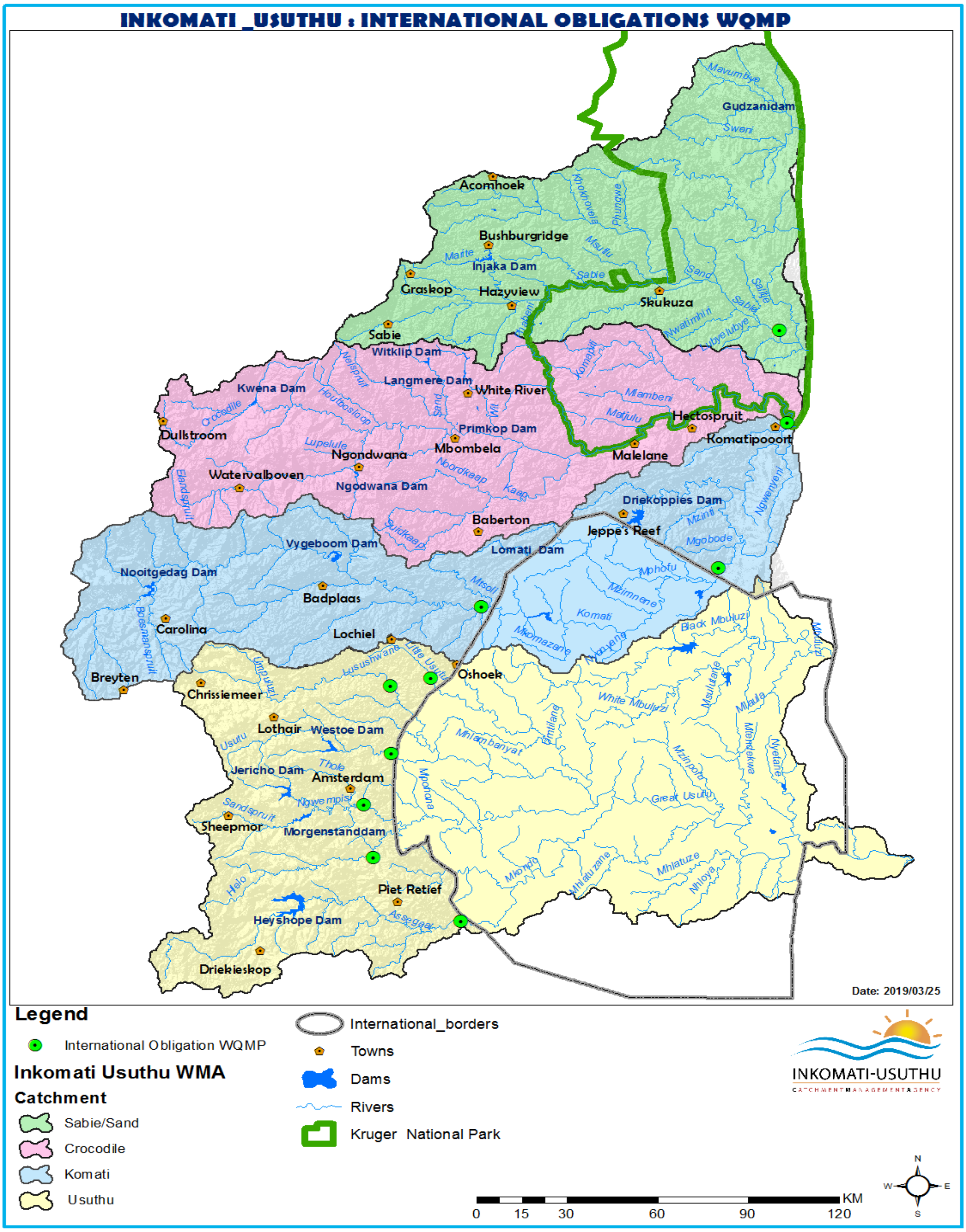


Figure 80 : International Obligation water quality monitoring points in the Inkomati-Usuthu WMA.

7.3. International Water Quantity Limits

The compliance of the flow is compared with the minimum requirement as per the Interim IncoMaputo Agreement (IIMA), tabulated below (Table 28).

Table 28: International Flow minimum requirement.

Flow measurement station	Flow minimum requirement (m^3/s)
Sabie river at lower sabie rest camp	0.6
Crocodile River at Tenbosch	1.17
Komati River at Komatipoort	2.6
Komati River at Hooggenoeg	0.6
Assegaai River at Zandbank	0.1
Hlelo River at Merrieskloof	0.1

7.4. International Water Quantity Compliance Status

The average data reported was collected over a period of three hydrological years from 2020/21 to 2022/23. The compliance percentage status per station was calculated using an average data over 3-day period and was compared against the minimum required flow. All the stations in 2022/23 complied with the minimum flow requirements except Crocodile River at Tenbosch and Komati River at Komatipoort (Table 29) which may be attributed to transmission losses.

Table 29: Water quantity status for Internatinal obligations site(s).

Station	Flow minimum requirement (m^3/s)	2020/21	2021/22	2022/23	Compliance status
Sabie river at lower Sabie rest camp	0.6	**0%**	**0%**	**0%**	Non-compliance
		100%	**100%**	**100%**	Compliance
Crocodile River at Tenbosch	1.17	**3%**	**2%**	**1%**	Non-compliance
		97%	**98%**	**99%**	Compliance
Komati River at Komatipoort	2.6	**17%**	**4%**	**2%**	Non-compliance
		83%	**96%**	**98%**	Compliance
Komati River at Hooggenoeg	0.6	**0%**	**0%**	**0%**	Non-compliance
		100%	**100%**	**100%**	Compliance
Assegaai River at Zandbank	0.1	**0%**	**0%**	**0%**	Non-compliance
		100%	**100%**	**100%**	Compliance
Hlelo River at Merrieskloof	0.1	**23%**	**0%**	**0%**	Non-compliance
		97%	**100%**	**100%**	Compliance

7.5. International Water Quality Guideline limits

The average data reported was collected over a period of a year from January 2022 to December 2022. The compliance of the indicator parameters is compared with the water quality guidelines as per the Interim IncoMaputo Agreement (IIMA), tabulated below (Table 30).

Table 30: International Water Quality Guideline limits.

Variables/Parameters	International Water Quality Guidelines Limits
Total Coliforms (TC) in cfu/100ml	10 000
Faecal coliforms (FC) in cfu/100ml)	2 000
Faecal Streptococci (FS) in cfu/100ml)	1 000
Electrical Conductivity (EC) in mS/m)	150
Sulphate (SO_4) in mg/l)	250
Phosphate (PO_4) in (mg/l)	2
pH	6.5-8.5
Nitrates (NO_3) in mg/l	50
Ammonia (NH_3) in mg/l	1
Copper (Cu) in mg/l	0.02
Iron (Fe) in mg/l	N/A
Manganese (Mn) in mg/l	0.3
Biological Oxygen Demand (BOD) in mg/l	<5
Chemical Oxygen Demand (COD) in mg/l	10
Chloride (Cl) in mg/l	250
Fluoride (F) in mg/l	0.75
Potassium (K) mg/l	50
Sodium (Na) in mg/l	200
Turbidity (TUR) in NTU	5
Dissolved Oxygen (DO) in %	>75

7.6. International Water Quality Compliance Status

The compliance status of each IO site is indicated by colours: Compliance (Green) or non-compliance (Red) as indicated in the maps below.

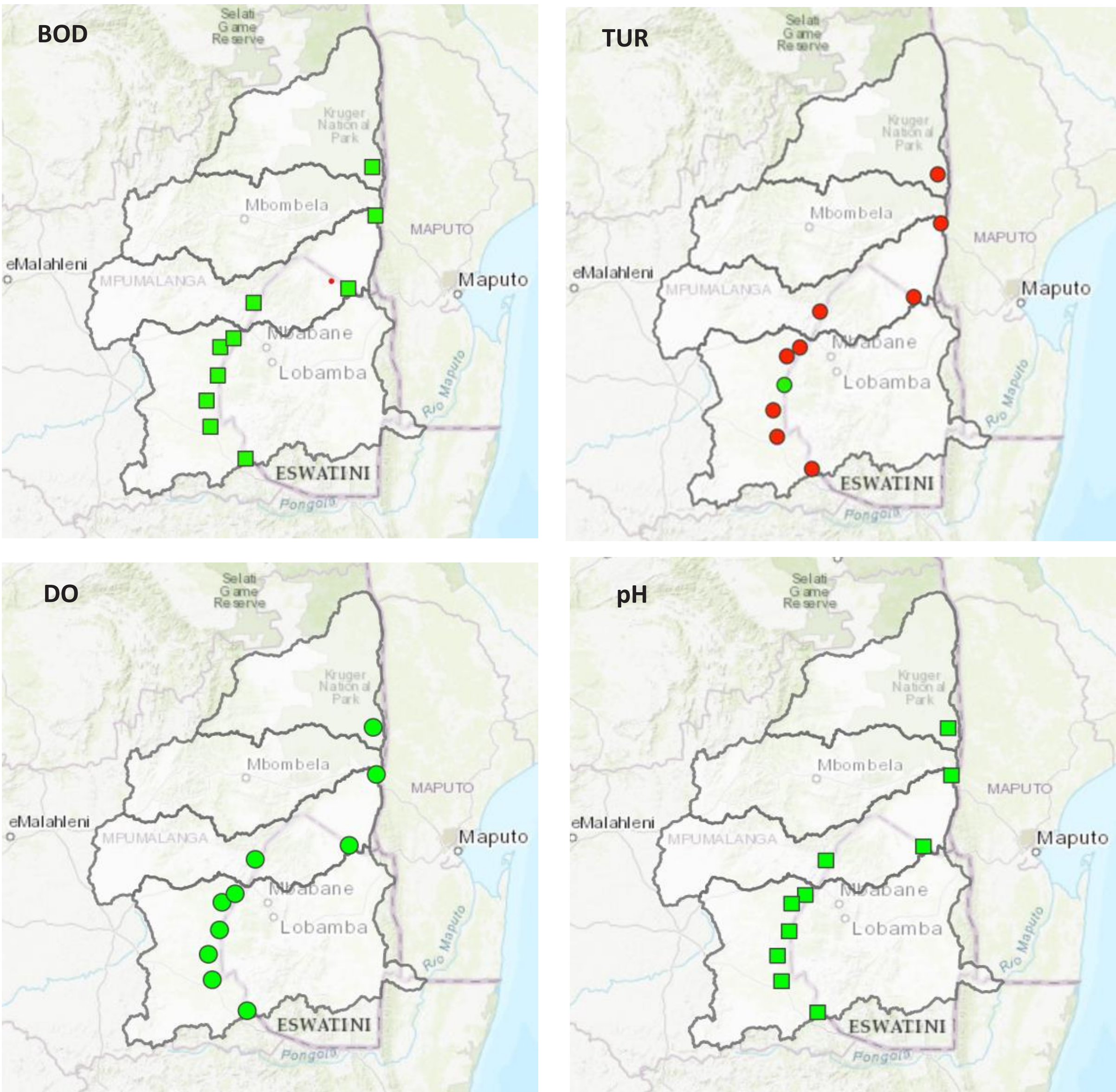


Figure 81 : Maps showing water quality status (BOD, TUR, DO, and pH) for international obligation site (s).

Almost all variables as shown in Figure 81 complied with the international water quality guidelines limit as per the IIMA. The RSA therefore complied with the water quality limits discharged (allowed to flow) into the Republic of Mozambique and Kingdom of eSwatini as per the international obligation agreement throughout the reporting period, except for turbidity which indicated non-compliance at all international Obligation sites, except Usuthu River within the basin due to the stringent turbidity limit and the high flows that result in soil erosion as well as illegal sand mining.

The compliance status of each IO site is indicated by colours: Compliance (Green) or non-compliance (Red) as indicated in the maps below.

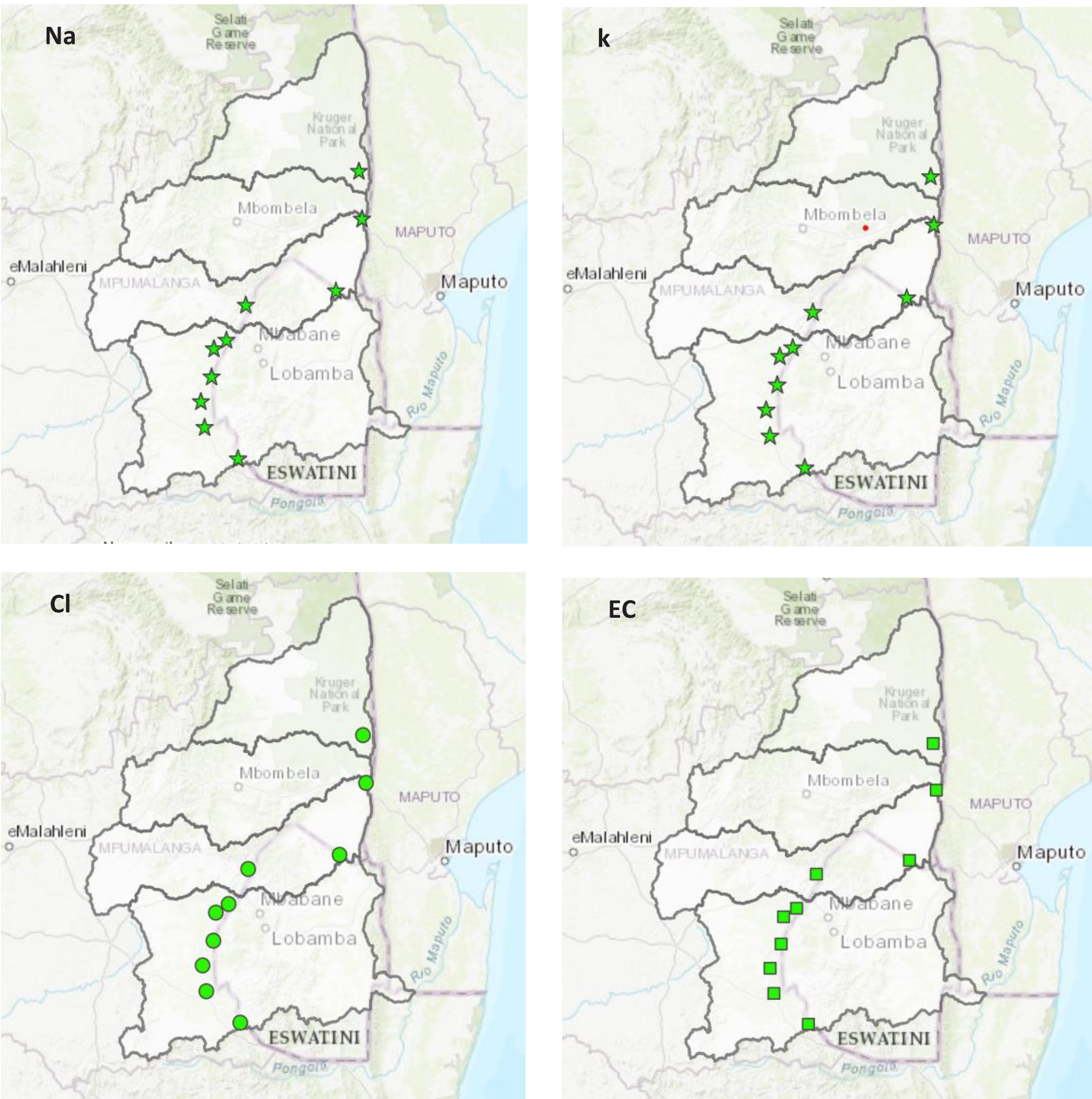


Figure 82: Maps showing water quality status (Na, K, Cl, and EC) for international obligation site(s).

All variables as shown in Figure 82 complied with the international water quality guidelines limit as per the IIMA. The RSA therefore complied with the water quality limits discharged (allowed to flow) into the Republic of Mozambique and Kingdom of eSwatini as per the international obligation agreement throughout the reporting period.

The compliance status of each IO site is indicated by colours: Compliance (Green) or non-compliance (Red) as indicated in the maps below.

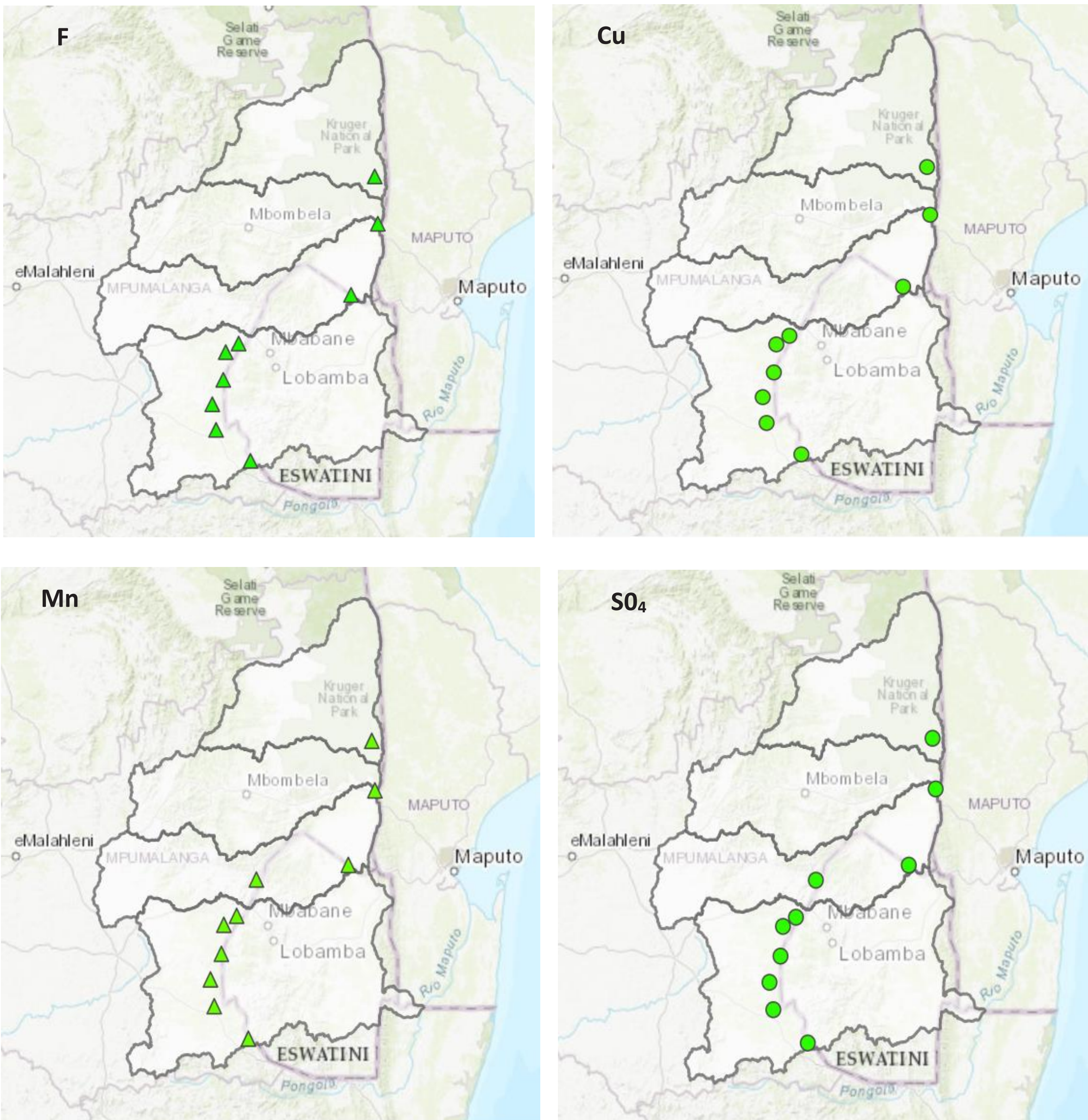


Figure 83: Maps showing water quality status for international obligation site(s).

Discussion of Results

All variables as shown in Figure 83 complied with the international water quality guidelines limit as per the IIMA. The RSA therefore complied with the water quality limits discharged (allowed to flow) into the Republic of Mozambique and Kingdom of eSwatini as per the international obligation agreement throughout the reporting period.

The compliance status of each IO site is indicated by colours: Compliance (Green) or non-compliance (Red) as indicated in the maps below.

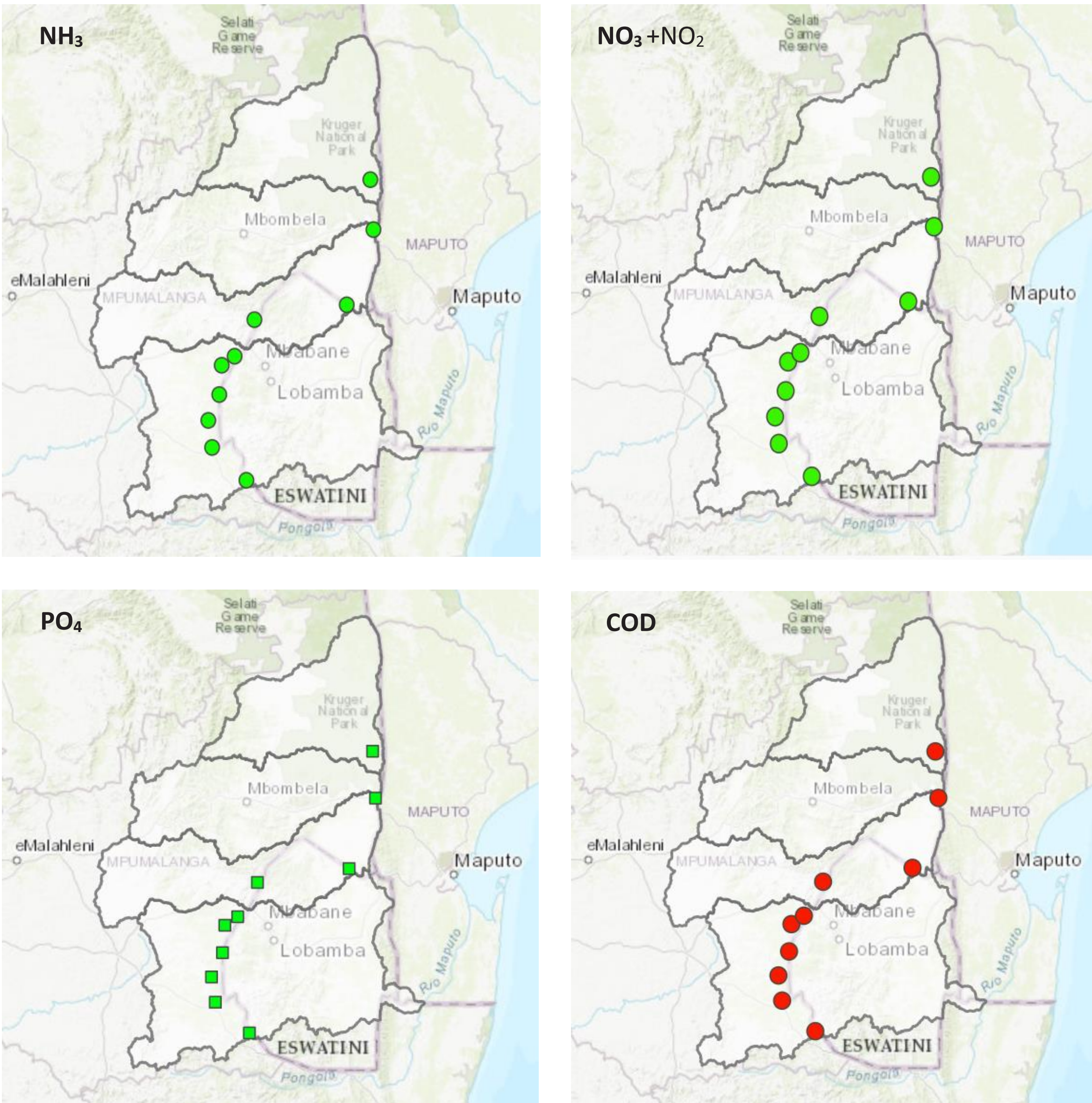


Figure 84: Maps showing water quality status for international obligation site(s).

Discussion of Results

Almost all variables as shown in Figure 84 complied with the international water quality guidelines limit as per the IIMA. The RSA therefore complied with the water quality limits discharged (allowed to flow) into the Republic of Mozambique and Kingdom of eSwatini as per the international obligation agreement throughout the reporting period, except for chemical oxygen demand which indicated non-compliance for at all international Obligation sites within the basin.

The compliance status of each IO site is indicated by colours: Compliance (Green) or non-compliance (Red) as indicated in the maps below.

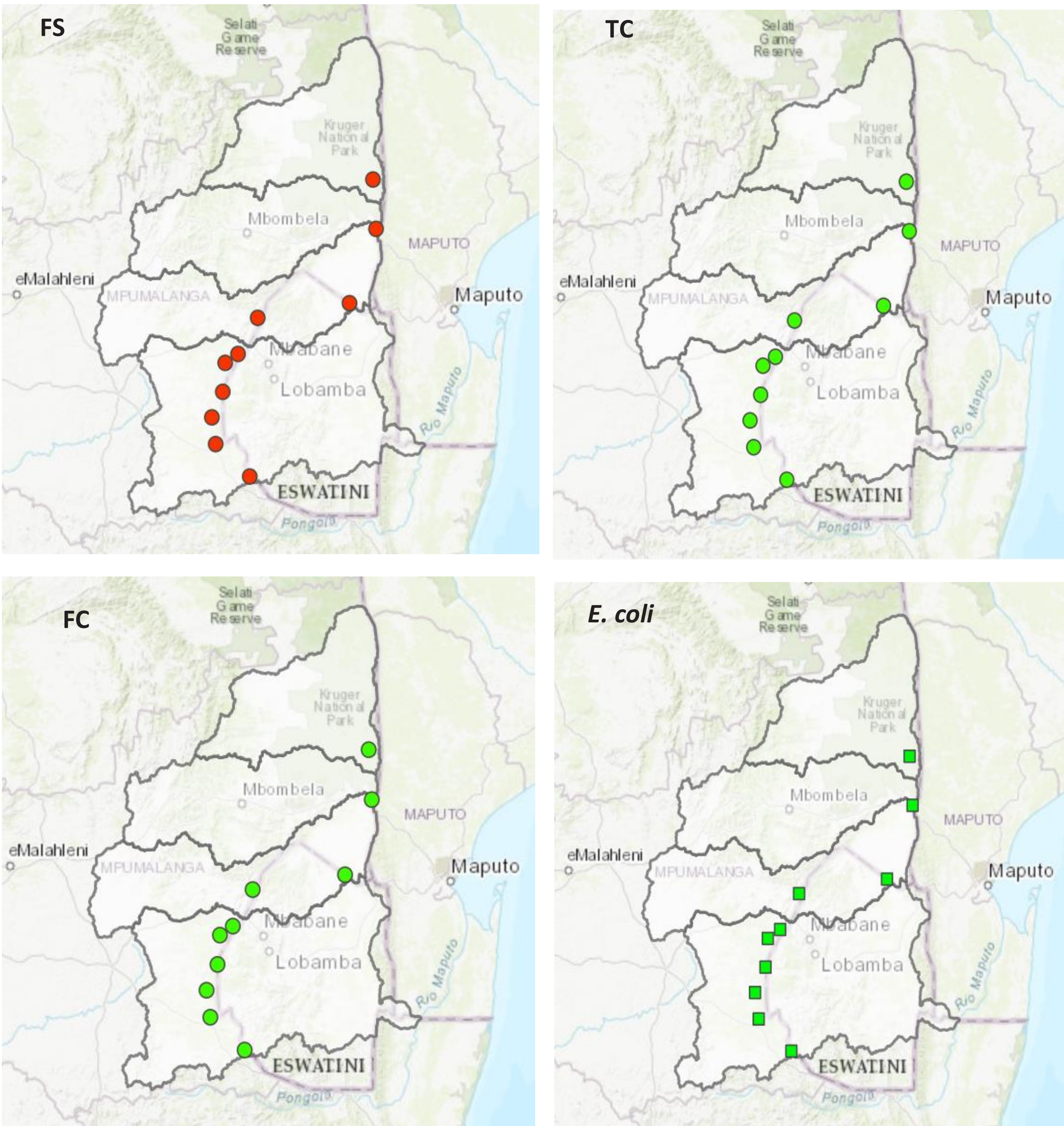


Figure 85: Maps showing water quality status (FS, TC, FC, E-coli) for international obligation site(s).

Almost all variables as shown in Figure 85 complied with the international water quality guidelines limit as per the IIMA. The RSA therefore complied with the water quality limits discharged (allowed to flow) into the Republic of Mozambique and Kingdom of eSwatini as per the international obligation agreement throughout the reporting period, except for *Faecal Streptococci* which indicated non-compliance at all international Obligation sites within the basin. Note that *E. coli* does not form part of the IIMA however reported for information purposes using 2 000 (cfu/100ml) as a limit.

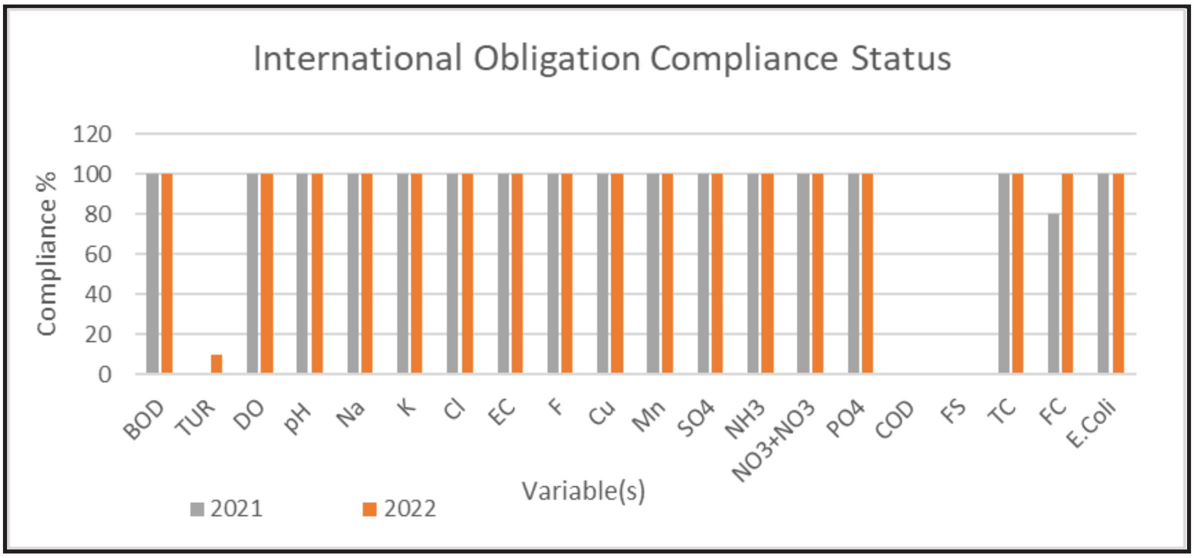


Figure 86: Water quality compliance status for international obligation site(s).

The RSA complied with the international water quality limits discharged (allowed to flow) into Kingdom of eSwatini as well as Republic of Mozambique as per the international agreement from January to December 2022. Yearly compliance percentage of international Obligation sites within Inkomati-Usuthu WMA with international water quality guideline were 100% compliance with all variables except TUR, DO and FS. In 2022, the percentage compliance remained constant at 100% and showed improvement for TUR and FC as compared to 2021 as illustrated in Figure 86.

CHAPTER 8 CONCLUSION AND RECOMMENDATIONS

8.1. Conclusion

Hydrology and water quality are key drivers to ecosystem responses at ecological water requirements sites. The hydrological analysis spans two hydrological years, 2021-22 and 2022-23, with the latter ending on March 31, 2023. The summer rainfall received since the start of the 2021 hydrological year has resulted in normal to above normal riverflow levels in the Inkomati Usuthu WMA. The water resource status of the Inkomati Usuthu WMA has been high in comparison to the three previous hydrological years (2018-2020), and as a result, the ecological reserve requirement was met 90-100% at all EWR sites.

The EWR compliance for flow and water quality is always poor during dry seasons in river systems where riverflow levels are not supplemented by upstream dam releases augmentations. However, surface water quality in the Inkomati-Usuthu WMA complied with the RQOs, TWQG and IWQG limits for most of the monitored points and this showed that the water quality within the WMA is in a relatively good state. Furthermore, there exist challenges with other variables in the water resources. The presence of *E. coli* in water resource indicates that the water has been contaminated with human or animal faecal material and this is a challenge in the entire WMA. *E coli* contamination has a potential health risk for individuals who use water directly from the resource which may also lead to waterborne diseases for those people and is a threat for crop production, especially those crops eaten raw.

Salts and Nutrients (Electrical Conductivity and phosphate) are not a major cause for concern in the catchment. It is only in selected areas where the water quality status related to these parameters are punctuated by non-compliance. The Boesmanspruit, Gladdespruit, and Kaap River systems are threatened by metal and toxic substance contamination especially manganese and arsenic arising from mining activities (active mines, defunct mines and decanting mines).

Eutrophication status of the dams within the WMA were mostly oligotrophic (low levels of nutrients, with an average chlorophyll-*a* concentration of less than 10 ug/L). Based on the trophic status it was safe to undertake recreational activities within the water bodies during the period reported.

The overall integrated ecostatus for each of the four catchments within the WMA was calculated as category C, which is consistent with the integrated ecostatus calculated from previous results. This indicates that despite the site-specific issues, the overall biotic condition for each of the four catchments has remained constant at Category C (moderately modified), with loss and change of natural habitat and biota in terms of frequency of occurrence and abundance. The resilience of the system to recover from human impacts has not been lost and its ability to recover to a moderately modified state following disturbance has been maintained.

In the Sabie-Sand catchment, EWR S-1-5 represents all biophysical nodes within IUA (X3-2 and X3-3) and have not met the management Class I due to water quality and aquatic biota not complying to the TEC. In the Komati, EWR K-1 and EWR K-2 are the only biophysical nodes within IUA X1-2 and X1-3 respectively and met Management Class II. This means the IUA X1-2 is moderately used. EWR K-3 is representing all biophysical nodes within IUA X1-9 and has met the management Class III, indicating that the IUA heavily used. In the Crocodile, EWR E-1 and EWR E-2 represents all biophysical nodes within IUA X2-3 and X2-5 respectively and did not meet Management Class I due to aquatic biota not complying to the TEC. EWR C3 represents all biophysical nodes of X2-2 and did not meet Management Class II due to aquatic biota not complying to the TEC. EWR C7 represents all biophysical nodes of X2-10 and did not meet Management Class II due to water quantity and quality not complying to the TEC. It was not possible to conclude on other IUAs because not all components were assessed for example water quantity and aquatic biota were not measured/sampled, due to lack of measuring station and no access, respectively. To address this, alternative sites will be established in the same sub-quaternary reach or source data from other spheres of government or institutions.

The primary impact within the IUA for Sabie-Sand, Crocodile and Komati catchments are mostly non-flow related as the TEC for most of EWR sites measured were met at 100% or above 90%., while water quality deterioration is evident for microbial pollution (*E. coli*) and toxic substance (NH_3) which indicated non-compliance to set RQOs.

Ammonia contributed to the deterioration of the PES which resulted in TEC not being met for water quality. Ammonia is a common toxicant derived from domestic, industrial, or agricultural pollution (fertilizers, organic matter) and natural processes. NH_3 is highly toxic to fish and other aquatic life. The toxicity of ammonia is critically dependent on pH and temperature. The un-ionized form ammonia (NH_3) is more toxic than the ionized form ammonium (NH_4 +). As pH and temperature increases, NH_4 + is converted to NH_3, and the toxicity increases. The pH and temperature measured at all EWR sites within the IUA were within acceptable limits hence the toxicity of ammonia was low, and the aquatic biota was moderately modified.

The Republic of South Africa complied with the international water quantity and water quality limits discharged (allowed to flow) into Kingdom of eSwatini as well as Republic of Mozambique per the international agreement throughout the reporting period, except few variables and sites that indicated non-compliance.

8.2. Recommendations

It is recommended that the land use activities impacting on water resources quality be efficiently controlled through Source Directed Controls (SDC) as per the provision(s) of the National Water Act No 36 of 1998. SDC focus on managing the quantity and quality of water entering water resource with the primary purpose of ensuring that the water quantity and water quality RQOs that have been set for the water resource are achieved. The aquatic species are sensitive to changes in physical drivers such as water quality, hydrology, and geomorphology and when these drivers are within the set TEC the integrity of the aquatic ecosystems is protected and maintained.

SDC include regulatory mechanisms such as water quality discharge standards for wastewater, conditions in water use authorisations, pollution prevention, control of emergency incidents, best waste management practices and waste minimisation technologies. Additionally, progressive implementation of self-regulation is encouraged.

The authorisation of a water use related to water quality is an important tool for SDC and must consider Resources Directed Measures (RDM) such as the Class, Reserve and RQOs before issuance of an authorisation. The purpose of water use authorisation is to ensure that water is used for the purpose(s) authorised only and enable water manager(s) to achieve their resource quality objectives (RQOs), and hence contribute to sustainable development. It is therefore critically important to implement the SDC and RDM in an integrated and structured manner to achieve a balance between protecting and utilising of water resources for the current and future generation.

The RQO implementation plan is in place, which involves various stakeholders such as all spheres of government, water users, researchers and civil society. However, there is no formal implementation structure or committee. It is recommended that the Implementation Plan Management Committee (IPMC) be established to roll out the implementation plan.

It is also recommended that EWR and IO sites which were not sampled or measured be measured going forward by ensuring that alternative sites are established or data sourced from other spheres of government or institutions (DWS, KPN, KOBWA, MTPA).

It is recommended that the report be done per Catchment per year (e.g., each catchment will be revisited after 4 years) and this allow us to provide more details, collect adequate data and assess all biophysical nodes per catchment instead of focusing only on EWR sites.

For integrated water quality management, it is recommended that the authorisation process be aligned with other environmental authorisation especially sensitive, vulnerable and important water resource areas or alternatively regulate or prohibit any activities in order to protect water resource or instream or riparian habitat within these areas in terms of section 26(1)(g).

BIBLIOGRAPHY

Department of Water and Sanitation (DWS). June 2013. National Water Resource Strategy. 2nd ed. Pretoria.

Department of Water and Sanitation. May 1996. South African Water Quality Guidelines Volume 8 Field Guide. 2nd ed. Pretoria.

Government Notice No. 1616, December 2016, Gazette, National Water Act, 1998(No 36 of 1998): Classes of Water Resources and Resource Quality Objectives for the Catchments of the Inkomati.

Government Notice No. 1616, December 2016, Gazette, National Water Act, 1998(No 36 of 1998): Classes of Water Resources and Resource Quality Objectives for the Catchments of the Inkomati.

Republic of South Africa. August 1998. National Water Act (Act 36 of 1998). Pretoria.

Republic of South Africa, Republic of Mozambique and Kingdom of ESwatini. August 2002. Co-operation on the Protection and Sustainable Utilisation of the Incomati and Maputo watercourses. Maputo.

DWAF, 2002. National Eutrophication Monitoring Programme –Implementation Manual, PRETORIA.

Van Ginkel, C. (2011). Eutrophication: Present reality and future challenges for South Africa. Water SA 37(5): 693–701.

Bol, R., Gruau, G., Mellander, P-E, Dupas, R., Bechmann, M., Skarbøvik, E., Bieroza, M., Djodjic, F., Glendell, M., Jordan, P., Van der Grift, B., Rode, M., Smolders, E., Verbeeck, M., Gu, S., Klumpp, E., Pohle, I., Fresne, M., and Gascuel-Odoux C. (2018). Challenges of Reducing Phosphorus Based Water Eutrophication in the Agricultural Landscapes of Northwest Europe. Frontiers in Marine Science 5: 276-292.

Moran, P. (2006). Water nutrients, plant nutrients, and indicators of biological control on water hyacinth at Texas field sites. Journal of Aquatic Plant Management 44: 109-114

Dickens, C. W., and Graham, P. M. 2002. The South African Scoring System (SASS) Version 5 Rapid Bioassessment Method for Rivers. African Journal of Aquatic Science, 27, 1-10.

Kleynhans, C.J. 2008. Module D: Fish Response Assessment Index in River EcoClassification: Manual for EcoStatus Determination (version 2) Joint Water Research Commission and Department of Water Affairs and Forestry report. WRC Report No. TT330/08.

Kleynhans, C.J., MacKenzie, J., and Louw, M.D. 2007. Module F: Riparian Vegetation Response Assessment Index in River Eco classification: Manual for Ecostatus Determination (version2).

Joint Water Research Commission and Department or Water Affairs and Forestry report. WRC Report No. TT 333/08.

Thirion, C. 2008. Module E: Macroinvertebrate Response Assessment Index in River EcoClassification: Manual for EcoStatus Determination (version 2). Joint Water Research Commission and Department of Water Affairs and Forestry report. WRC Report No. TT 332/08.

Murray K (1999) National Aquatic Ecosystem Biomonitoring Programme: National Implementation Assessment. NAEBP Report Series 8. Institute for Water Quality Studies. Department of Water Affairs and Forestry, Pretoria.

Gerber A, Gabriel MJM (2002) Aquatic Invertebrates of South African Rivers: Field Guide 1st Edition. Institute of Water Quality Studies. Department of Water Affairs and Forestry, Pretoria.

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