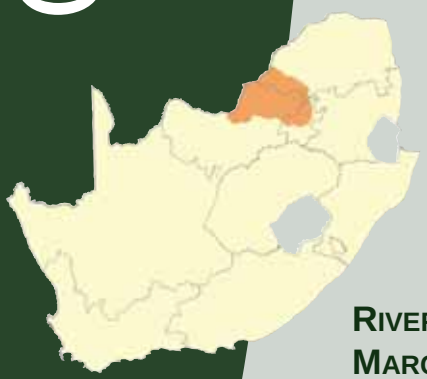
Crocodile (West) Marico Water Management Area

STATE-OF-RIVERS REPORT: MONITORING AND MANAGING THE ECOLOGICAL STATE OF RIVERS IN THE CROCODILE (WEST) MARICO WATER MANAGEMENT AREA



RIVER HEALTH PROGRAMME
MARCH 2005

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Introduction

The Relationship between People and the Natural Environment

We live in an era where most aspects of the structure and functioning of Earth's ecosystems cannot be understood without accounting for the strong influence of humanity. Social and ecological systems are co-evolving at both local and planetary levels. Despite tremendous improvements in technological, economic and material well-being - at least in some parts of the world - people in all parts of the world rely on the capacity of the biosphere to support and sustain social and economic development. Freshwater is the bloodstream of the biosphere's capacity.

Two broad paradigms influence the management of natural resources, namely a development paradigm whose goal is to put water to work for people and another that advocates water for the benefit of all, including ecosystems and the physical environment. Under the first paradigm, social well-being is considered to follow directly from economic development. Ecosystems are essentially harvested to support an economic sector for the production of social value.

A coordinated effort to bring the development paradigm together with environmental concerns was initiated in the 1980's with the introduction of the concept of 'sustainable development'. Sustainable development in respect of water resources seeks to ensure that future generations can meet their own water needs while promoting socio-economic development and improved quality of life for all in the current generation. This can only be achieved through utilising water resources within the ability of these ecosystems to satisfy society's needs now and in the future.

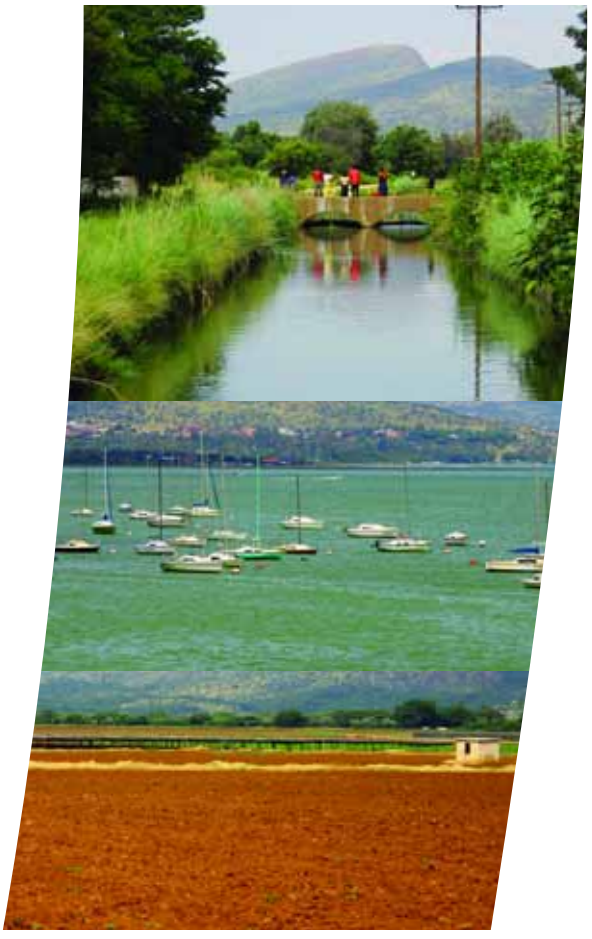
Rivers in both rural and urban settings are complex, multifunctional ecosystems that have developed their own self-sustaining balance. Modification of a particular function over another may cause an imbalance that, in the case where it persists, may eventually lead to degradation of the aquatic environment and ecology. There is a great diversity of ways that rivers have been modified depending on the needs of their adjacent communities. In the extreme, some urban streams have gradually been turned into canals for transporting waste. Some have been covered, turned into sewers and ‘forgotten’. With the recent increase in environmental awareness, even urban streams are being revisited and their aesthetic and environmental values appreciated. Rehabilitation of rivers, whereby the state of the river is improved in terms of physical characteristics, chemical quality, ecological diversity and aesthetic appearance, is receiving increasing attention.

It is acknowledged that, due to both social and ecological complexity, a pathway to sustainability cannot be charted in advance but must rather be navigated through processes of learning and adaptation. Therefore, sustainable development should not be seen as a destiny but as a journey based on an ethos that shapes the behaviour of individuals, institutions and nations. There is a risk that the material success of humans can lead to them being mentally disconnected from nature - a belief system of human progress as independent of nature. However, a critical element of this journey of sustainable development is to be aware of the ways in which ecosystems respond to disturbances, to learn from the feedbacks that the environment provides, and to adapt our actions in ways that would improve the harmony between the healthy functioning of ecosystems and society's developmental aspirations.

The River Health Programme

The River Health Programme (RHP) was initiated in 1994 in response to the need to monitor, assess and report on the ecological state of river ecosystems based on their biological condition in relation to all the human-induced disturbances affecting them. The Department of Water Affairs and Forestry, as the legal custodians of water resources in South Africa, has played the leading role in initiating and designing the RHP.

During the initial few years, the emphasis was on research and development of the basic monitoring protocols. From 1996, the programme became operational when a number of provincial implementation teams started applying the RHP design. Today, the RHP is a co-operative venture with participants from many government and non-government organisations, including provincial government departments, local authorities, universities, conservation agencies and private sector organisations. All of these organisations have a stake in collecting data and making information available on the state of the rivers in their areas of responsibility. Through collaborating and combining their resources, a joint implementation team can achieve more than would be possible for any of the organisations on their own.



STATE-OF-RIVERS REPORTING

The overall goal of communicating natural resource information should be to change the behaviour of the recipients of the information. In the case of the RHP, the program must:

(1) Provide information to inform ecologically sound management of rivers in South Africa; and
(2) Inform and educate the people of South Africa regarding the health of their rivers.

Changed behaviours relate to the degree to which water resource managers incorporate river health information in their decision-making processes. Similarly, a positive change in civil society's perception and appreciation of rivers would testify to effective communication. To achieve these goals, RHP practitioners had to rethink the formats used for packaging information as well as the strategies used for disseminating information. Out of this emerged the State-of-Rivers (SoR) reporting concept.

SoR reporting is aligned with the Pressure-State-Response (PSR) framework that was developed by the Organisation for Economic Co-operation and Development (OECD). According to this framework, social and economic activities exert **pressure** on an ecosystem, and as a consequence, the **state** of that ecosystem changes. These states can result in **responses** (policies and management actions) from society that ultimately aim at mitigating undesirable impacts through directly managing pressures and indirectly influencing the state of ecosystems.

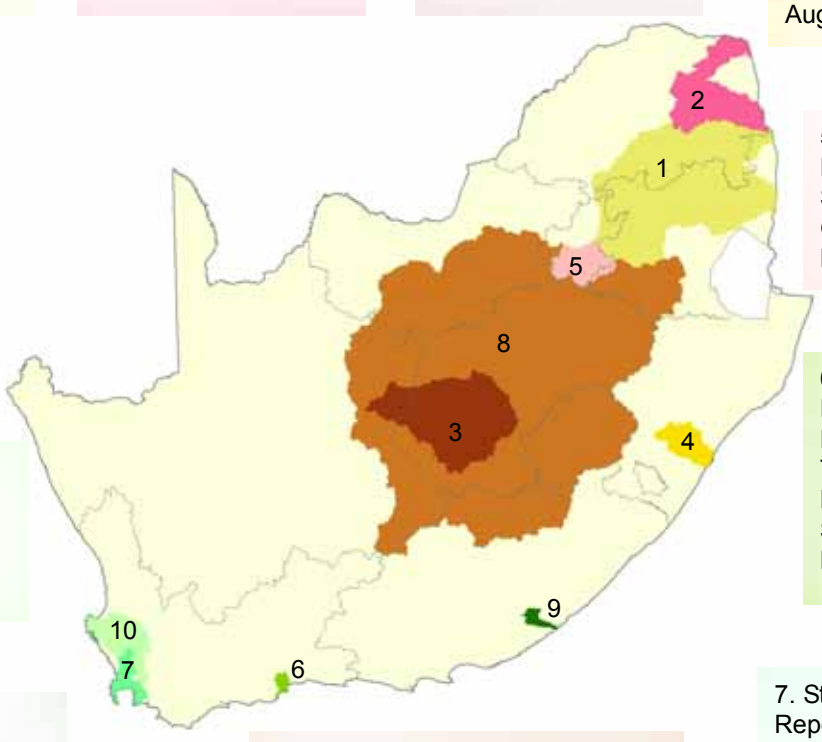
EXISTING STATE-OF-RIVERS REPORTS AND PRODUCTS

1. State-of-Rivers Report: Crocodile, Sabie-Sand & Olifants River Systems March 2001

2. State-of-Rivers Report: Letaba & Luvuvhu River Systems December 2001

3. State-of-Rivers Poster: Modder River December 2001

4. State-of-Rivers Report: uMngeni River and Neighbouring Rivers and Streams August 2002



5. State-of-Rivers Poster: Ecological State of the Southern Gauteng Rivers March 2003

6. State-of-Rivers Report and Summary Poster: The Hartenbos and Klein Brak River Systems March 2003

7. State-of-Rivers Report: Diep, Hout Bay, Lourens and Palmiet River Systems August 2003

8. State-of-Rivers Report: Free State Region River Systems March - May 2004
State-of-Rivers Posters:
River Health Free State Region
River Health Freistata
River Health Vrystaatstreek
River Health Free State

9. State-of-Rivers Report: Buffalo River System November 2004

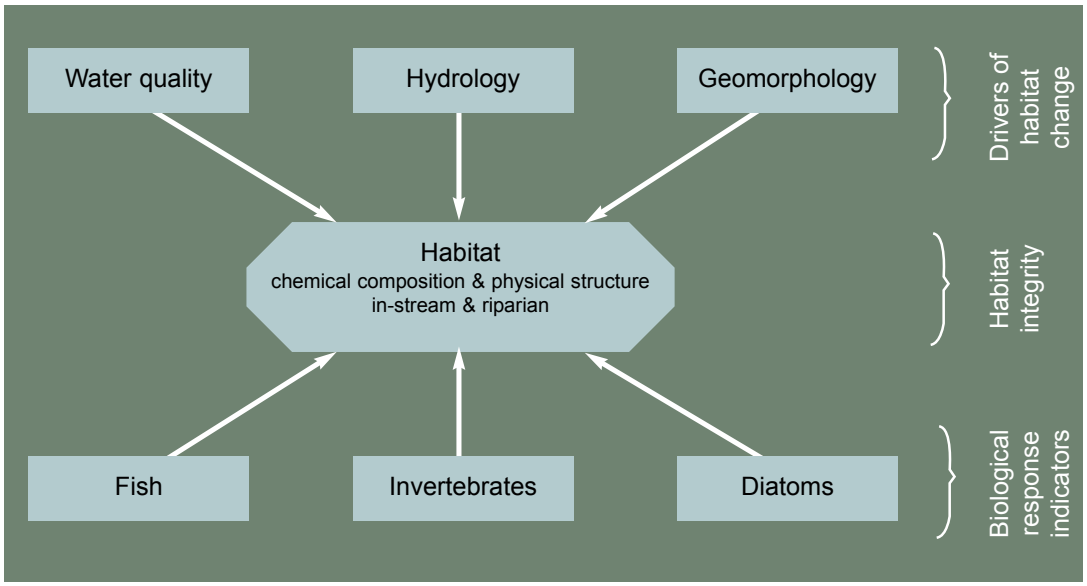
10. State-of-Rivers Report: Berg River System March 2005

THE 2004 CROCODILE (WEST) MARICO RIVER SURVEY

The RHP has been operational in the Gauteng and Limpopo provinces for a number of years, with several river surveys having been conducted in these provinces. At the beginning of 2004, the Department of Agriculture, Conservation, Environment & Tourism (DACET) of the North West Province indicated that they would like to champion the launch of the RHP in their province. The RHP teams of Gauteng and Limpopo, together with DWAF: RQS, agreed to take part in a river survey and SoR reporting exercise for the Crocodile (West) Marico WMA, and in the process transfer some of their know-how to the new North-West team. River surveys took place during a total of eight weeks spread out between April and August of 2004. This report is intended to be a summary report of the major findings from these biomonitoring surveys. It is not a technical report detailing the results of the surveys undertaken. For technical information please contact the RHP champions for each of the provinces comprising this Water Management Area and DWAF Resource Quality Services.

ECOLOGICAL STATUS ASSESSMENT

The **ecological status (EcoStatus)** of a river refers to its overall condition or health, i.e. the totality of the features and characteristics of the river and its riparian areas, which manifests in its ability to support a natural array of species. This ability relates directly to the capacity of the system to provide a variety of goods and services.



For this report, data was collected primarily on habitat integrity and the biological response indicators shown in the above figure. To achieve this, available water quality and flow data as well as an assessment of the geomorphological state of rivers were used in a qualitative way by experts in order to determine the habitat template to which aquatic biota would respond. The integrated response of the habitat to modifications and the response of the biota to this, determines the health of the surveyed rivers. The outcome of this overall assessment will be referred to as the EcoStatus and comprises six indicators, namely:

- Instream Habitat Integrity
- Riparian Zone Habitat Integrity
- Riparian Vegetation Integrity
- Fish Assemblage Integrity
- Macro-invertebrate Integrity
- Water Quality (as indicated by diatoms)

ECOSTATUS INDICES

The RHP makes use of a suite of ecological indicators that have specifically been selected for their ability to integrate the impact of multiple disturbances on the state of rivers.

- ***Instream Habitat Integrity*** - This encompasses considerations of the severity of impacts on instream features such as the modification of the volume of water, a change in the flow regime (i.e. natural flow patterns), bed and channel modification, water quality, alien water plants, alien fauna that influences habitat directly and waste disposal. All of these impacts are considered in terms of their impact on the natural instream habitat features that would be expected for a particular type of river.

Instream Habitat, Riparian Zone Habitat and Riparian Vegetation Integrity

- ***Riparian Zone Habitat Integrity and Riparian Vegetation Integrity*** - This considers the severity of impacts on riparian features such as the modification of the volume of water, a change in the flow regime (i.e. natural flow patterns), channel modification, water quality, reduction in vegetation and invasion by alien plants. All of these impacts are considered in terms of their impact on the natural riparian habitat features that would be expected for a particular type of river.

- ***Fish Assemblage Integrity*** - Fish are relatively long-lived and are good indicators of the longer-term changes in the condition of river habitats. These changes may be in response to alteration in river flows, changes in river structure or changes in the chemical composition of the water. Fish biologists assess the characteristics of a fish assemblage that occur in a specific reach - for example the number of species found, their respective sensitivity to various forms of disturbances, preferences to particular environmental conditions, different age classes and the general health and condition of fish (i.e. tumours, lesions etc.) - to arrive at an overall expression of health.

Fish Assemblage Integrity

- ***Macro-invertebrate Integrity*** - Aquatic macro-invertebrates include beetles, mussels, snails, crabs, worms and insect larvae. These organisms have relatively short life cycles therefore are good indicators of changes in water quality and habitat conditions over the short term.

Macro-invertebrate Integrity

- ***Water Quality*** - In this study diatoms were used to support the assessment of water quality. Diatoms are unicellular algae with their cell walls made of silica. A typical diatom community consists of a myriad of species, each with its unique shape. Each species has a specific water quality preference and tolerance. After sample collection in the field, dominant diatom species are identified in a laboratory with the aid of a microscope. Where the water quality preferences of dominant diatom species are known, conclusions can be drawn regarding the water quality at a particular site.

Water Quality

The ecological importance and sensitivity (EI&S) of the various river reaches were also determined in this survey. EI&S provides an indication - from an ecological perspective - of whether a river should receive a high level of protection or not. The assessment of a river's EI&S relies on various measures, where:

- Ecological importance refers to the diversity, rarity or uniqueness of the habitats and biota. Consequently, it reflects how important the protection of these ecological attributes are, from a local, national and even international perspective.
- Ecological sensitivity refers to the ability of the ecosystem to tolerate disturbances and to recover from certain impacts.

Through integrating the above measures, the following EI&S categories can be assigned to a river:

EI&S Category	Description
VERY HIGH	A high or very high EI&S indicates that there is strong ecological motivation for awarding a high level of protection to the associated river, and such rivers should ideally be maintained in a natural or good river health category.
HIGH	
MODERATE	A low/marginal or moderate EI&S denotes that a river has relatively lower conservation value and that such a catchment is more suited to development than one where a river has a higher EI&S.
LOW / MARGINAL	

River Health Categories

A river health categorisation is used to provide a simplified user-friendly key to a much more intricate and complex process of assessing the EcoStatus of a river. Each river health category relates to a level of ecosystem health, which in turn relates to the potential of the river to support a particular range of ecosystem services. The river health categories and their relation to the water resource classification system as proposed by the Department of Water Affairs and Forestry are presented in the table below:

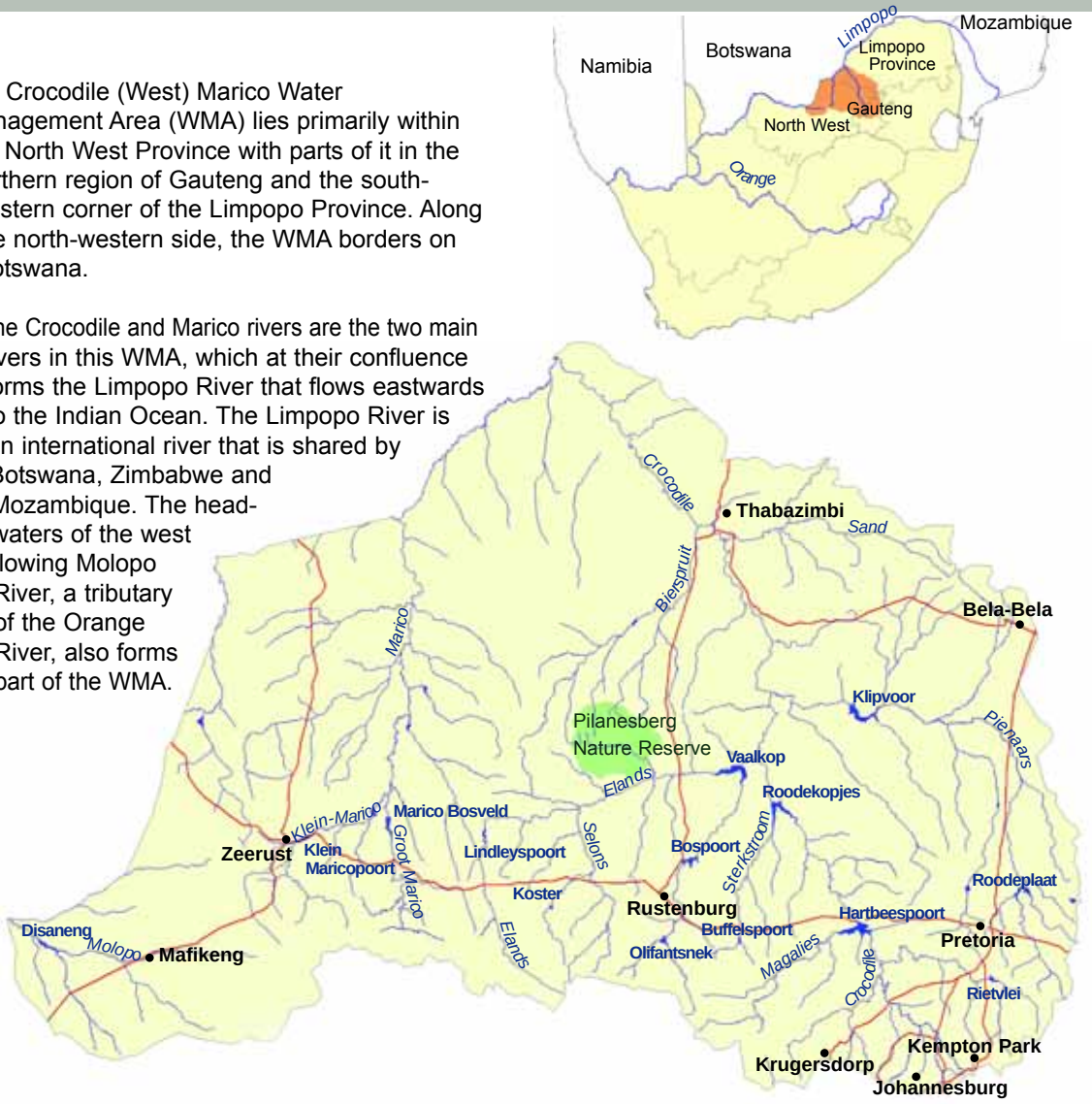
River Health Categorisation		Water Resource Classification System (National Water Resource Strategy, 2004)	
Category	**Description**	**Proposed Class**	**Description**
Natural	No or negligible modification of instream and riparian habitats and biota.	Natural	Human activity has caused no or minimal changes to the historically natural structure and functioning of biological communities, hydrological characteristics, chemical concentrations and the bed, banks and channel of the resource.
Good	Ecosystem essentially in good state; biodiversity largely intact.	Moderately used or impacted	Resource conditions are slightly to moderately altered from the Natural class due to the impact of human activity and water use.
Fair	Sensitive species may be lost, with tolerant or opportunistic species dominating.	Heavily used or impacted	Resource conditions are significantly changed from the Natural class due to human activity and water use, but are nonetheless ecologically sustainable.
Poor	Mainly tolerant species present or alien species invasion; disrupted population dynamics; species are often diseased.	Unacceptably degraded resources	Due to over-exploitation, these rivers are already in a state that is ecologically unsustainable.

Overview

Overview of the Crocodile (West) Marico Water Management Area

The Crocodile (West) Marico Water Management Area (WMA) lies primarily within the North West Province with parts of it in the northern region of Gauteng and the south-western corner of the Limpopo Province. Along the north-western side, the WMA borders on Botswana.

The Crocodile and Marico rivers are the two main rivers in this WMA, which at their confluence forms the Limpopo River that flows eastwards to the Indian Ocean. The Limpopo River is an international river that is shared by Botswana, Zimbabwe and Mozambique. The head-waters of the west flowing Molopo River, a tributary of the Orange River, also forms part of the WMA.



Important features in this WMA include the Bafokeng Tribal Area, the Pilanesberg Nature Reserve, the Cradle of Humankind Heritage site, the dolomitic wetland or "eye" system found at the source of the Marico and Molopo rivers and large dams such as Hartbeespoort, Rooikopjes, Vaalkop, Roodeplaat, Klipvoor and Molatedi.

The natural mean annual runoff (MAR) of the Crocodile (West) Marico WMA is 855 million m^3/annum. Approximately 75 % of the total surface runoff from the WMA flows down the Crocodile River, while the Marico catchment contributes 20 % and the Upper Molopo catchment 5 %.

More than half of the total water use in the WMA comprises urban, industrial and mining use, approximately a third is used by irrigation and the remainder of the water requirements are for rural water supplies and power generation. These water requirements are far more than what can be provided by the current water resources. In order to meet the current demand, much of the water in the WMA is being imported mainly from the Vaal River system for domestic and industrial use purposes. Rand Water, which is the largest water board in South Africa, together with Magalies Water and Botshelo Water (the North West Water Supply Authority), are the three water boards that supply water in this WMA.

Physical Characteristics

Climate and rainfall

Climatic conditions in the Crocodile (West) Marico WMA vary significantly from east to west. The climate across the Water Management Area is temperate, and semi-arid in the east to dry in the west. Rainfall is strongly seasonal, with most rainfall occurring as thunderstorms during the summer period of October to April. Mean annual rainfall ranges from 400 to 800 mm and decreases from the eastern to the western side of the WMA. The mean annual temperature ranges between 18 and 20 °C. Maximum and minimum temperatures are experienced during January and July respectively.

Topography

The Crocodile (West) Marico WMA has a fairly uniform terrain with an altitude ranging from approximately 1700 m.a.s.l. on the Witwatersrand to about 900 m.a.s.l. at the confluence of the Crocodile and Limpopo rivers.

The topography of the southern parts of the WMA varies from plains which have a moderate to low relief to more complex lowlands, hills and mountains to closed hills and mountains with relief varying from moderate to high. The central parts consist predominantly of plains with a low relief and towards the north the WMA is recognised by plains and lowlands with a low to moderate relief.

Main topographic features of the WMA include the Witwatersrand, Magaliesberg, Waterberg and Pilanesberg.

Geology

The diverse geology in the WMA has some of the richest mineral deposits in the world.

North of the Magaliesberg the geology is largely dominated by the Bushveld Igneous Complex. Formations in this complex are extremely rich in minerals and a number of mines have been developed in the area as a result. Platinum, chrome and vanadium mining in particular, are taking place at a large scale.

In the Upper Crocodile sub-catchment, dolomitic rock is found in the Rietvlei Dam catchment, towards Krugersdorp, the Marico and Molopo catchments and north of Randfontein and Krugersdorp. Pretoria abstracts a significant quantity of its water supply from these water rich dolomitic compartments. Dolomitic rock is also found at the confluence of the Tolwane and Pienaars rivers as well as the confluence of the Pienaars and Crocodile rivers in the Apies/Pienaars sub-catchment.

The rest of the catchment consists of sedimentary rock, with the quartsitic Magaliesberg being the prominent feature. These mountains are regarded among the oldest in the world at 2.5 billion years old.

Soils

Soil types of the Crocodile (West) Marico WMA are broadly classified as:

- Moderate to deep sandy loam - southern and far eastern regions
- Moderate to deep clayey loam - the rest of the catchment.

Most of the clayey loam soils in particular are highly suitable for commercial agriculture when sufficient water is provided.

Natural Vegetation Types

According to Low and Rebelo's (1998)* vegetation map of South Africa, the Crocodile (West) Marico WMA is dominated by the Mixed Bushveld vegetation type. The vegetation found here varies from dense short bushveld to a more open tree savanna. This vegetation type is found in areas where the rainfall varies between 350 and 650 mm/a and the altitude comprises low relief plains at an altitude range of 700 to 1000 m.a.s.l.

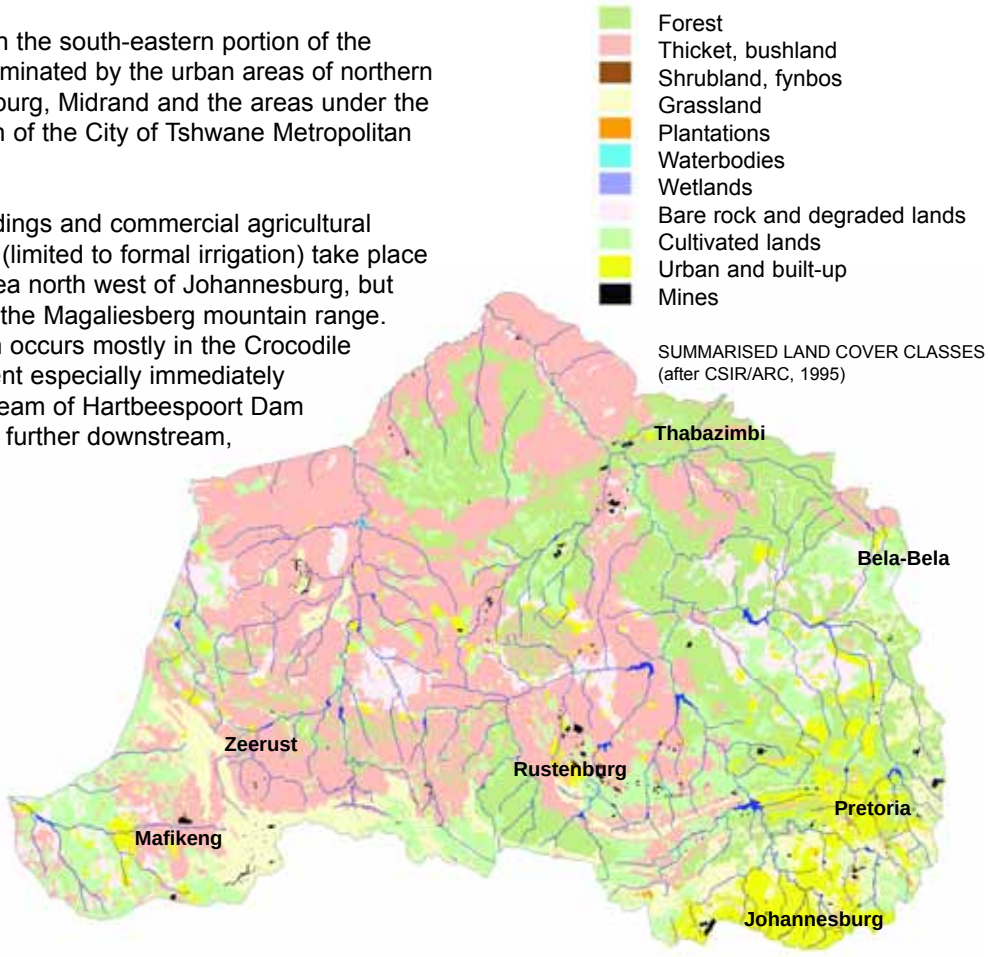
The northern parts of the WMA is dominated by Mixed Bushveld, Sweet Bushveld and Mopane Bushveld vegetation types. The central and western parts are dominated by Mixed Bushveld, while North-eastern Mountain Grassland and Mixed Bushveld vegetation types are found in the eastern parts. Dry Sandy Highveld Grassland and Moist Cool Highveld Grassland vegetation types are largely found in the southernmost region of the WMA.

* Low and Rebelo's (1998) description of vegetation types is referred to since the vegetation component of the Ecoregion approach is based on this version of the classification of vegetaton types. Eco-regions were key in the delineation of the Ecological Study Units.

LAND-USE

Land-use in the south-eastern portion of the WMA is dominated by the urban areas of northern Johannesburg, Midrand and the areas under the jurisdiction of the City of Tshwane Metropolitan Council.

Smallholdings and commercial agricultural activities (limited to formal irrigation) take place in the area north west of Johannesburg, but south of the Magaliesberg mountain range. Irrigation occurs mostly in the Crocodile catchment especially immediately downstream of Hartbeespoort Dam but also further downstream,



south of Thabazimbi as well as along the mainstem of the Crocodile River. A very wide variety of crops are produced, ranging from intensive vegetable production to tobacco, maize, cotton, citrus and sub-tropical fruits, sorghum, sunflowers and soya bean. A significant amount of irrigation also takes place near Mafikeng, situated in the Molopo catchment with water sourced from the Grootfontein dolomitic compartments. Dry land crops (usually maize) are grown in the south and south-eastern parts of the WMA where the rainfall is higher, while in the drier northern and western regions, land-use consists mostly of stock and game farming. Further away from the main river channels, most of the land-use is small-scale irrigation from farm dams as well as the raising of small and large livestock and game animals.

Extensive mining activities occur north and east of Rustenburg - mainly in a circular belt around the perimeter of the Bushveld Igneous Complex. These mines are mainly focused on the platina group of metals which are in great demand on the world market at the moment, as well as granite mining. Rustenburg is considered one of the fastest growing cities in Africa because of the platinum mining operations. In the Upper Crocodile River sub-catchment, small open-cast stone and sand quarries are common as well as a number of large platinum and chrome mines. Limited mining occurs in the rest of the WMA.

Social and Economic Characteristics

Population

The Crocodile (West) Marico WMA is the second most populous water management area in the country.

In 2001, the population of this WMA has been estimated to be 6.7 million people. Approximately 85 % of the population in the WMA live in the urban metropolitan area of Johannesburg and Tshwane, situated in the Upper Crocodile and Apies / Pienaars sub-catchments where they are attracted by the economic activity and employment opportunities in the region. Extensive informal settlements have as a result, sprung up around the periphery of the major urban centres.

The number and density of population declines with increasing distance from these upper reaches and the rural population is more evenly distributed than the urban population.

Economic Profile

Economic activity in the WMA is dominated by the urban and industrial complexes of northern Johannesburg and Pretoria and platinum mining north-east of Rustenburg.

About 25 % of the Gross Domestic Product (GDP) of South Africa originates from the Crocodile (West) Marico WMA. This constitutes the largest, single contribution to the national wealth from any of the water management areas. The WMA's gross geographic product (GGP), which is the total value of all final goods and services produced within the economy in a geographic area for a given period, was R130.1 billion in 1997. The major sectors contributing to the GGP are manufacturing (22.7 %), government (18.7 %), transport (15.7 %), finance (17.7 %) and the significant mining activities in the Rustenburg, Bafokeng and Madibeng (Brits) areas. Mining is an important and stable sector of the regional economy that provides strong employment opportunities.

Other Water Resources of the WMA

Groundwater

An important feature with regards to the water resourses in the Crocodile (West) Marico WMA, are the large dolomitic aquifers which occur along most of the southern part of the Water Management Area from Pretoria to Mafikeng. Large quantities of water are abstracted from these aquifers, mainly for urban and irrigation use, while a significant portion of the base flow of several rivers originates as springs from these aquifers. Along the lower Crocodile River, sandy aquifers are found from which large quantities of water are abstracted for irrigation purposes. Sandy aquifers also occur in the catchments of the Molopo River. The remainder of the WMA is mostly underlain by fractured rock aquifers, which are well utilised for rural water supplies.

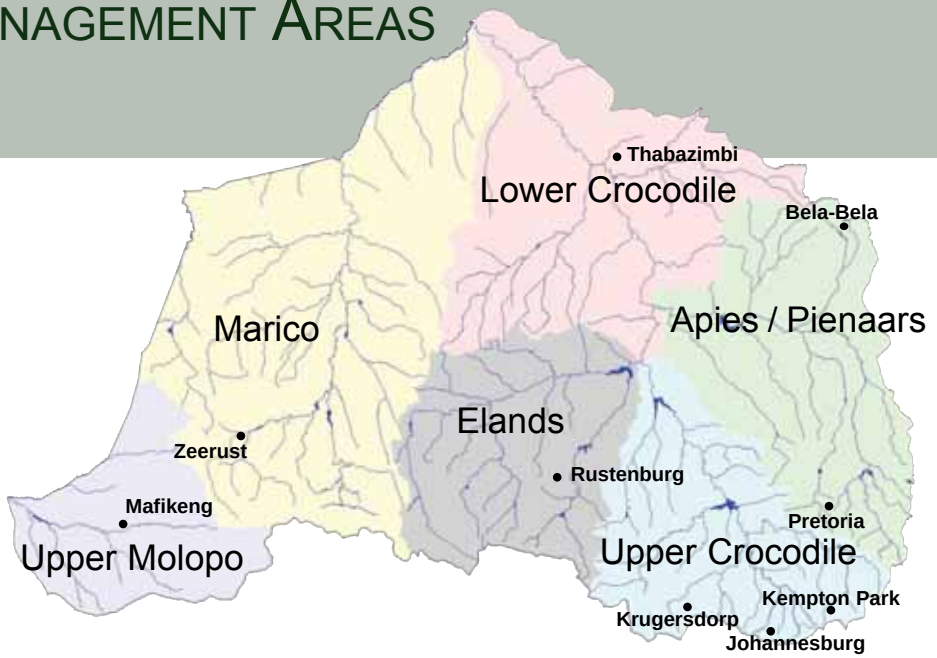
Wetlands

The wetlands of the Crocodile (West) Marico WMA occur in a variety of biomes contributing to an amazingly rich diversity of wetlands in terms of setting, type, biodiversity and extent. Some of these are:

- The extensive Moretele floodplain wetlands and the Dolomitic Eyes of Marico and Molemane in the wetter Mixed Lowveld Bushveld biome;
- The pristine Waterval valley bottom mire in the mountains of Kgaswane Nature Reserve within the Clay Thorn Bushveld biome;
- The Dry Sandy Highveld Grassland hosts extensive karst related wetland systems such as the mire at Gerhard Minnebron or the one at Schoonspruit; and
- The arid Kalahari Plains Thorn Bushveld hosts unique wetlands such as the endorheic Heuningvlei with its seep zones or the Molopo wetland complex on the border with Botswana.

Two unique wetland groups needs further mentioning. One group is the eyes, mires and peatlands associated with the karst landscape which dominates large parts of the North West Province and that underlay a variety of the biomes. The second group are the endorheic pans. These pans are as diverse in character as they are in setting. They vary from small permanently inundated pans to temporary playa-like pans from the wetter east to the more arid western parts of the province.

SUB-MANAGEMENT AREAS



The Crocodile (West) Marico water management area is divided into six sub-areas by the Department of Water Affairs and Forestry for water resources planning purposes. The delineation was largely based on practical considerations such as size and location of sub-catchments, homogeneity of natural characteristics, location of dams, and economic development. The six sub-management areas are described below:

Apies / Pienaars sub-management area
The Apies / Pienaars sub-management area comprises the Apies River catchment, the Pienaars River catchment and the catchment of the Moretele and Tlholwe rivers down to its confluence with the Crocodile River. The Apies River joins the Pienaars River to the north of Hammanskraal. The Apies River drains the Pretoria CBD, parts of the central-eastern suburbs and most of the western Pretoria industrial and urban areas. Increased high surface water runoff is channelled into the Apies River from these areas. The Pienaars River joins the Crocodile River just below the confluence of the Crocodile and Elands rivers. Roodeplaat Dam and Klipvoor Dam are the major dams in the sub-catchment while Pretoria in the southern part and Bela-Bela, situated in the northern part of the sub-catchment, are the major towns. The upper and middle reaches of this sub-management area in particular are densely settled.

The Pienaars River drains the area from Pretoria northwards to the Waterberg Mountains near the town of Bela-Bela. All the main rivers are perennial and their flows are supplemented by substantial discharges of treated domestic and industrial effluent. Flows in these rivers are also enhanced by water imported from the Vaal River system to the south of Johannesburg, which is used principally for domestic and industrial water supplies prior to treatment and discharge.

Upper Crocodile sub-management area
This area corresponds to the catchment of the Crocodile River upstream of the confluence of the Elands River which includes the major tributaries of the Sterkstroom, Magalies, Bloubankspruit, Jukskei and Hennops rivers. The Crocodile River has its source in the Witwatersrand mountain range at a height of 1 700 m.a.s.l. The northern suburbs of Johannesburg, as well as parts of adjacent cities such as Kempton Park and Krugersdorp are situated in this sub-catchment. There are two large dams in this sub-catchment, namely Hartbeespoort and Roodekopjes. The upper reaches of the catchment are densely settled.

Elands sub-management area
The Elands sub-management area consists of the Elands River catchment which includes the tributaries of the Koster, Selons and Hex rivers. The Elands River is a tributary of the Crocodile River and the confluence is situated below Roodekopjes Dam. Large portions of this catchment are tribal areas. Rustenburg is the only major city in this sub-catchment and the major dams are Bospoort Dam on the Hex River and Vaalkop Dam on the Elands River. Mining of platinum and its associated platina group of minerals are the dominant land-use in the catchment and is rapidly expanding.

Lower Crocodile sub-management area
This sub-management area represents the remainder of the Crocodile River catchment, downstream of the confluence of the Elands River. The river flows in a north/north-westerly direction until the confluence with the Marico River. After the confluence the river is known as the Limpopo River. The Lower Crocodile River has two large tributaries, namely the Sand River and the Bierspruit which join the Crocodile River west of the town of Thabazimbi. Irrigation is the dominant water demand in this sub-area.

Marico sub-management area
The Marico sub-management area corresponds to the catchment of the Marico River. Main tributaries of the Marico River include the Klein and Groot Marico rivers. This sub-area forms the western part of the WMA. Major dams in this sub-catchment are the Marico-Bosveld Dam in the upper catchment and the Molatedi Dam further downstream. The town of Zeerust is found in this sub-management area with smaller settlements scattered throughout. The Groot Marico River is fed by a number of springs within the Groot Marico dolomitic aquifer compartment. These dolomitic eyes include the Molemane Eye and the Marico Eye. The upper reaches of this catchment are not densely populated.

Upper Molopo sub-management area
The Upper Molopo sub-management area comprises the upper part of the Molopo River catchment. The Molopo River rises from the Molopo Eye near Mafikeng and flows westwards to form the northern border of the North West Province with Botswana. The Molopo River is a tributary of the Orange River. It ceases as a surface flow and discharges into pans in Botswana before turning south and emerging as surface flow just before it reaches the Orange River. The source of the Molopo River is the main supplier of water to the town of Mafikeng. Irrigation is also a dominant water demand in this sub-management area.

Management and conservation challenges for the burning Bodibe peatland in the North West Province

The Bodibe is a karst related peatland located between the towns of Mafikeng and Lichtenburg in the North West Province. The peat in this wetland has been on fire since early 2003. A current partnership between the community, local/district government, provincial departments and Working for Wetlands is trying to arrest the spreading of the fire.

The onset of organised agriculture and the formation of large townships have lead to pressures on the water resources of this area. Surface runoff, dammed streams and groundwater were used to irrigate maize fields and to supply water to the human settlements. The increase in population has lead to more demands on water resources. It was especially the groundwater resources that were targeted for exploitation. This resulted in a drop in the regional water table to such an extent that the eyes and springs have dried up and could not sustain flow to the peatland. The peatland started to dry out, desiccation fissures developed all over the surface. Severe drought desiccated the peatland even further and the upper portion started to burn when the veld was burnt to improve grazing for the local community's stock.

Working for Wetlands has put in place a cut-off wall (about 120 m long, 5 m deep and 0.6 m wide). This wall has arrested the spread of the fire and it is hoped that it would trap water entering the system thereby facilitating the restoration of this system.

It is expected that with global climatic change peatlands in semi-arid regions will come under more pressure. These marginal peatlands such as Bodibe would eventually become a victim of struggle for water between man and the environment.

Burning peatland at Bodibe, near Mafikeng due to over utilisation of groundwater by local municipalities and farmers.

Summary

Status of the Crocodile (West) Marico Water Management Area

The overall EcoStatus of the Crocodile (West) Marico WMA is poor, with 13 of the 23 units surveyed classified as poor. Only 10 were classified as fair or better (see table below). This WMA is highly developed: about 25 % of the Gross Domestic Product (GDP) of South Africa originates from the Crocodile (West) Marico. The industrial, mining and agricultural sectors within this WMA play a vital role in contributing to this economic achievement and are highly dependent on water resources within the WMA.

Some parts of the WMA are still in good to natural condition. These are found primarily in the headwaters of catchments with very little development and human impact. Examples of river reaches in near pristine condition include the headwaters of the Groot Marico and Skeerpoort rivers.

EcoStatus Category*	Number of Ecological Study Units
POOR	13
FAIR	7
GOOD	2
NATURAL	1

* Note: In those instances where the EcoStatus was intermediate, e.g. POOR/FAIR, the first stated category is the predominant status and is classified as such in the above table. Using the POOR / FAIR example - this would fall under the POOR category.

There are a number of management responses that have been identified throughout the course of the survey. Some of these need to focus directly on the riparian zone and instream habitat, some need to be addressed at the catchment level and others are directly related to water use and quality.

Riparian Zone

The riparian zone is an important ecological link between the river and the terrestrial component of a catchment. In addition it provides a necessary buffer between the river itself and any potential impacts that might originate from within the catchment. The protection of the riparian zone should be a management priority, where management responses should include:

- The minimisation of future development within the riparian zone, and control and management of existing activities that occur within the riparian zone, such as grazing, sand winning and slasto mining. All these activities change the structure and functioning of the riparian zone - sometimes irreversibly (the responsibility of landowners; farmers; developers; rural communities; Department of Water Affairs and Forestry (DWAF); National Department of Agriculture (NDA); Department of Mineral and Energy Affairs (DME); Department of Environmental Affairs and Tourism (DEAT); Gauteng Department of Agriculture, Conservation and Environment; North-West Department of Agriculture, Conservation, Environment & Tourism; as well as District and Local Municipalities).
- The clearing of alien vegetation within the riparian zone (the responsibility of Working for Water, DWAF and provincial departments responsible for environmental quality).

In order to successfully restore and rehabilitate the riparian zone, rivers need to be prioritised in terms of their desired conservation status. This will provide guidance as to which rivers require urgent attention within the WMA (the future CMA will play a role in this regard).

Instream Habitat

The integrity of the instream habitat is vital for maintaining biota and a healthy river system. Aquatic flora and fauna are often highly specific in terms of their habitat preferences, for example the depth of the water, type of bottom substrate and velocity of flow. Instream flow patterns are often affected by impoundments which alter the variability and quantity of flows. Within the Crocodile (West)

Marico WMA there are many impoundments - it is recommended that DWAF investigate these impoundments for opportunities to manage releases that simulate natural flow patterns. This will ensure that aquatic flora and fauna that are dependent on seasonal flows, for example to trigger reproductive responses, will return or flourish within specific river reaches downstream of impoundments. Environmental flow requirements are deter-mined as part of an ecological reserve determination. The implementation of instream flow objectives is subject to classifying a river in terms of the level of protection that it should receive. Both of these actions are the responsibility of DWAF.

More directed management responses related to instream habitat integrity include:

- The control of instream alien flora and fauna - alien species not only alter instream habitat, for example through their feeding behaviour, but may contaminate the natural gene pool through cross-breeding (the responsibility of provincial environmental affairs), and
- The installation of fish ladders and eelways in suitable flow regulating structures - this will allow natural migration patterns and will improve the functional connectivity down the length of a river system (the responsibility of provincial environmental affairs).

Catchment and Land-use

It is important to realise that what happens within the broader catchment, can have a direct impact on the ecological integrity of the river within it. Within the Crocodile (West) Marico WMA, two issues linked to broader catchment management were identified:

- Wetlands form an integral part of the water resources within a catchment and are often degraded by activities that occur in the surrounding catchment. There are a number of seeps, springs and palustrine wetlands within the WMA. These are largely unknown and require urgent characterisation, delineation and classification in terms of their desired protection status (the responsibility of DWAF, DEAT and provincial environmental affairs).
- Urban development within the catchment is often accompanied by impervious surfaces (roads, paving, roofs etc). Flows that would normally percolate into the ground now travel across the land surface. Surface runoff flows more rapidly and at greater volumes than groundwater flows. There is a need to manage surface stormwater runoff at the source in order to sustain groundwater flows and attenuate stormwater damage (the responsibility of Local Municipalities, DWAF and landowners).

Water use

The water budget is the balance between supply and demand within a system (e.g. a WMA). It is important that the demand for water resources in the Crocodile (West) Marico WMA is within the systems sustainable capability. A number of economic activities, most notably agriculture, industry and mining, within the WMA use vast quantities of water. (In the Gauteng portion of the WMA, domestic use is a major contributor to overall water use, although most of this water is imported from the Upper Vaal WMA.) In a water scarce country it is essential that water use is efficient and not wasteful. There is a specific need to monitor and control mining activities through the issuing of water use and discharge licences, with the recognition that in some cases a license application can and should be declined (the responsibility of DWAF & DME).

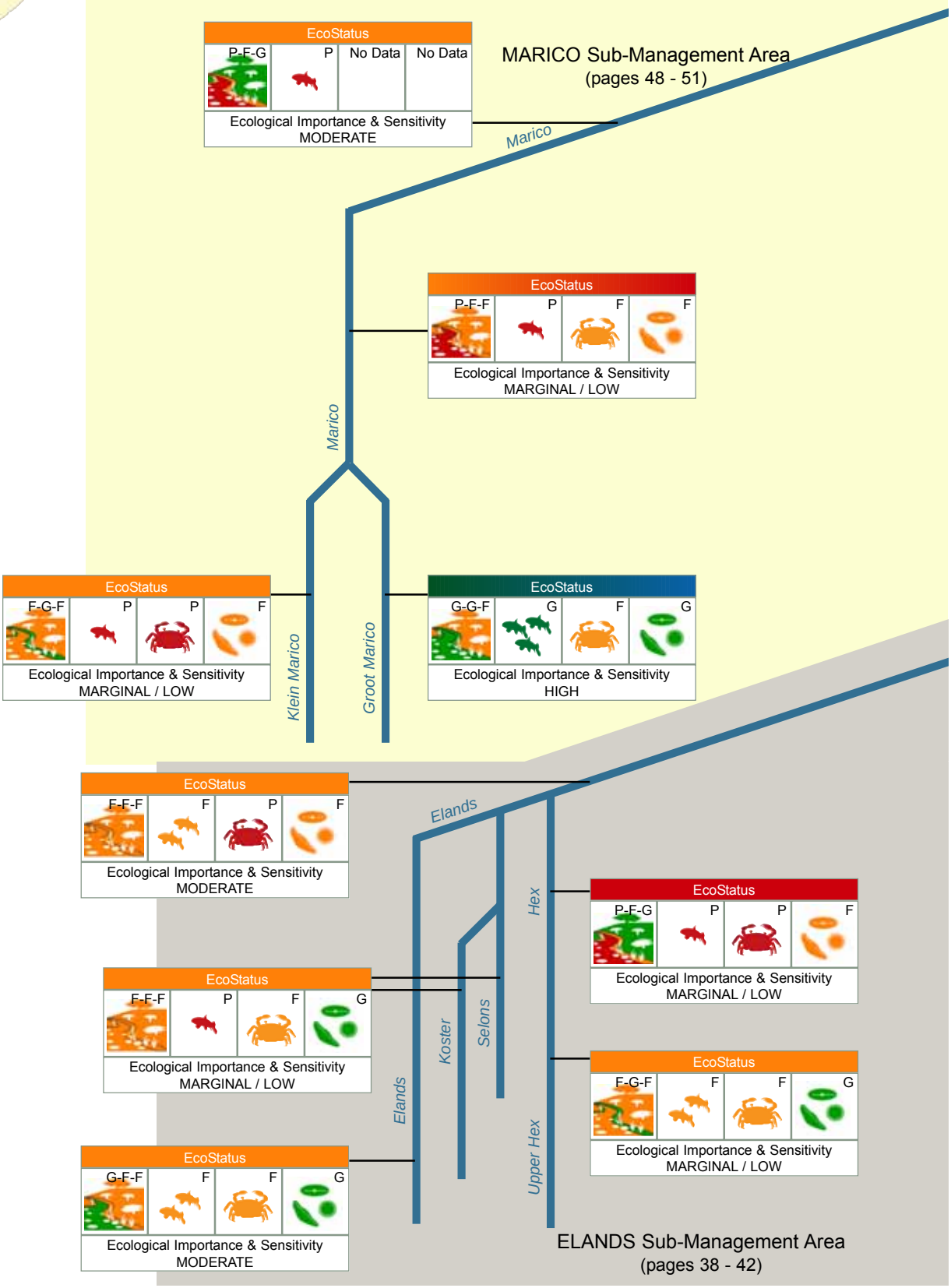
Water quality

In highly developed WMAs, such as the Crocodile (West) Marico, water quality issues are always on the list requiring management responses. The first step in managing water quality problems would be to set the water quality objectives for the rivers within the WMA. Once this has been undertaken it is important to monitor water quality to ensure that the objectives are being adhered to. Within the WMA there are a number of sources of pollution that are contributing to the reduced levels of water quality. These include:

- Agricultural return flows (the responsibility of DWAF, NDA, organised agriculture and farmers to improve their practices),
- Industrial discharges (the responsibility of DWAF and industry to adhere to licence conditions and take responsibility for the health of the water resources they use), and
- Sewage spills and discharges (the responsibility of DWAF and municipalities to upgrade the sewerage systems and improve their management).

THE CROCODILE (WEST) MARICO WATER MANAGEMENT AREA

Summary



Limpopo

Marico

LOWER CROCODILE
Sub-Management Area
(pages 44 - 47)

EcoStatus
P-P-P | P | P | P
Ecological Importance & Sensitivity
MODERATE

EcoStatus
F-P-P | F | P | F
Ecological Importance & Sensitivity
MODERATE

Sundays

Sand

EcoStatus
P-P-P | F | F | F
Ecological Importance & Sensitivity
MODERATE

Tooys

Plat

Pienaars

EcoStatus
P-P-P | F | P | No Data
Ecological Importance & Sensitivity
MODERATE

EcoStatus
F-F-P | F | P | P
Ecological Importance & Sensitivity
MODERATE

Apies

EcoStatus
P-P-P | P | P | P
Ecological Importance & Sensitivity
MARGINAL / LOW

Pienaars

EcoStatus
P-P-P | P | P | F
Ecological Importance & Sensitivity
MARGINAL / LOW

Apies / Pienaars
Sub-Management Area
(pages 24 - 27)

Elands

Karee

Rose

EcoStatus
P-P-F | P | P | P
Ecological Importance & Sensitivity
MARGINAL / LOW

EcoStatus
P-F-F | P | P | F
Ecological Importance & Sensitivity
MARGINAL / LOW

Crocodile

Sterkstroom

EcoStatus
P-P-P | P | P | P
Ecological Importance & Sensitivity
MARGINAL / LOW

EcoStatus
P-P-P | F | P | No Data
Ecological Importance & Sensitivity
MODERATE

EcoStatus
G-F-F | G | F | G
Ecological Importance & Sensitivity
MODERATE

Magalies

Skeerpoort

Jukskei

Rietspruit

Rietvlei

EcoStatus
P-P-P | P | P | P
Ecological Importance & Sensitivity
MARGINAL / LOW

EcoStatus
G-G-F | G | N | N
Ecological Importance & Sensitivity
HIGH

The icons are explained on pages 6 to 9

UPPER CROCODILE Sub-Management Area
(pages 28 - 37)

Longterm Monitoring and Management Programme for River Health

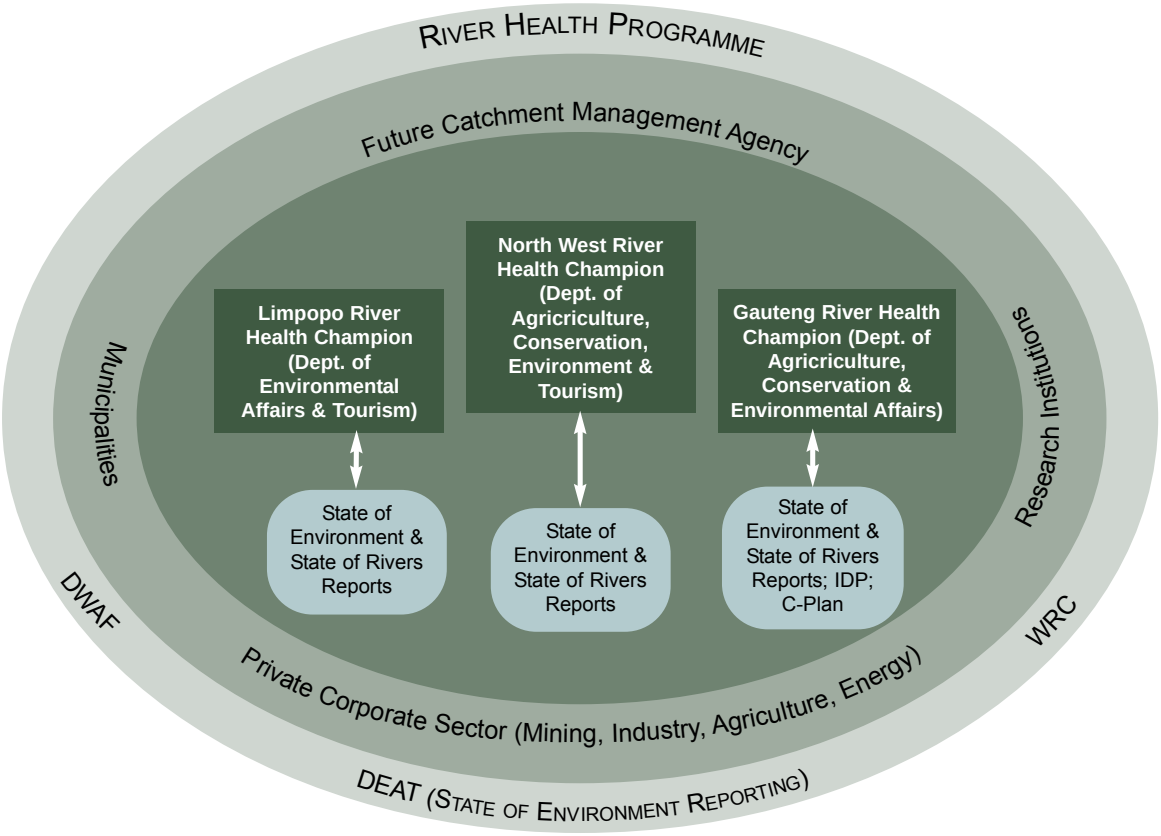
Institutional Arrangements

The Crocodile (West) Marico Water Management Area falls mainly within the North West Province, but it also incorporates sections of the Limpopo and Gauteng provinces. A cross-provincial team of river ecologists is therefore required to ensure the successful implementation of the River Health Programme (RHP) in this Water Management Area (WMA).

The institutional arrangements that currently exist for the RHP in this WMA are depicted in the figure below. Three River Health Provincial Champions are responsible for ensuring implementation of the programme in their respective provinces and to coordinate monitoring programmes with provincial neighbours. These champions are also responsible for reporting back to the National Coordinating Team. In each province, relevant stakeholders are assisting the champions with the biomonitoring programmes, for example research institutions, mining companies and municipalities.

A Catchment Management Agency (CMA) will be established in terms of Chapter 7 of the National Water Act (Act No. 36 of 1998) for the Crocodile (West) Marico WMA within the next two years (by end of 2006). It is anticipated that the CMA will have an important role to play in the River Health Monitoring Programme for this WMA, especially as a coordinating body on a catchment level between provinces and the relevant national departments.

In the three provinces, application of the RHP occurs mainly in the context of the State of Environment reporting obligation of the provinces and also to inform the aquatic biomonitoring programme of the province in Gauteng. Although links have been established between the provincial departments responsible for environmental monitoring and reporting and the regional offices of the Department of Water Affairs and Forestry, true partnerships between these provincial and national agencies are still lacking.



Monitoring Programmes

Monitoring protocols have been implemented by each province in the 2004 survey with recommended timeframes for repeat surveys. Repeat surveys will revisit existing sites as well as aim to expand the number of monitoring sites in areas of low coverage, for example the Upper Molopo sub-management area.

In Limpopo Province, the RHP started in earnest in 1997. However, the Crocodile (West) Marico WMA was only surveyed in 2004, the survey on which this report is based. Due to capacity constraints, the future surveys of this WMA in the Limpopo Province, will only be done in a 3-4 year return period.

Gauteng Province started to implement the RHP in 1999. The upper Crocodile (West) Marico WMA was surveyed for the first time in 2001 and is monitored on a 4-year cycle. The first cycle ended in 2005 and the next sampling period for this WMA in Gauteng, will start in 2007 and the results will be published in a SoR report in 2009.

In North West Province the RHP will be implemented in earnest from 2005. Previously, in 1999, a few sites in the WMA were surveyed, but due to capacity constraints, monitoring ceased. In 2004 a renewed effort by the Department of Agriculture, Conservation, Environment & Tourism to revive the programme in the North West Province was initiated and the RHP was revitalised with the assistance of the Department of Water Affairs & Forestry. The 2004 survey was conducted for the Crocodile (West) Marico WMA and it will be monitored in future on a 2-3 year cycle.

Management Actions

The biomonitoring indices used in the River Health Programme are good indicators of the ecological state of rivers and can therefore flag problem areas where corrective measures are required. However, river management can be quite complex and therefore different institutions have to plan and work together to reach appropriate decisions. Different stakeholders might have different interests in a specific river, but in the end each one needs to understand and respect the others' interests in order to manage their collective interest in river health.

In the Crocodile (West) Marico WMA, management decisions are not yet being co-ordinated on a catchment level, but it is anticipated that the coming Catchment Management Agency will play a key role in this regard. However, in the Limpopo and Gauteng provinces (where the RHP has been running for a few years), the respective RHP teams have identified problem issues and have proposed and implemented appropriate management actions (see pages 16 and 17). In the North West Province, the RHP has only recently been initiated therefore management actions have yet to be addressed. In the next State of the River report for the Crocodile (West) Marico WMA, the North West Province will be able to contribute in this regard.

ECOLOGICAL STUDY UNITS

For the purpose of this study, the rivers in the Water Management Area were clustered based on ecological similarity - these clusters are referred to as ecological study units. A total of twenty two ecological study units were assessed. These ecological study units, the sub-management areas in which they fall, the ecoregions that they comprise, as well as the main rivers and tributaries that form part of each ecological study unit (and hence the ecological assessment), are summarised on the following page.

Ecological Study Units

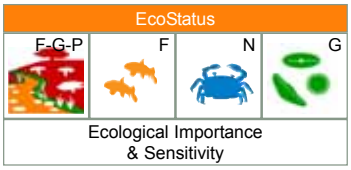
The ecological study units provided the boundaries within which ecological assessments were done. The delineation of these ecological study units was largely based on ecoregions and rivers that were similar, available information relating to riverine ecology, as well as the importance of the river from an ecological and land-use point of view.

Ecoregions

Ecoregion delineation is an approach that is followed to classify rivers into areas of broad ecological similarity (DWAF, 2003). Factors such as terrain morphology, natural vegetation, geology, soil characteristics, altitude, rainfall and runoff variability are considered when ecoregions are delineated. Rivers in the same ecoregion are hence ecologically more similar than rivers in different ecoregions.

Results of this survey

The overall ecostatus and individual integrity of the ecological indicator groups (i.e. fish, macroinvertebrates, instream and riparian habitat and diatoms), and the ecological importance and sensitivity of each ecological study unit, are presented per sub-management area and are summarised by the following icon which is colour-coded according to the results of each index i.e. the appropriate river health category.



Sub-management Area:
MARICO

Ecological Study Units:
- Klein Marico
- Groot Marico
- Middle Marico
- Lower Marico

Ecoregions:
- Highveld
- Western Bakenveld
- Bushveld Basin
- Limpopo Plain

Main Rivers and Tributaries:
- Klein Marico
- Groot Marico

Sub-management Area:
LOWER CROCODILE

Ecological Study Units:
- Middle Crocodile
- Sundays
- Lower Crocodile

Ecoregions:
- Western Bakenveld
- Bushveld Basin
- Limpopo Plain

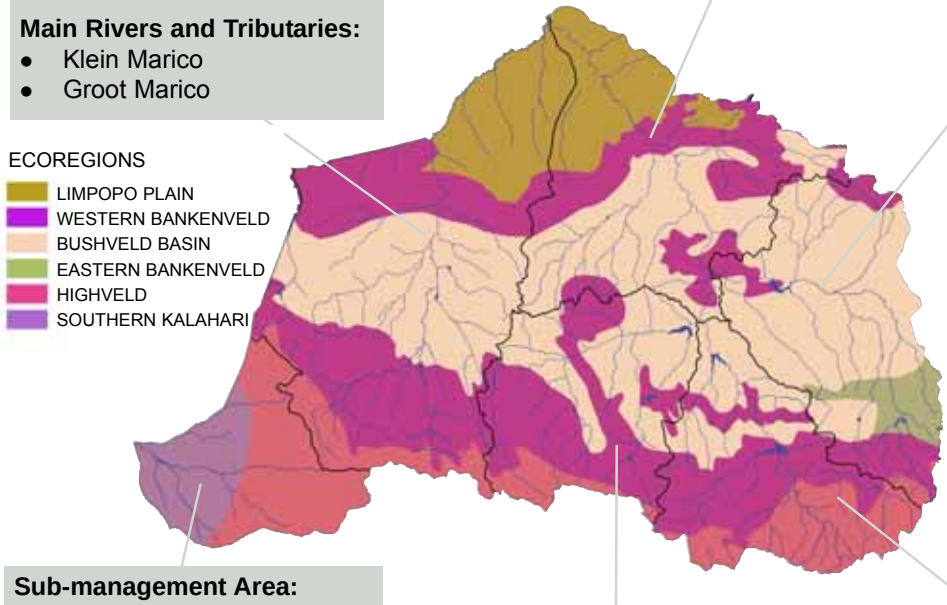
Main Rivers and Tributaries:
- Crocodile downstream of Roodekopjes
- Sundays

Sub-management Area:
Apies / Pienaars

Ecological Study Units:
- Plat
- Lower Pienaars
- Upper Pienaars
- Apies

Ecoregions:
- Western Bakenveld
- Bushveld Basin
- Eastern Bakenveld

Main Rivers and Tributaries:
- Pienaars
- Tshwane
- Kutswane
- Apies
- Moretele / Plat
- Tooyspruit



Sub-management Area:
UPPER MOLOPO

Ecological Study Units:
Not surveyed

Ecoregions:
- Highveld
- Southern Kalahari

Main Rivers and Tributaries:
- Molopo
- Ramatlabama
- Polfonteinspruit
- Madebe

Sub-management Area:
ELANDS

Ecological Study Units:
- Upper Elands
- Selons/Koster
- Upper Hex
- Lower Hex
- Lower Elands

Ecoregions:
- Highveld
- Western Bakenveld
- Bushveld Basin

Main Rivers and Tributaries:
- Elands
- Koster
- Selons
- Hex
- Klein Hex

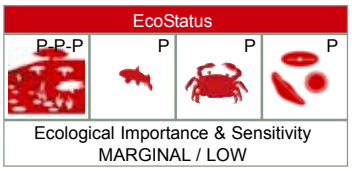
Sub-management Area:
UPPER CROCODILE

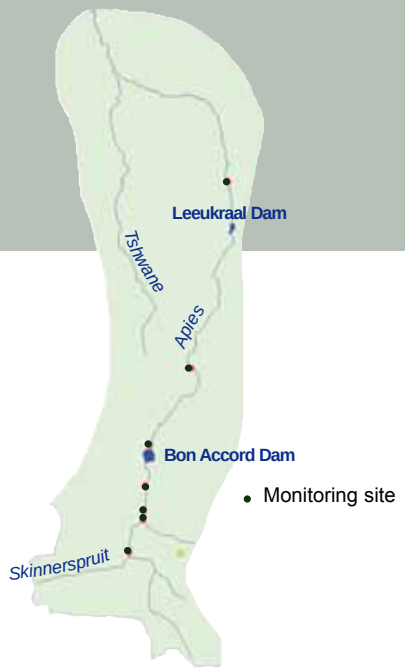
Ecological Study Units:
- Crocodile Highveld
- Magalies
- Skeerpoort
- Crocodile Western Bakenveld
- Upper Sterkstroom
- Lower Sterkstroom
- Middle Crocodile
- Rose / Kareespruit

Ecoregions:
- Highveld
- Western Bakenveld
- Bushveld Basin

Main Rivers and Tributaries:
- Sterkstroom
- Magalies
- Skeerpoort
- Rosespruit
- Kareespruit
- Crocodile
- Jukskei
- Klein Jukskei
- Hennops

Apies





EcoStatus

The overall EcoStatus for this study unit is POOR and comprises the following indices:

The ***Instream Habitat Integrity*** is POOR - this reach of river has been canalised and straightened in the urban areas. This has resulted in higher flows which in turn have also altered channel and bed shape. Urban runoff, sewage spills and litter from settlements impact heavily on water quality and the functional integrity of the river. ***Riparian Zone Habitat Integrity*** is POOR - channel modification plays the largest role in altering the habitat integrity of the riparian zone by changing the natural flow and flood patterns of the river.
Riparian Vegetation Integrity is POOR - most riparian vegetation has been cleared due to high levels of development. Alien vegetation encroachment is high in some areas; mulberries, jacaranda and sesbania are the most common species.

Fish Assemblage Integrity is POOR - sensitive species such as *Chiloglanis sp.* (rock catlet or suckermouth), *Amphilius sp.* (stargazer mountain catfish) and *Aplocheilichthys sp.* (topminnow) are lost, even hardy species have lowered frequencies of occurrence.
Macro-invertebrate Integrity is POOR - diversity and abundance is heavily impacted by urban runoff (increased volumes and reduced lag times) as well as reduced water quality.

Water Quality is POOR, flows have intermediate levels of nutrients and are free from significant organic pollution. Sources of pollution are primarily from urban activities. Pretoria Central, Iscor and large parts of Attridgeville contribute to reduced quality.

Ecological Importance and Sensitivity (EI&S)

EI&S is MARGINAL / LOW - species and habitat diversity is low because of canalised system, however some riffle and wetland habitats are present and sections of the river near Bon Accord Dam have been earmarked for rehabilitation. The Wonderboom Nature Reserve conserves some natural area.

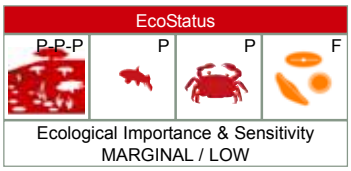
Drivers of Change

- High levels of development and urbanisation
- Canalisation and alteration of flow patterns

Management Responses

- Restore and rehabilitate channel morphology and riparian vegetation
- Control of urban runoff which is impacting on water quality
- Reduction and clean-up of litter from human settlements

UPPER PIENAARS



EcoStatus

The overall EcoStatus for this study unit is POOR and comprises the following indices:

The ***Instream Habitat Integrity*** is POOR primarily because of flow and bed modifications upstream from the Roodeplaat Dam caused by high levels of urbanisation and land-use activities such as small holdings, and chicken and dairy farming. Urban return flows contribute to higher than normal flows in the summer months and illegal dumping of garden refuse and building rubble on unoccupied land is problematic. The ***Riparian Zone Habitat Integrity*** is POOR - urban flood waters cause severe bank erosion. Below Roodeplaat Dam there is quite a lot of sedimentation. Channel modifications are mainly due to berms used for storm water management purposes. ***Riparian Vegetation Integrity*** is POOR - riparian vegetation in many areas has been cleared for development, from Lynwood Road to Magaliesberg there is no vegetation in the riparian zone and below the Roodeplaat Dam many developments are impacting on the riparian fringe. There is also serious alien vegetation infestation mainly of blue gum and wattle species.

The ***Fish Assemblage Integrity*** is also POOR - sensitive species such as *Chiloglanis sp.* (rock catlet or suckermouth) and *Amphilius sp.* (stargazer mountain catfish) are lost because of urbanisation and flows from sewage works. Even hardy species are under stress. ***Macro-invertebrate Integrity*** is POOR - reduced water quality has the largest impact on invertebrates.

Water Quality is FAIR, flows have intermediate levels of nutrients but are free from significant organic pollution. Main sources of pollution include urban return flows, sewage spills, and chicken and dairy farming activities.

Ecological Importance and Sensitivity (EI&S)

EI&S is MARGINAL / LOW - riparian and instream biotic diversity is low. Habitat types although not varied provide some unique examples: the Colbyn wetland in Hartebeespruit is a peat wetland, with more wetland types found upstream of the Silverlakes Golf Estate. Conservation areas include Bronberg, Fairie Glen and Moreletaspruit.

Drivers of Change

- Roodeplaat Dam altering natural flow regimes - wall construction does not allow flexible releases
- An increase in impervious surfaces due to increasing urbanisation has resulted in higher than normal peak flows, especially in the summer months
- Lack of riparian vegetation zone in many areas because of high levels of development and poor management
- Reduced water quality impacting on aquatic fauna and flora

Management Responses

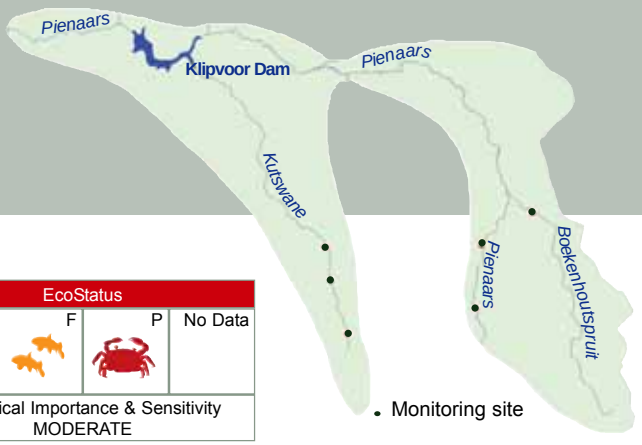
- Control impingement of development into the riparian zone
- Improve solid waste disposal facilities and educate people of the impacts of littering
- Stabilise bank erosion
- Identify and control sources of pollution that are reducing water quality
- Map wetlands that require protection and investigate ways to conserve them
- Remove alien trees, especially wattle and blue gum

THE WONDERBOOM NATURE RESERVE

The Wonderboom Nature Reserve is situated in the northern part of Tshwane straddling the Magaliesberg Mountains. This reserve is famous for its magnificent specimen of the Wonderboom. The Wonder tree is a wild fig (*Ficus salicifolia*) that is more than 1 000 years old, and legend has it that it grew this big because the chief of an indigenous tribe lies buried beneath its roots. Branches of this trunk first spread out radially but gradually drooped towards the ground, where they sent out roots from which sprang a circle of new trunks. In time, two of the offspring produced a third generation. Today the Wonderboom has 13 distinct trunks that cover an area of 1,5 ha. It is recorded that the tree was once big enough to shade 1 000 people at a time, or 22 ox-wagons with 20 oxen in front of each! Today, it is much smaller - probably because of the devastating fire in 1870 started by a hunting party or because of infestation by a parasite, which put it in quarantine for 20 years.

Sources:http://www.places.co.za and http://www.tshwane.gov.za

Lower Pienaars



EcoStatus			
P-P-P	F	P	No Data
Ecological Importance & Sensitivity MODERATE			

EcoStatus

The overall EcoStatus for this study unit is POOR and comprises the following indices:

The ***Instream Habitat Integrity*** is POOR because of flow modifications caused by the Klipvoor Dam, abstraction for irrigation purposes and weirs. Sedimentation caused by runoff from overgrazed areas in the riparian zone is impacting on channel bed morphology. Some parts of this river reach are still in good condition.
The ***Riparian Zone Habitat Integrity*** is POOR - changes in the flow regime have impacted on riparian ecosystems. Sand mining activities along the Boekenhoutspruit are resulting in increased sedimentation. Two tributaries to the Lower Pienaars lie close to Bela-Bela and both are highly disturbed by alien plant species. The main alien species found here are blue-gum and lantana.
Riparian Vegetation Integrity is POOR - vegetation decrease in the riparian zone is due to overgrazing and results in many open areas along the river up to the confluence with the Apies River. Alien vegetation encroachment is high in the upper sections of this reach and less in the lower sections.

Fish Assemblage Integrity is FAIR to POOR - stress conditions created by urbanisation and flows from sewage works have resulted in the loss of sensitive species. Even hardy species have lowered frequencies of occurrence. Eels are lost due to obstructions.
Macro-invertebrate Integrity is POOR - diversity and abundance is heavily impacted by return flows from urban and industrial areas.

Water Quality - although no diatom data is available, water quality is very poor and requires urgent intervention to reduce pollution levels.

Ecological Importance and Sensitivity (EI&S)

The EI&S is MODERATE - a diversity of species types is still present in this river reach (e.g. otters and yellowfish). The floodplain landscape offers a variety of habitat types and refugia. The Wallmannsthal Military Base offers some degree of protection of natural areas.

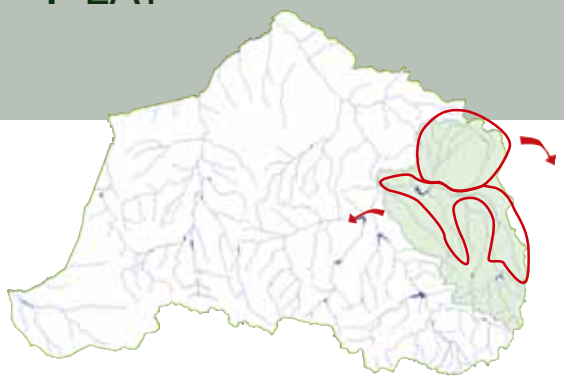
Drivers of Change

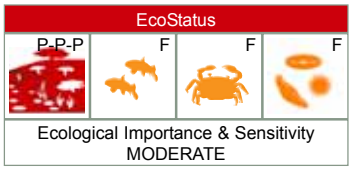
- Impacts of impoundments on natural hydrological regime of river
- High levels of urbanisation and industrial discharges impacting on water quality

Management Responses

- Clear alien vegetation from riparian zone and catchment
- Manage and control overgrazing in riparian zone
- Manage and enforce compliance of sand winning activities in the riparian zone
- Identify sources of pollution and enforce water quality standards

PLAT





EcoStatus

The overall EcoStatus for this study unit is POOR and comprises the following indices:

The ***Instream Habitat Integrity*** is POOR - there are a number of agricultural dams and weirs as well as the Bela-Bela Municipality that have a serious impact on the aquatic biota and connectivity of this river reach because large volumes of water are being abstracted. The flows in the middle sections of this river reach are also being choked by debris from alien vegetation, mainly Eucalyptus species. The ***Riparian Zone Habitat Integrity*** is POOR with water abstraction having a large impact on riparian habitat. The presence of alien vegetation is causing a reduction in the undergrowth, leading to bank instability - banks on river bends are badly eroded, leading to a change in terrace structure. ***Riparian Vegetation Integrity*** is POOR with indigenous vegetation largely replaced by aliens - extensive growth of blue gum, lantana, poplar, seringa, prickly pear, bramble and sesbania were observed.

The ***Fish Assemblage Integrity*** is FAIR to POOR - in the lower sections the river is naturally very dry but these conditions are exacerbated by water abstraction and as a result only hardy species are found and often are limited to isolated pools. Upper sections are in fair condition with *Clarias theodorae* (snake catfish) still present. ***Macro-invertebrate Integrity*** is FAIR to POOR - water abstraction and subsequent riparian habitat alteration has the largest impact on invertebrates. The upper sections are still in reasonably fair condition.

Water Quality is FAIR, flows have between low and intermediate levels of nutrients and are free from significant organic pollution. Some localised urban runoff and sewage outflow contribute to moderate water quality scores.

Ecological Importance and Sensitivity (EI&S)

The EI&S is MODERATE - riparian vegetation diversity is moderate because the river is in a transition zone between mountain and bushveld. Instream habitat is high, comprising wetlands, riffles, pools, runs and cascades in high flow conditions. There are a number of private nature reserves offering some degree of protection for natural areas.

Drivers of Change

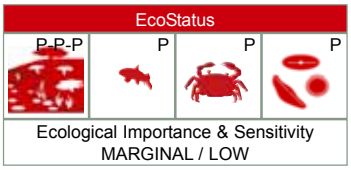
- Agriculture - demand for irrigation water has resulted in reduced flows in the river altering natural habitat
- Alien vegetation encroaching in riparian zone and blocking flows in some areas

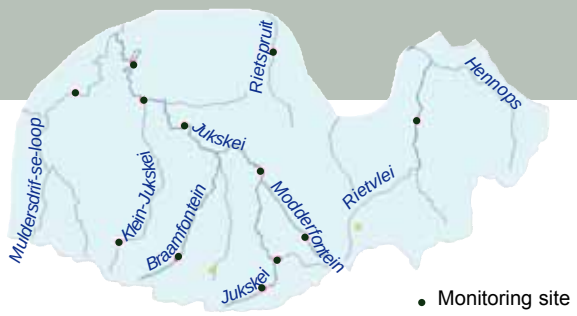
Management Responses

- Control and manage water use especially for irrigation purposes
- Determine environmental flow requirements and implement ecological reserve
- Eradicate invasive alien plants and rehabilitate degraded riparian habitats
- Identify and control sources of urban pollution especially sewage spills

Upper Crocodile
Sub-Management Area

Crocodile Highveld





EcoStatus

The overall EcoStatus for this study unit is POOR and comprises the following indices:

The ***Instream Habitat Integrity*** is POOR because of urban development - the majority of the river is canalised, urban runoff is high because of paved areas and sewage spills and industrial discharges are common because infrastructure can not cope with the high levels of utilisation. It must be mentioned that some of the tributaries feeding the Crocodile River are not as severely impacted. The ***Riparian Zone Habitat Integrity*** is also POOR primarily because the river has been engineered and the flow patterns completely altered. ***Riparian Vegetation Integrity*** is POOR - natural vegetation has been completely altered because of urbanisation, and encroachment by poplar species is severe.

The ***Fish Assemblage Integrity*** is POOR - increased flow volumes and increased peak flows after heavy rains because impervious surfaces have altered natural flow regimes. There is complete loss of sensitive species and even hardy species have lowered frequencies of occurrence. ***Macro-invertebrate Integrity*** is POOR - diversity and abundances are severely impacted by urban runoff including sedimentation, sewage flows and industrial discharges.

Water Quality is POOR with high levels of nutrients and an increased frequency of water quality problems. The percentage of species tolerant to organic pollution indicates that the water is free from significant organic pollution. Water quality in the urban areas is severe - mostly because of sewage spillages and industries discharging into the sewer network. The sewerage system is not able to cope with the increase in housing density.

Ecological Importance and Sensitivity (EI&S)

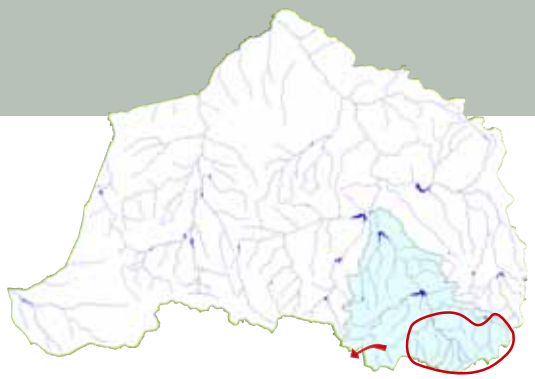
The EI&S is MARGINAL / LOW, the number of functional habitat types and species diversity is low because of the complete alteration of channel morphology and the natural flow regime. The African bullfrog is one unique species that manages to survive in this reach of river but is under constant threat as a result of changing land-use.

Drivers of Change

- Urbanisation - impervious surfaces, lack of sufficient capacity of sewer system, channel and flow modification
- Increased change of land-use from natural to urban and industrial

Management Responses

- Upgrade sewerage system and improve management
- Reduce pollution from sewers, illegal discharges and reduction of instream solid waste (litter)
- Manage surface stormwater runoff at source
- Clear alien invasives from riparian zone
- Encourage and support the Giant Bullfrog Project to ensure the survival of this 'near threatened' species and its habitat
- Encourage infiltration by reducing impervious surfaces to aid flood attenuation



Magaliesberg Protected Natural Environment (MPNE)

On 12 August 1977, the Magaliesberg which comprises approximately 37 000 ha, was declared a "Nature Area" in terms of the Physical Planning Act 88 of 1967. This Act introduced the concept of "Nature Areas" or Protected Natural Environments as they are now called in South African law.

The Magaliesberg Mountain range, stretching 125 km between Tshwane Metropolitan area, Johannesburg and Rustenburg, is of great geological importance. It has a rich concentration of valuable minerals and contains an archeological history representing the origins of humankind with a rich collection of hominid and pre-hominid fossils.

Evidence of occupation by early San communities is found in the rock paintings in the mountain. Bakgatla, Bakwena and Bafokeng can all trace their history in this area. A few monuments exist that commemorate the wars between Nguni and Sotho and the Boer and the English.

Presently the mountain is under severe pressure from developments such as mining, agriculture and recreation.

History of Johannesburg Streams

Johannesburg may not be built on a river or harbour, but its streams are the source of two of southern Africa's mightiest rivers.

A number of streams meander through the suburbs of Johannesburg, and form the source of two of southern Africa's primary rivers - the Limpopo and the Orange. Most of the springs from which many of these streams emanate are now covered in concrete and canalised, accounting for the fact that the names of early farms in the area often end with "fontein", meaning "spring" in Afrikaans. Braamfontein, Rietfontein, Zevenfontein, Doornfontein, Zandfontein and Randjesfontein are some examples.

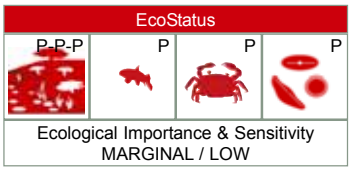
When the first white settlers reached the area that is now Johannesburg, they noticed the glistening rocks on the ridges, running with trickles of water, fed by the streams - giving the area its name, the Witwatersrand, "the ridge of white waters". Another explanation is that the whiteness comes from the quartzite rock, which has a particular sheen to it after rain.

Adapted from Lucille Davie's article 'Water, water….everyway' - December 24, 2004
Source: Johannesburg News Agency; www.joburg.org.za

Johannesburg
Canalised stream running through Johannesburg

Upper Crocodile
Sub-Management Area

Crocodile Western Bankenveld



EcoStatus

The overall EcoStatus for this study unit is POOR and comprises the following indices:

Instream Habitat Integrity is POOR - this can be attributed to the severe modifications to the channel morphology and flow patterns. Patterns have changed because of development, an increase in return flows resulting in higher peak flows, water being imported into the system and sewer discharges into the river. Solid waste in the form of general litter is problematic in the riparian zone and instream. The ***Riparian Zone Habitat Integrity*** is POOR - the modifications of channel morphology and flow has had a serious impact on the riparian habitats; bank erosion and inundation of the riparian zone have all contributed to low scores. ***Riparian Vegetation Integrity*** is POOR with alien vegetation encroachment and vegetation clearing both impacting on riparian vegetation integrity. At Ben Albert's Nature reserve, however, there are relatively fewer alien species, greater cover and recruitment of indigenous riparian species and the riparian zone is well covered with vegetation. The Sweethome site has a considerable forest of monkey thorn which is in need of conservation. It has a reasonably high percentage of indigenous riparian species and recruitment, but with highly invasive alien species like the castor-oil plant and herbaceous alien species present.

The ***Fish Assemblage Integrity*** is POOR - there is a complete loss of sensitive species (*Amphilius sp.* (Stargazer mountain catfish) and *Opsaridium sp.* (barred minnow)). Even hardy species are under stress with lowered frequencies of occurrence. ***Macro-invertebrate Integrity*** is POOR - reduced water quality and flow modifications due to urban and industrial runoff have a severe impact on invertebrates.

Water Quality is POOR - flows have high levels of nutrients and water quality problems but are free from significant organic pollution. This is primarily the result of urban runoff and industrial discharges.

Ecological Importance and Sensitivity (EI&S)

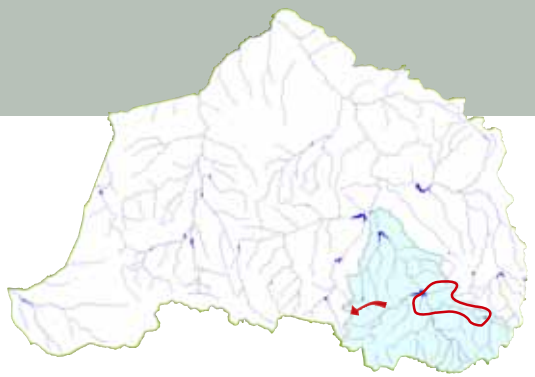
The EI&S is MARGINAL / LOW although there is some diversity of habitat due to the influence of the Brakenveld ecoregion. Overall however species and habitat diversity is low with little natural area left for protection or conservation.

Drivers of Change

- High levels of urbanisation - sewerage system unable to cope resulting in sewage discharges
- Discharges from industries into the sewer system
- Canalisation and alteration of flow patterns
- Invasive alien plants in riparian zone and in catchment

Management Responses

- Reduce and clean-up litter pollution
- Control of discharges into river - both sewage and industrial - to improve water quality
- Clear invasive aliens in riparian zone



Hartbeespoort Dam

The Hartbeespoort Dam, located in the Crocodile River Catchment in the North West Province, is a landmark for many people, attracting tourists from all over South Africa. However, Hartbeespoort Dam has, for decades, received large loads of wastewater effluent from Johannesburg, Midrand and Krugersdorp and will continue to do so well into the foreseeable future. The subsequent level of pollution is such that the dam regularly experiences dense blooms of cyanobacterial algae, with associated levels of algal toxins that pose a significant threat to human and animal health. Increasing development around the dam also results in additional pressure on the water quality of the dam.

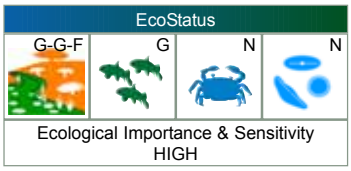
Some interventions to address this problem include:

- Enhanced wastewater treatment in the watershed draining to Hartbeespoort Dam;
- Maximizing wastewater re-use for irrigation and other purposes at or close to the point of generation;
- Sound land-use planning in the shoreland area and in the catchment draining to Hartbeespoort Dam;
- Development and operation of an instream ferric sulphate dosing facility to reduce phosphorus loads from both point and nonpoint sources within the Crocodile River catchment;
- Development of a commercial fishery on the dam to manage and control coarse fish populations and promote sustainable game fishery;
- Restoration of shoreland wetland and floodland ecosystems;
- Development and delivery of a programme of public information to the Hartbeespoort Dam communities inclusive of non-resident users;
- Ongoing monitoring of the response of the reservoir to the aforementioned interventions, and the conduct of further pilot scale studies as may be required; and
- Liaison with the relevant government entities, such as the local municipality, DWAF and NW-DACET, on matters relevant to the reservoir ecosystem and continuing development of the catchment, shoreline and recreational uses.

Hartbeespoort Dam

Skeerpoort

• Monitoring site



EcoStatus

The overall EcoStatus for this study unit is NATURAL / GOOD and comprises the following indices:

The **Instream Habitat Integrity** is GOOD - there are several dolomitic eyes at the source of the Skeerpoort River which are still in pristine condition. Some farming activities have impacted on flows lower down in the system. The **Riparian Zone Habitat Integrity** is GOOD - there is very minimal impact on the riparian zone with some localised bank erosion. The **Riparian Vegetation Integrity** is FAIR with alien vegetation encroachment having an impact at a small number of localities and some vegetation clearing for agriculture.

Fish Assemblage Integrity is GOOD to NATURAL with some impacts due to farming activities influencing fish diversity. Eels are lost due to obstructions, especially Hartbeespoort and Roodekopjes dams. **Macro-invertebrate Integrity** is NATURAL - macro-invertebrate diversity and abundance is high and close to natural conditions with species present that require permanent flows and high water quality conditions.

Water Quality is NATURAL, flows have low to intermediate levels of nutrients and free from significant organic pollution.

Ecological Importance and Sensitivity (EI&S)

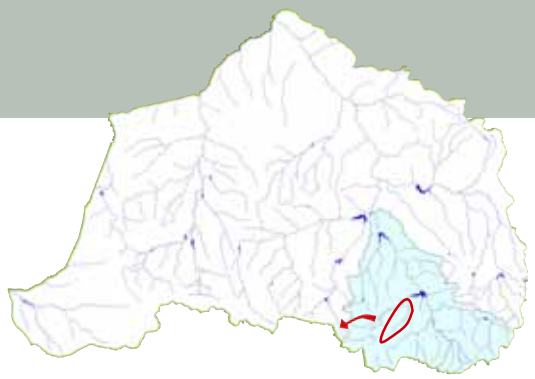
The EI&S is HIGH with high scores for unique and diverse biota as well as for providing habitat as refugia for biota during periods of environmental stress. The Cradle of Humankind, a World Heritage Site, is a significant conservation achievement for the area.

Drivers of Change

- Farming activities - although currently have minimal impact

Management Responses

- Restrict development to a minimum, as the greater part of the Skeerpoort catchment is situated within a proclaimed nature reserve
- Monitor farming activities - ensure impacts are minimal into the future
- Eradicate alien invasive plant species

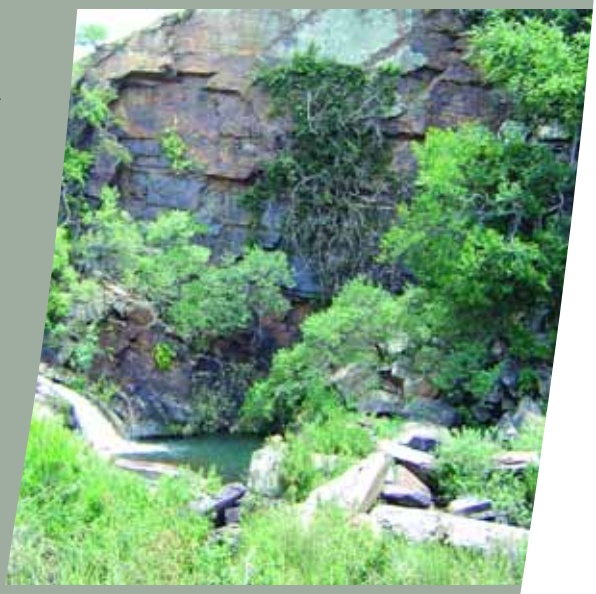


Cradle of Humankind

In 1997 the South African government signed the 1972 UNESCO Convention on the protection, preservation and promotion of the world's natural and cultural heritage making South Africa eligible to nominate sites of unique international significance. In 1999 the National Department of Environmental Affairs and Tourism, the office of the Premier of Gauteng and the Gauteng Department of Agriculture, Conservation, Environment and Land Affairs (DACEL, now known as GDACE) nominated the fossil hominid sites of Sterkfontein, Swartkrans, Kromdraai and environs known as the Cradle of Humankind. The Cradle of Humankind was inscribed on the World Heritage List on 2 December 1999. The Cradle of Humankind World Heritage Site comprises a strip of thirteen dolomitic caves containing the fossilised remains of plants, animals and, most importantly, hominids (members of the human family and our near relatives). These fossils are a superbly preserved record of the stages in the evolution of humankind within the past 4 million years.

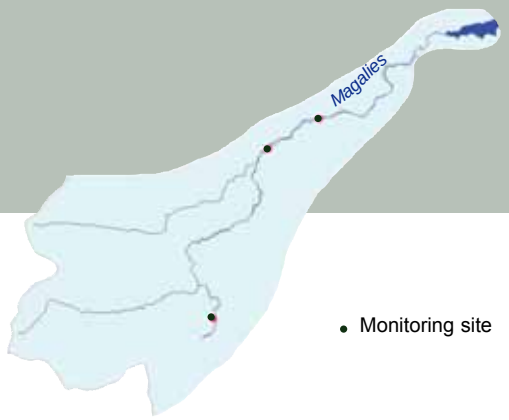
Taung Child

Source: http://www.cradleofhumankind.co.za/index_.html
Accessed 15 Nov 2004



Skeerpoort

Magalies



EcoStatus			
P-P-P	F	P	No Data
Ecological Importance & Sensitivity MODERATE			

EcoStatus

The overall EcoStatus for this study unit is POOR and comprises the following indices:

The ***Instream Habitat Integrity*** is POOR - this is attributed to high levels of water abstraction primarily for bottling. Water abstraction by farmers is also high with 25 furrows on the Magalies River alone. Many people rely on the furrow water for domestic use. The Magalies River has it's main source at Malony's eye upstream from the town of Magaliesburg. A constant flow of water surfacing at Malony's eye from the Steenkoppies dolomitic compartment feeds the river throughout the year.
The ***Riparian Zone Habitat Integrity*** is POOR - furrows have resulted in inundation of the riparian vegetation and flow modification has altered natural riparian habitats.
The ***Riparian Vegetation Integrity*** is POOR with riparian vegetation being cleared for agricultural and housing purposes. Alien vegetation encroachment is serious; poplars, wattles and blue gums are the most common.

Fish Assemblage Integrity is FAIR - the upper reaches still sustain some sensitive species, while the lower sections are impacted by water abstraction and flow modifications.
Macro-invertebrate Integrity is POOR overall, primarily because of water abstraction and therefore habitat alteration and some localised impacts on water quality from the town of Magaliesberg. Although in the upper reaches integrity can be classified as fair.

Water Quality - although no diatom data is available water quality is good with localised impacts from lodge developments along the river and return flow from pig farms, chicken farms and flower farms in the area.

Ecological Importance and Sensitivity (EI&S)

The EI&S is MODERATE - in the upper reaches species intolerant to changes in flows are present as well as some unique species of stoneflies, Perlidae, and fish (*Amphilius uranoscopus* (stargazer mountain catfish)). In the lower reaches habitat and species diversity are reduced due to flow modifications.

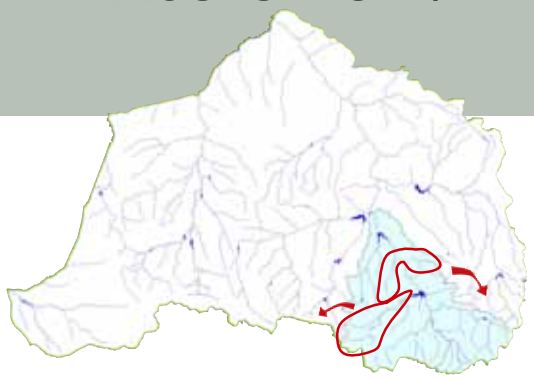
Drivers of Change

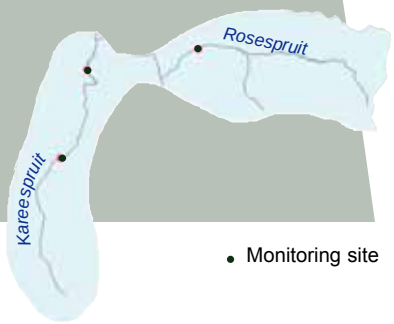
- Serious encroachment of alien vegetation in the riparian zone
- High levels of water abstraction resulting in changes in the natural flow regime of the river
- Large volumes of water extracted from the Steenkoppies/Holfontein compartment for agricultural use
- Flow regulating structures - large number of weirs for irrigation altering flow patterns

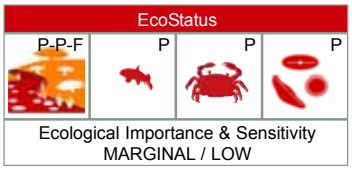
Management Responses

- Monitor and control water use and abstraction - ensure that the ecological reserve is determined and maintained
- Clear alien vegetation in the riparian zone
- Consider installing fish ladders in suitable flow regulating structures

ROSESPRUIT / KAREESPRUIT







EcoStatus

The overall EcoStatus for this study unit is POOR and comprises the following indices:

The ***Instream Habitat Integrity*** is POOR - the Kareespruit and the Rosespruit are impacted on by agricultural return flows, industry, and sewage inflows respectively. The ***Riparian Zone Habitat Integrity*** is POOR primarily because of channel modification and bank erosion caused by industrial and agricultural activities. The ***Riparian Vegetation Integrity*** is FAIR to POOR with some removal of vegetation from the riparian zone and the occurrence of alien vegetation encroachment.

The ***Fish Assemblage Integrity*** is POOR - only hardy species are present in the Kareespruit while no fish were caught in the Rosespruit. ***Macro-invertebrate Integrity*** is POOR due to severe water quality problems. Diversity of macro-invertebrates is very low.

Water Quality is POOR with flows measuring high levels of nutrients and the sites sampled were classified as heavily contaminated with organic pollution. The high vanadium levels in the area around Rosespruit are impacting so severely on the water quality that farmers have stopped using borehole water in the vicinity because of contaminated groundwater.

Ecological Importance and Sensitivity (EI&S)

EI&S is MARGINAL / LOW - instream flow modifications and water quality problems have impacted on the diversity of species and habitat types found in this river reach. This is typical of a river being heavily utilised for agricultural purposes where flows are regulated by impoundments and water quality modified by irrigation return flows and the use of agricultural chemicals. This results in stress conditions for the biota with a resultant reduction in sensitive species.

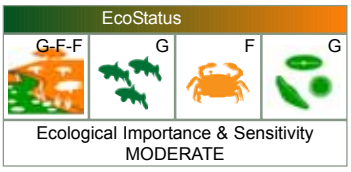
Drivers of Change

- Industrial activities impacting on flow and channel morphology
- Surface and groundwater contamination by industries
- Flow modifications due to agricultural return flows and bank erosion

Management Responses

- Manage and minimise industrial and agricultural water pollution
- Restore and rehabilitate channel morphology and riparian vegetation
- Ensure compliance to water quality objectives especially with regards to groundwater contamination

Upper Sterkstroom



- Monitoring site

EcoStatus

The overall EcoStatus for this study unit is GOOD / FAIR and comprises the following indices:

The ***Instream Habitat Integrity*** is GOOD with some water abstraction upstream of Buffelspoort Dam for farming. Some small weirs are present but have minimal impact on flows and channel morphology.
The ***Riparian Zone Habitat Integrity*** is FAIR - there are a few weirs which when full inundate the riparian zone which cause some localised bank erosion.
The ***Riparian Vegetation Integrity*** is FAIR - this is primarily attributable to the widespread invasion of alien vegetation, mostly poplars and blue gums.

The ***Fish Assemblage Integrity*** is GOOD to NATURAL - sensitive species with permanent flow and high water quality requirements are present. Frequency of occurrence is close to natural. Eels are lost due to flow regulating structures obstructing their migration routes.
The ***Macro-invertebrate Integrity*** is FAIR with flow and habitat modifications contributing to localised impacts on invertebrates.

The ***Water Quality*** is GOOD - flows have between low and intermediate levels of nutrients and are free from significant organic pollution.

Ecological Importance and Sensitivity (EI&S)

The EI&S is MODERATE with a high proportion of species dependent on permanently flowing water and some protection of natural areas offered by the Magalies Protected Natural Environment.

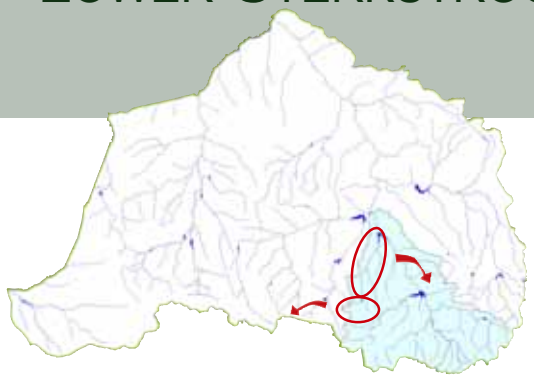
Drivers of Change

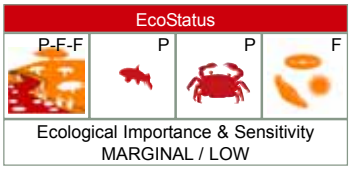
- Water abstraction for irrigation
- Widespread infestation by alien vegetation
- Resort development

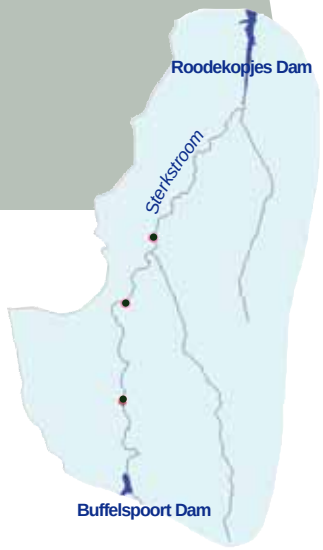
Management Responses

- Clear alien vegetation in riparian zone and in catchment
- Construct fish ladders where appropriate
- Monitor water use for irrigation
- Determine environmental flow requirements and implement the ecological reserve
- Identify and monitor wetlands to ensure ecological functions are maintained

LOWER STERKSTROOM







• Monitoring site

EcoStatus

The overall EcoStatus for this study unit is POOR and comprises the following indices:

The ***Instream Habitat Integrity*** is POOR primarily because of mining activity in the area. Water abstraction and mine de-watering has altered the natural flow regime of the river to such an extent that the upper reaches of the river are drier than they should be and the lower reaches are wetter than they should be. In some cases water abstraction points have become mining process dams severely impacting on flows and channel morphology. The ***Riparian Zone Habitat Integrity*** is also FAIR because of flow and channel modifications due to mining activities. The ***Riparian Vegetation Integrity*** is FAIR with moderate abundances of alien vegetation in the riparian zone. Increasing levels of development has resulted in vegetation removal.

The ***Fish Assemblage Integrity*** is POOR - water quality problems originating from mines create stress conditions for most fish species, sensitive species are lost due to the cumulative impacts of reduced water quality and flow modifications and obstructions. The ***Macro-invertebrate Integrity*** is POOR with water quality having the largest impact on invertebrate diversity and abundances and flow and habitat modifications contributing to low scores.

Water Quality is FAIR - flows have intermediate levels of nutrients and emerging signs of water quality problems with organic pollution likely to contribute to eutrophication of the sites sampled. Impacts on water quality originate primarily from mining activities with mines acting as a salt sink, increasing salinity levels in both surface and groundwater resources.

Ecological Importance and Sensitivity (EI&S)

The EI&S is MARGINAL / LOW - low scores can be attributed to the low diversity of species and habitat types within this reach of river, primarily the result of severe modifications of flows and of channel morphology.

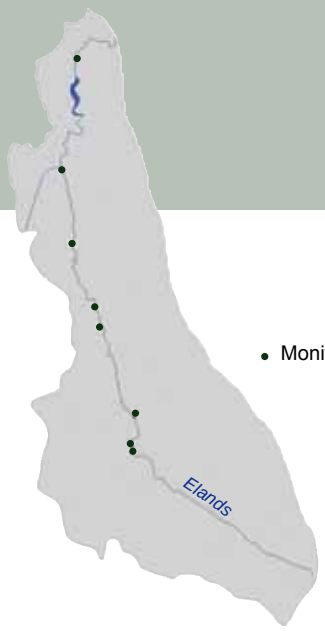
Drivers of Change

- Mining operations - flow and channel alterations, and reduced water quality (high salinity levels)
- Informal settlements related to mining activities - impacts on water quality and natural resource use
- Groundwater usage for citrus farming along the northern foot of the Magaliesberg range

Management Responses

- Zone, licence and monitor mining activities
- Monitor water quality to ensure resource directed water quality objectives are being adhered to
- Rehabilitate riparian vegetation
- Monitor and manage sewage and solid waste disposal from informal settlements

UPPER ELANDS



EcoStatus			
G-F-F	F	F	G
Ecological Importance & Sensitivity			
MODERATE			

EcoStatus

The overall EcoStatus for this study unit is FAIR and comprises the following indices:

Instream Habitat Integrity is GOOD - water abstraction and flow modification is low due to the presence of small dams and weirs which have little impact. However there is some turbidity which may be sedimentation from the shale and slasto mining and farming activities adjacent to the river. The ***Riparian Zone Habitat Integrit***y is FAIR - alien vegetation encroachment has resulted in some bank erosion and mining activities have resulted in some channel modification. The ***Riparian Vegetation Integrity*** is FAIR - there is a large infestation of wattle species along this reach and some vegetation clearing for dryland agriculture along the river banks.

The ***Fish Assemblage Integrity*** is FAIR to GOOD with some sensitive species possibly lost due to turbidity and sedimentation from slate quarries. The ***Macro-invertebrate Integrity*** is FAIR, primarily because of the sensitivity of invertebrates to turbidity and sedimentation.

Water Quality is GOOD - flows have between low and intermediate levels of nutrients and are free from significant organic pollution.

Ecological Importance and Sensitivity (EI&S)

EI&S is MODERATE - there is a range of diverse instream habitats (waterfalls, rapids and pools) as well as many wetlands in the highveld area. In the lower reaches there is cattle and game farming with some overgrazing.

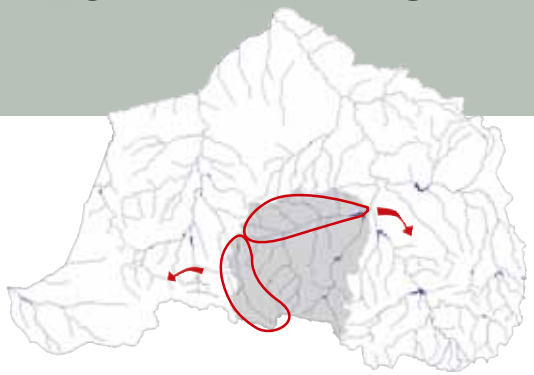
Drivers of Change

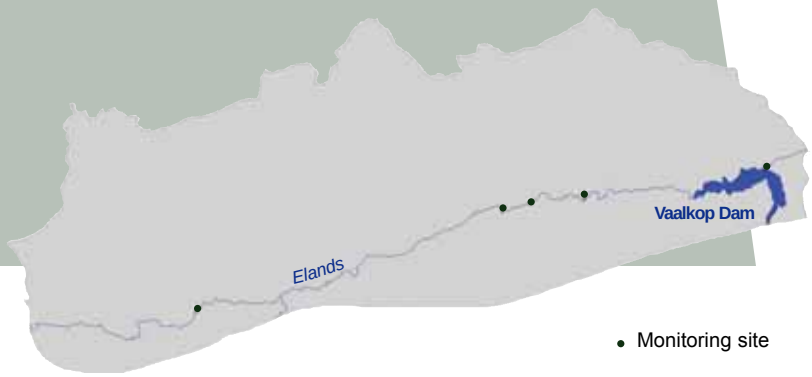
- Sedimentation resulting from the slate quarries and agriculture
- High infestation of alien plant species
- Inadequate management of some sewage treatment facilities

Management Responses

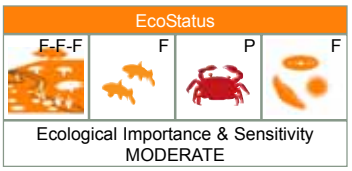
- Manage mining activities to reduce sedimentation
- Clear alien vegetation in riparian zone
- Map and monitor highveld wetlands to ensure protection and continued functioning as sediment traps

LOWER ELANDS





• Monitoring site



EcoStatus

The overall EcoStatus for this study unit is FAIR and comprises the following indices:

The ***Instream Habitat Integrity*** is FAIR to POOR - this is primarily due to the mines and development in the area. The majority of these negative impacts are however confined to localised areas; the upper reaches of the river are in satisfactory condition. The ***Riparian Zone Habitat Integrity*** is FAIR with some return flows from the mines, although very localised, and some potential bank erosion problems in the future due to large toppling bushwillow trees. The ***Riparian Vegetation Integrity*** is FAIR due to some degraded areas in the lower reaches.

The ***Fish Assemblage Integrity*** is FAIR - sensitive species are lost due to flow modification and obstruction of movement. Water quality problems originating from mines create stress conditions for fish species along some sections. ***Macro-invertebrate Integrity*** is POOR mostly because of reduced water quality and habitat alteration.

Water Quality is FAIR mainly because of large settlements and mines in the area. Flows have intermediate levels of nutrients and there is emerging evidence of organic pollution - this might be nutrients from the surrounding platinum mines.

Ecological Importance and Sensitivity (EI&S)

The EI&S is MODERATE - diversity of habitats is low with some deep kloofs and pools in the Pilanesberg area. The Vaalkop Dam and the Pilanesberg Nature Reserve provide some protection of the indigenous vegetation in the area as well as a number of game farms along the river.

Drivers of Change

- Informal settlements contributing to organic pollution
- Platinum mining operations - nutrient rich return flows
- Urban settlements - spillages and discharges reducing water quality

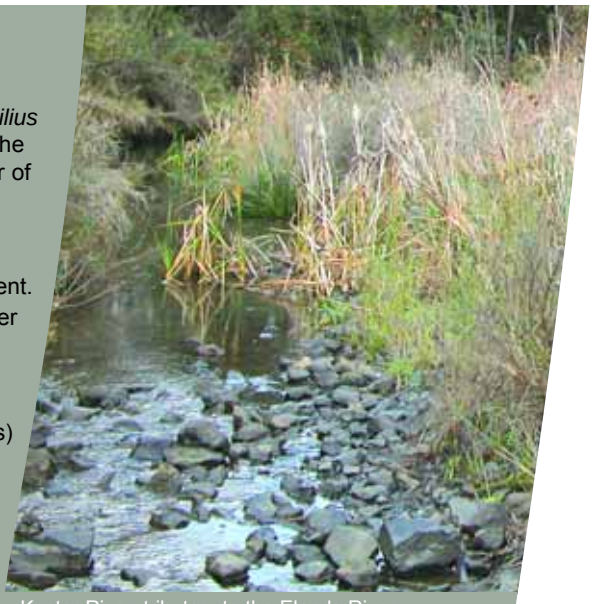
Management Responses

- Manage mining activities to reduce water quality problems
- Plan settlements not to impinge on riparian zone
- Stabilise bank erosion
- Improve on management of water quality impactors, e.g. tannery and sewage treatment works

THE ELANDS RIVER

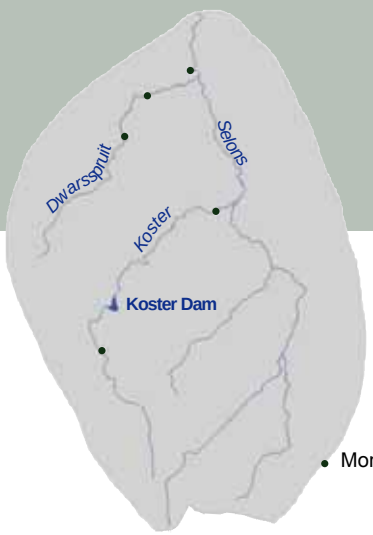
Two fish species, *Chiloglanis pretoriae* (shortspine suckermouth) and *Amphilius uranoscopus* (stargazer mountain catfish) were conspicuously absent from the Elands River. Both species are highly dependent on clear, fast flowing water of good quality. Possible scenarios that may explain their absence include:

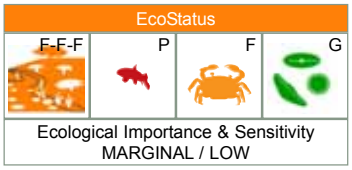
- The Elands River was naturally perennial but these species were never able to invade this tributary due to a natural obstruction to their movement.
- The Elands was perennial and colonized by both species. When the river stopped flowing in the dry season (became seasonal) due to water abstraction for agricultural use together with use by alien trees next to the river, both species disappeared.
- Extensive slate quarries along the upper Elands River (up to Swartruggens) had a detrimental influence on the water quality, especially in terms of increased turbidity and fine sediment, influencing their spawning success and food source (riffle-dwelling aquatic invertebrates). This, together with generally decreasing flows, has led to the disappearance of both species from the Elands River.



Koster River, tributary to the Elands River

SELONS / KOSTER





EcoStatus

The overall EcoStatus for this study unit is FAIR and comprises the following indices:

Instream Habitat Integrity is FAIR - downstream of Koster Dam flow is regulated for irrigation purposes. Releases are fairly constant but not all the water is used for irrigation therefore some water flows downstream of the dam. In the upper reaches of the catchment tributaries are seasonal and are fed by natural springs. The ***Riparian Zone Habitat Integrity*** is FAIR with some flow modification between the Koster Dam and the confluence of the Koster and Selons rivers. Water abstraction for irrigation is evident. The ***Riparian Vegetation Integrity*** is FAIR because of severe infestation by alien vegetation, primarily seringa and poplars in the upper reaches.

The ***Fish Assemblage Integrity*** is POOR with considerably reduced frequency of occurrence of species due to flow obstructions and water abstraction - mostly hardy species are present. These are *Barbus paludinosus* (straightfin barb), *Pseudocrenilabrus philander* (Southern mouthbrooder) and *Tilapia sparrmanii* (vleikurper or banded tilapia). The ***Macro-invertebrate Integrity*** is FAIR mainly due to flow modifications.

Water Quality is GOOD, flows have between low and intermediate levels of nutrients and the water is free from significant organic pollution.

Ecological Importance and Sensitivity (EI&S)

EI&S is MARGINAL / LOW with very low scores for species and habitat diversity. Most refugia and migration corridors are localised and very little land is formally protected.

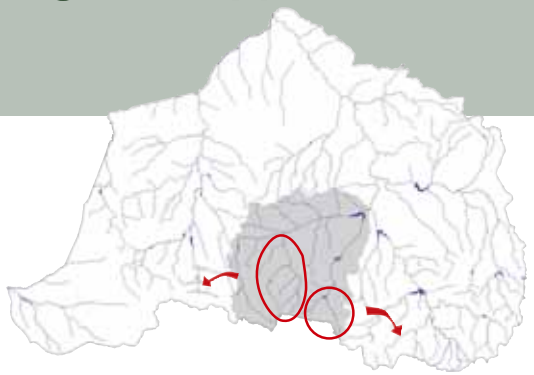
Drivers of Change

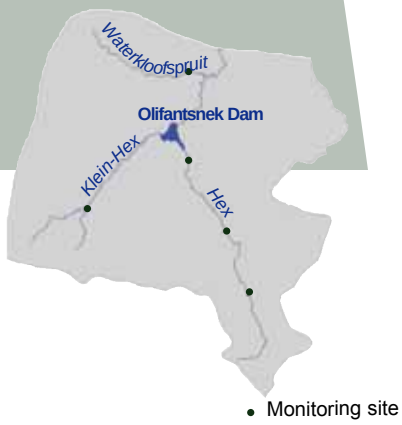
- Impoundment of river altering natural flow regimes
- Water abstraction for irrigation not efficient

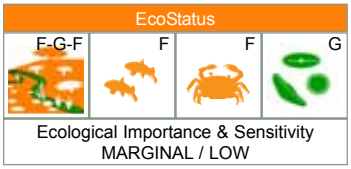
Management Responses

- Clear alien vegetation from riparian zone and catchment
- Manage water use and investigate abstraction for irrigation to ensure scheme is efficient

UPPER HEX







EcoStatus

The overall EcoStatus for this study unit is FAIR and comprises the following indices:

Instream Habitat Integrity is FAIR - Olifantsnek Dam is situated at the confluence of the Hex and Klein Hex rivers, there is some water abstraction from the river for irrigation purposes and some sedimentation as a result of bank erosion. Low abundances of *Myriophyllum aquaticum* (parrot's feather) were observed. The ***Riparian Zone Habitat Integrity*** is GOOD with only localised areas of erosion adjacent to river bridges. Downstream of the Olifantsnek Dam there is some localised impacts, upstream of the dam natural vegetation predominates. The ***Riparian Vegetation Integrity*** is FAIR - there is some infestation by poplar species, although not very abundant. Wattle infestation in parts of the catchment is severe.

The ***Fish Assemblage Integrity*** is FAIR - this is attributable to water abstraction in some sections which lowers the frequency of occurrence of some species, although some sensitive species such as minnows and yellowfish are still present. ***Macro-invertebrate Integrity*** is FAIR - impacts are mostly due to localised habitat alteration.

Water Quality is GOOD - flows have between low and intermediate levels of nutrients and are free from significant organic pollution. Waterkloofspruit is well known for its exceptionally good water quality.

Ecological Importance and Sensitivity (EI&S)

EI&S is MARGINAL / LOW primarily because of the low diversity of habitat in this reach of the river, although the wetlands at Waterkloofspruit are significant. The Kgashwane Mountain Reserve and the Magaliesberg Protected Natural Environment (MPNE) conserve the natural landscape and restrict development.

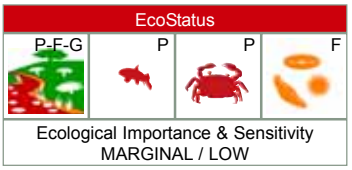
Drivers of Change

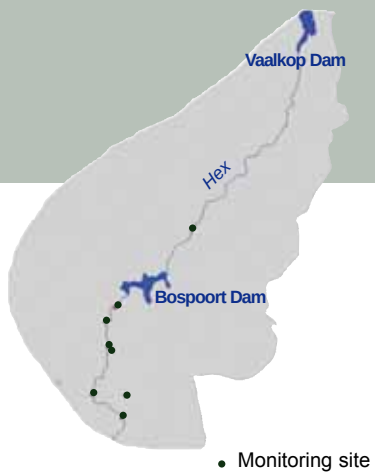
- Water abstraction for irrigation
- Downstream impacts of dam - alteration of natural flow regimes

Management Responses

- Clear alien species from riparian zone and catchment
- Stabilise localised erosion points
- Control solid waste dumping and burial
- Regulate water use of irrigation schemes
- Determine environmental flow requirements and implement the ecological reserve
- Identify and monitor wetlands to ensure ecological functions are maintained

Lower Hex





EcoStatus

The overall EcoStatus for this study unit is POOR and comprises the following indices:

The ***Instream Habitat Integrity*** is POOR, primarily because of high levels of development especially in terms of mining activities as well as water abstraction for irrigation purposes. There are a number of weirs that comprise the irrigation scheme but their use is limited. Stretches of the river have been diverted for the mines but more recently for the upgrade of the N4 Platinum Toll Highway.
The ***Riparian Zone Habitat Integrity*** is FAIR - channel modifications caused by diversions for mining have impacted on riparian zone habitats. The ***Riparian Vegetation Integrity*** is GOOD - there is some vegetation clearing for sand winning activities and some pockets of sesbania and blue gums, both of which are very localised.

The ***Fish Assemblage Integrity*** is POOR - sensitive species are lost due to flow modifications and obstructions. Water quality problems originating from the mines and from agriculture have created stress conditions for fish species.
The ***Macro-invertebrate Integrity*** is POOR, the cumulative impacts of reduced water quality and, flow and habitat modifications have had a large effect on invertebrate diversity and abundance.

Water Quality is FAIR - flows have between low and intermediate levels of nutrients but are largely free of significant organic pollution. High conductivity readings were recorded - high salinity levels are possibly due to mines.

Ecological Importance and Sensitivity (EI&S)

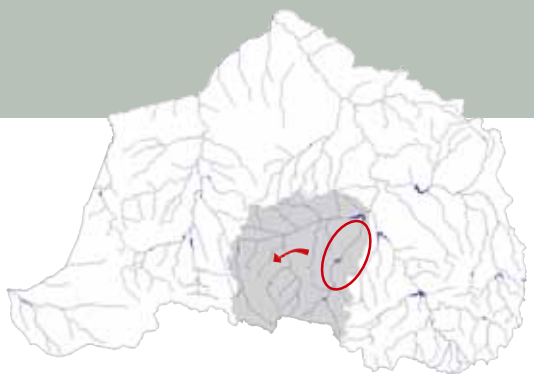
The EI&S is MARGINAL / LOW - diversity of habitat and species is low with some localised refugia for slightly sensitive species and protected natural area in the form of a conservancy around Bospoort Dam.

Drivers of Change

- Mining operations - river diversions and polluted discharges and seepages
- Road construction - river diversions for the N4 Platinum Toll Highway and mining activities

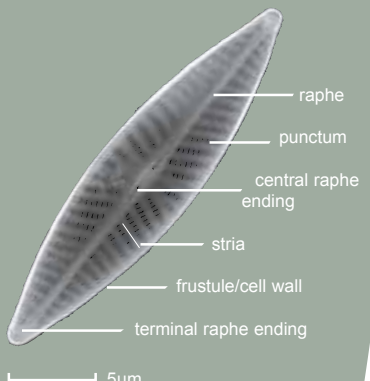
Management Responses

- Manage mining activities through the issuing of water use and discharge licences
- Monitor water use for irrigation purposes - investigate more efficient use of irrigation water
- Consider installing fish ladders in suitable weirs



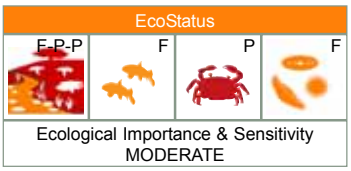
What are the characteristics of a Diatom?

- A unique cell wall composed of silica known as a frustule
- A raphe fissure or slit (found in many but not all diatoms) which allows the diatom to move when mucilage is excreted
- A golden-brown chloroplast containing the pigment fucoxanthin
- Food reserves are stored as oil droplets, which add buoyancy to counteract the heavy silica frustule and chrysolaminarin for starch storage
- Diatom communities are composed of a myriad of species, each of which has a specific preference or tolerance towards water quality variables
- For many diatom species these specific pollution tolerances are known
- If the water quality tolerances for the majority of species within a community (the dominant species) are known then conclusions may be drawn regarding the water quality of the site from which the diatoms were taken



Diatom

Sundays



EcoStatus

The overall EcoStatus for this study unit is FAIR and comprises the following indices:

The ***Instream Habitat Integrity*** is FAIR to GOOD - the river flows through cattle and game farming land. Water abstraction is limited to a few irrigation areas. Numerous weirs were present in the river prior to the 2000 floods - most of these were destroyed, those remaining have limited take-off. Some overgrazing combined with Sandveld has led to considerable deposition of sand in pools and on bends. Flow variability is still good. The ***Riparian Zone Habitat Integrity*** is POOR mainly due to bank erosion that was caused by damaged weirs, while some erosion is due to overgrazing. There is some encroachment of terrestrial species into the riparian zone which indicates some flow modification - although vegetation is largely natural and bank structure is generally intact. ***Riparian Vegetation Integrity*** is POOR - Agriculture, resorts and stock have the greatest impact on the riparian vegetation. The Sundays system has a high number of riparian species and in the upper sections the vegetation is good (e.g. the Vingerkraal-se-loop tributary to the Sundays). There is some alien vegetation encroachment by seringa, prickly pear and herbaceous aliens.

The ***Fish Assemblage Integrity*** is FAIR - moderately sensitive species still occur; the lower sections are impacted by water abstraction during low flow periods. ***Macro-invertebrate Integrity*** is POOR - the upper sections of this river reach are generally in good condition, it is the lower reaches where reduced water quality and habitat alteration impact on invertebrate diversity.

Water Quality is FAIR, flows have between low and intermediate levels of nutrients and are free from significant organic pollution - impacts are primarily due to agricultural return flows.

Ecological Importance and Sensitivity (EI&S)

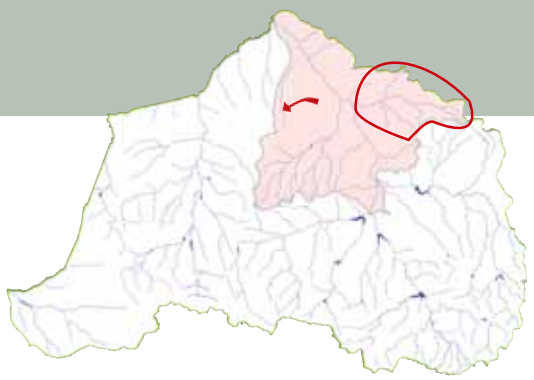
The EI&S is MODERATE - diversity of species is moderately high, influenced by the location of the river in a transition zone between Waterberg and Bushveld. There are many interconnecting tributaries which provide a diverse range of habitat and refugia for many species. The Marakele Reserve and numerous game farms offer protection of natural areas.

Drivers of Change

- Alien vegetation encroachment in the riparian zone
- Flow modifying structures - damaged weirs

Management Responses

- Clear alien vegetation from riparian zone
- Ensure that an EIA is undertaken if the repair of any of the damaged weirs is being considered
- Monitor agricultural return flows
- Determine natural flow regime of river and the ecological reserve
- Minimise overgrazing to reduce sediment input into the river



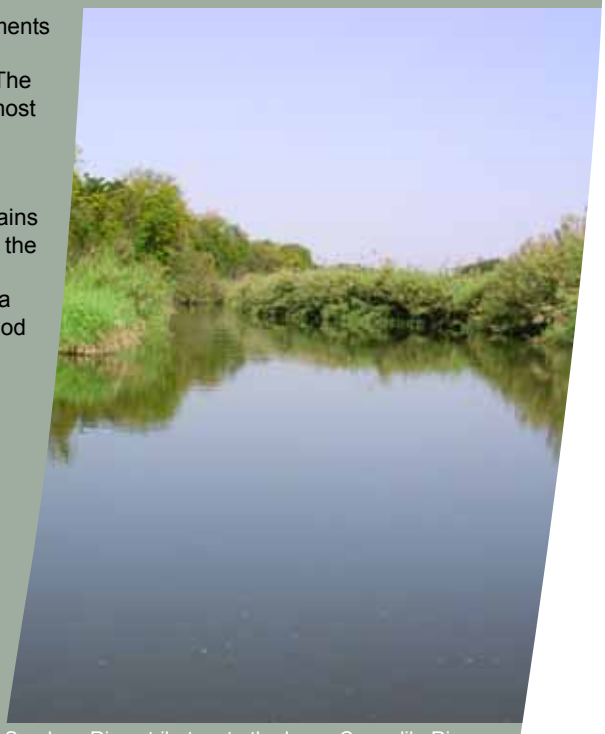
The Importance of the Sundays River to the Lower Crocodile River

Cumulative impacts arising from the upper and middle Crocodile River catchments have seriously affected the flow regime of the lower Crocodile River. In most years, the river stops flowing and the diversity of aquatic fauna is declining. The river is also seriously fragmented by the placement of dams and weirs and most of these structures are barriers to the free movement and migration of fish species.

The Sundays River and its Sand River tributary, rise in the Waterberg Mountains and join the Crocodile River a short distance upstream from Thabazimbi and the Ben Alberts Nature Reserve. For most of its length, the river flows through game and cattle country. The foothill zone of the Sundays River also boasts a number of wetlands. There are very few weirs along the river and there is good connectivity between the Crocodile River and the Waterberg. These factors result in the Sundays River to be in a markedly better ecological condition than the remainder of the lower Crocodile River catchment.

It is therefore apparent, that the Sundays River is both acting as a refuge for the more sensitive biota of the lower Crocodile River, while also providing a near permanent supply of relatively clean water to the lower river. This rejuvenation of flow is viewed as an important factor in maintaining the status of the Crocodile River in the Thabazimbi area and for maintaining the river in the Ben Alberts Reserve.

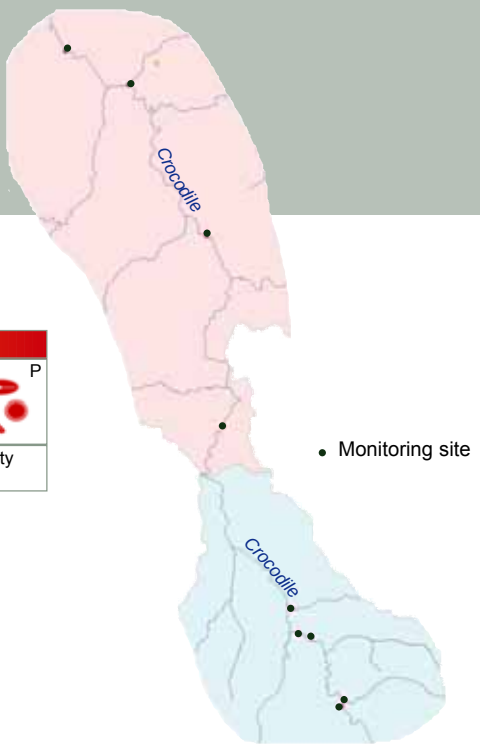
It is strongly recommended that no developments should be considered in this catchment without a detailed study of the environmental implications.

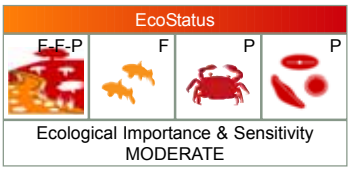


Sundays River, tributary to the lower Crocodile River

Lower Crocodile
Sub-Management Area

Middle Crocodile





EcoStatus

The overall EcoStatus for this study unit is FAIR / POOR and comprises the following indices:

Instream Habitat Integrity is FAIR - the Hartbeespoort Dam releases water into canals and the river for irrigation purposes. Releases from the Roodekopjes Dam are also fairly constant therefore the river flows throughout the year. Excess water seeps into sand aquifers from which it is abstracted. This excess base flow impacts on the natural flow and flood regimes. The ***Riparian Zone Habitat Integrity*** is FAIR with some localised areas of bank erosion in the Atlanta area. Higher than normal base flows stimulate the growth of riparian vegetation. The ***Riparian Vegetation Integrity*** is POOR to FAIR with some land cleared for irrigation of agricultural fields. Alien vegetation is widespread - seringa, sesbania, weeping willow and Spanish reed are the most common species.

The ***Fish Assemblage Integrity*** is FAIR to POOR with sensitive species such as *Chiloglanis spp.* (rock catlet or suckermouth) still present due to increased base flows and presence of rapids and riffles where dissolved oxygen concentrations are high. Reduced water quality due to urban return flows, impoundments and industrial discharges is impacting on fish diversity. Eels are lost from the system due to migration obstructions.

Macro-invertebrate Integrity is POOR - eutrophication causes algal growth on hard surfaces in rapids and riffles leading to loss of suitable habitat.

Water Quality is POOR - flows have between low and intermediate levels of nutrients with some evidence of organic pollution. Sources of pollution are primarily urban and industrial diffuse source return flows.

Ecological Importance and Sensitivity (EI&S)

EI&S is MODERATE - habitat diversity is low primarily because the landscape has lost the various floodplain geomorphic features. Roodekopjes Dam has some surrounding wetland habitat which attracts water birds, however very little natural area is formally protected. Some sections of the river are still fine - the value of the natural environment as a legitimate land-use still needs to be recognised.

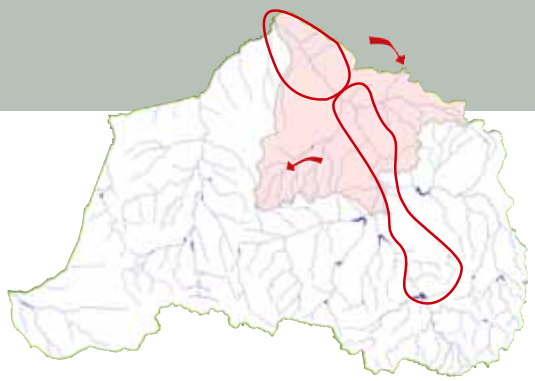
Drivers of Change

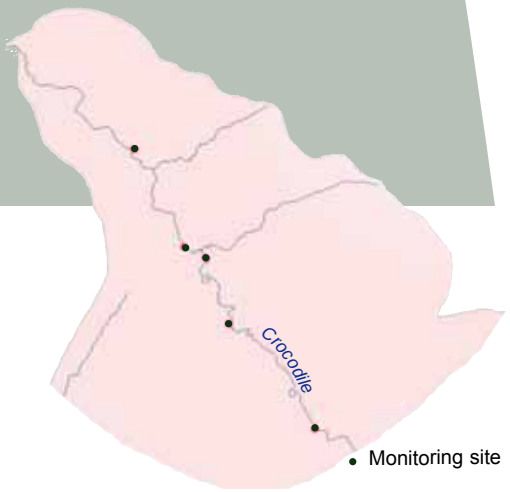
- Impoundments altering natural flow regime
- Reduced water quality - eutrophication of water
- Invasive aliens encroaching on riparian zone

Management Responses

- Control snowball effect of development - monitor land-use changes
- Enforce compliance of water quality standards
- Clear alien vegetation in riparian zone and in catchment
- Rehabilitate riparian habitat to restore the river's ability to provide ecosystem services such as flood attenuation and sediment trapping

LOWER CROCODILE





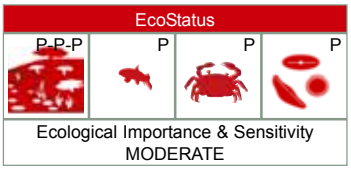
EcoStatus

The overall EcoStatus for this study unit is POOR and comprises the following indices:

The ***Instream Habitat Integrity*** is POOR - there is extensive irrigation and multiple abstraction points along this reach of river which has a severe impact on river functioning. Flows are regulated through a series of weirs and dams resulting in unseasonal releases (to maintain irrigation) which leads to undercutting of river banks and increased sedimentation.
Riparian Zone Habitat Integrity is POOR - the large number of dams in this region and upstream are causing a loss in flow variability. Low flows are depositing fine sediments in pools and on bends. A lack of high flow events is resulting in reed encroachment and the encroachment of terrestrial vegetation on flood benches.
Riparian Vegetation Integrity is POOR - riparian vegetation has been cleared in many areas for agriculture and the setting up of pumps using the water from the river. A number of game farms along the river protect certain sections of the riparian vegetation. Syringa and castor-oil plants are the main alien species threatening this section of the river as they are found in large numbers. The area of the Crocodile River near the Kilpspruit confluence has high levels of agriculture which has degraded the riparian zone in many areas.

Fish Assemblage Integrity is POOR - only hardy species are present, loss of habitat and connectivity of the river has resulted in stress conditions for most fish species.
Macro-invertebrate Integrity is POOR - reduced water quality and diminished flows are leading to dry sections and isolated pools. This reduction in suitable habitat has a severe impact on invertebrate diversity.

Water Quality is POOR - flows have between low and intermediate levels of nutrients and the sites sampled are heavily contaminated with organic pollution. Low scores can be attributed to high agricultural return flows.



Ecological Importance and Sensitivity (EI&S)

EI&S is MODERATE - this is a low gradient river therefore instream habitat diversity is naturally low, however a large number of pools and weir backwaters provide refuge for a variety of species including crocodiles, hippos and otters. This river reach provides a corridor from the Limpopo to the Bushveld which is very important for the migration of birds and animals. Private game farms offer some degree of protection of the surrounding natural landscape.

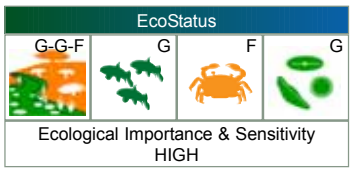
Drivers of Change

- Extensive water use for agricultural purposes - abstraction for irrigation impacts on natural flow regime of the river
- Dams and weirs act as barriers to flow and the migration of fauna
- Reduced water quality due to agricultural return flows

Management Responses

- Control water use and manage water abstraction for irrigation purposes
- Determine environmental flow requirements and implement the ecological reserve
- Monitor and control agricultural return flows
- Stabilise bank erosion
- Clear alien invasives from the riparian zone

GROOT MARICO



- Monitoring site

EcoStatus

The overall EcoStatus for this study unit is GOOD / NATURAL and comprises the following indices:

Instream Habitat Integrity is GOOD but is affected by agricultural return flows and water abstraction. There are a number of farm dams and old furrows adjacent to and within the river channel as well as some development upstream of the Marico-Bosveld Dam. Overall the ***Riparian Zone Habitat Integrity*** is GOOD. There is minimal impact on the riparian zone due to existing flow regulating structures and no increasing trend of land clearing for agriculture in the riparian zone.
The ***Riparian Vegetation Integrity*** is FAIR. This is primarily because of the presence of alien vegetation such as various species of wattle, blue gum, seringa and Spanish reed.

Fish Assemblage Integrity is GOOD to NATURAL. The tributaries feeding into the Groot Marico are fairly clear of sediment and several sensitive species were found, these include *Amphilius sp.* (stargazer mountain catfish), *Chiloglanis sp.* (rock catlet or sucker-mouth), *Labeobarbus marequensis* (large-scale yellowfish) and *Labeobarbus polylepis* (small-scale yellowfish).
The ***Macro-invertebrate Integrity*** is FAIR, this is mainly due to localised poor water quality and habitat alteration.

Water Quality is GOOD. The nitrogen and phosphate levels were classified as between low and intermediate and according to the percentage of species tolerant to organic pollution the water was considered free from significant organic pollution.

Ecological Importance and Sensitivity (EI&S)

EI&S is HIGH, development in this region is low therefore natural vegetation predominates. This reach of the river is perennial therefore it provides refugia for a number of species, however the Marico-Bosveld Dam and other weirs prevent the migration of certain fish species and eels upstream. There are a number of wetlands above the dam along the tributaries feeding into the Marico. The Marico-Bosveld Nature Reserve conserves the area surrounding the dam. The *Tilapia sparmanii* (banded tilapia) in the Marico Eye are genetically unique and unique invertebrate species also occur here.

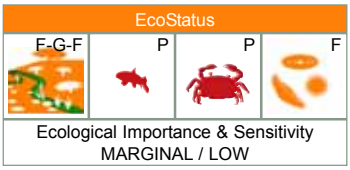
Drivers of Change

- Flow regulating structures - dams and weirs - especially the Marico-Bosveld Dam
- Water abstraction for irrigation
- Shale and slasto mining on the Highveld along some tributaries
- Recreational activities (diving and camping) in the source area
- Alien fish (Bass) in the upper reaches of the Kaaloog-se-loop

Management Responses

- Clear alien vegetation in riparian zones
- Consider installing fish ladders and eelways in suitable flow regulating structures
- Identify and map wetlands that occur for potential future protection
- Stabilise areas of local erosion
- Monitor agricultural return flows to ensure reduced non-point source pollution
- Monitor recreational activities and implement control measures
- Control alien fish
- Ensure that the ecological reserve is determined and maintained.

KLEIN MARICO



EcoStatus

The overall EcoStatus for this study unit is FAIR and comprises the following indices:

Instream Habitat Integrity is FAIR, this is primarily due to the presence of the Klein-Maricopoort and Kromellenboog dams. Both dams impact on the levels of water in the river and natural sedimentation patterns. Above the Klein-Maricopoort Dam habitat integrity is less impacted. The ***Riparian Zone Habitat Integrity*** is GOOD primarily because of the low levels of development in the area. At Oopgenoeg and Nahoek water abstraction has resulted in some wetlands drying up.
The ***Riparian Vegetation Integrity*** is FAIR due to the presence of alien vegetation and the removal of some vegetation for agriculture.

Fish Assemblage Integrity is POOR, only the most hardy of species are present due to reduced flows and localised poor water quality.
The ***Macro-invertebrate Integrity*** is POOR due to the impact of the dams on water flow but primarily due to the impacts of reduced water quality especially near the town of Zeerust.

The ***Water Quality*** in general is FAIR - flows have intermediate levels of nutrients and there is some evidence of organic pollution.

Ecological Importance and Sensitivity (EI&S)

EI&S is MARGINAL / LOW, overall diversity of habitat types is low. There are however some locally unique areas with noteworthy features such as abundant and often large, Wild Olive trees at Ottoshoop and Molemane Eye Game Reserve. The Molemane dolomitic eye and associated wetland represents a unique, relatively undisturbed wetland ecosystem and is rich in invertebrate species with some unique and isolated fish populations.

Drivers of Change

- Water abstraction
- Return flows from urban runoff at Zeerust
- Impoundment of river altering natural flow regimes
- Sedimentation of Kromellenboog Dam
- Alien fish (Bass) in the upper reaches of the Molemaneloop

Management Responses

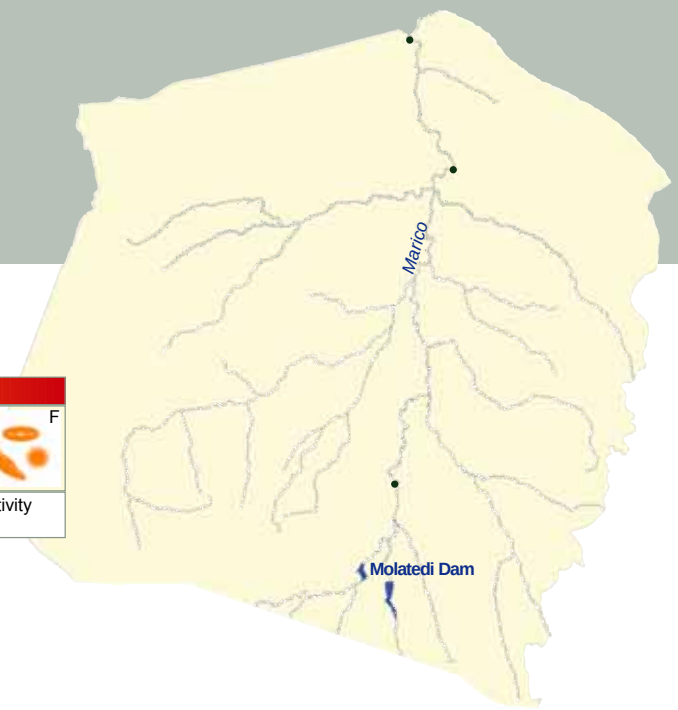
- Identify sources of urban runoff that impacts on water quality
- Clear alien vegetation from riparian zone
- Ensure that the ecological reserve is determined and maintained
- Map and monitor wetlands to ensure future ecological functioning
- Control alien fish

HERMAN CHARLES BOSMAN

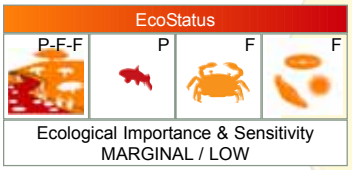
Herman Charles Bosman is regarded as one of South Africa's pre-eminent writers of short stories. His work has left a treasury of stories, essays, chronicles and poems, mostly woven around the follies, idiosyncrasies, humaneness and nobility of the human spirit. Bosman was born in 1905 at Kuilsrivier, near Cape Town. Shortly afterwards his family moved to Johannesburg where he was educated. On receiving his degree, Bosman was appointed to a teaching post in the Groot Marico district. A most fruitful year, for the place and the people enthralled him. They provided him with the background for his best-known works, the Oom Schalk Lourens and Voorkamer sketches, in which he managed to capture the Great Marico of the 1930s and 1940s in a timeless air of nostalgia.

(Source: The Herman Charles Bosman Literary Society; http://www.marico.co.za/ accessed 4/1/2005)

Middle Marico



• Monitoring site



EcoStatus

The overall EcoStatus for this study unit is FAIR / POOR and comprises the following indices:

Instream Habitat Integrity is POOR - the demand for water exceeds supply. Water abstraction for irrigation is high resulting in serious flow modification, resulting in some cases in tributaries becoming dry. The impoundments Kromellenboog, Marico Bosveld and Molatedi dams impact on the natural flow regime of the river. The ***Riparian Zone Habitat Integrity*** is FAIR - water abstraction has resulted in vegetation in the riparian zone tending towards a terrestrial nature because of the drying up of the river. This has also resulted in some areas experiencing heavy erosion which is exacerbated by overgrazing. The ***Riparian Vegetation Integrity*** is FAIR to GOOD with some clearing of riparian vegetation for maize fields.

Fish Assemblage Integrity is POOR - considerably lowered frequency of occurrence of species was encountered, primarily due to water obstructions and abstractions. Only hardy species were naturally present. ***Macro-invertebrate Integrity*** is FAIR to POOR primarily because of flow modification and reduced water quality from agricultural return flows.

Water Quality is FAIR - flows have between low and intermediate levels of nutrients and the percentage of species tolerant to organic pollution indicates flows are free from significant organic pollution.

Ecological Importance and Sensitivity (EI&S)

EI&S is MARGINAL / LOW - species and habitat diversity is low, the three dams impact on the river's flow regime and thus on the riparian ecosystems. There are some game farms below Molatedi Dam and the Madikwe Nature Reserve conserving some natural habitat in the area.

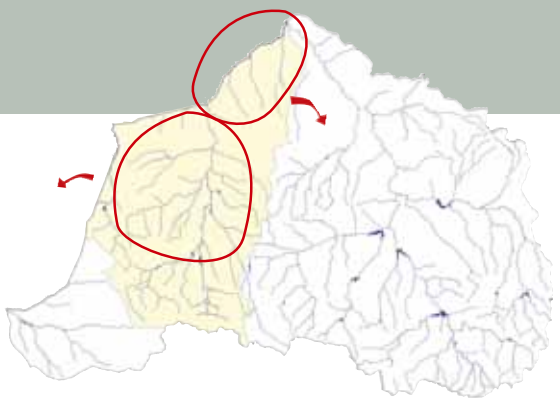
Drivers of Change

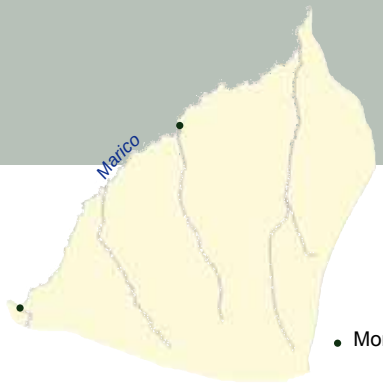
- Water demand exceeding supply
- Impoundments altering natural flow regimes
- Irrigated commercial farmland and water abstraction
- Overgrazing

Management Responses

- Establish environmental flow requirements
- Determine measures to facilitate a more favourable water balance (demand vs. supply)
- Investigate dam releases that simulate natural flow patterns
- Establish erosion rehabilitation programmes
- Control overgrazing and infestation by sickle bush

LOWER MARICO





EcoStatus

The overall EcoStatus for this study unit is FAIR and comprises the following indices:

The **Instream Habitat Integrity** is POOR, this is primarily because of flow releases from the Molatedi Dam. Water is released every 4 to 6 weeks into some weirs for irrigation and supply to Botswana. The surrounding area is quite flat and this results in the inundation of large areas covering shallow instream habitats. Therefore although the releases are beneficial to riparian vegetation, they are having a detrimental effect on aquatic biota. The ***Riparian Zone Habitat Integrity*** is FAIR - At Molatedi Dam there is a large variety of vegetation, which is abundant due to the mixed bedrock streambed. The vegetation is highly impacted by the lack of water downstream of Molatedi. Although there are many old established trees, the extent of riparian vegetation cover is low, ground cover and indigenous riparian tree species recruitment is low. The flow regulation in this area can potentially impact on the extent of the riparian zone and the riparian species present. The large thorn apple, Kariba weed and the large cocklebur are the alien plant species found in this area. The ***Riparian Vegetation Integrity*** is GOOD - the vegetation is in good condition because on the South African side of the border fence there is a foot and mouth fence which protects the riparian zone. Cultivation adjacent to the river is limited due to steep riverbanks.

The ***Fish Assemblage Integrity*** is POOR - frequency of occurrence of species is low due to reduced flows. Mostly hardy species are present. ***Macro-invertebrate Integrity*** - there are no SASS scores for this reach of river.

Water Quality - there was no diatom data sampled in this reach of river therefore no score is available; however water quality is reduced because of irrigation return flows.

EcoStatus			
P-F-G	P	No Data	No Data
Ecological Importance & Sensitivity MODERATE			

Ecological Importance and Sensitivity (EI&S)

EI&S is MODERATE - the surrounding landscape is dry therefore the riparian zone offers refugia for many species of amphibians and birds including the white-backed vulture. The area comprises mostly game farms, while on the Botswana side communal farming and hunting game farms are common.

Drivers of Change

- Irrigated commercial agriculture - farmers request water from dams when levels in weirs are low

Management Responses

- The riverbed downstream of Molatedi Dam is dry and the rapid release of water would lead to erosion. Natural flow should be simulated by regulated releases

THE LOWER CROCODILE AND MARICO FISH AND AQUATIC INSECT LIFE

In both the Lower Crocodile and Marico rivers, flows are largely managed on demand for irrigation purposes. This results in unseasonally high pulses of flow in the river and extended periods of low flow. The managed flow regime, when combined with the large numbers of dams and weirs, has resulted in river habitats becoming severely fragmented with what were largely perennial rivers now being distinctly seasonal in nature. For extended periods, weirs and deep pools are the only refuge for any aquatic life. The fish and invertebrates that still occur in the river are very tolerant species that can survive the impacts of water regulation and pollution.

While it is recognised that these rivers have been in a largely modified condition for many years, it is suspected that the status of the lower catchment could still be declining. Through improved management this downward trend can be mitigated.

Upper Molopo

Sub-Management Area

Upper Molopo

No bio-monitoring took place in the Upper Molopo sub-management area in this 2004 survey. It is the intention of subsequent surveys that the scope of biomonitoring be broadened to include this area. The information presented in this section is based on previous, unrelated surveys and provides some interesting background information on the area.

Drivers of Change

- Dams in the river
- Poor sanitation and sewage return flows
- Mining/cement industries in the catchment
- Insufficient storm water systems
- Erosion due to over grazing
- Lack of solid waste management

Unique biota	Major threats	Surrounding land-use
Fish The cichlid fish (*Tilapia sparmanii*) is genetically and morphologically distinct from other known conspecific populations and reclassification as a new species is currently under investigation. Insecta Three new mayfly (Ephemeroptera) distribution records One new dragonfly (Odonata) species Two new caddisfly (Tricoptera) species Crustacea Four new seed shrimp (Ostracods) distribution records and one new species	Habitat loss due to weir construction and water abstraction. The ecological reserve still has to be determined. Wetlands do not receive enough water flow due to abstraction for domestic use in Mafikeng. This is a direct threat to the shortfin barb population. Pesticide and herbicide use for red-billed quelea *(Quelea quelea)* control threatens the water quality and reed habitat. Alien bass (*Micropterus salmoides*) predate on indigenous fish and invertebrate species. The bass have already restricted the distribution of the shortfin barb to the reed areas downstream of the eye. Construction of roads and presence of weirs leads to genetic isolation of biota. Water quality threats include leaching from septic tanks and agricultural chemicals.	Area around the eye is used as holiday accommodation (100 houses, used since 1900's) and is part of a conservancy. Recreational use is limited to non-motorized activities. Major land-use in the area is agriculture, mostly cattle.

The unique dolomitic eyes of the Crocodile (West) Marico Water Management Area

Dolomitic eyes are water bodies fed by groundwater originating from fractures in the underlying dolomite. The fractures and intrusions of geological formations impenetrable to water in the dolomite form aquifers, dolomite compartments and dolomitic eyes. Aquifers are subterranean waterways/ tunnels and reservoirs from which water is forced above ground through openings (fractures), which are called dolomitic eyes or springs.

The dolomitic area covers approximately 4022 km^2 of the North West Province and forms the main catchment of the east-flowing Limpopo River system and the west-flowing Molopo River. The interdependence of ground and surface water is apparent in the ecology of the dolomitic eyes. These eyes are influenced by the water quality and quantity of both the surface water and the groundwater.

The sources of the Molopo, Molemane and Marico rivers are unique dolomitic eyes (springs) and associated wetland systems. These dolomitic eyes are of great conservation significance as they are biologically unique. One of the main contributing factors to the unique resident ecological communities is the geographical isolation at surface water level. Eyes have been isolated for millennia, allowing for speciation through genetic mutations and adaptation to localized environmental conditions. The groundwater linkages in the aquifer systems contribute to the sensitivity of the dolomitic eyes as groundwater abstraction kilometers away could reduce the water levels at the dolomitic eyes.

The J.L.B Smith Institute of Ichthyology was contracted by the Department of Nature and Environmental Conservation to study the dolomitic ecosystems in the Western Transvaal. The table above highlights some of the results of this study that emphasized the biological diversity and major threats to the dolomitic eyes (Skelton et al. 1994).

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REFERENCES

Departement of Water Affairs and Forestry, 2003. *Ecoregions of South Africa - Level 1*. Department of Water Affairs and Forestry, Pretoria.

Departement of Water Affairs and Forestry, 2004. *National Water Resources Strategy*. First Edition, September 2004. DWAF, Pretoria.

Low, A.B. & Rebelo, A.G. (eds). 1998. *Vegetation of South Africa, Lesotho and Swaziland.* Second Edition, February 1998. Department of Environmental Affairs and Tourism, Pretoria.

Skelton E. R., Ribbink A.J. and Twentyman-Jones V. (Eds). 1994. *The Conservation of Dolomitic Ecosystems in the Western Transvaal, South Africa*. JLB Smith Institute of Ichthyology, Grahamstown.

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