ECOSTATUS OF THE CROCODILE RIVER CATCHMENT, INKOMATI RIVER SYSTEM

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INKOMATI CATCHMENT MANAGEMENT AGENCY

Compiled by:

MPUMALANGA TOURISM AND PARKS AGENCY

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List of Abbreviations

DWA - RQS	=	Department Water Affairs - Resource Quality Services
FRAI	=	Fish Response Assessment Index
GPS	=	Global Positioning System
m a.s.l.	=	metres above sea level
KNP	=	Kruger National Park
MIRAI	=	Macro-invertebrate Response Assessment Index
PES	=	Present Ecological State
RHP	=	River Health Programme
SASS5	=	South African Scoring System, Version 5
SQ	=	Subquatenary
SQR	=	Subquatenary River

1. INTRODUCTION

The ICMA appointed the MTPA as service provider to conduct biomonitoring within the Crocodile River catchment on the 2012/2013 budget to determine the Present Ecostatus of this river system. Biomonitoring in the Crocodile River was conducted during 2012/2013, with the last formal biomonitoring on the Crocodile River last being conducted during 1998 (Hill et.al. (WRC report no.850/2/01)). During the 2012/13 survey fifty-seven sites were sampled in the Crocodile River and its tributaries, including the Elands River, Houtbosloop, Lunsklip, Alex's se loop, Noord Kaap, Suid Kaap and Queens Rivers (Figure 1). Existing RHP (River Health Programme) sites were used as far as possible to be able to make use of existing data for comparison. Standard river biomonitoring techniques were used and data collected were analysed using the Fish Response Assessment Index (FRAI) and Macro Invertebrate Response Assessment Index (MIRAI) models. These sites were sampled from September 2012 to May 2013. The habitats of the upper reaches above the 1000 m elevation were mostly high velocities over cobbles, the middle reaches 400 – 1000 m elevation were medium to high velocities over boulders, and the lower reaches below 400 m elevation were mostly low velocities over gravel and sand.

1.1 Objectives of the Survey

The objective of this survey is to provide useful ecological information through an aquatic assessment and to determine the present ecological status of the associated aquatic habitat of the Crocodile River and trends in aquatic health over time, in order to inform management interventions required to address systemic and point specific impacts.

1.2. Study Area

Inkomati River catchment description

The Inkomati River drains parts of Mpumalanga, Swaziland and Mozambique between the Limpopo River system in the north and the Pongola River system in the south. The Inkomati River basin is one of the most important river basins in South Africa and it consists of three adjacent sub-basins, the Komati, Crocodile and Sabie (Figure 1). The Inkomati River basin incorporates the Mpumalanga Province in southern Africa, part of northern Swaziland and a part of southern Mozambique. The main river descents from the highland plateau in Mpumalanga and Swaziland and flows through the coastal plains of Mozambique towards the Indian Ocean. The river flows eastwards through the lowveld region of Mpumalanga and Swaziland where it is heavily used for agricultural purposes before finally flowing into Mozambique where it discharges into the Indian Ocean just north of Maputo at Villa Laisa. The total basin area is about 46,800 km^2 of which 63% is in South Africa, 5% in Swaziland and 32% in

Figure 1: Map of the Incomati Basin.

Mozambique. The average discharge of the Inkomati Water Course at the estuary is about 100 m^3s^{-1} to 200 m^3s^{-1}, corresponding to about 3,600 million m^3 per year, to which South Africa contributes 82%, Swaziland about 13% and Mozambique about 4%.

There are a large number of dams in the basin which can be classified as large and most of them are located in South Africa. Dams with more than 2,060 million m^3 combined storage capacity have been built in the Inkomati basin in South Africa and Swaziland, these dams are primarily used for irrigation. Two of these major dams are in the lower Inkomati basin, the Driekoppies Dam in South Africa and the Maguga Dam in Swaziland. Both these dams have no provision for fish ways and are completely obstructing the upstream movement of fish. These dams disrupt the natural flow regimes of the rivers and are managed by Komati Basin Water Authority (KOBWA) which is responsible for the Komati River Basin Development Plan. Water use is intense, with 50% of the water generated in the basin being abstracted. Water scarcity have been evident since the mid – 1980's, and has become more severe, as well as the effects of droughts and floods. The intensive use of water of the Inkomati system for irrigation has impacted on the health of the river system. The health of the river system as a whole is also threatened by loss and degradation of habitats, in particular due to sedimentationand eutrophication, flow modification and the introduction of alien invasive species. In addition to these threats, the system is also threatened by extensive coal mining across the head waters with resultant risk of pollution by acid mine waters (Darwall et al., 2009).

The most unique topographical feature of the drainage area is the Drakensberg Escarpment that follows a winding course across the area, its general trend being from north to south. From the escarpment steep slopes trail down eastwards and merge with the granite hills of the typical Middleveld. The land west at the Great Escarpment is mountainous and deeply dissected. From west to east, the basin comprises the Precambrium granites and gneiss of the primitive systems, the Cretaceous (west of the Lebombo) and Karroo lavas of the Mesosoic period followed by Cretaceous basins east of the Lebombo.

The flow regime of the Inkomati River is characterized as torrential with high flows during the wet season, from November to March, and relative low flows in the dry season, from April to October.

The fish fauna is dominated by Zambezian elements and is characterized by relative high endemicity with many restricted range species. The Inkomati support an estimated 56 species of fish (16% of the regional total), 75 species of Odonata (28% of the regional total) have been recorded to date, 202 of the selected aquatic plants (39% of the regional total), and 24 Moluscs (21% of the regional total) (Darwall et al., 2009).

Crocodile River

The Crocodile River is from an ecological point of view one of the most important rivers in South Africa. This is due to the broad range of riverine habitats, ranging from cold mountain streams in the Drakensberg to slow flowing temperate waters where the river meanders through the Lowveld. As a result of this, the Crocodile River is also one of the most biological diverse systems in the country, with at least 49 fish species (Roux et al*.,* 1999). The Crocodile River catchment has an area of 10 440 km^2 and rises at an altitude 2000 m above sea level in the Steenkampsberg Mountains near Dullstroom. The Upper Catchment consists of steep sided valleys, with sharply defined cliff slopes on the eastern edge of the Escarpment. From the Escarpment the river levels out in the Kwena Dam Basin, from where the Crocodile River winds along the valley of the Schoemanskloof down to the Montrose Falls and the confluence of the Elands River (Roux et al*.,* 1999).

Between Montrose Falls and the town of Nelspruit the Crocodile River is slightly incised into a broad, flat bottomed valley. Further downstream the steep sided river banks are densely covered with riparian vegetation and reed beds. Downstream of its confluence with the Kaap River, the gradient of the Crocodile River flattens out until its confluence with the Komati River at the town of Komatipoort. The river in this zone is meandering, incised into a wide sandy river bed and in some sections the river flows through multiple bedrock channels (Roux et al*.,* 1999). This river segment can be described as 40 m to 50 m wide, with mostly large sandy pools, occasional rapids and few riffles. This stretch is further characterised by a gentle slope with Lebombo riparian thickets and limited rhyolite bedrock patches.

The Crocodile River is a slow flowing river with mainly bedrock (dolerite intrusions and basaltic lava) or sandy pools; it has an average width of 45 m, and a low gradient. The area below 250 m altitude falls within the typical Bushveld with types of *Acacia, Combretum, Sclerocarya, Terminalia* etc as dominant trees. The Lowveld area has developed rapidly and agricultural activities have greatly increased. These developments abstract large volumes of water from the river, resulting in a decline of the flow especially during the dry season. Extensive reed (*Phragmites*) banks dominate the riparian zone of this river.

Table 1: List of reaches and sites visited within each reach.

SQ REACH CODE	RHP SITE CODE	SITE NAME	SQ RIVER NAME	GPS CO-ORDINATES (WGS84: dd mm ss.s)		ELEVATION RANGE (m a.s.l.)
				Lat. (S)	Long. (E)	
Crocodile River						
X21A-00930	X2CROC-VERLO	Verlorenvlei	Crocodile	25° 20' 59.0"	30° 06' 35.8"	2,080 – 2,100
	X2CROC-EHOEK	Elandshoek	Crocodile	25° 22' 01.0"	30° 06' 42.6"	2,040 – 2,060
	X2CROC-VALY1	Valyspruit	Crocodile	25° 29' 38.7"	30° 08' 36.8"	1,840 – 1,860
X21B-00962	X2CROC-ROODE	Roodekrans	Crocodile	25° 30' 08.9"	30° 11' 13.8"	1,700 – 1,720
	X2CROC-DONKE	Donkerhoek	Crocodile	25° 28' 01.7"	30° 13' 46.8"	1,320 – 1,340
	X2CROC-GOEDE	Goedehoop	Crocodile	25° 24' 34.6"	30° 18' 57.9"	1,200 – 1,220
X21D-00938	X2CROC-DOORN	Doornhoek	Crocodile	25° 23' 23.4"	30° 24' 23.3"	1,100 – 1,120
X21E-00943	X2CROC-STER1	Sterkspruit	Crocodile	25° 22' 31.8"	30° 28' 49.4"	1,020 – 1,040
	X2CROC-RIETV	Rietvlei	Crocodile	25° 23' 17.3"	30° 33' 56.5"	920 - 940
	X2CROC-INDEM	Die Rots	Crocodile	25° 25' 35.1"	30° 38' 09.7"	840 - 860
	X2CROC-MONTR	Montrose	Crocodile	25° 26' 55.3"	30° 42' 36.6"	780 - 800
X22B-00888	X2CROC-RIVUL	Rivulets	Crocodile	25° 25' 48.6"	30° 45' 26.8"	720 - 740
X22C-00946	X2CROC-STRKS	Ronde Geluk	Crocodile	25° 26' 28.6"	30° 53' 27.7"	660 - 680
	X2CROC-HALLS	Halls	Crocodile	25° 26' 53.6"	30° 56' 59.1"	640 - 660
X22J-00958	X2CROC-KAMAG	Kamagugu	Crocodile	25° 27' 03.7"	31° 01' 00.1"	560 - 580
X22K-01018	X2CROC-N4ROA	Kanyamazane	Crocodile	25° 30' 01.8"	31° 10' 43.3"	460 - 480
	X2CROC-WELT1	Gorge	Crocodile	25° 31' 09.8"	31° 14' 21.4"	380 - 400
X24C-01033	X2CROC-KAAPM	Kaapmuiden	Crocodile	25° 32' 12.0"	31° 18' 41.5"	320 - 340
X24D-00994	X2CROC-MATJU	Matjulwane	Crocodile	25° 31' 04.9"	31° 23' 34.9"	300 - 320
	X2CROC-MALEL	Malelane	Crocodile	25° 29' 09.5"	31° 30' 07.2"	280 - 300
X24E-00982	X2CROC-RIVE1	Riverside	Crocodile	25° 24' 35.0"	31° 33' 54.0"	260 - 280
X24H008880	X2CROC-MYAMB	Mbiyamiti	Crocodile	25° 18' 57.0"	31° 44' 54.0"	180 - 200
X24H-00934	X2CROC-TENBO	Tenbosch Weir	Crocodile	25° 21' 49.0"	31° 57' 22.0"	120 - 140
X24H-00953	X2CROC-NKONG	Nkongoma	Crocodile	25° 23' 38.0"	31° 58' 37.0"	120 - 140
Lunsklip River						
X21B-00898	X2LUNS-UVERL	Upper Verlorenvlei	Lunsklip	25° 18' 11.0"	30° 07' 23.6"	2,140 – 2,160
	X2LUNS-VERLO	Verlorenvalei	Lunsklip	25° 18' 37.5"	30° 08' 44.1"	2,060 – 2,080
X21B-00925	X2LUNS-UITWA	Uitwaakfontein	Lunsklip	25° 23' 36.8"	30° 18' 05.9"	1,220 – 1,240
Wilgekraalspruit						
Not on reach	X2WILG-WILG1	Wilgekraal	Wilgekraalspruit	25°27' 54.4"	30° 18' 17.0"	1,300 – 1,320
Alexanderspruit						
X21C-00859	X2ALEX-RIETF	Rietfontein	Alex-se-Loop	25° 16' 08.6"	30° 24' 30.9"	1,260 – 1,280
Buffelskloofspruit						
X21D-00957	X2BUFF-SOMER	Indabush	Buffelskloofspruit	25° 26' 17.3"	30° 26' 52.5"	1,160 – 1,180
Sterkspruit						
Not on reach	X2STER-R538B	Sterkspruit 2	Sterkspruit	25° 24' 55.3"	30° 29' 38.1"	1,080 – 1,100
Not on reach	X2JUNG-MOOIP	Jungle	Junglespruit	25° 24' 44.9"	30° 29' 49.9"	1,080 – 1,100
Elands River						
X21G-01037	X2ELAN-DOORN	Doornhoek	Elands	25°37' 54.1"	30° 19' 28.0"	1,380 – 1,400
X21J-01013	X2ELAN-HELML	Helmlock	Elands	25° 36' 01.5"	30° 33' 34.9"	980 – 1,000
	X2ELAN-GELUK	Eerste Geluk	Elands	25° 35' 26.1"	30° 36' 00.5"	960 – 980
X21K-01035	X2ELAN-ROODE	Elandsfontein	Elands	25° 34' 06.7"	30° 39' 45.7"	880 – 900
	X2ELAN-GOEDG	Goedgeluk	Elands	25° 31' 42.4"	30° 41' 53.9"	840 – 860
X21K-00997	X2ELAN-LINDE	Lindenau	Elands	25° 29' 39.5"	30° 42' 07.9"	820 – 840
Tautesloop						
Not on reach	X2TAUT-WINNA	Tautesloop	Tautesloop	25° 38' 39.1"	30° 13' 30.5"	1,540 – 1,560
Leeuspruit						
X21F-01100	X2LEEU-GELUK	Leeuspruit	Leeuspruit	25° 39' 42.2"	30° 15' 28.5"	1,520 – 1,540
Ngodwana						
X21H-01060	X2NGOD-GROOT	Ngodwana Dam	Ngodwana	25° 34' 55.0"	30° 40' 17.2"	940 – 960
Swartkoppiespruit						
X22G-01016	X2SWAR-KINDE		Swartkoppiespruit	25° 36' 37.4"	30° 24' 04.1"	1,140 – 1,160
Houtbosloop						
X22A-00913	X2HOUT-SUDWA	Sudwalaaskraal	Houtbosloop	25°23' 15.0"	30° 42' 38.2"	800 – 820
Visspruit						
X22C-00990	X2VISS-ALKMA	Alkmaar	Visspruit	25° 27' 30.1"	30° 48' 59.0"	740 – 760
Nelsriver						
X22D-00843	X2NELS-RHENO	Rhenoesterhoek	Nels	25° 12' 01.4"	30° 40' 43.2"	1,320 – 1,340
X22D-00842	X2NELS-SPITZ	Spitzkopje	Nels	25° 17' 37.2"	30° 47' 53.1"	1,020 – 1,040
Gladdespruit						
X22C-01004	X2GLAD-HERMA	Hermansburg	Gladdespruit	25° 31' 17.7"	30° 52' 42.1"	880 – 900
Whiteriver						
X22H-00836	X2WITR-VALLE	K'Shane	Wit	25° 24' 08.6"	31° 04' 06.2"	660 – 680

SQ REACH CODE	RHP SITE CODE	SITE NAME	SQ RIVER NAME	GPS CO-ORDINATES (WGS84: dd mm ss.s)		ELEVATION RANGE
Kaap Sub-catchment						
X23E-01154	X2QUEE-HILVE	Hilversum	Queens	25° 47' 27.3"	30° 54' 55.8"	720 – 740
X23F-01120	X2SUID-DAISY	Suid Kaap	Suid Kaap	25° 43' 49.0"	30° 59' 04.0"	640 – 620
Not on reach	X2HYSL-DYCED	Dycedale	Hyslop's Creek	25° 45' 59.3"	31° 05' 33.4"	800 – 820
X23B-01052	X2NOOR-RIVER	Noord Kaap	Noord Kaap	25° 36' 36.1"	31° 58' 34.4"	660 – 680
Not on reach	X2ORAT-MOUNT	Oratava	Oratava Creek	25° 44' 46.4"	31° 08' 34.4"	820 – 840
Not on reach	X2FIGT-COVIN	Figtree	Fig Tree Creek	25° 43' 24.2"	31° 09' 47.6"	620 – 640
Not on reach	X2HONE-LANCE	Lancaster	Honeybird Creek	25° 42' 09.4"	31° 12' 53.8"	560 – 580
Not on reach	X2LOUW-STATE	Louwscreek	Louws Creek	25° 44' 03.0"	31° 16' 12.3"	620 – 640

2. REACH AND SITE DESCRIPTION

A brief description of each river and reach follows (Table 1). The main features of each reach is discussed, which includes the length, general location, elevation range, aquatic ecoregion (Kleynhans et al. 2008), vegetation type (Mucina & Rutherford 2006), and the sites sampled within each reach during 2012 (Figure 2). Up- and downstream photos of some of the sampling points are included in Appendix A.

2.1. Crocodile River

The Crocodile River has been divided into 19 SQ reaches with the starting point on Veloren Valei Nature Reserve at an elevation of 2,260 m a.s.l. running in a general easterly direction towards the town of Komatipoort (118 m a.s.l.) and ending on South Africa's eastern border with Mozambique. A feature of the Crocodile River is the picturesque gorge, between Nelspruit and Malelane, with its spectacular granite plutons estimated to have formed between 2,700 and 3,000 million years ago (McCarthy & Rubidge 2005).

The total length of the 19 reaches covers a length of 326 km of river. Only one major impoundment, the Kwena Dam (built in 1984), is located in the Crocodile River where the Crocodile, Lunsklip, Alex-se-Loop, Wilgekraalspruit, Elanspruit and Badfonteinloop rivers converge.

2.2. Crocodile Tributaries

The Elands River and Kaap River are two large tributaries of the Crocodile River system and is discussed in 2.3 and 2.4. Of the smaller tributaries 10 were sampled and they are Lunsklip River, Wilgekraalspruit, Alexanderspruit, Buffelskloofspruit, Sterkspruit, Houtbosloop, Visspruit, Nelsriver, Gladdespruit and Whiteriver. One site per tributary was sampled except for the Lunsklip River where three sites were done and two sites each in Sterkspruit and Nelsriver. The tributaries downstream from Kaapmuiden are seasonal streams with very little or no water and they were not sampled.

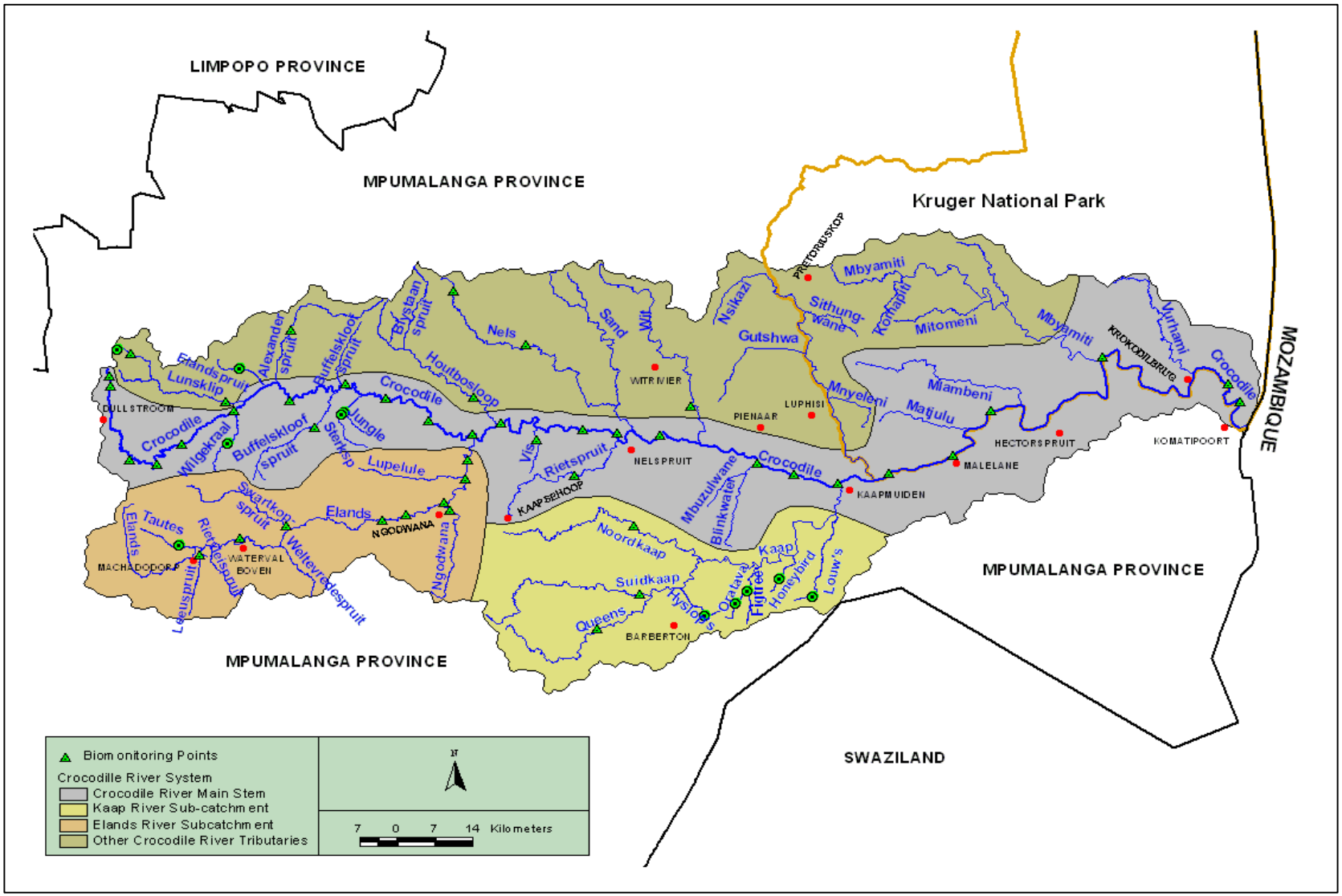


Figure 2: Map of Crocodile Catchment indicating all biomonitoring points

2.3. Elands River and Tributaries

The Elands River rises in a gentle sloping Highveld zone near the town of Machadodorp. Downstream of its source the Elands River have a steeper gradient for most of its length. It joins the Crocodile River 2km downstream of the Montrose falls. The water fall at Waterval Boven is an outstanding geomorphological feature of this river reach. It forms a natural, physical barrier to upstream migrating fish species. The section from Waterval Boven to Ngodwana can be characterised by exceptional riffle and rapid habitats. Tributaries of the Elands River also sampled included Leeuspruit, Swartkoppies spruit, Tautes-loop and Ngodwana.

2.4. Kaap Sub-catchment

The Noordkaap River, Suidkaap River and the Queens River are relatively large tributaries of the Kaap sub-catchment and one site on each of these tributaries was sampled. Five smaller tributaries, Hyslop's Creek, Oratava Creek, Figtree Creek, Honeybird Creek and Louw,s Creek originating from the Baberton Mountainlands, were also sampled. These five tributaries do not fall within a specific reach but are important refugia for this sub-catchment.

3. METHODS

The general approach used for this study was based on the rapid appraisal methods recommended by the Department of Water Affairs and Forestry in their guidelines for Resource Directed Measures for the Protection of Water Resources. Aquatic bio-assessment is an essential component of ecological risk assessment. It aims to measure present biological conditions and trends in an aquatic ecosystem and relate the observed variation to changes in available habitat. The availability of suitable habitat for aquatic biota is dictated by the physical drivers of the aquatic ecosystem such as water quality, geomorphology and hydrology. Aquatic biodiversity provide an integrative perspective of rivers as ecosystems by integrating pattern (structure) with processes (function). Biodiversity can also serve as a link between spatial and temporal phenomena and can explain the roles of functional processes in ecosystems. The purpose of this study is to use resident aquatic biota to characterize the existence and severity of impairments in the Crocodile River and to attempt to identify any sources and causes of impairment related to the catchment.

Aquatic bio-monitoring is an essential component of ecological risk assessment and aims to measure present biological conditions and trends in the aquatic ecosystem. It attempts to relate the observed variation to changes in available habitat, as dictated by physical system drivers of the system such as water quality, geomorphology, and hydrology (Figure 3 and 4) (Kleynhans & Louw, 2008). Several of the aquatic species and taxa that have

been recorded in the CrocodileRiver are considered highly sensitive to changes in the above-mentioned physical drivers and are expected to respond rapidly to any changes.

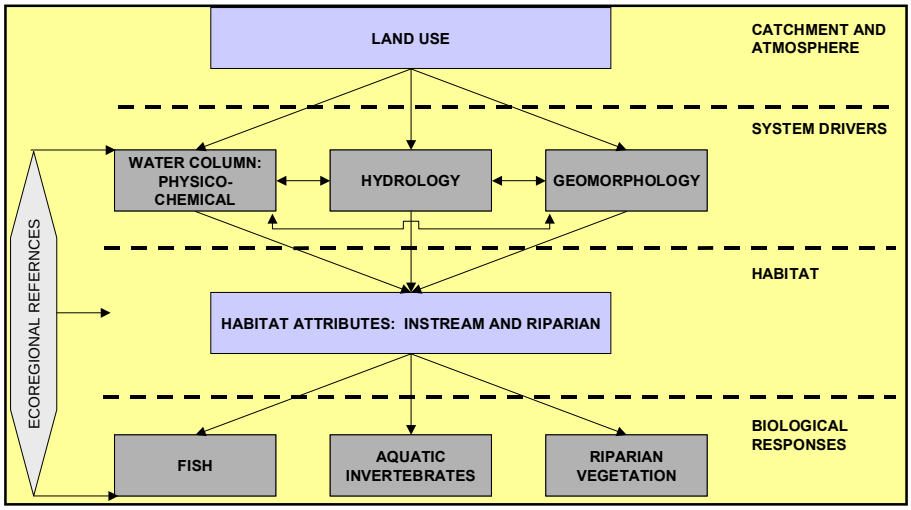


Figure 3: A simplified integration of influence of land use on physical driver determinants, habitats and the associated biological responses.

3.1. Fish assemblage

Fish are good indicators of long-term (several years) effects and broad habitat conditions, and changes in the available habitat conditions (Karr et al. 1986). This is because fish are "top of the food chain", relatively long-lived and mostly highly mobile. Assemblages include a range of species that represent a variety of trophic levels (omnivores, herbivores, insectivores, planktivores, piscivores). They tend to integrate effects of lower trophic levels; thus, fish assemblage structure is reflective of integrated environmental health.

Reference condition for fish species in the Crocodile River was based largely on Gaigher 1969, Skelton 1993, Jubb 1967, National River Health surveys (2004 surveys), the former Transvaal Directorate of Nature Conservation Database and own experience in the river. Species most likely to have occurred at each site was listed under the expected for each site. The presence, absence or abundance of taxa in comparison to the expected reference condition was largely based on previously available data. The PESEIS Front End Model was used to derive reference species and frequency of occurrence per SQ reach incorporating all historic data available (DWA, 2013, In prep). Photos of the fish species recorded at sampling sites are attached in the Appendix (Scott et al., 2004).

3.1.1. Sampling

Fish were sampled using a 10mm-mesh scoop-net and a SAMUS DC electro shocking device. Electro shocking is highly effective and entails the use of an electronic device to rapidly catch fish. The sampling of fish by using an electro shocker is based on the fact that the flow of direct electric current (DC) in water causes an anode reaction (galvanotaxis) in fish. The anode reaction in fish (pulling fish towards anode) is explained by the fact that fish orientate and move in the direction of ions. Under the influence of the electrical current fish are stunned and drawn towards the anode. The effectiveness of electro fishing is dependent on the electric current (Amperes) and not necessarily the voltage. The current should be strong enough to create an effectively large zone of fishing. However, it should allow fish to swim freely towards landing gear. If the voltage is higher than critical around the anode, fish will tend to fall in a state of nervous shock and may sail out or drop to the bottom. Apart from the critical electric parameters to be considered, the conductivity of waters (salinity), temperatures, surface of electrodes, species and the size of fish are also important parameters. These parameters can only be determined on site with a considerable degree of experience. All fish species were identified and anomalies and general age structure were recorded. Sampling effort per site was kept to about 30 minutes.

3.1.2. Analysis

The presence, absence or abundance of fish species in comparison to the expected reference condition was based on all baseline data obtained and available habitat at each site during the survey. Fish assemblage diversity and abundance vary depending on the season and the integrity of the available habitat. This data was used in the Fish Response Assessment Index (FRAI) to evaluate changes from reference conditions. The FRAI is a rule-based model recently developed by DWAF (Kleynhans, 2008) and is an assessment index based on the environmental intolerances and preferences of the reference fish assemblage and the response of the constituent species of the assemblage to particular groups of environmental determinants or drivers.

These intolerance and preference attributes are categorized into metric groups with constituent metrics that relates to the environmental requirements and preferences of individual species. Assessment of the response of the species metrics to changing environmental conditions occur either through direct measurement (surveys) or are inferred from changing environmental conditions (habitat). Evaluation of the derived response of species metrics to habitat changes are based on knowledge of species ecological requirements. Usually the FRAI is based on a combination of fish sample data and fish habitat data.

Changes in environmental conditions are related to fish stress and form the basis of ecological response interpretation and to determine the “Present Ecological Category” of the fish assemblage. The PESEIS Front End Model was used to derive reference species and frequency of occurrence per SQ reach incorporating all historic data available (DWA, 2013, In prep). Data compilation was done according to models that was developed to determine the Ecostatus (Kleynhans, 2008). The River Data Integration Application (RIVDINT) which was

developed in a project between RQS and MTPA (Kleynhans, 2013, In prep.) and was also utilised during the data compilation and analysis process.

All data and models are captured in an electronic appendix.

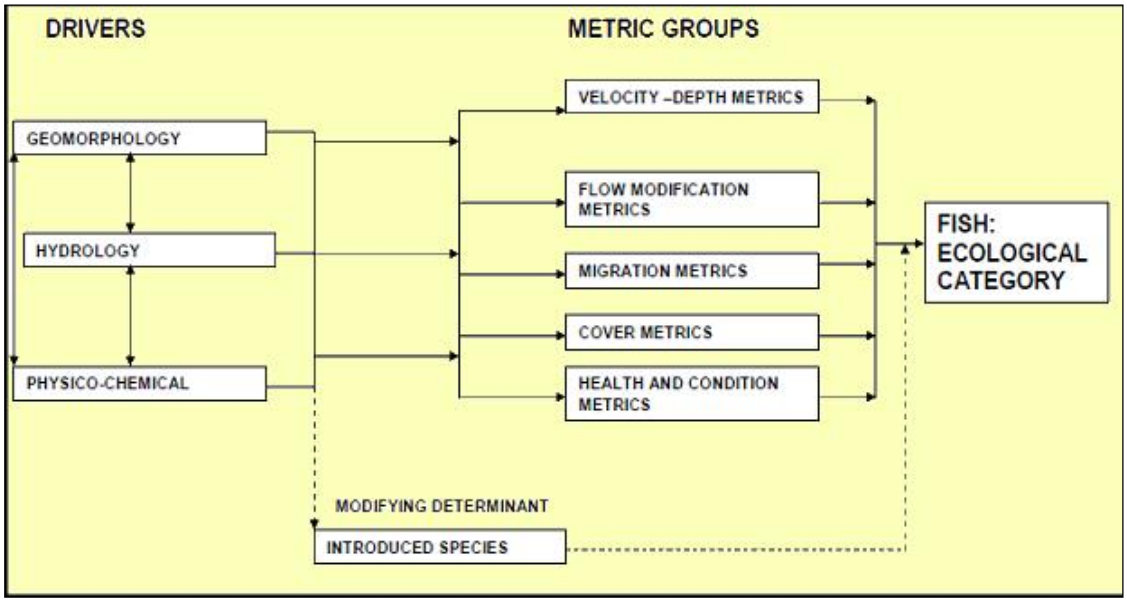


Figure 4: The relationship between ecological drivers, fish metric groups and Ecological Category

3.2. Aquatic Macro Invertebrates

Macro invertebrate assemblages are good indicators of localized conditions in rivers. Because many benthic macro invertebrates have limited migration patterns, or a sessile mode of life, they are particularly well-suited for assessing site-specific impacts (upstream/downstream studies). Benthic macro invertebrates are abundant in most streams. Many small streams (1st and 2nd order) naturally support a diverse macro invertebrate fauna, but only support a limited fish fauna. Benthic macro invertebrate assemblages are made up of species that constitute a broad range of trophic levels and pollution tolerances, thus providing strong information for interpreting cumulative effects.

Aquatic macro invertebrates have therefore been used to assess the biological integrity of stream ecosystems with reasonably good success throughout the world (Rosenberg and Resh 1993, Resh et al. 1988, Barbour et al. 1996). Aquatic macro invertebrates are more commonly used for this purpose than any other biological group (O'Keeffe and Dickens 2000) and aquatic macro-invertebrate communities offer a good reflection of the prevailing flow regime and water quality in a river.

Aquatic macro invertebrates are important processors of transported organic matter in rivers and serve a vital function in purifying the water in a river. Aquatic macro-invertebrates also provide a valuable food source for larger animals within and even outside the system (Skorozjewski & de Moor 1999, O' Keeffe and Dickens 2000, Weber et al 2004, Allan 1995). In order to continue functioning optimally, species in a river system require regular inputs of nutrients and sediments, as well as flowing water. A specific river system supports a particular assemblage of species forming functional communities within reaches. These communities are adapted to the prevailing flow conditions that control temperature, sediment transport and nutrient flows. A decrease or increase in flow, sediment transport or nutrient loads will lead to changes in community structures through loss of certain species and increases in others, as well as providing conditions for a range of new or otherwise scarce species to flourish.

The four major components of a stream system that determine productivity for aquatic organisms are the flow regime, physical habitat structure (e.g., channel form and substrate distribution), water quality (e.g., temperature, dissolved oxygen), and energy inputs from the watershed (e.g., nutrients and organic matter) (Milhous and Bartholow, 2004). Distribution of an aquatic macro invertebrate population is ultimately set by the physical-chemical tolerance of the individuals in the population to an array of environmental factors. The distribution pattern resulting from habitat selection by a given aquatic macro invertebrate species reflects the optimal overlap between habit (mode of existence) and physical environmental conditions that comprise the habitat.

3.2.1. Sampling

Aquatic invertebrates were collected using a standard net and taxa were identified to at least family level according to the SASS5 sampling technique (Dickens and Graham, 2001). Taxa collected from streams were analysed according to the standard SASS technique. Chutter (1998) developed the SASS protocol as an indicator of water quality. It has since become clear that SASS gives an indication of more than mere water quality, but rather a general indication of the present state of the invertebrate community. Sampling should preferably be concentrated during the low flow periods to represent "End of Wet", "Dry" or "End of Dry" season.

3.2.2. Analysis

The interpretation of values can differ significantly for different eco-regions in the country (Davies & Day, 1998). Dallas (2007) used available SASS-5 Score and ASPT values for each eco-region in South Africa to generate biological bands that could be used as a guideline for interpreting the values obtained during the present study. Because SASS was developed for application in the broad synoptic assessment required for the River Health Program (RHP), it does not have a particularly strong cause-effect basis. The MIRAI (Macro Invertebrate Assessment Index) was also used to interpret the Ecological Condition of the macro invertebrate for the sites. The MIRAI is a rule-based model recently developed by DWAF (Thirion, 2008). It integrates the ecological

requirements of the invertebrate taxa in a community or assemblage to their response to modified habitat conditions.

All data and models are captured in an electronic appendix.

3.3. Present Ecological Status

The Present Ecological Status (PES) of the river is expressed in terms of various components that is drivers (physic-chemical, geomorphology, hydrology) and biological responses (fish, riparian vegetation and aquatic invertebrates), as well as an integrated state, the ecostatus.

(a) The PES per SQR is assessed according to 6 metrics that represents a very broad qualitative assessment of both the instream and riparian components of a river

(b) Only the main PES categories (A to F) were used for interpretation. It is not considered realistic to distinguish boundary categories (A/B etc.) on a desktop level as the boundaries between categories are essentially fussy within the A to F delineation and that there exist a probability that the SQR may be a member of any of the two neighbouring categories.

(c) Individual metric ratings should be considered when considering the condition of the instream of riparian PES. Depending on the purpose of the assessment and the EI (Ecological Intolerance rating) and ES (Ecological Sensitive rating), it may be necessary that the instream and riparian integrity be determined according to the IHI (Index of Habitat Integrity) (Kleynhans & Louw, 2008).

The scale used for river health describes five different states of health, from an A class (natural) to an E class (unacceptable). The results of applying the biological and habitat indices during a river survey provide the contexts for determining the degree of ecological modification at the monitoring site. Thus, the degree of modification observed at a particular site translates in to Present Ecological State.

Class	Ecological State of River	Description
A	Natural	No measurable modification
B	Good	Largely unmodified
C	Fair	Moderately modified
D	Poor	Largely modified
E	Unacceptable	Seriously/critically modified

3.4. Odonata: Dragonfly Biotic Index (DBI)

Environmental Biomonitoring Services were approached by the Mpumalanga Tourism and Parks Agency (MTPA) to select monitoring sites and apply the DBI method. Dr John Simaika[1], who developed the DBI method as part

[1] Dr John Simaika, Honorary Researcher, Department of Conservation Ecology & Entomology, Faculty of AgriSciences, Stellenbosch University, South Africa

of his doctorate was approached to assist. A total of 29 sites were selected from the headwaters of the Crocodile River to below the point where the Inkomati River merges with the Sabie River in Mozambique below the town of Sabia. The 29 sites incorporated elevations ranging from 2,100 to 20 m a.s.l. Adult Odonata were recorded at each of the selected sampling points.

This report therefore aims to present the application and results of the application of the DBI (adult Odonata monitoring) along the main Crocodile River and its extension into Mozambique.

This report is attached at the end of the Ecostatus Report of the Crocodile River as an additional report:
A Survey Of Adult Odonata Along The Crocodile-Inkomati River Main Stem From Source To Ocean: A pilot project to determine the application of the Dragonfly Biotic Index (DBI) as an indicator of river health

4. RESULTS

Bio-monitoring results summarised for each reach in the Crocodile River and its tributaries are indicated in Table 2. Sites in each reach, samplers, date sampled and present state are indicated. The bio-indicators used were the Macro-invertebrate Response Assessment Index (MIRAI) and the Fish Response Assessment Index (FRAI). River class marked with an asterisk (*) were estimated conditions based on taxa expected (historical data) to occur, expert knowledge and extrapolation from sites that were sampled in 2012/2013.

Table 2: Biomonitoring results summarised for each reach in the Crocodiel River and its tributaries.

RIVER REACH CODE	RHP SITE CODE	SAMPLER	DATE	BIO-INDICATORS		ECOSTATUS	RIVER REACH LENGTH
				MIRAI	FRAI		
Crocodile River							
X21A-00930	X2CROC-VERLO	FR; GD	19/09/2012	B	C	**B/C**	30.76 km
	X2CROC-EHOEK	FR; GD	18/09/2012				
	X2CROC-VALYS	FR; GD	18/09/2012				
X21B-00962	X2CROC-ROODE	FR; GD	19/09/2012	B	C	**C**	30.05 km
	X2CROC-DONKE	FR; GD	19/09/2012				
	X2CROC-GOEDE	FR; GD	09/10/2012				
X21C-00909	Kwena Dam						
X21D-00938	X2CROC-DOORN	NS		D*	C*	**C***	18.66 km
X21E-00947		NS		C/D*	C*	**C***	1.62 km
X21E-00943	X2CROC-STERK	FR; GD	28/09/2012	C	C	**C**	37.97 km
	X2CROC-RIETV	FR; GD	28/09/2012				
	X2CROC-INDEM	FR; GD	28/09/2012				
	X2CROC-MONTR	FR; GD	28/09/2012				
X22B-00888	X2CROC-RIVUL	FR; GD	29/09/2012	B/C	B	**B/C**	14.60 km
X22C-00946	X2CROC-STRKS	FR; GD	29/09/2012	B	B/C	**B/C**	18.91 km
	X2CROC-HALLS	FR; GD	29/09/2012				
X22J-00958	X2CROC-KHAMA	FR; GD	08/10/2012	C	B	**C**	14.44 km
X22K-01018	X2CROC-N4ROA	FR; GD	08/10/2012	C	B/C	**C**	15.22 km
	X2CROC-WELT1	NS					
X24C-01033	X2CROC-KAAPM	NS		C*	C*	**D***	7.22 km
X24D-00994	X2CROC-MATJU	AD		C	B/C	**C**	22.91 km
	X2CROC-MALEL	AD; HS	27/08/2012				
X24E-00982	X2CROC-RIVE1	AD		C*	C	**C**	11.22 km
X24F-00953	X2CROC-MAROE	AD; HS	30/08/2012	C	C	**C**	31.02 km
X24H-00880	X2CROC-MYAMB	AD		C*	C	**C**	28.59 km

RIVER REACH CODE	RHP SITE CODE	SAMPLER	DATE	BIO-INDICATORS		ECOSTATUS	RIVER REACH LENGTH
				MIRAI	FRAI		
	X2CROC-CBRDG	AD; HS	28/08/2012				
X24H-00934	X2CROC-TENBO	AD		C	C	C	20.95 km
	X2CROC-NKONG	AD; HS	28/09/2012				
Lunsklip River							
X21B-00898	X2LUNS-UPPER	FR; GD	18/09/2012	B	B	B	10.99 km
	X2LUNS-VERLO	FR; GD	18/09/ 2012				
X21B-00925	X2LUNS-UITWA	FR; HA	20/09/2012	B	C	B/C	21.45 km
Wilgekraalspruit							
Not on reach	X2WILG-WILG1	AH; HM	21/09/2012				
Alexanderspruit							
X21C-00859	X2ALEX-RIETF	FR; HA	20/09/2012	B/C	C	C	36.94 km
Elandspruit							
Not on reach	X2ESPR-RUSTE	FR; HA	20/09/2012				
Buffelskloofspruit							
X21D-00957	X2BUFF-SOMER	FR; HA	21/09/2012	C	C	C	27.07 km
Sterkspruit							
Not on reach	X2STER-R538B	FR; HA	26/09/2012				
Not on reach	X2JUNG-MOOIP	FR; HA	26/09/2012				
Elands River							
X21G-01037	X2ELAN-DOORN	AH; HM		A/B	C	B/C	19.72
X21J-01013	X2ELAN-HELML	AH; HM		A/B	C	B	35.01
	X2ELAN-GELUK	AH; HM					
X21K-01035	X2ELAN-ROODE	AH; HM		B	B	B	9.41 km
	X2ELAN-GOEDG	AH; HM					
X21K-00997	X2ELAN-LINDE	AH; HM		B	B	B	10.95 km
Tautesloop							
Not on reach	X2TAUT-WINNA	AH; HM					
Leeuspruit							
X21F-01100	X2LEEU-GELUK	AH; HM		C	C	C	12.89 km
Swartkoppiespruit							
X22G-01016	X2SWAR-KINDE	AH; HM		C	B	B/C	28.30 km
Houtbosloop							
X22A-00913	X2HOUT-SUDWA	AH; HM		B	C	B/C	28.31 km
Visspruit							
X22C-00990	X2VISS-ALKMA	AH; HM		C	C	C	9.99 km
Nelsriver							
X22D-00843	X2NELS-RHENO	AH; HM		C	C	C	24.89
X22D-00842	X2NELS-SPITZ	AH; HM		C	C	C	35.10
Gladdespruit							
X22C-01004	X2GLAD-HERMA	AH; HM		B	C	B/C	21.45 km
Whiteriver							
X22H-00836	X2WITR-VALLE	AH; HM		C	C	C	21.45 km
Kaap River							
X23E-01154	X2QUEE-HILVE	AH; HM		C	C	C	43.44 km
X23F-01120	X2SUID-DAISY	AH; HM		C	C	C	15.46
Not on reach	X2HYLS-DYCED	AH; HM					
X23B-01052	X2NOOR-RIVER	AH; HM		C	C	C	53.83 km
Not on reach	X2ORAT-MOUNT	AH; HM					
Not on reach	X2FIGT-COVIN	AH; HM					
Not on reach	X2HONE-LANCE	AH; HM					
Not on reach	X2LOUW-STATE	AH; HM					

AD = Dr Andrew Deacon (Fish)
AH = Andre Hoffman (Fish)
FR = Francois Roux (Fish)
GD = Gerhard Diedericks (SASS5)
HM = Hannes Marais (SASS5)
HA = Heather Aspeling (SASS5)
HS = Hendrik Sithole (SASS5)
NS = Not sampled

Crocodile River Mainstem Reaches

SQ REACH NUMBER X21A-00930

SQ Reach (downstream-->)	SQR Name	Fish sites	SASS sites	FRAI	MIRAI	Instream ecostatus	PES Category	Riparian PES	Length km
X21A-00930	Crocodile	X2CROC-VELOR; X2CROC-EHOEK; X2CROC-VALY1	X2CROC-VELOR; X2CROC-EHOEK; X2CROC-VALY1	C	B	BC	C	C	30.76

General description

Reach X21A-00930: – Verlorenvlei – Roodekrans

The Crocodile River originates at an elevation of 2,260 m a.s.l from where it seeps and eventually converges in partial sub-surface stream channels. This then becomes a small mountain stream that flows out of the Verlorenvlei Nature Reserve, through private land characterised by small farm dams and domestic cattle grazing land before entering the town of Dullstroom. Farm dams and trout stocking is common characteristic of the river directly above Dullstroom downstream towards the Highland Golf & Trout Estate, where the river plunges over a waterfall.

The reach starts at the origin of the Crocodile River and ends a few kilometres upstream from where the river plunges from the montane grasslands into thornveld. Monitoring points sampled in the Crocodile River within this reach included the Verlorenvlei (X2CROC-VERLO), Elandshoek (X2CROC-EHOEK) and Valyspruit (X2CROC-VALYS) sampling points. All three monitoring points are located within Mucina's Lydenburg Montane Grassland (Gm 18) and the Eastern Bankenveld aquatic ecoregion. There are few exotic weeds present in the riparian zone, with mostly pine trees and wattle (*Acacia mearnsii*) in isolated spots along the reach.

Fish

The fish assemblage found in this reach consisted of only one fish species, *Barbus anoplus*, which were collected in relative low abundance (Appendix A). Four indigenous fish species were expected which included *Barbus neefi* and two C*ichlidae* species. Moderate siltation originating from degraded catchment impacts the river in this reach.

A Fish Response Assessment Index (FRAI) score of 76.5% was calculated for this reach based on all available information, placing this reach in an Ecological Class C (moderately impaired with a moderate diversity and low abundance). The relative low ecological class (C) can be related to numerous dams, accumulated sediments and in general, reduced water quality. As this reach falls within the proclaimed fly-fishing zone the regular stocking of trout (*Salmo trutta and Oncorhynchus mykiss)* occurs within the numerous dams and weirs constructed to create fish habitat for this alien and invasive species. This predacious species has a dramatic

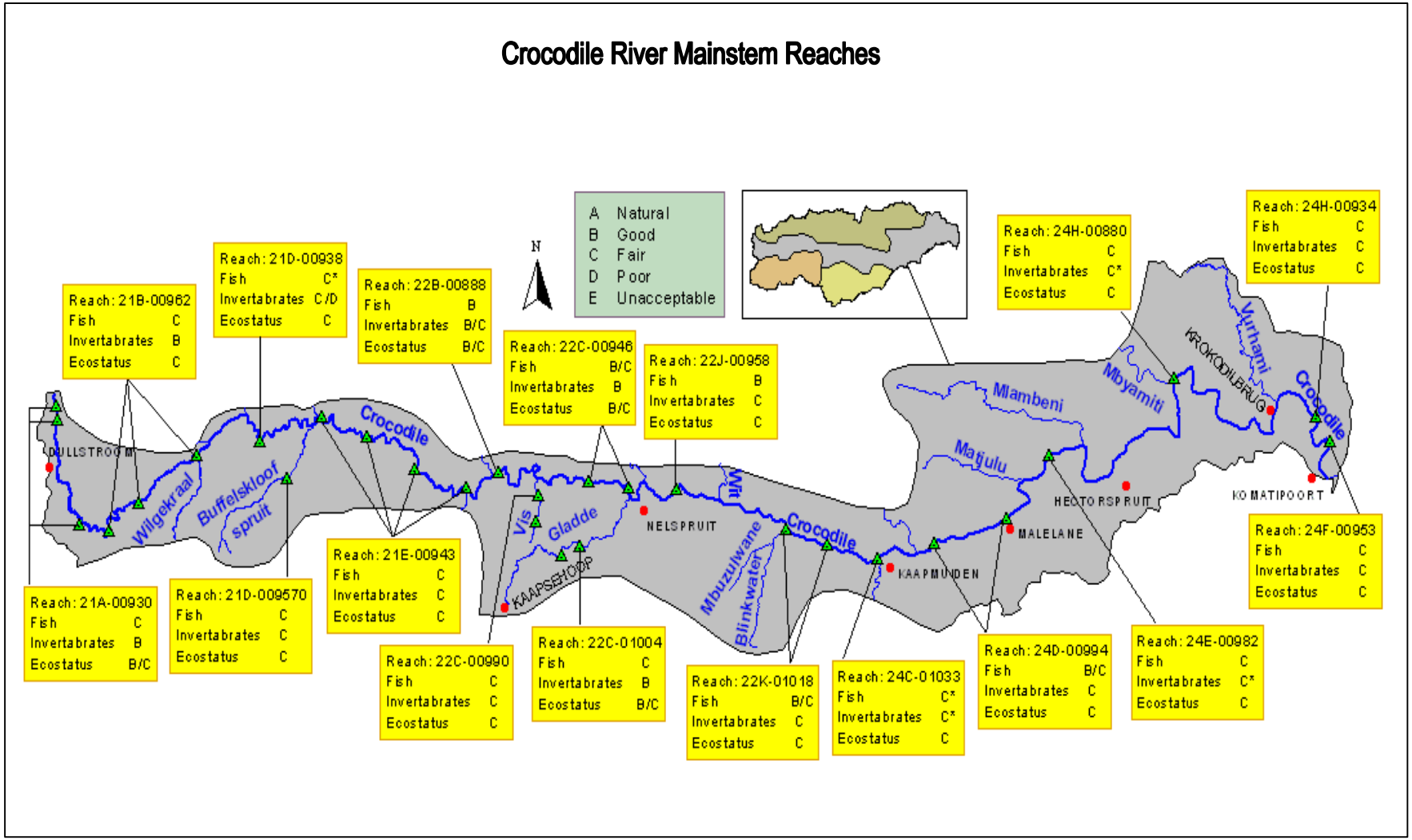


Figure 5: Map indicating Crocodile River Mainstem reaches indicating Fish, Invertebrates and Ecostatus Ratings for each reach. SQ Reaches X21D-009570; X22C-00990 and X22C-01004 are part of the Crcodile River Tributaries section.

impact on the indigenous fish species and would explain the relative low species diversity and species abundance.

Invertebrates

Instream habitat is generally good, with more sediment dominating the substrate than would be expected under natural conditions. Taxa diversity is relatively low in the headwaters, with low nutrients and food availability the main drivers of the community composition. Taxa diversity is low (16 taxa) when the river flows out of the Verlorenvlei Nature Reserve, increasing (downstream) within the reach downstream to 23 and 27 taxa at the Elandshoek and Valyspruit sites respectively. There is a considerable downstream increase in sensitive taxa between the sites, which is mainly attributed to increase in nutrients and food availability. Algal growths were recorded on the substrates of the river downstream from Dullstroom. Based on the 2012 SASS5 results, the reach was categorised overall as a B, which represents slightly modified conditions. These modified conditions are linked to modifications in flow, water quality and sediment deposition. Causes for these modifications are linked to small farm dams, storm-water run-off from roads and Dullstroom town, and the trampling of stream banks by domestic cattle.

In a survey of the Crocodile River carried out in 1966 to 1967, focusing on Ephemeroptera (mayflies), the families Oligoneuridae and Ephemeridae were recorded (Matthew 1968). Both families were absent from the 2012 sample. The river was sampled in September 2012, and Oligoneuridae is generally associated with summer flows. The species from the family Ephemeridae collected was originally described as *Eatonica schoutedeni*, but is now considered to be *Ephemera mooiana* (Barber-James & Lugo-Ortiz 2003). This species of mayfly has since not been collected in the Crocodile River, and is thought in all likelihood to be extinct.

Instream ecostatus

The Ecostatus for this reach was consistent with a Class BC suggesting a slightly to moderately impaired habitat.

SQ REACH NUMBER X21B-00962

SQ Reach (downstream-->)	SQR Name	Fish sites	SASS sites	FRAI	MIRAI	Instream Ecostatus	PES Category	Riparian PES	Length km
X21B-00962	Crocodile	X2CROC-DONKE; X2CROC-GOEDE; X2CROC-RHOODE	X2CROC-DONKE; X2CROC-GOEDE; X2CROC-RHOODE	C	B	BC	C	C	30.05

General description

X21B-00962 – Crocodile River: Roodekrans - Goedehoop

The reach starts about 1.3 kilometres upstream from the Roodekrans sampling point. The Crocodile River flows in a north-easterly direction through the Lydenburg Montane Grasslands towards the Highlands Gate Golf Estate. The Crocodile River drops for several meters down a waterfall into a gorge that flows into an incised floodplain above the Kwena Dam. The Kareespruit, flowing from the Highlands Gate Golf Estate merges with the Crocodile River below the waterfall, and a few further downstream with the Krokodilspruit. The vegetation type below the waterfall is categorised as the Lydenburg Thornveld (Mucina et al. 2006). Three sampling points are located in this reach, namely X2CROC-ROODE, X2CROC-DONKE and X2CROC-GOEDE. Up- and downstream photos of each site is included as an Appendix. The growth of exotic weed species in the riparian zone increases considerably from below the waterfall.

Large numbers of small farm dams, located on small tributaries of the Crocodile River, dominates the area above the falls. After the falls, small-scale crop and live-stock farming dominates the area to above the Kwena Dam. The vegetation type is described as the Lydenburg Thornveld.

The length of the reach is 30.05 km, and the elevation ranges from 1,766 above Roodekrans to 1,200 m a.s.l., at the Crocodile-Lunsklip confluence. Below the falls and the Kwena Dam, irrigated crops and small scale live-stock farming is the main land use.

Fish

The fish assemblage recorded in this reach consisted of five species (Appendix A) and included the flow sensitive species *Amphillius uranoscopus and Chiloglanis pretoriae.* Ten indigenous fish species were expected which included the critically endangered red data species *Chiloglanis bifurcus*. This species is endemic to the Crocodile – Incomati system ranging at an altitude from 900m to 1200m. The absence of this species is of great concern and according to literature this species is threatened by increasing water abstraction, flow regulation, as well as decreasing water quality. The newly described endemic species *Kneria kwena* can also be expected to occur in this reach, but were not recorded. This species is also threatened through habitat destruction and introduced alien fish species. The absence of *Amphillius natalensis* which is flow sensitive and has a high flow intolerance rating were also not recorded, indicating reduced flow and flow modification, as well as habitat alteration. These sensitive species are furthermore impacted by the presence of excessive siltation that decreases habitat availability in the form of interstitial spaces between rocks and cobbles.

A Fish Response Assessment Index (FRAI) score of 70.4% was calculated for this reach based on all available information, placing this reach in an Ecological Class C (moderately impaired with a moderate diversity and low abundance). The relatively low ecological class (C) can be related to accumulated sediments and reduced water quality originating from degraded catchment impacts on the river reach.

Invertebrates

The instream habitat is considered to be good, with stream banks intact in the upper portion of the reach (Roodekrans), and stream bank scouring in the lower parts of the reach (Goedehoop). Taxa diversity increase from the upper to the lower part of the reach. The Goedehoop site, in the lower part of the reach, have been sampled since 1993, and the SASS taxa recorded in 2012 are very similar. Conditions based on the aquatic macro-invertebrates were rated as slightly impaired (B-category).

Instream Ecostatus

The Ecostatus for this reach was consistent with a Class BC suggesting a slightly to moderately impaired habitat.

SQ REACH NUMBER X21D-00938

SQ Reach (downstream-->)	SQR Name	Fish sites	SASS sites	FRAI	MIRAI	Integrated ecostatus	PES Category	Riparian PES	Length km
X21D-00938	Crocodile	X2CROC-DOORN	X2CROC-DOORN	C	D	CD	C	C	18.66

General description

Reach X21D-00938: - Kwena Dam Buffelskloof South

This reach covers approximately 18.7 km of the Crocodile River from below Kwena Dam up to point where the Crocodile merges with the Buffelskloofspruit. The elevation in the reach ranges from 1,150 below the dam-wall to 1,030 m a.s.l. where it merges with the Buffelskloofspruit (south). The river below the dam is severely influenced by flow regulation, with the riparian vegetation generally comprising dense stands of trees and shrubs. The vegetation type is classified as Lydenburg Thornveld. The area directly below the dam falls into the Eastern Bankenveld aquatic ecoregion merging into the Northern Escarpment Mountains further downstream.Land-use is restricted to small holdings with limited agricultural activities. Only one site is located on this reach namely, X2CROC-DOORN.

The Kwena Dam, situated in the upper boundary of this reach, was constructed in 1984 for irrigation purposes. Known impacts of large dams include flow regulation, habitat alteration, migrational barriers, altered physical and chemical water quality, and more (Davies et al. 1993; Davies & Day 1998). Stream bank scouring is common throughout the reach, with the riparian zone dominated by large trees.

Fish

Due to intense river regulation below the Kwena Dam biomonitoring could not be conducted as water was released from the Kwena Dam for irrigation demands in the Lowveld. The fish assemblage expected for this

reach was derived from the recently developed PES EIS and eleven indigenous fish species were expected which included flow sensitive species *Amphillius natalensis, Amphillius uranoscopus,* as well as *Chiloglanis bifurcus* and *Chiloglanis pretoriae*. However, previous fish surveys by MTPA as late as 2010 indicate a drastic loss of species diversity with low abundances recorded. The reason for this can be ascribed to flow regulation of the Kwena Dam as well as temperature changes resulting from bottom releases from this dam.

A Fish Response Assessment Index (FRAI) score of 72.3% was calculated for this reach based on all available information, placing this reach in an Ecological Class C (moderately impaired with a moderate diversity and low abundance).

Invertebrates

No SASS data was collected at the sampling point within this reach (X2CROC-DOORN), and stream category has therefore been based on perceived impacts of the dam and on what is expected to occur in the reach. The stream category was rated as severely impaired (D-class) below the dam, mainly based on conditions encountered in general below dams where flow is regulated. The level of confidence with the establishment of the stream category is therefore considered to be reasonable.

Instream ecostatus

The Ecostatus for this reach was consistent with a Class CD suggesting a moderately to considerably impaired habitat. This low value is largely influenced by the impact of a-seasonal releases from Kwena Dam, disrupting the natural ecological processes that occur in the river.

SQ REACH NUMBER X21E-00947

SQ Reach (downstream-->)	SQR Name	Fish sites	SASS sites	FRAI	MIRAI	Integrated ecostatus	PES Category	Riparian PES	Length km
X21E-00947	Crocodile			C	CD	C	B	B	1.62

General description

Reach X21E-00947: - Crocodile-Buffelskloof South – Buffelskloof North

The reach length is only 1.62 km, and it is located on the Crocodile River below the Buffelskloof “South” tributary draining from the south-southwest, and above the Buffelskloof “North” tributary draining from the north. The aquatic ecoregion, impacts, land-use and land cover is very similar to the lower portions of the Doornhoek reach. No sites are located within this reach.

The FRAI, MRAI and Ecostatus for this reach was derived and/or extrapolated from previous surveys and expert judgement and indicate that the Ecostatus for the fish is a class C (moderately impaired with a moderate diversity and abundance of species) and for the invertebrates a class CD (Moderately to considerably impaired with a moderate diversity of taxa consisting mainly of tolerant taxa).

SQ REACH NUMBER X21E-00943

SQ Reach (downstream-->)	SQR Name	Fish sites	SASS sites	FRAI	MIRAI	Integrated ecostatus	PES Category	Riparian PES	Length km
X21E-00943	Crocodile	X2CROC-INDEM; X2CROC-MONTR; X2CROC-RIETV; X2CROC-STER1	X2CROC-INDEM; X2CROC-MONTR; X2CROC-RIETV; X2CROC-STER1	C	C	C	C	D	37.97

General description

Reach X21E-00943: - Sterkspruit – Montrose Falls

Four sampling points, X2CROC-INDEM; X2CROC-MONTR; X2CROC-RIETV; X2CROC-STER1, are located in this 37.97 km reach, stretching from the Crocodile's confluence with the Buffelskloofspruit "North" tributary to above the Montrose Falls. The Elands River merges with the Crocodile River below the Montrose Falls. The elevation in this reach ranges from 1,017 – 768 m a.s.l. The vegetation type of the reach is classified as Legogote Sour Bushveld, and most of the reach falls within the Northern Escarpment Mountains aquatic ecoregion.

There are several orchards and irrigated lands along the main river with large portions of crops established in riparian zones.

Fish

This section of the river provide a high diversity of fast shallow and fast deep habitat types and thus favouring flow dependant species. In total four different species of an expected ten species were collected which include *Amphillius uranoscopus* and *Chiloglanis pretoriae*(Appendix A). *Barbus argenteus* which inhabits pools and riffles in clear rocky streams were also found in abundant numbers representing all age classes (juveniles, sub-adults, adults) indicating that the breeding function is presently not disrupted. Despite intensive surveys of four monitoring sites the critically endangered red data species *Chiloglanis bifurcus* which is endemic to the Crocodile – Incomati system ranging at an altitude from 900m to 1200m, could not be located. The absence of this species is of great concern and according to literature this species is threatened by increasing water abstraction, flow regulation, as well as decreasing water quality.

A Fish Response Assessment Index (FRAI) score of 75.9% was calculated for this reach based on all available information, placing this reach in an Ecological Class C which is moderately impaired with a moderate diversity and low abundance.

Invertebrates

Instream habitat is very good, with the negative influence of the dam slightly reduced by the contribution of several tributaries. River bank scouring is still evident throughout most of the reach, attributed to flow releases from the dam and the lack of establishing and maintaining buffer strips between crops, developments and the riparian vegetation. The important function of riparian vegetation and especially their ability to filter pollutants (e.g. nutrients and sediments) and protect water quality is well documented across the globe (Allan 2004; Chamier et al. 2012; Everson et al. 2007; Groeneveld & Griepentrog 1985; Harrisonet al. 1999).

The first data available for Ephemeroptera (mayflies) at the Montrose site was in collected in 1966 and 1967 by Matthew (1968). SASS data in this reach were collected in 1993 to 1996 and again in 1999. There are several families recorded during these monitoring periods that were absent in 2012. These families are Polymitarcidae (1993, 1999), Prosopistomatidae (1966, 1967, 1993, & 1996), Psephenidae (1993-1996, 1999) and Athericidae (1993-1996, 1999). Specimens from the Polymitarcidae family were recorded at abundances of 2-10 specimens at the Montrose site in 1993 and the Sterkspruit site in 1999. Only one individual was recorded at the Sterkspruit site in 2012. The nymphs are generally associated with slow-flowing waters, burrowing in hard substrates (e.g. wood and muddy banks) or interstitially in silt, silt-gravel and clay substrates (Barber-James & Lugo-Ortiz2003). The species recorded in the catchment during the 1966-67 sampling period was listed as *Ephoron savignyi* in Matthew (1968). The reason for the absence of Polymitarcidae could be linked to either habitat alterations and/or the availability of food. Polymitacidae family is generaly considered to be collector-gathers feeding on decomposing plant material (Waltz & Burian 2008), and the species *E. savignyi* is known from U-shaped burrows among dense clay-silt substrates (Barber-James & Lugo-Ortiz 2003).

Families recorded in 2012 that were absent in the 1993 to 1999 samples includes some of the Gastropods (snails) families. Planorbinae, Physidae, Corbiculidae and Sphaeriidae were recorded at most of the sites within this reach in 2012, although not in high abundance. The bivalves are filter feeders, and the gastropods generally scrapers. The family Physidae are exotic invaders, as are some species from the family Planorbinae. These invasive species are more tolerant to pollution than indigenous snails, and can outcompete other aquatic invertebrates for food sources (Appleton 2003). Conditions based on the aquatic macro-invertbrates was categorised as moderately impaired (C-class).

Instream ecostatus

The Ecostatus for this reach was consistent with a Class C suggesting a moderately to considerably impaired habitat. This low value is largely influenced by the impact of a seasonal releases from Kwena Dam, disrupting the natural ecological processes that occur in the river.

SQ REACH NUMBER X22B-00987

SQ Reach (downstream-->)	SQR Name	Fish sites	SASS sites	FRAI	MIRAI	Integrated ecostatus	PES Category	Riparian PES	Length km
X22B-00987	Crocodile			BC	C	C	C	C	5.88

General description

On this relative short reach (5.88km) there is no biomonitoring sites located. The FRAI, MRAI and Ecostatus for this reach was derived and/or extrapolated from previous surveys and expert judgement and indicate that the Ecostatus for the fish is a class BC (slightly to moderately impaired with a moderate diversity and abundance of species) and for the invertebrates a class C (Moderately impaired with a moderate diversity of taxa consisting +mainly of tolerant taxa).

SQ REACH NUMBER X22B-00888

SQ Reach (downstream-->)	SQR Name	Fish sites	SASS sites	FRAI	MIRAI	Integrated ecostatus	PES Category	Riparian PES	Length km
X22B-00888	Crocodile	X2CROC-RIVUL	X2CROC-RIVUL	B	BC	BC	C	C	14.60

General description

Reach X22B-00888: - Houtbosloop – Visspruit

The reach length is 14.6 km, with the Houtbosloop confluence the upstream boundary, and the Visspruit confluence the downstream boundary. Elevation ranges from 744 to 703 m a.s.l. The reach is categorised by slower flowing pool areas with occasional rapids and riffles. The Elands River, Houtbosloop and Stats rivers are the major tributaries of this reach.

One site was sampled in this reach (X2CROC-RIVUL). Most of the reach falls within the 4.04 level II aquatic ecoregion of the North Eastern Highlands (Kleynhans et al. 2008). The main vegetation is decribed representative of the Legogote Sour Bushveld (Mucina & Rutherford 2006).

Citrus crops are the main land-use along the reach, with crops planted close to the edge of the river in many places. To compound this, invasive exotic weed species dominate the riparian zone, suppresing the growth of the indigenous vegetation and undermining the ecological integrity of the riparian zones.

Fish

This reach can be seen as a transitional zone between the cold water (mountain streams) and temperate (Lowveld streams) with more tolerant fish species moving into this reach. The fish assemblage found in this reach consisted of five fish species from the expected possible 13 species (Appendix A). The critically endangered endemic Incomati suckermouth (*Chiloglanis bifurcus*) was sampled only in this reach of the mainstem Crocodile River. The presence of this species, although in low abundance, is highly significant. Of further importance is the presence of *Labeobarbus marequensis* (Lowveld large scale yellow fish), which favours flowing waters of perennial rivers and migrates into higher altitudes to spawn in rapids. The reason for the relative low abundance of fish species can be attributed to a low diversity of habitat types. Furthermore the presence of weirs constructed within this reach results in damming of the river creating lentic habitat types. In addition to this, sedimentation and siltation were recorded caused by bank instability and land use practices within this reach.

A Fish Response Assessment Index (FRAI) score of 83.4% was calculated for this reach based on all available information, placing this reach in an Ecological Class B (slightly impaired with a low diversity and abundance of species).

Invertebrates

Instream habitat at the sampling point was considered as very good, with all biotopes well represented. Conditions were categorised as a class B/C, which improved when compared to upstream conditions. It is assumed that the freshwater contributions from the Elands River and the Houtbosloop have a dilution effect and mitigate the impacts associated with the Kwena Dam. Based on the aquatic macro-invertebrates, the reaches of the Elands and Houtbosloop above their confluence with the Crocodile were both categorised as moderately impaired, suggesting relatively good stream conditions. These results put emphasis on the importance of maintaining good conditions in the tributaries of catchments.

Instream ecostatus

The Ecostatus for this reach was consistent with a Class BC suggesting a slightly to moderately impaired habitat.

SQ REACH NUMBER X22C-00946

SQ Reach (downstream-->)	SQR Name	Fish sites	SASS sites	FRAI	MIRAI	Integrated ecostatus	PES Category	Riparian PES	Length km
X22C-00946	Crocodile	X2CROC-HALLS; X2CROC-STRKS	X2CROC-HALLS; X2CROC-STRKS	BC	B	BC	C	C	18.91

General description

Reach X22C-00946: - Visspruit - Gladdespruit

The reach starts below the confluence of the Crocodile River and the Visspruit, with a length of 18.91 km to its downstream boundary which is the confluence with the Gladdespruit. Elevation ranges from 703 m a.s.l. at the upstream boundary to 645 m a.s.l. at the Gladdespruit confluence. The instream habitat in this reach is characterised by bedrock and slow flowing pools, with occasional rapids and riffles. The Visspruit south of the Crocodile River and the Sterkspruit north of the river are the main tributaries to this reach. Two sampling points were located in this reach.These are X2CROC-STRKS (Ronde Geluk) and X2CROC-HALLS (Halls).

Most of the reach falls within the North Eastern Highlands aquatic ecoregion, but a small section is located in the transitional area between the Northern Escarpment Mountains and the North Eastern Highlands. The vegetation type is described as the Legogote Sour Bushveld. The dominant land-use in the areas adjacent the river is crops, mainly citrus. There are several planted areas infringing on the riparian zone, and infestation with invasive and exotic weeds is extremely high.

Fish

Within this reach close to the town of Nelspruit the river can be classed as a low gradient stream creating a high diversity of habitat types which include fast deep, fast shallow, slow deep and slow shallow flow-depth-classes. This high diversity of habitat types facilitates an increase of fish diversity with a combination of temperate as well as cold water species resulting in high species diversity, 14 expected species. The fish assemblage found in this reach consisted of five species (Appendix A) which included more tolerant temperate species such as *Oreochromis mossambicus* and *Clarias gariepinus*. *Labeobarbus marequensis* were also recorded in relative abundance representing all age classes indicating successful spawning.

A Fish Response Assessment Index (FRAI) score of 78.45% was calculated for this reach based on all available information, placing this reach in an Ecological Class BC (slightly to moderately impaired with a low diversity and abundance of species).

Invertebrates

Taxa diversity at both sites sampled within the reach was relatively high, with several families considered sensitive in the SASS index present and abundant. Both the Polymitarcidae and Prosopistomatidae families were present at the Sterkspruit 2 (X2CROC-STRKS) site in 2012.

When comparing the 2012 data to data collected in this reach in 1993 to 1996, 2000 and 2009, clear changes in community structure are evident.

- The family Atyidae (*Caridina* spp.) was recorded at A (2-10) and B (11 – 100) abundances in the lower portions of the reach in 2009, and in B and C (101 – 1000) abundances at the Sterkspruit (X2CROC-STRKS) and Halls (X2CROC-HALLS) sites in 2012. This sudden occurrence of *Caridina* spp. is possibly linked to an increase in the availability of nutrients and detritus which is a major food source for this taxa (Hart et al. 2003; Hart et al. 2001; Yam & Dudgeon 2005).
- Sphaeridae was present at relatively high abundances (A-B) from 1993 to 1994, but was not recorded since. They are filter feeders, but it is not clear why they would be absent from this reach since last recorded in 1994.

Instream ecostatus

The Ecostatus for this reach was consistent with a Class BC suggesting a slightly to moderately impaired habitat.

SQ REACH NUMBER X22J-00993

SQ Reach (downstream-->)	SQR Name	Fish sites	SASS sites	FRAI	MIRAI	Integrated ecostatus	PES Category	Riparian PES	Length km
X22J-00993	Crocodile			BC	C	C	D	D	4.29

General description

The FRAI, MRAI and Ecostatus for this reach was derived and/or extrapolated from previous surveys and expert judgement and indicate that the Ecostatus for the fish is a class BC (slightly to moderately impaired with a moderate diversity and abundance of species) and for the invertebrates a class C (Moderately impaired with a moderate diversity of taxa consisting mainly of tolerant taxa).

SQ REACH NUMBER X22J-00958

SQ Reach (downstream-->)	SQR Name	Fish sites	SASS sites	FRAI	MIRAI	Integrated ecostatus	PES Category	Riparian PES	Length km
X22J-00958	Crocodile	X2CROC-KAMAG	X2CROC-KAMAG	B	C	C	C	C	14.44

General description

Reach X22J-00958: - Nelsriver – White River

The reach length of the Crocodile River is 14.44 km, with the upstream boundary starting at the Nelsriver confluence and the downstream boundary at the White River confluence.The main tributary contributing to this reach is the Nelsriver at the upper boundary and the Rietspruit flowing in from the south. Elevation ranges from 602 m a.s.l. at the upstream boundary to 524 m a.s.l. at the White River confluence. The instream habitat in this reach is characterised by bedrock and slow flowing pools, with occasional rapids and riffles.

The reach falls within the North Eastern Highlands aquatic ecoregion, and in the Pretoriuskop Sour Bushveld vegetation type. The river in this reach receives waste water and storm-water from the city of Nelspruit, and the lower parts of the reach are characterised by citrus orchids and tabacco lands. Exotic weeds are fairly dominant in the riparian vegetation.

Fish

This reach is situated downstream of Nelspruit is highly impacted from urbanisation effects, reducing water quality and quantity. The habitat diversity consist primarily of slow flowing pools with bedrock and occasional fast shallow instream habitats. The reduced habitat diversity consequently dictates low species diversity although the expected species diversity for this reach is high with a total of 20 expected species. Sensitive species expected for this area include *Barbus eutaenia, Opsaridium peringueyi* as well as the mormyrids species *Petrocephalus wesselsi* and *Marcusenius macrolepidotus.* The expected species for this reach can be mostly classified as temperate species associated with Lowveld river reaches, namely *Micralestes acutidens, Labeo cylindricus* and *Barbus viviparus*. The fish assemblage collected in this reach consisted of nine species (Appendix A) which included *Barbus eutaenia, Barbus unitaeniatus, Marcusenius macrolepidotus* and *Chiloglanis pretoriae*. These sensitive species are relative intolerant to flow alterations and modified water quality. Of concern is the absence of certain sensitive species which could possibly be related to reduced water quality conditions.

A Fish Response Assessment Index (FRAI) score of 85.2% was calculated for this reach based on all available information, placing this reach in an Ecological Class B (slightly impaired with a low diversity and abundance of species).

Invertebrates

Only one site was sampled in this reach. Very few sensitive taxa were present, and those that were recorded at abundances of 1 or A (2-10). The family Tricorythidae, as an example, are generally present at relatively high abundances, and only 1 individual was encountered. High abundances (C) of the families Baetidae, Chironomidae and Simuliidae were recorded at the one sampling point in this reach. The conditions reflected in historical data (1993 – 1996) were not much better, with low taxa diversity.

In most parts of the reach, instream habitat is fairly limited, with large boulders, bedrock and deep pools dominating. A very low diversity of taxa associated with the marginal vegetation biotope was recorded, based on taxa expected to occur in this biotope. There is very little doubt that the storm-water run-off from the town of Nelspruit and surroundings will have a negative influence on the instream community. This was evident as conditions in 2012 based on the aquatic macro-invertebrate community changed from a B (slightly impaired) above Nelspruit to a C (moderately impaired) below Nelspruit.

It is interesting to note that when comparing the 1993 – 1996 RHP data at this site below Nelspruit to the 2012 data, conditions appear to have improved. This observation however is based on the monitoring of one site only in a stretch of over 14 km of river.

Instream ecostatus

The Ecostatus for this reach was consistent with a Class C suggesting a moderately impaired habitat.

SQ REACH NUMBER X22K-00981

SQ Reach (downstream-->)	SQR Name	Fish sites	SASS sites	FRAI	MIRAI	Integrated ecostatus	PES Category	Riparian PES	Length km
X22K-00981	Crocodile			BC	C	C	C	C	11.66

General description

Reach X22K-00981: - White River - Blinkwater

This reach of the Crocodile River starts at an elevation of 542 m a.s.l below the White River confluence to 478 m a.s.l. at above the Blinkwater confluence. The White River and Rietbokloop from north and Tipperary Spruit from the south are the main tributaries contributing to this reach. Instream habitat is characterised by deep slow flowing pools with riffles, glides and rapids over mainly bedrock and large boulders. No sampling points were sampled in this reach

The reach is located in the North Eastern Highlands aquatic ecoregion and in the Pretoriuskop Sour Bushveld vegetation type. Citrus and Tabacco crops, rural settlements, and waste water treatment works are the main

features of the land-use in this reach. South from Karino there is a newly constructed industrial site at the edge of the river downstream from where the R538 national road crosses the Crocodile River.

No monitoring points were located on this reach. The reach was categorised as a C-class (moderately impaired) based on historical data, expert opinions of taxa expected, and extrapolating from the up- and downstream reaches.

The FRAI, MRAI and Ecostatus for this reach was derived and/or extrapolated from previous surveys and expert judgement and indicate that the Ecostatus for the fish is a class BC (slightly to moderately impaired with a moderate diversity and abundance of species) and for the invertebrates a class C (Moderately impaired with a moderate diversity of taxa consisting mainly of tolerant taxa).

SQ REACH NUMBER X22K-01018

SQ Reach (downstream-->)	SQR Name	Fish sites	SASS sites	FRAI	MIRAI	Integrated ecostatus	PES Category	Riparian PES	Length km
X22K-01018	Crocodile	X2CROC-N4ROA; X2CROC-WELT1	X2CROC-N4ROA; CROC-WELT1	BC	C	BC	C	C	15.22

General description

Reach X22K-01018: - Blinkwater - Kaap

The reach falls within the area locally known as the Crocodile Gorge. The upper boundary of the reach is below the Blinkwater confluence, and it ends above the Crocodile and Kaap River confluence. The elevation ranges from 478 at the upstream boundary to 330 m a.s.l. at the downstream boundary.

The aquatic region has been classified as Lowveld, and the vegetation type as Scrap Forest. Most of the natural vegetation in the gorge is still intact, with roads along the edge of the river, and a few scattered citrus farms at the edges of the reach's boundary. Two sites (X2CROC-N4ROA and X2CROC-WELTI) were sampled within this reach.

Fish

This reach consists of the Crocodile Valley Gorge with a relative steep gradient and comprise of pools and large boulders with a diversity of fast deep habitats. Due to inaccessibility and the deep habitats present, fish biomonitoring is impeded. The fish assemblage recorded in this reach consisted of 12 species (Appendix A) with a possible 24 expected species. The expected species were derived from the PES EIS with a relative high confidence level, but certain migratory species only use these habitats only at certain times of their life history stages.The expected species for this reach can be mostly classified as temperate species associated with Lowveld river reaches, namely *Barbus annectens, Chiloglanis paratus, Chiloglanis swierstrai* and *Tilapia rendalli*. Of the 12 species recorded during the surveys sensitive species include *Barbus eutaenia, Barbus unitaeniatus*

and Opsaridium peringueyi. Futhermore two *Chiloglanis* species were recorded, *Chilolganis pretoriae and Chiloglanis paratus* in relative abundance. The presence of *Opsaridium peringueyi* (Southern barred minnow), is unique as this is the only record of this species surveyed during this biomonitoring on the Crocodile River system. This species is classified as vulnerable (IUCN) and favour shallow, clear, flowing waters of perennial rivers frequenting pools below rapids or where water flows over sand and gravel. The range of this species is greatly reduced through habitat changes to flowing rivers by dams and water abstraction.

A Fish Response Assessment Index (FRAI) score of 81.95% was calculated for this reach based on all available information, placing this reach in an Ecological Class BC (slightly to moderately impaired with a low diversity and abundance of species).

Invertebrates

Instream habitat at the one point sampled in this reach was good, with all the SASS-biotopes well represented. The taxa diversity was high, but taxa considered sensitive in the SASS index were absent or present at low abundances. Of the nine Ephemeroptera (mayflies) families expected to occur, only three were recorded. The family Oligoneuridae is known to be seasonal, but the other Ephemeroptera families absent were Leptophlebiidae, Polymitarcyidae, Prosopistomatidae, Machadorythidae and Tricorythidae. The absence of so many sensitive taxa clearly illustrates that conditions in the stream was impaired at the time of sampling.

Instream ecostatus

The Ecostatus for this reach was consistent with a Class BC suggesting a slightly to moderately impaired habitat.

SQ REACH NUMBER X24C-01033

SQ Reach (downstream-->)	SQR Name	Fish sites	SASS sites	FRAI	MIRAI	Integrated ecostatus	PES Category	Riparian PES	Length km
X24C-01033	Crocodile	X2CROC-KAAPM	X2CROC-KAAPM	C	C	C	D	C	7.22

General description

Reach X24C-01033: - Kaap - Nsikazi

The length of this reach on the Crocodile River is 7.22 km, with the Kaap River the upstream boundary and the Nsikazi River the downstream boundary. Elevation ranges from 330 at the upstream to 307 m a.s.l. at the Nsikazi confluence. The Kaap River is the only major tributary contributing to this reach.

The aquatic ecoregion was classified as Lowveld, and the vegetation type as Granite Lowveld. The main land-use is sugarcane, citrus, subsistence farming, and the Matsulu settlement area. Crops are planted very close to the river in some areas. Only one site X2CROC-KAAPM was sampled within this reach.

Fish

This proper Lowveld reach is downstream from the Crocodile River Gorge and impacted by the Kaap River tributary. The habitat type consists of a low gradient stream, large sandy pools with isolated riffles and runs. All the Lowveld associated fish species is expected within this reach which include *Hydrocynus vittatus* (tigerfish), *Glossogobius giurus*, *Chiloglanis swierstrai, Mesobola brevianalis* and the different *Labeo (Labeo rosae; Labeo ruddi; Labeo congoro)* species. The fish assemblage collected in this reach consisted of 11 (Appendix A) of expected 26 indigenous fish species. Species recorded include: *Barbus eutaenia, Amphilius uranoscopus, Chiloglanis pretoriae, Labeo cylindricus* and *Micralestes acutidens.* These species were recorded in relative abundance comprising most of the age classes (juveniles, sub-adults, adults) indicating successful breeding.

A Fish Response Assessment Index (FRAI) score of 76.2% was calculated for this reach based on all available information, placing this reach in an Ecological Class C (moderately impaired with a low diversity and abundance of species).

Invertebrates

No sampling was carried out in this reach in 2012. The reach was categorised as a C-class (moderately impaired) based on historical data, expert opinions of taxa expected, and extrapolating from the up- and downstream reaches. The Matthew (1968) study on Ephemeroptera sampled the Kaapmuiden site (X2CROC-KAAPM) during 1966 and 1967. During this period he recorded:

- 8 species of the Baetidae family;
- several unidentified species of Caenidae, and;
- one species each of the families Heptageniidae, Leptophlebiidae, Oligoneuridae, Polymitacidae, Prosopistomatidae, Machadorythidae and Tricorythidae.

Matthew's data indicates that sensitive taxa were still dominant in this stretch of the Crocodile River during the late 1960's.

Instream ecostatus

The Ecostatus for this reach was consistent with a Class C suggesting a moderately impaired habitat.

SQ REACH NUMBER X24D-00994

SQ Reach (downstream-->)	SQR Name	Fish sites	SASS sites	FRAI	MIRAI	Integrated ecostatus	PES Category	Riparian PES	Length km
X24D-00994	Crocodile	X2CROC-MALEL; X2CROC-MATJU	X2CROC-MALEL; X2CROC-MATJU	BC	C	C	D	C	22.91

General description

Reach X24D-00994: - Nsikazi - Matjulu

The reach is represented by 22.91 km of the Crocodile River, starting below the Nsikazi confluence (307 m a.s.l.) to where it merges with the Matjulu River (277 m a.s.l.). The Nsikazi River forms the eastern boundary of the Kruger National Park (KNP), and the Crocodile River the southern boundary. Named tributaries from the Kruger National Park in the north contributing to this reach includes the Nsikazi River, Kwamachiyaliwane, Behmansanga, Boomalwynspruit, Kwamhlebeni, Mvovoveni, Mhlumeni, Tinsimbini and Masimbatane. From the south of the reach, major tributaries includes the Jan-Tin Creek, Salt Creek and Buffalo Creek. The highly organic and thermally polluted perennial waste water stream from the TSB Sugar-mill also flows into the Crocodile River above the Malelane Bridge into the KNP. Many of the tributaries listed are seasonal, and there are several unnamed ephemeral tributaries.

The instream habitat in this section of the river is dominated with sand and gravel. Only small sections of cobbles, boulders and bedrock are available. The Marginal vegetation is dominated by reeds and grass. The area near the broken bridge were characterised by more boulders and bedrock than the rest of the reach. This section of the Crocodile River forms the Kruger National Park border with the northern bank in the KNP and the southern bank impacted by the town of Malelane, low density housing and tourism accommodation as well as irrigated agriculture (mostly sugarcane and citrus).

The reach falls into the Lowveld aquatic ecoregion, and the vegetation type was classified in as Granite Lowveld. The town of Matsulu is wedged between the Nzikazi and Crocodile rivers, on the south-western boundary of the KNP and west of the Nzikazi River. Matsulu is north of the Crocodile River. The town of Malelane is located close to the southern-eastern boundary of the reach. The land-use in the Kruger National Park is conservation and the southern portions of the reach is characterised by sugarcane, mining, settlements and waste water steam from the TSB sugar-mill flowing through the Malelane Golf Course. Two sites (X2CROC-MALEL and X2CROC – MATJU) were monitored on this reach.

Fish

This Lowveld reach is within the Kruger National Park and is characterised as a low gradient stream comprising of large sandy pools with isolated riffles and runs. All the Lowveld associated fish species is expected within this

reach which include *Hydrocynus vittatus* (tigerfish), *Glossogobius giurus*, *Chiloglanis swierstrai, Mesobola brevianalis* and the different *Labeo (Labeo rosae; Labeo ruddi; Labeo congoro)*species. The fish assemblage collected in this reach consisted of 12 (Appendix A) of expected 35 indigenous fish species. Species recorded include: *Amphilius uranoscopus, Barbus eutaenia, Barbus trimaculatus, Chiloglanis paratus and Chiloglanis pretoriae, Labeobarbus marequensis, Micralestes acutidens, Oreochromis mossambicus* and *Pseudocrenilabrus philander.* These species were recorded in relative low abundance in particularly the flow dependant species *Chiloglanis pretoriae* and *Barbus eutaenia*. Most of the age classes (juveniles, sub-adults, adults) were present indicating successful breeding.

A Fish Response Assessment Index (FRAI) score of 78.85% was calculated for this reach based on all available information, placing this reach in an Ecological Class BC (slightly to moderately impaired with a low diversity and abundance of species).

Invertebrates

Only one site was sampled within this 22.91 km reach. Several taxa expected to occur and recorded in 2009 were absent, many of them sensitive indicators on the SASS index, and several associated with marginal vegetation. Sensitive taxa expected but absent in the 2012 sample included the mayfly families Heptageniidae, Leptophlebiidae, and Tricorythidae. Where several species of Baetidae and Hydropsychidae (caddisflies) were expected, only two Baetidae species were recorded, and one Hydropsychidae species.

Matthew (1968) in his study on Ephemeroptera (mayflies) recorded six species of Baetidae, and one species each of Caenidae, Heptageniidae, Leptophlebiidae, Prosopistomatidae and Tricorythidae in 1966 and 1967. The absence of so many sensitive families (not to mention species) in 2012 compared to historical data is of great concern.

Taxon diversity is quite low in this section of the river (21 taxa sampled in 2012 compared to an average of 26 taxa for the previous 4 years. However the ASPT of 5.3 compares favourably with the average ASP of 5.4 over the previous 4 years. Only one high scoring taxon, the stonefly family Perlidae was found during this survey, indicating a problem with the water quality in this reach of the river. The MIRAI placed this reach in a C category indicating moderately modified conditions. Although this deterioration can be attributed to a combination of flow, water quality and habitat impact, it is clear that the water quality had the largest impact. These changes are most likely related to upstream impacts as well as more localised impacts from land use activities.

Instream ecostatus

The Ecostatus for this reach was consistent with a Class C suggesting a moderately impaired habitat. .

SQ REACH NUMBER X24E-00982

SQ Reach (downstream-->)	SQR Name	Fish sites	SASS sites	FRAI	MIRAI	Integrated ecostatus	PES Category	Riparian PES	Length km
X24E-00982	Crocodile	X2CROC-RIVE1	X2CROC-RIVE1	C	C	C	D	C	11.22

General description

Reach X24E-00982: - Matjulu - Mlambeni

The reach of 11.22 km starts below the Matjulu confluence (277 m a.s.l.) and stretches to the Mlambeni confluence (249 m a.s.l.). The Crocodile River forms the southern boundary of the KNP. The main tributaries are from the KNP, and include the Matjulu and Timfeneni seasonal streams. Only one site (X2CROC-RIVE1) was monitored on this reach.

The entire reach falls within the Lowveld aquatic ecoregion, and the Granite Lowveld vegetation type. The main land-uses include conservation, sugarcane, citrus and the Leopard Creek Golf Estate.

Fish

This reach is situated close to the town of Malelane and falls within the Kruger National Park protected area. This reach is typical of the Lowveld reaches comprising of large sandy pools and runs with isolated rock riffles. All Lowveld species were expected to occur within this reach and from PES EIS it was derived that 35 species were expected to occur. In total 12 indigenous species were recorded which included *Barbus radiatus, Barbus trimaculatus, Chiloglanis swierstrai, Hydrocynus vittatus, Labeo cylindricus and Labeo molybdinus and Micralestes acutidens.* The presence of the near threatened red data species *Chiloglanis swierstrai i*s unique. This species is endemic to the Lowveld and warmer reaches of the Limpopo, Incomati and Phongolo river systems. This species prefers sandy stretches of flowing water where it lives over sand banks burying itself in the sand. This species is intolerant to flow modification of the river.

A Fish Response Assessment Index (FRAI) score of 78.85% was calculated for this reach based on all available information, placing this reach in an Ecological Class C (moderately impaired with a low diversity and abundance of species).

Invertebrates

No monitoring points were located on this reach. The reach was categorised as a C-class (moderately impaired) based on historical data, expert opinions of taxa expected, and extrapolating from the up- and downstream reaches.

There are no sampling sites in this river reach and the condition was extrapolated taking into account the upstream (X24D-00994) and downstream (X24F-00953) reaches. The instream habitat in this section of the river

is similar to that in the upstream reach. The southern bank of the river is mostly impacted by irrigated agriculture. This reach was extrapolated to be in a C category.

Instream ecostatus

The Ecostatus for this reach was consistent with a Class C suggesting a moderately impaired habitat.

SQ REACH NUMBER X24F-00953

SQ Reach (downstream-->)	SQR Name	Fish sites	SASS sites	FRAI	MIRAI	Integrated ecostatus	PES Category	Riparian PES	Length km
X24F-00953	Crocodile	X2CROC-NKONG	X2CROC-NKONG	C	C	C	D	C	31.02

General description

Reach X24F-00953: - Mlambeni - Mbyamiti

This is a 31.02 km reach of the Crocodile River, with the Mlambeni confluence (249 m a.s.l.) the upstream boundary and the Mbyamiti River (200 m a.s.l.) the downstream boundary. The Crocodile River forms the southern boundary of the KNP. The major tributaries include the Mlambeni, Mhlalathi, Lwakahle and Hlongo seasonal streams flowing from the KNP. A large weir is located in this reach, named the Van Graan Dam.

The upper reaches of this reach is inundated by van Graan se Dam and are not included in the assessment. The instream habitat in this section of the river is characterised by larger areas of bedrock compared to the upstream reaches. The section of the river upstream of van Graan se Dam is sandier than the downstream reaches. It is likely that the dam is retaining a large portion of the fines as the river becomes bedrock-dominated just downstream of the dam. A weir is located approximately 2 km downstream of the dam. The Maroela weir is located approximately 2 km downstream of the sampling site. Another site: X2CROC-LWAKA was sampled in the late nineties as part of the pilot implementation of the RHP but was not included in this survey. Apart from the irrigated agriculture, Marloth Park is located towards the end if the reach.

The entire reach falls within the Lowveld aquatic ecoregion, and the Granite Lowveld vegetation type. The main land-uses include conservation, sugarcane and citrus.

Fish

This section of the river provides a moderately high diversity of habitat types and consequently the diversity of fish species in this reach is moderately high. The fish assemblage is dominated by more tolerant lowveld fish species, namely *Labeo cylindricus, Labeobarbus marequensis, Chiloglanis paratus and Chiloglanisswierstrai*. Five indigenous fish species were collected of an expected 35 with a relative low abundance and is listed in

Appendix A. This relative low abundance can be ascribed to limited accessible fish habitat and restricted access to certain areas due to the presence of numerous crocodiles and hippopotami.

A Fish Response Assessment Index (FRAI) score of 73.2% was calculated for this reach based on all available information, placing this reach in an Ecological Class C (moderately impaired with a high diversity of species).

Invertebrates

The PES was categorised as moderately impaired (C), with only one site sampled. A single specimen from the family Palaemonidae (prawns) was recorded. The family Tricorythidae was recorded for the first time (low abundance) at the site in 2012 after being absent for a few years (C. Thirion, personal communication, 28 May 2013). Only one Hydropsychidae species and two Baetidae species were recorded. Several sensitive taxa expected to be present were absent.

There were no highly sensitive taxa in this reach during the current survey and only the flatheaded mayfly (Heptageniidae) was found in 2010. Since the start of the RHP surveys in 1996 only 4 highly sensitive taxa have been found in this reach indicating that the water quality problems in this reach have been present for more than 15 years already. Seven of the 14 moderately sensitive taxa collected since 1996 were found during the current survey. These seven taxa included Macrobrachium, the rarely found river prawn. Interestingly the Philopotamid caddisflies have not been found since 1996. The MIRAI placed this reach in a C category indicating moderately modified conditions. Although this deterioration can be attributed to a combination of flow, water quality and habitat impact, it is clear that the water quality had the largest impact, followed by habitat modification. These changes are most likely related to upstream impacts as well as more localised impacts from land use activities.

Instream ecostatus

The Ecostatus for this reach was consistent with a Class C suggesting a moderately impaired habitat. .

SQ REACH NUMBER X24H-00880

SQ Reach (downstream-->)	SQR Name	Fish sites	SASS sites	FRAI	MIRAI	Integrated ecostatus	PES Category	Riparian PES	Length km
X24H-00880	Crocodile			C	C	C	D	C	28.59

General description

Reach X24H-00880: - Mbyamiti - Vurhami

This reach of the Crocodile River from below the Mbyamiti confluence (200 m a.s.l.) to the Vurhami confluence (155 m a.s.l.) is 28.59 km in length. Major tributaries contributing from the KNP include the Bume, Soswanini and Mangilana, and the Kumoyana from the south.

The instream habitat in this section of the river is dominated with sand and gravel. Only small sections of cobbles, boulders and bedrock are available. The Marginal vegetation is dominated by reeds and grass. This section of the Crocodile River forms the Kruger National Park border with the northern bank in the KNP and the southern bank impacted by the as irrigated agriculture (mostly sugarcane). There is a weir located approximately 300m downstream of the bridge over the Crocodile River resulting in backup of the river. The low-level bridge was replaced by a higher level bridge in 2010 that also had an impact on the habitat at the Crocodile Bridge site.

The entire reach falls within the Lowveld aquatic ecoregion, and the Granite Lowveld vegetation type. The main land-uses include conservation, sugarcane and citrus. Large portions of the crops are established very close to the river downstream from the Crocodile Bridge.

The FRAI, MRAI and Ecostatus for this reach was derived and/or extrapolated from previous surveys and expert judgement and indicate that the Ecostatus for the fish is a class C (moderately impaired with a moderate diversity and abundance of species).

Invertebrates

The PES was categorised as moderately impaired (C), with only one site sampled at Crocodile Bridge. The riffles historical sampled washed away during the early-2012 floods, and is now a pool (H. Sithole, notes on field data sheet, 28 August 2012). The low diversity of 15 taxa are therefore contributed to habitat alteration more than water quality, even though it might be, in reality, a combination of the two.

Matthew (1968) sampled the site for Ephemeroptera in 1966 and 1967, and encountered 10 species of Baetidae, two species of Caenidae and Leptophlebiidae, and one species each of Heptageniidae and Tricorythidae.

Taxon diversity is quite low in this section of the river (15 taxa sampled in 2012 compared to a maximum of 25 taxa since 1993). However the ASPT of 5.5 compares favourably with the average ASP of 5.1 over the previous 4 years. Only one high scoring taxon, the flat headed mayfly family Heptageniidae was found during this survey, indicating a problem with the water quality in this reach of the river. The MIRAI placed this reach in a C category indicating moderately modified conditions. These changes are most likely related to upstream impacts as well as more localised impacts from land use activities. Another problem in this section of the river is the occasional dominance of the exotic Thiaridae .

SQ REACH NUMBER X24H-00934

SQ Reach (downstream-->)	SQR Name	Fish sites	SASS sites	FRAI	MIRAI	Integrated ecostatus	PES Category	Riparian PES	Length km
X24H-00934	Crocodile	X2CROC-TENBO	X2CROC-TENBO	C	C	C	D	C	20.95

General description

Reach X24H-00934: - Vurhami - Komati

This is the final reach on the Crocodile River, with its upstream boundary below the Vurhami confluence (155 m a.s.l.) and the Komati River confluence (118 m a.s.l.) the downstream boundary. The Crocodile River forms the southern boundary of the KNP. The main seasonal tributaries contributing to this reach come from the KNP. These include the Makambue, Shidzumbalala, Dzuweni, Wescott, Mpanamana and Nwangela streams.

The instream habitat in this section of the river is dominated with sand and gravel. However, there are substantial areas that are bedrock dominated. The Marginal vegetation is dominated by reeds and grass. The area near the broken bridge were characterised by more boulders and bedrock than the rest of the reach. This section of the Crocodile River forms the Kruger National Park border with the northern bank in the KNP and the southern bank impacted by the as irrigated agriculture (mostly sugarcane). The town of Komatipoort is located at the lower section of the reach close to the confluence with the Komati River.

The reach falls within two aquatic ecoregions, with the upstream portion classified as Lowveld and the lower part of the reach against the Lebombo Mountains categorised as the Lebombo Upland ecoregion. Vegetation type is also represented by two types, the Lowveld in the upper portions and the Tshokwane-Hlane Basalt Lowveld bordering the Lebombo Mountains.

Fish

This Lowveld reach is close to Tenbosch which is downstream of the Crocodile River Bridge within the Kruger National Park. The habitat surveyed is downstream of the Tenbosch weir with a relative high habitat diversity comprising of pools, riffles and runs. This habitat is typical of the Lowveld reaches with a substrate consisting primarily of sand and bedrock with isolated boulders. All Lowveld fish species is expected to occur within this reach and comprise of 35 indigenous fish species. The fish assemblage in this reach consisted of 15 species (Appendix A) and was the highest fish diversity recorded within one reach during this survey. Of the 15 species recorded the following species of importance were noted and is typical temperate, tolerant species: *Barbus afrohamiltoni, Barbus radiatus, Barbus viviparous, Chiloglanis swierstrai, Glossogobius giurus and Labeo congoro.*The low abundance of *Chiloglanis swierstrai* could be an indication of flow modification resulting from over-abstraction for irrigational purposes.

A Fish Response Assessment Index (FRAI) score of 72.9% was calculated for this reach based on all available information, placing this reach in an Ecological Class C (moderately impaired with a high diversity of species).

Invertebrates

Taxon diversity is quite low in this section of the river (19 taxa sampled in 2012 compared to a maximum of 25 taxa since 1996, and an average of 20 taxa over the last 5 years). The SASS5 score (78) and ASPT (4.1) is lower than the median SASS5 score of 108 and ASPT of 5. No high scoring taxa were found during this survey, indicating a problem with the water quality in this reach of the river compared to 2 taxa over the last 5 years and 4 taxa since 1996. The MIRAI placed this reach in a C category indicating moderately modified conditions. Although this deterioration can be attributed to a combination of flow, water quality and habitat impact, it is clear that the water quality had the largest impact. These changes are most likely related to upstream impacts as well as more localised impacts from land use activities. Another problem in this section of the river is the occasional dominance of the exotic Thiaridae

One site was sampled in this reach, and the PES based on the aquatic macro-invertebrates was categorised as moderately impaired (C-class). SASS data for 1996 and 1999 were available. Only one family of Ephemeroptera (Baetidae) was recorded in 2012, and no families of the orders Trichoptera and Coleoptera were recorded. Taxa missing in 2012 that were regularly encountered in the 1996 and 1999 data include the following:

- Tricorythidae: B – C abundances 1996 & 1999, absent in 2012;
- Baetidae: > 2 spp. in 1996 & 1999, only 2 species in 2012;
- Hydropsychidae: 2 spp. in A – B abundances 1996 & 1999, completely absent in 2012;
- Caenidae, Heptageniidae, Leptophlebiidae, Elmidae: present 1996 & 1999, absent in 2012, and;
- Thiaridae: Present in 1996 & 1999 at A – B abundances. C-abundances recorded in 2012.

The absence of a relatively large group of sensitive taxa in the 2012 survey is a cause for concern.

Instream ecostatus

The Ecostatus for this reach was consistent with a Class C suggesting a moderately impaired habitat.

Summary of Crocodile River Mainstem Indices

FRAI Categories

Figure 6 summarises the FRAI categories for 18 SQ reaches. It indicates that the overall FRAI for the Crocodile River mainstem is a Class C moderately impaired with a moderate diversity and low abundance of species. The expected trend would be for the high altitude mountain streams to be of a higher class with a gradual decrease towards the lower-lying reaches. However, in this study close to the source of the Crocodile River near Dullstroom the upper reaches are in a Class C and is impacted by the trout industry with the stocking of alien and invasive species and their related impacts. Numerous dams and weirs as well as land use practices further have an impact on the fish community within these reaches. Downstream of these reaches the Kwena Dam and its operating rules have an impact on the downstream river with these reaches remaining in a Class C. In the lower-lying reaches close to the confluence with the Houtbosloop and Elands River, the reaches improve slightly to a class BC, but decrease again after the Crocodile Gorge entering the Kruger National Park to an overall Class C. This C Class category is maintained throuthout into Mozambique.

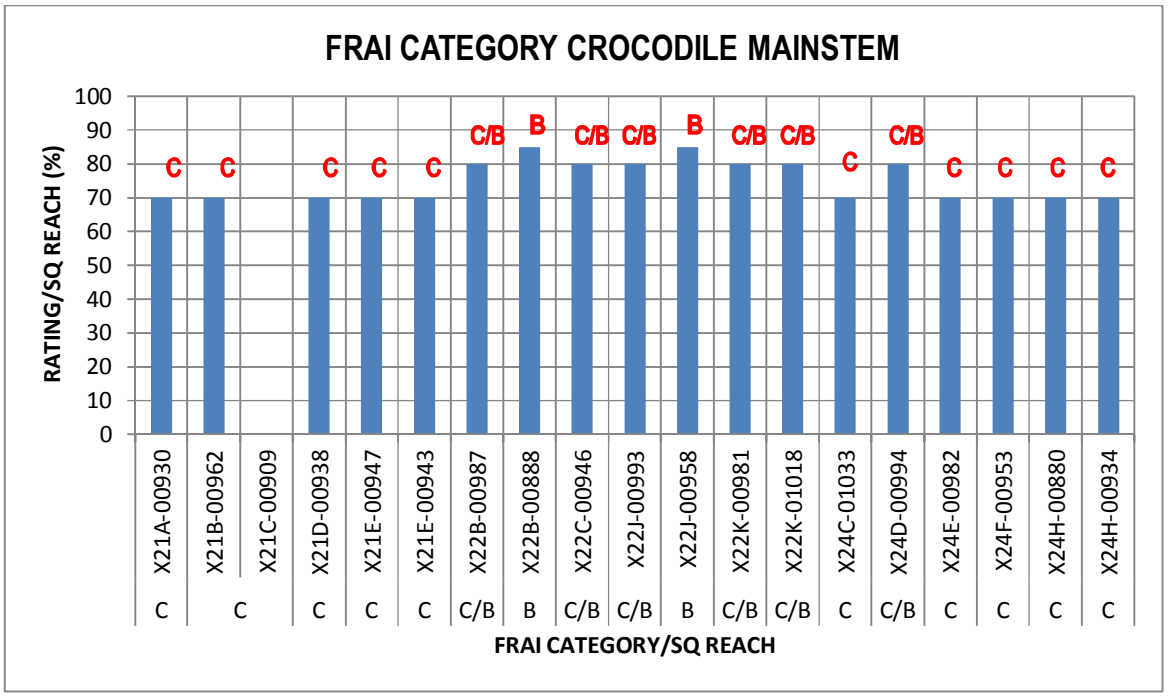


Figure 6: FRAI category for the Crocodile River Mainstem SQ reaches. SQ Reach X21C-00909 is situated in the Kwena Dam basin and was not surveyed.

MIRAI Categories

Based on the aquatic invertebrate community, the Crocodile River is categorised as slightly impaired (B-class) in the headwaters (Verlorenvalei Nature Reserve) all the way to where it flows into the Kwena Dam. Flow regulation and impacts associated with large dams results in deterioration of the reach to a class D (severely impaired). Conditions steadily improve to moderately impaired (C-class) further downstream from the dam, with considerable improvements (B/C) in the reaches below the confluence with the Elands and Houtbosloop Rivers. The river condition steadily improves to a class B above Nelspruit. Downstream from Nelspruit the Crocodile River is categorised as moderately impaired (C-class), which is maintained to where the river merges with the Komati River at the town of Komatipoort near the South Africa-Mozambique border (Figure 7).

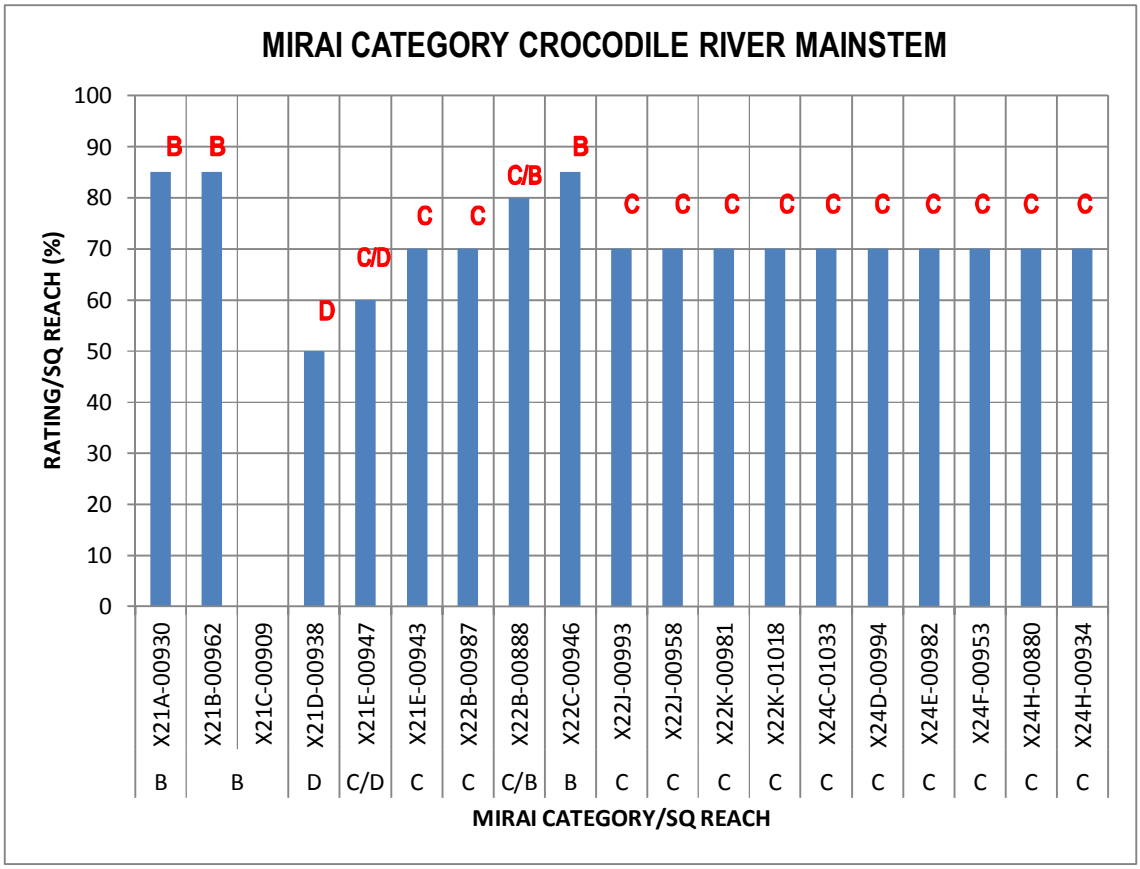


Figure 7: MIRAI category for the Crocodile River Mainstem SQ reaches. SQ Reach X21C-00909 is situated in the Kwena Dam basin and was not surveyed.

Instream and Integrated Ecostatus rating of the Crocodile River Mainstem

The Instream Ecostatus Rating is derived from the fish assemblage (FRAI) and the macro-invertebrate assemblage (MIRAI). From Figure 8 it is evident that the Instream Ecostatus Rating is consistent throughout the mainstem ranging from a Class CB to a Class C. The Integrated Ecostatus Rating is derived from the fish (FRAI) and macro-invertebrates (MIRAI) assemblages and riparian index (VEGRAI) and is fairly consistent with the Instream Ecostatus Rating, Class C (Figure 9).

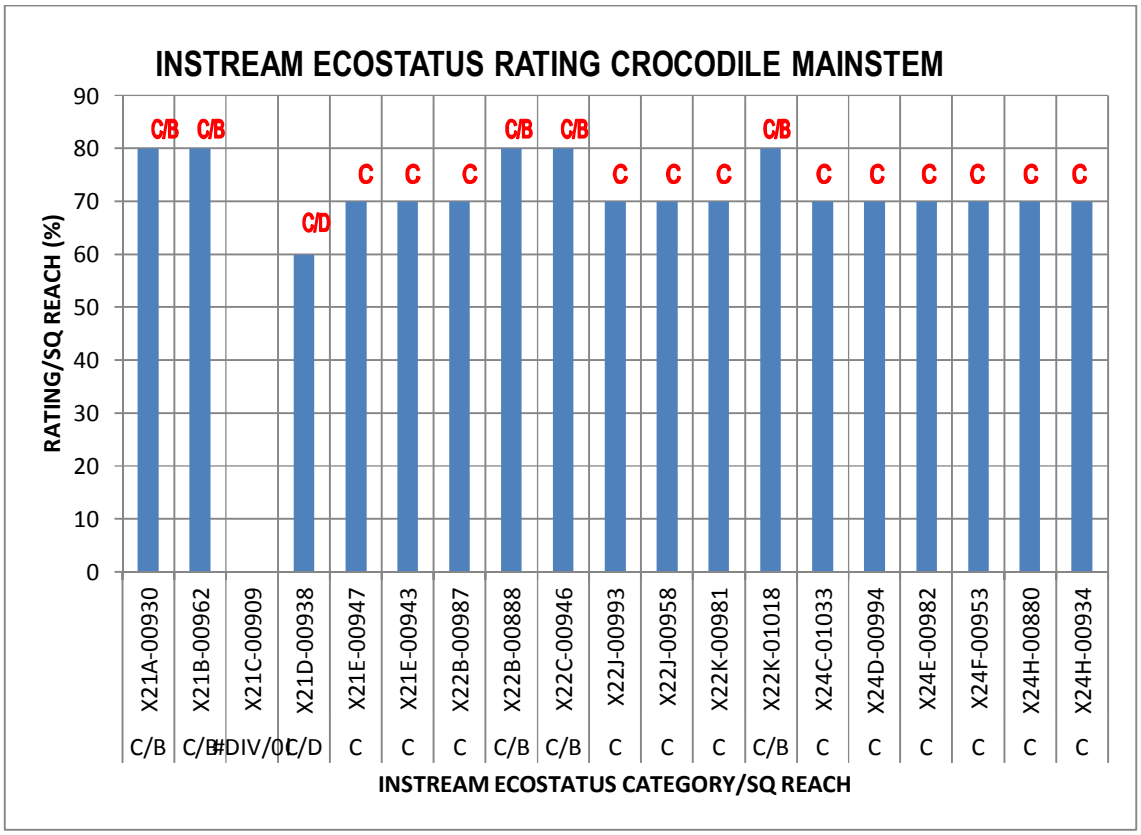


Figure 8: Instream Ecostatus rating for the Crocodile River Mainstem SQ reaches. SQ Reach X21C-00909 is situated in the Kwena Dam basin and was not surveyed.

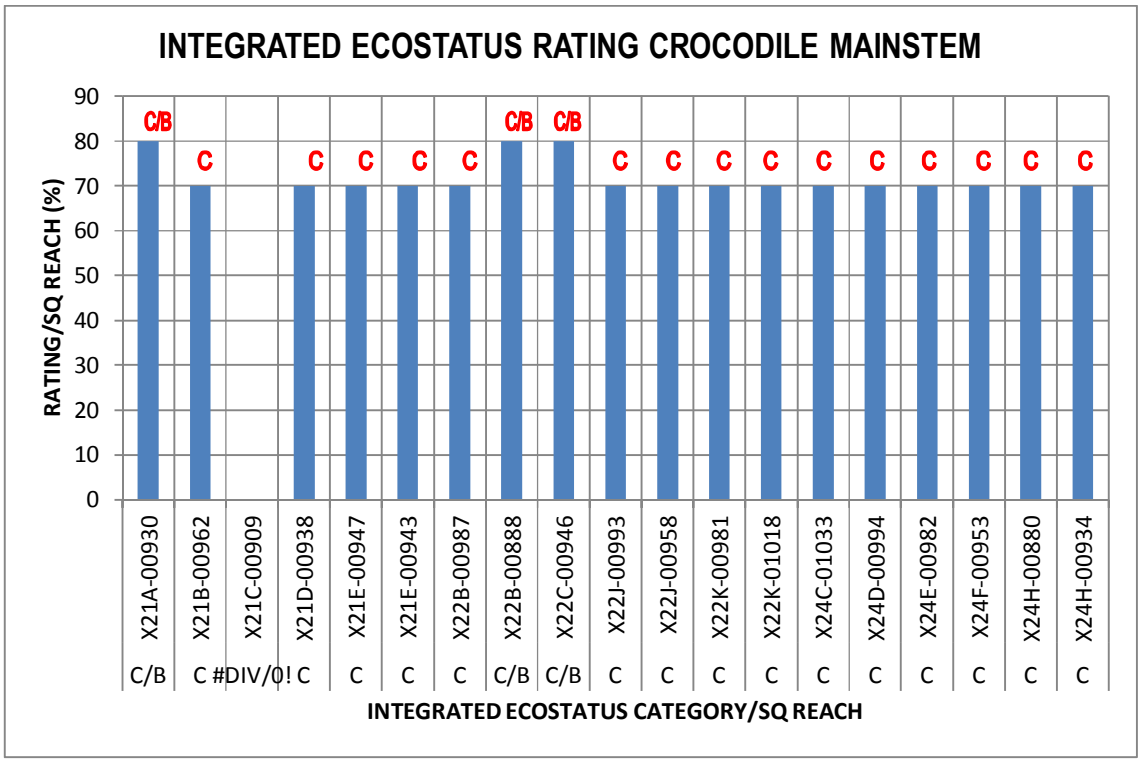


Figure 9: Integrated Ecostatus rating for the Crocodile River Mainstem SQ reaches. SQ Reach X21C-00909 is situated in the Kwena Dam basin and was not surveyed.

PES Categories

For the PES rating (Present Ecological Status) which is a desktop study derived from the PES EIS it can be seen that the overall PES rating is a Class C, moderately modified, although the lower reaches below the Crocodile Gorge is a Class D, largely modified (Figure 10).

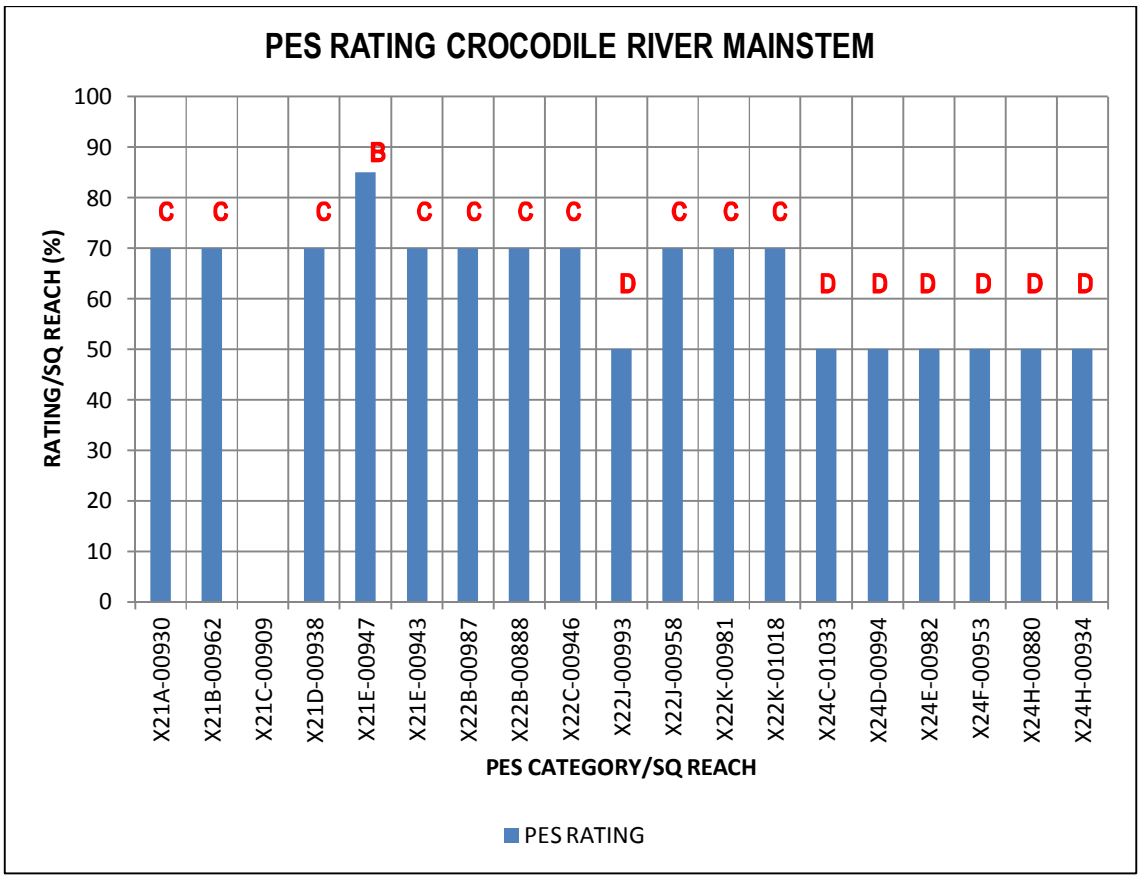


Figure 10: PES rating for the Crocodile River Mainstem SQ reaches. SQ Reach X21C-00909 is situated in the Kwena Dam basin and was not surveyed.

Crocodile River Tributaries

Lunsklip River

The Lunsklip River originates on the Velorenvalei Nature Reserve at an elevation of 2,240 m a.s.l., flowing eastwards towards its confluence with the Crocodile River upstream from Kwena Dam. The river was divided into two reaches, with the upper reach including the origin of the river to where it merges with a tributary below the R540 national road between Dullstroom and Lydenburg (Mashishing). The reach below this to where it merges with the Crocodile River is the next reach. Both of these reaches are characterised by many farm dams and weirs, stocked mainly with exotic rainbow trout (*Oncorhynchus mykiss*).

SQ REACH NUMBER X21B-00898

SQ Reach (downstream-->)	SQR Name	Fish sites	SASS sites	FRAI	MIRAI	Integrated ecostatus	PES Category	Riparian PES	Length km
X21B-00898	Lunsklip	X2LUNS-VELOR	X2LUNS-VELOR	B	B	B	D	C	10.99

General description

Reach X21B-00898: - Velorenvalei–Pleasantways

The reach length is 10.99 km, originating at 2,240 m a.s.l. towards its downstream boundary at 1,849 m a.s.l. The headwaters of the river are in very good condition, after which the stream is frequently dammed for the purpose of maintaining exotic fish populations. Several small tributaries contribute to the reach, which are also dammed for exotic fish breeding. The entire reach falls within the Eastern Bankenveld aquatic ecoregion, and the Lydenburg Montane Grassland vegetation type. Land-use is mainly trout fishing, but there are a few commercial pine plantations and small-scale live-stock farming.

Fish

In this reach only one species was found of an expected three species. The species collected is *Barbus anoplus* recorded in relative low abundance. Their relative low abundance can be related to the presence of numerous dams within this reach that is regularly stocked with the alien and invasive species Rainbow trout (*Oncorhynchus mykiss).* A Fish Response Assessment Index (FRAI) score of 85.5% was calculated for this reach based on all available information, placing this reach in an Ecological Class B (slightly impaired with a low diversity and abundance of species). The relative low ecological class (B) can be related to excessive sedimentation and the presence of predatory introduced alien fish species (Rainbow trout).

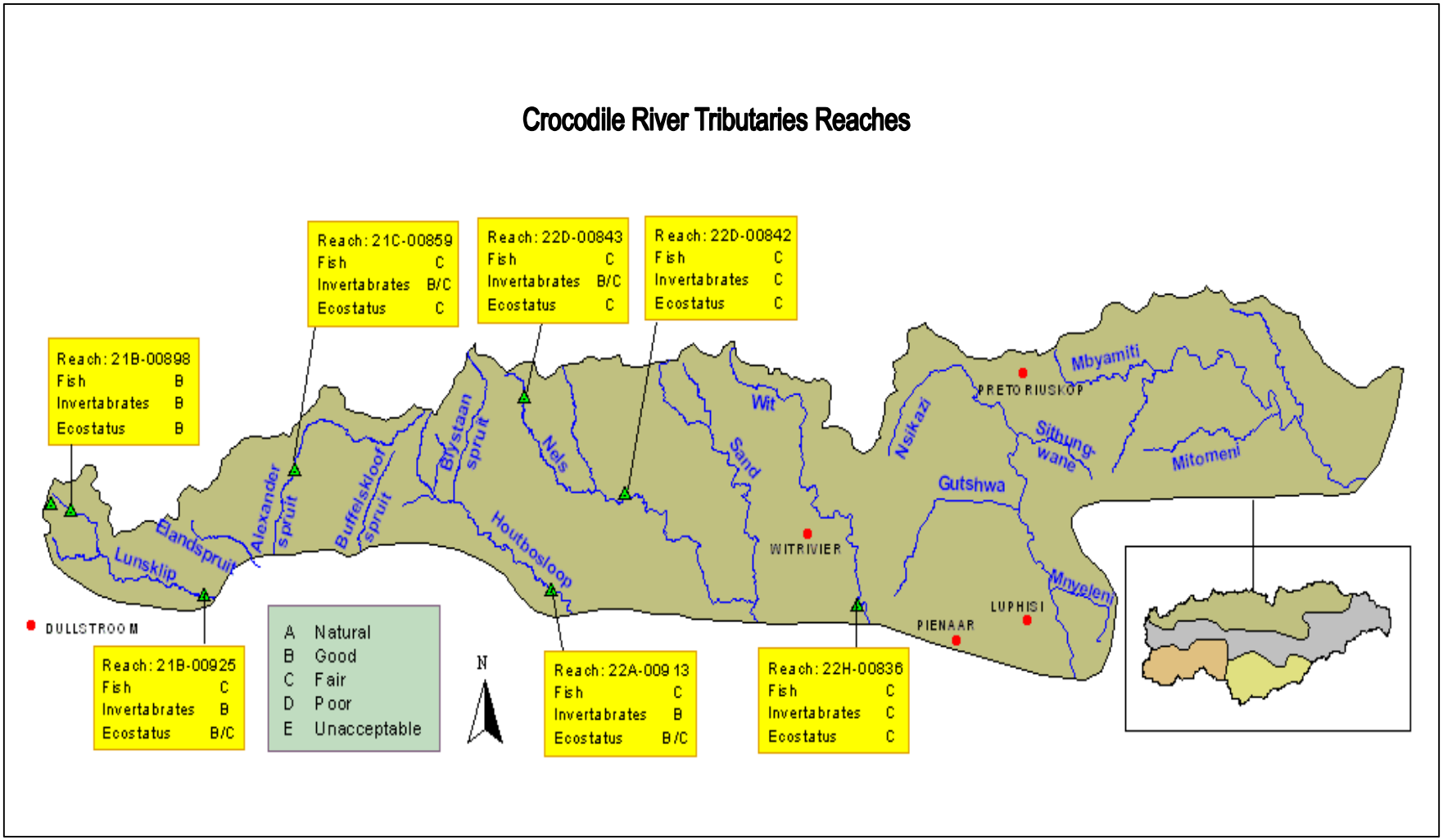


Figure 11: Crocodile River Tributaries indicating Fish, Invertebrates and Ecostatus ratings for each reach. Ratings for the SQ Reaches X21D-009570 Buffelskloofspruit; X22C-00990 Gladdespruit and X22C-01004 Visspruit can be viewed on Figure 5.

Invertebrates

Two points in the Verlorenvalei Nature Reserve was sampled within this reach. There are records of Calopterygidae in this reach, all from a 1999 SASS survey that are unusual for the family. The family Calopterygidae is represented by one species, *Phaon iridipennis* (Glistening Demoiselle), and the larvae is generally restricted to Lowveld streams. The adult are mostly restricted to woody riparian zones, sometimes in wooded areas several meters away from water. Families regularly encountered that were absent from the 2012 sample included Athericidae and Tipulidae. The families Planorbinae and Sphaeridae was recorded for the first time in 2012 since monitoring was initiated in 1993. Most families expected to occur were present. The reach was categorised as slightly impaired.

Instream ecostatus

The Ecostatus for this reach was consistent with a Class B suggesting a slightly impaired habitat. This high value largely reflects close to reference habitat conditions.

SQ REACH NUMBER X21B-00925

SQ Reach (downstream-->)	SQR Name	Fish sites	SASS sites	FRAI	MIRAI	Integrated ecostatus	PES Category	Riparian PES	Length km
X21B-00925	Lunsklip	X2LUNS-UITWA	X2LUNS-UITWA	C	B	BC	C	D	21.45

General description

Reach X21B-00925: - Pleasantways - Crocodile

The reach length is 21.45 km, starting upstream below the Pleasantways tributary (1,849 m a.s.l.) flowing through impoundments and weirs towards the Steenkampsberge. The Lunsklip plummets down a waterfall towards the point where it merges with the Crocodile River at an elevation of 1,198 m a.s.l.

The reach falls within the Eastern Bankenveld aquatic ecoregion, and in the Lydenburg Montane Grassland vegetation type above the Steenkampsberge and Lydenburg Thornveld below the waterfall. Land-use includes mainly exotic trout farms, a few commercial pine plantations, small-scale live-stock farming and irrigated crops in the portion of the reach close to the Kwena Dam.

Fish

This reach is characterised as the reach from below the Dullstroom escarpment to the Kwena Dam and consist of high habitat diversity which include habitat types associated with slow and deep fish velocity depth classes. Of the eight expected fish species, only three species were recorded in very low abundance. The species recorded were *Amphilius uranoscopus, Chiloglanis pretoriae* and *Barbus neefi,* of which two of these can be considered flow sensitive species intolerant to flow modifications. *Amphilius natalensis* and *Barbus argenteus* are of the

expected species not found and both of these species can be considered sensitive to flow modification and water quality changes. Strong evidence was recorded of eutrophication and enrichment in the form of green filamentous algae which cover large sections of the instream habitat. This eutrophication can be related to a large upstream trout aquaculture farm and its water quality reducing impacts. The water in this reach has a foul odour which can be associated with the upstream land use practices (aquaculture).

A Fish Response Assessment Index (FRAI) score of 76.8% was calculated for this reach based on all available information, placing this reach in an Ecological Class C (moderately impaired with a low diversity and abundance of species). The relative low ecological class (C) can be related to eutrophication, reduced water quality and the presence of predatory introduced alien fish species (Rainbow trout).

Invertebrates

SASS monitoring records exist for October 1996, May, July and August 1999, and June 2000. The monitoring in 2012 was carried out during September. The diversity of aquatic macro-invertebrates at the sampling point in the September 2012 survey was the lowest recorded to date. The ASPT of 6.4 is however very similar to previous records, indicating that sensitive taxa are still dominant in the community. Families regularly recorded during previous surveys but absent in 2012 included Tubelaria, Oligochaeta, Hydracarina, Perlidae, Prosopistomatidae, Philopotamidae, Coenagrionidae, Elmidae, Helodidae, Psephenidae, Ancylidae and Planorbinae. The absence of several sensitive taxa (low diversity) could suggest deteriorated conditions, but more information is required to confirm this. The reach was categorised as a B-class (slightly impaired).

Instream ecostatus

The Ecostatus for this reach was consistent with a Class BC suggesting a slightly to moderately impaired habitat.

SQ REACH NUMBER X21C-00859

SQ Reach (downstream-->)	SQR Name	Fish sites	SASS sites	FRAI	MIRAI	Instream ecostatus	PES Category	Riparian PES	Length km
X21C-00859	Alexanderspruit	X2ALEX-RIETF	X2ALEX-RIETF	C	BC	C	C	C	36.94

General Description

X21C-00859 – Alexanderspruit: Klipspruit, Rietfontein

The Alex-se-Loop was labelled as one reach, with a total length of 36.94 km. The reach originates on the Tree Falls Trout Hatchery at an elevation of 2,000 m a.s.l., and flows through the hatchery's commercial pine trees and a vast array of weirs stocked with exotic trout. The river then flows through Komatiland Forest's Uitsoek

plantation before entering agricultural lands, again with numerous trout dams. The agricultural lands are located in the riparian zone of the river. The river flows into the Kwena Dam.

The portion of the reach extends into the dam, but where it flows into the dam the elevation is 1190 m a.s.l. A very small portion of the upper reaches fall within the Northern Escarpment Mountains aquatic ecoregion, and the bulk in the Eastern Bankenveld. The upper portion of reach's' vegetation type is classified as Lydenburg Montane Grassland and lower portions towards the dam as Lydenburg Thornveld.

Fish

The habitat availability in this reach is severely impaired due to bank instability, increased siltation and sedimentation and the damming of certain river sections. In total four fish species of the expected seven species were collected in this reach which included *Amphilius uranoscopus* and the newly described *Kneria kwena. Kneria kwena* is an endemic species that only occurs in the upper reaches of the Badfontein area. Shoals of this species occur in small, clear silt free, rocky streams. They are reported to breath air and climb over damp rocks and up the sides of waterfalls during migrations. In this species the males develop disc-like contact organs on each gill-cover and adjacent body region, used for maintaining contact with the females during mating. Both the above mentioned species are sensitive to water quality changes and flow alterations within the river habitat. The absence of the expected species *Amphilius natalensis* is of concern and can possibly be related to the predatory impact of the alien and invasive species trout.

A Fish Response Assessment Index (FRAI) score of 70.7% was calculated for this reach based on all available information, placing this reach in an Ecological Class C (moderately impaired with a low diversity and abundance of species). The relative low ecological class (C) can be related to sedimentation and the impact of forestry in the upper reaches. Furthermore, numerous dams and weirs relating to the trout industry are present and the impact of trout on the endemic species is well documented.

Invertebrates

Taxa diversity is moderately high in this reach with 28 taxa recorded at the Rietfontein site and 27 taxa at the Klipspruit site (earlier data). The SASS5 scores and ASPT at the 2 sites are very similar (175 & 172 and 6.3 &6.4). The only high scoring taxa found in this section of the reach within the last 4 years was >2 spp of Baetidae. Based on the 2012 SASS5 results, the reach was categorised overall as a BC, which represents slightly modified conditions. These modified conditions are linked to modifications in flow and water quality. Causes for these modifications are linked to small farm dams and agricultural activities.

Instream ecostatus

The Ecostatus for this reach was consistent with a Class C suggesting a moderately impaired habitat.

SQ REACH NUMBER X21D-00957

SQ Reach (downstream-->)	SQR Name	Fish sites	SASS sites	FRAI	MIRAI	Instream ecostatus	PES Category	Riparian PES	Length km
X21D-00957	Buffelskloof	X2BUFF-SOMER	X2BUFF-SOMER	C	C	CD	C	C	27.07

General description

Reach X21D-00957: - Cluvia Pass – Sterkstroom

The Buffelskloof South originates north from where the Cluvia Pass road meets N4 Schoemanskloof road between Lydenburg and Machadodorp. The elevation is 1,720 m a.s.l., and the river flows through Sappi's commercial pine plantations north-easterly towards the Crocodile River.

The reach length from the point from where it was marked on maps is 27.07 km. The actual river length is a bit longer. The elevation where the Buffelskloof South enters the Crocodile River, downstream from Kwena Dam, is 1,028 m a.s.l. The upper portion of the reach falls within the Eastern Bankenveld aquatic ecoregion, from where it flows into the Northern Escarpment Mountains ecoregion. The vegetation types are similar, with Lydenburg Montane Grassland in the upper reaches and Legogote Sour Bushveld in the lower portion of the reach. The reach is characterised by commercial forestry in its origin, numerous trout dams in its upper reaches, with agricultural crops (in most cases right up to the edge of the stream) in the riparian zone and adjacent floodplains.

Fish

The Buffelskloof spruit is a small tributary entering the Crocodile river downstream of the Kwena Dam and can be considered as a stream with a high gradient and high habitat diversity including riffles, runs and pools. Eleven species are expected within this reach which include sensitive species such as *Amphilius natalensis, Chiloglanis bifurcus, Chiloglanis pretoriae, Kneria kwena and Barbus argenteus.* Of these expected species, only four species were collected namely *Amphilius uranoscopus, Barbus anoplus, Barbus neefi and Kneria kwena.* As stated previously *Kneria kwena* is endemic to these reaches. The abundance of the species collected were relatively high including most of the age classes (juveniles, sub-adults and adults) indicating that successful breeding is taking place at present. The low species diversity and loss of expected species can be related to over-abstraction of water in this reach for irrigational purposes. Furthermore presence of illegal weirs obstructing migrational routes in this reach prevents the re-colonisation of species. Land use practices further contribute to the high siltation and sedimentation loads recorded within this reach.

A Fish Response Assessment Index (FRAI) score of 74.6% was calculated for this reach based on all available information, placing this reach in an Ecological Class C (moderately impaired with a low diversity and abundance of species).

Invertebrates

Instream habitat is generally good. The sampling site in this reach is located towards the lower end of the reach. Taxon diversity during 2012 is moderately low (20 taxa) compared to the 2009 survey when 26 taxa were recorded. There were only two high scoring taxa recorded (>2 spp Hydropsychidae and >2 spp Baetidae) compared to the 14 expected under reference conditions, however it is expected that another 4 high scoring taxa are still present within the reach. Based on the 2012 SASS5 results, the reach was categorised overall as a C, which represents moderately modified conditions. These modified conditions are mostly linked to modifications in water quality and habitat. Causes for these modifications are linked to small farm dams and agricultural activities in the reach.

Instream ecostatus

The Ecostatus for this reach was consistent with a Class C suggesting a moderately impaired habitat.

SQ REACH NUMBER X22A-00913

SQ Reach (downstream-->)	SQR Name	Fish sites	SASS sites	FRAI	MIRAI	Instream ecostatus	PES Category	Riparian PES	Length km
X22A-00913	Houtbosloop	X2HOUT-SUDWA	X2HOUT-SUDWA	C	B	BC	C	C	28.31

General description

The elevation in this reach which falls withing the Great Escarpment Mountains ecoregion,ranges from1 015 m a.s.l. – 743 m a.s.l. The catchment has largely been transformed to forestry. Areas of concern within this reach are the high siltation and sedimentation load resulting in embedment of stones in current. Large fires in the forestry area in 2012 resulted in extreme levels of siltation within the catchment.

Fish

Areas of concern within this reach are the high siltation and sedimentation load resulting in embedment of stones in current. These imbedded rocks and stones decrease interstitial spaces resulting in the loss of available fish habitat for small rheophilic fish species. Only two indigenous fish species, *Chiloglanis pretoriae* and *Barbus argenteus*, were collected. Of concern is that 15 species were expected to occur and this can be ascribed to the loss of available fish habitat due to sedimentation.

A Fish Response Assessment Index (FRAI) score of 69.4% was calculated for this reach based on all available information, placing this reach in an Ecological Class C (moderately impaired with a low diversity and abundance of species).

Invertebrates

This reach consists of a small to medium size tributary of the Crocodile River, not far from the Sudwala caves. The bio-monitoring point sampled in this reach includes X2HOUT-SUDWA.The in-stream habitat is dominated by, gravel, sand-mud, bedrock and vegetation were scares. Siltation was eminent. Based on the 2012 SASS5 results, the reach was categorised overall as B, which represents little modified conditions. These modified conditions are linked to modifications in flow, water quality and sediment deposition. Impacts are mainly due to forestry activities and dirt roads. Sedimentation is a concern as well as erosion. 23 taxa were present at this monitoring site. Highly sensitive taxa included Beatidae, Heptagenidae, Hydropsychidae and Perlidae.

Instream ecostatus

The Ecostatus for this reach was consistent with a Class BC suggesting a slightly to moderately impaired habitat.

SQ REACH NUMBER X22A-00875; X22A – 00919; X22A - 00917

SQ Reach (downstream-->)	SQR Name	Fish sites	SASS sites	FRAI	MIRAI	Instream ecostatus	PES Category	Riparian PES	Length km
X22A-00875 X22A- 00919 X22A-00917	Houtbosloop			C C C	AB B B	B C/B C/B	C C C	C C C	10.38km 0.66km 2.67km

General description

The FRAI, MRAI and Ecostatus for this reach was derived and/or extrapolated from previous surveys and expert judgement and indicate that the Ecostatus for the fish is a class C (moderately impaired with a moderate diversity and abundance of species) and for the invertebrates a class B (slightly impaired with a moderate diversity of taxa consisting mainly of tolerant taxa).

SQ REACH NUMBER X22C-00990

SQ Reach (downstream-->)	SQR Name	Fish sites	SASS sites	FRAI	MIRAI	Instream ecostatus	PES Category	Riparian PES	Length km
X22C-00990	Visspruit	X2VISS-ALKMA	X2VISS-ALKMA	C	C	C	C	C	9.99

General description

Reach X22C-00990: Visspruit

This reach is a tributary of the Crocodile River, west of the town of Nelspruit. It originates at an elevation of 1 240 m a.s.l. and flows to an elevation of 703 m a.s.l. where it joins up with the Crocodile River. The instream

habitat is dominated by sandy runs resulting from excessive erosion and sedimentation. Most of the reach falls withing the Great Escarpment Mountains aquatic ecoregion. The riparian vegetation is dominated by dense stands of alien plant species such as *Lantana camara* and *Rubus* spp. The catchment has largely been transformed to monoculture forestry and tropical fruit irrigation farming.

Fish

Nine indigenous species were expected including the sensitive flow dependant *Amphilius uranoscopus*, but only three species were sampled and in low abundance. These were two of the smaller barb species, *Barbus anoplus* and *Barbus trimaculatus* and the larger rheophilic *Labeobarbus marequensis*. The reason for the low abundance of fish collected can be related to low habitat diversity and reduced available fish habitat.

A Fish Response Assessment Index (FRAI) score of 71.2% was calculated for this reach based on all available information, placing this reach in an Ecological Class C (moderately impaired with a low diversity and abundance of species).

Invertebrates

This reach consists of a small tributary of the Crocodile River, upstream west of the town of Nelspruit. The bio-monitoring point sampled in this reach includes X2VISS-ALKMA.The in-stream habitat is dominated by, bedrock, gravel, vegetation and sand-mud. Because of the sandy substrate boulders and bedrock are limited. Based on the 2012 SASS5 results, the reach was categorised overall as C, which represents significantly modified conditions. These modified conditions are linked to modifications in flow, water quality and sediment deposition. Impacts are mainly due to agricultural activities, dirt roads and small bridges. Sedimentation is a concern as well as erosion. Exotic plants such as Lantana and Bramble are found on the banks of the stream.

Instream ecostatus

The Ecostatus for this reach was consistent with a Class C suggesting a moderately impaired habitat.

SQ REACH NUMBER X22C-01004

SQ Reach (downstream-->)	SQR Name	Fish sites	SASS sites	FRAI	MIRAI	Instream ecostatus	PES Category	Riparian PES	Length km
X22C-01004	Gladde	X2GLAD-HERMA	X2GLAD-HERMA	D	C	C	C	C	36.72

General description

Reach X22C-01004:- Gladdespruit

This reach is a tributary of the Crocodile River, very close to the town of Nelspruit. It originates close to Kaapschehoop at an elevation of 1 675 m a.s.l. and flows to an elevation of 645 m a.s.l. where it joins up with the

Crocodile River. The instream habitat is dominated by bedrock and sandy runs resulting from excessive erosion and sedimentation. Most of the reach falls withing the Great Escarpment Mountains aquatic ecoregion. The riparian vegetation is dominated by dense stands of alien plant species such as *Lantana camara* and *Rubus* spp. The catchment has largely been transformed to monoculture forestry and tropical fruit irrigation farming.

Fish

The combination of cold water species from the higher altitude of this reach and the more temperate species from the lower part of the reach results in a high number of expected species. Fifteen indigenous fish species were expected which included the critically endangered, flow dependant, red data species *Chiloglanis bifurcus,* and another three flow dependant species, *Chiloglanis paratus*, *Chiloglanis pretoriae* and *Amphilius uranoscopus*. Only one indigenous small barbus, *Barbus argenteus*, was found in high abundance.

A Fish Response Assessment Index (FRAI) score of 54.6% was calculated for this reach based on all available information, placing this reach in an Ecological Class D (moderately impaired with a low diversity and abundance of species).

Invertebrates

This reach consists of a small tributary of the Crocodile River, upstream west of the town of Nelspruit. The bio-monitoring point sampled in this reach includes X2GLAD-HERMA. The in-stream habitat is dominated by, bedrock, gravel, vegetation and sand-mud. Because of the sandy substrate, boulders and bedrock are limited. Based on the 2012 SASS5 results, the reach was categorised overall as C/B, which represents some modified conditions. These modified conditions are linked to modifications in flow, water quality and sediment deposition. Impacts are mainly due to agricultural activities, dirt roads and small bridges. Sedimentation is a concern as well as erosion. Exotic plants such as Lantana and Bramble are found on the banks of the stream.

Instream ecostatus

The Ecostatus for this reach was consistent with a Class BC suggesting a slightly to moderately impaired habitat.

SQ REACH NUMBER X22D-00843

SQ Reach (downstream-->)	SQR Name	Fish sites	SASS sites	FRAI	MIRAI	Instream ecostatus	PES Category	Riparian PES	Length km
X22D-00843	Nels	X2NELS-RHENO	X2NELS-RHENO	C	BC	C	C	D	24.89

General description

Reach X22D-00843: Nelsriver

The Nels River originates at an elevation of 1 690 m a.s.l. The reach falls withing the Great Escarpment Mountains aquatic ecoregion. The catchment has largely been transformed to forestry (Pines). The riparian vegetation is dominated by dense stands of alien plant species.

Fish

The fish assemblage present in this reach was characterised by a low abundance and diversity. Seven indigenous fish species were expected, but none were collected. Only the exotic species, *Oncorhynchus mykiss* (Rainbow trout), was collected. Trout is stocked by farmers and this piscivorous species has a detrimental effect on the indigenous species.

A Fish Response Assessment Index (FRAI) score of 71.3% was calculated for this reach based on all available information, placing this reach in an Ecological Class C (moderately impaired with a low diversity and abundance of species). The relative low ecological class (C) can be related to excessive sedimentation and the presence of predatory introduced alien fish species (Rainbow trout).

Invertebrates

This reach consists of a small to medium size tributary of the Crocodile River, upstream west of the town of Nelspruit. The bio-monitoring point sampled in this reach includes X2NELS-RHENO.The in-stream habitat is dominated by, gravel, vegetation and sand-mud. Because of the sandy substrate boulders and bedrock are limited. Based on the 2012 SASS5 results, the reach was categorised overall as B/C, which represents some modified conditions. These modified conditions are linked to modifications in flow, water quality and sediment deposition. Impacts are mainly due to forestry activities, dirt roads and small bridges. Sedimentation is a concern as well as erosion. Exotic plants such as Lantana and Black Wattle are growing on the banks of the stream

Instream ecostatus

The Ecostatus for this reach was consistent with a Class C suggesting a moderately impaired habitat.

SQ REACH NUMBER X22F-00842

SQ Reach (downstream-->)	SQR Name	Fish sites	SASS sites	FRAI	MIRAI	Instream ecostatus	PES Category	Riparian PES	Length km
X22F-00842	Nels	X2NELS-SPITS	X2NELS-SPITS	C	C	C	C	D	35.10

General description

Reach X22D-00842:- Nelsriver

The elevation in this reach ranges from 1 060 – 740 m a.s.l. A steep gradient with large riffles and rapids with fast flowing habitats is dominant in this reach. The reach falls withing the Great Escarpment Mountains aquatic ecoregion. The catchment has largely been transformed to forestry (Pines). The riparian vegetation is dominated by grass species and dense stands of alien plant species.

A steep gradient with large riffles and rapids with fast flowing habitats is dominant in this reach. The catchment has largely been transformed to forestry (Pines). The riparian vegetation is dominated by grass species and dense stands of alien plant species.

Fish

In this reach only two of the expected eight species were recorded. These two species were typical for this reach of fast flowing habitats which included riffles and runs. Both of these species can be classified as flow dependant species, namely *Amphilius uranoscopus* and *Chiloglanis pretoriae*. Of the eight expected species the absence of the catadromous species, *Anguilla mossambica*, as well as the absence of reophilic *Labeobarbus marequensis* is of concern. Their absence could possibly be related to limited available habitat due to excessive siltation and sedimentation.

A Fish Response Assessment Index (FRAI) score of 76% was calculated for this reach based on all available information, placing this reach in an Ecological Class C (moderately impaired with a low diversity and abundance of species).

Invertebrates

This reach consists of a small to medium size tributary of the Crocodile River, upstream west of the town of Nelspruit. The bio-monitoring point sampled in this reach includes X2NELS-SPITZ.The in-stream habitat is dominated by, bedrock, gravel, vegetation and sand-mud. Because of the sandy substrate boulders and bedrock are limited. The less common invertebrate of the Calamoceratidei Taxa was found in this reach. Based on the 2012 SASS5 results, the reach was categorised overall as C, which represents significant modified conditions. These modified conditions are linked to modifications in flow, water quality and sediment deposition. Impacts are

mainly due to forestry activities, dirt roads and small bridges. Sedimentation is a concern as well as erosion. Exotic plants such as Lantana and Black Wattle are growing on the banks of the stream.

Instream ecostatus

The Ecostatus for this reach was consistent with a Class C suggesting a moderately impaired habitat.

SQ REACH NUMBER X22F-00977

SQ Reach (downstream-->)	SQR Name	Fish sites	SASS sites	FRAI	MIRAI	Instream ecostatus	PES Category	Riparian PES	Length km
X22F-00977	Nels			C	C	C	D	C	6.65

General description

The FRAI, MRAI and Ecostatus for this reach was derived and/or extrapolated from previous surveys and expert judgement and indicate that the Ecostatus for the fish is a class C (moderately impaired with a moderate diversity and abundance of species) and for the invertebrates a class C (Moderately impaired with a moderate diversity of taxa consisting mainly of tolerant taxa).

SQ REACH NUMBER X22H-00836

SQ Reach (downstream-->)	SQR Name	Fish sites	SASS sites	FRAI	MIRAI	Instream ecostatus	PES Category	Riparian PES	Length km
X22H-00836	Whiterivier	X2WITR-VALLE	X2WITR-VALLE	C	C	C	E	E	21.45

General description

Reach X22H-00836: White River

The Whiterivier originates north of the town Whiterivier at an elevation of 1 180 m a.s.l. and flows past the town and smallholdings to the confluence with the Crocodile River at an elevation of 524 m a.s.l. The reach falls withing the Great Escarpment Mountains aquatic ecoregion. The catchment has largely been transformed to agricultural smallholdings. The riparian vegetation is dominated by dense stands of alien plant species. Within this reach most of the river habitats have been altered to lentic conditions due to the numerous dams and weirs. The natural flow regime is greatly reduced due to the impact and flow regulation from these dams.

Fish

The fish assemblage present in this reach was characterised by a low abundance and diversity. Eleven indigenous fish species were expected, but only three tolerant species, *Tilapia sparrmanii, Pseudocrenilabrus philander* and *Clarias gariepinus*, were collected. No flow dependant species such as *Amphilius uranoscopus* or *Chiloglanis pretoriae* were collected. Large numbers of the exotic species, *Micropterus salmoides* (Largemouth bass), was collected and this piscivorous species can be the reason for the low abundance of fish species collected.

A Fish Response Assessment Index (FRAI) score of 71.3% was calculated for this reach based on all available information, placing this reach in an Ecological Class C (moderately impaired with a low diversity and abundance of species). The relative low ecological class (C) can be related to excessive sedimentation and the presence of predatory introduced alien fish species (Largemouth bass).

Invertebrates

This reach of the White River is a small to medium tributary of the Crocodile River above the Primkop dam. The bio-monitoring point sampled in this reach was, X2-WITR-VALLE. The in-stream habitat is dominated by, cobbles, bedrock, vegetation and sand-mud. Based on the 2012 SASS5 results, the reach was categorised overall as B/C, which represents some modified conditions. These modified conditions are linked to modifications in flow and water quality. Impacts are mainly due to agricultural activities and human settlements. Siltation is present in the out of current areas. The abundance of the Coenagrionidae taxa was visibly high in all the habitats.

Instream ecostatus

The Ecostatus for this reach was consistent with a Class C suggesting a moderately impaired habitat.

Summary Crocodile Tributaries Indices

FRAI Categories

Figure 12 summarises the FRAI categories for the 13 SQ reaches done on the smaller tributaries of the Crocodile River. The overall FRAI for the smaller tributaries is a Class C which indicates that the tributaries are moderately impaired with a moderate diversity and low abundance of species. Exotic fish species, forestry and agricultural smallholdings have a negative impact on the fish communities. The only tributary in a Class D is the Gladdespruit which is impacted on by urbanization, agricultural smallholdings and forestry.

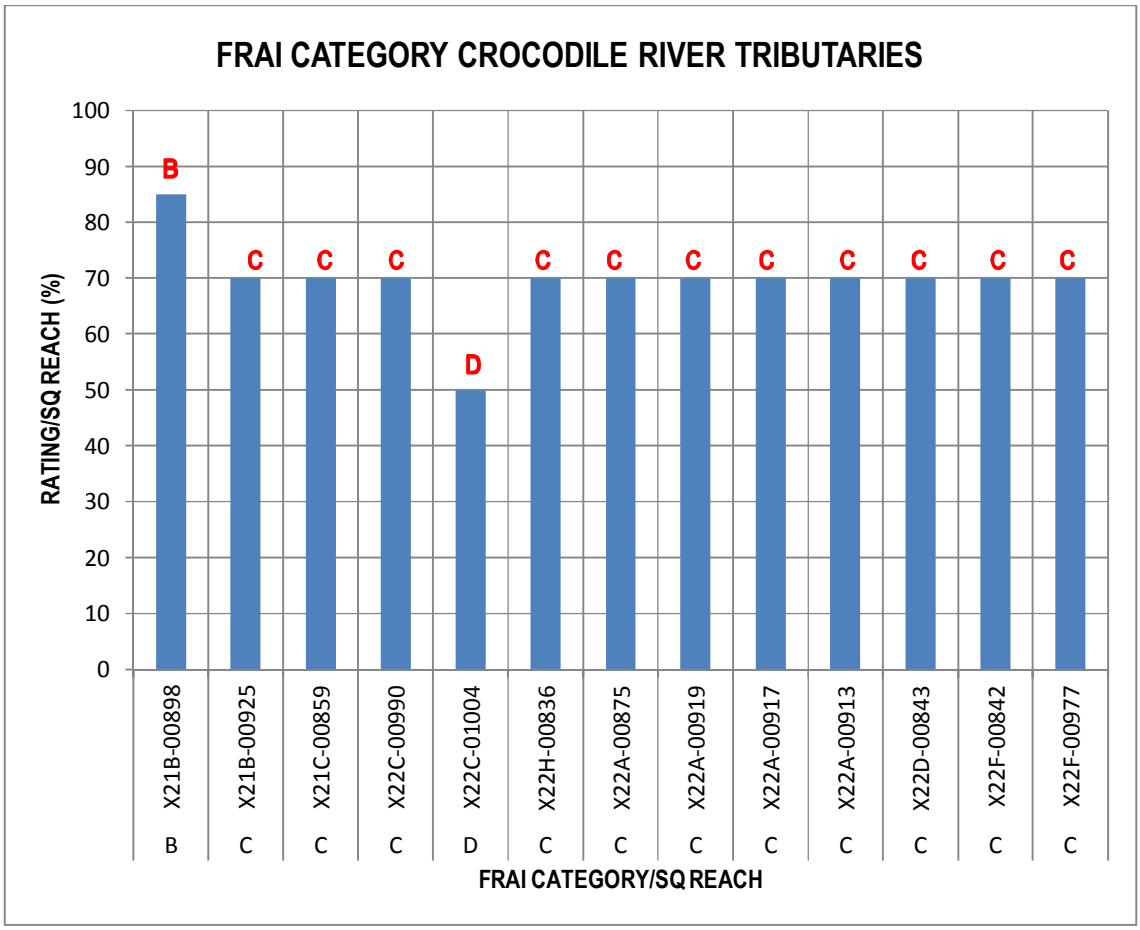


Figure 12: FRAI category for the Crocodile River tributaries SQ reaches.

MIRAI Categories

Based on the aquatic invertebrate community the upper reach Crocodile River tributaries (Lunsklip and Alexanderspruit) upstream of the Kwena Dam are categorized as slightly impaired B classes. The other tributaries downstream of the Kwena Dam are categorized as moderately impaired C class rivers with the Houtbosloop tributaries at a B Class (slightly impaired).

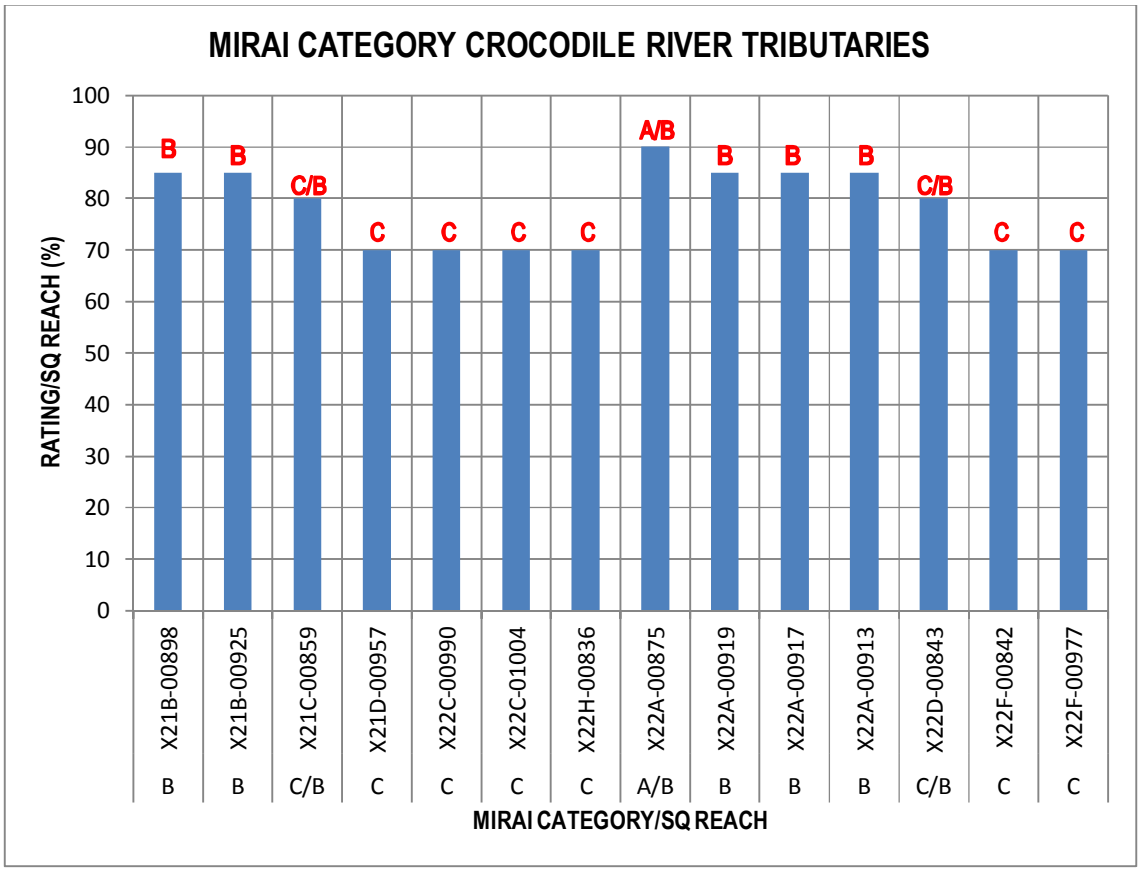


Figure 13: MIRAI category for the Crocodile River tributaries SQ reaches.

Instream and Integrated Ecostatus Ratings for the Crocodile Tributaries

From figure 14 and 15 it is evident that the Instream Ecostatus rating as well as the Integrated Ecostatus rating is a consistent C class, moderately impaired. It is only the Lunsklip River where the ecostatus improve slightly ranging from a class C to a class C/B.

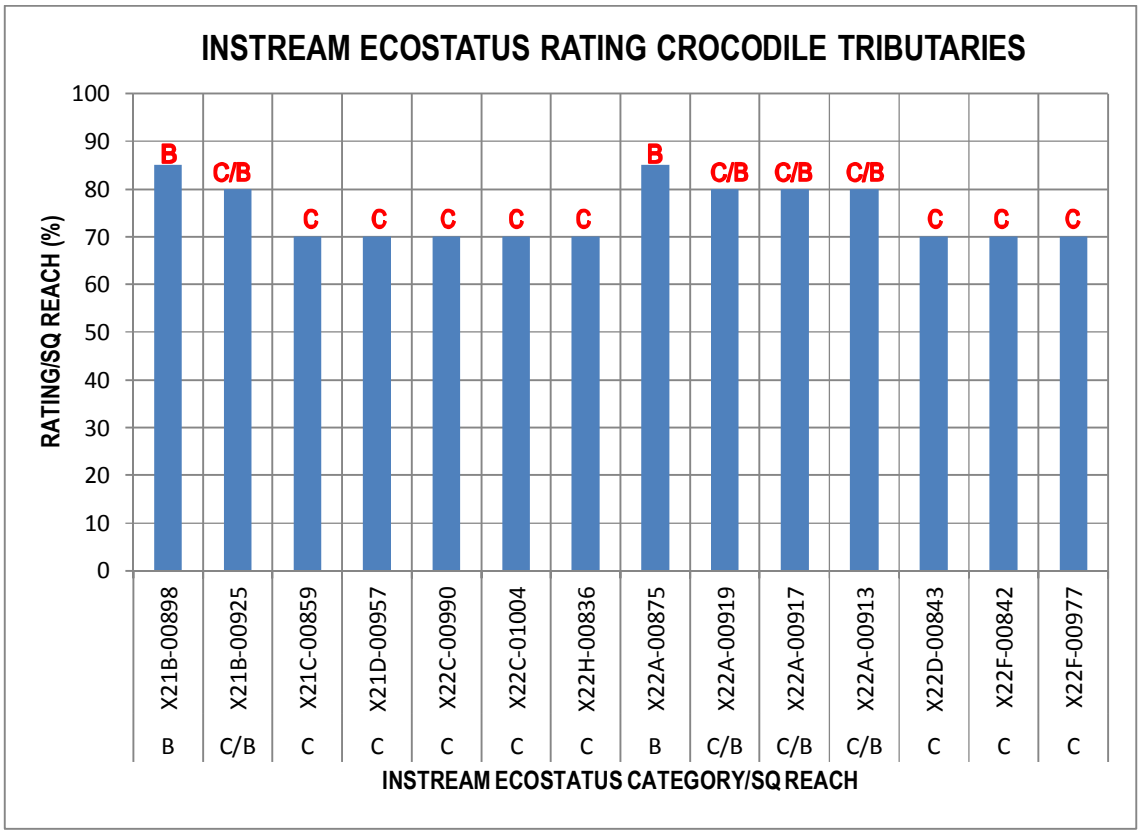


Figure 14: Instream Ecostatus rating for the Crocodile River tributaries SQ reaches.

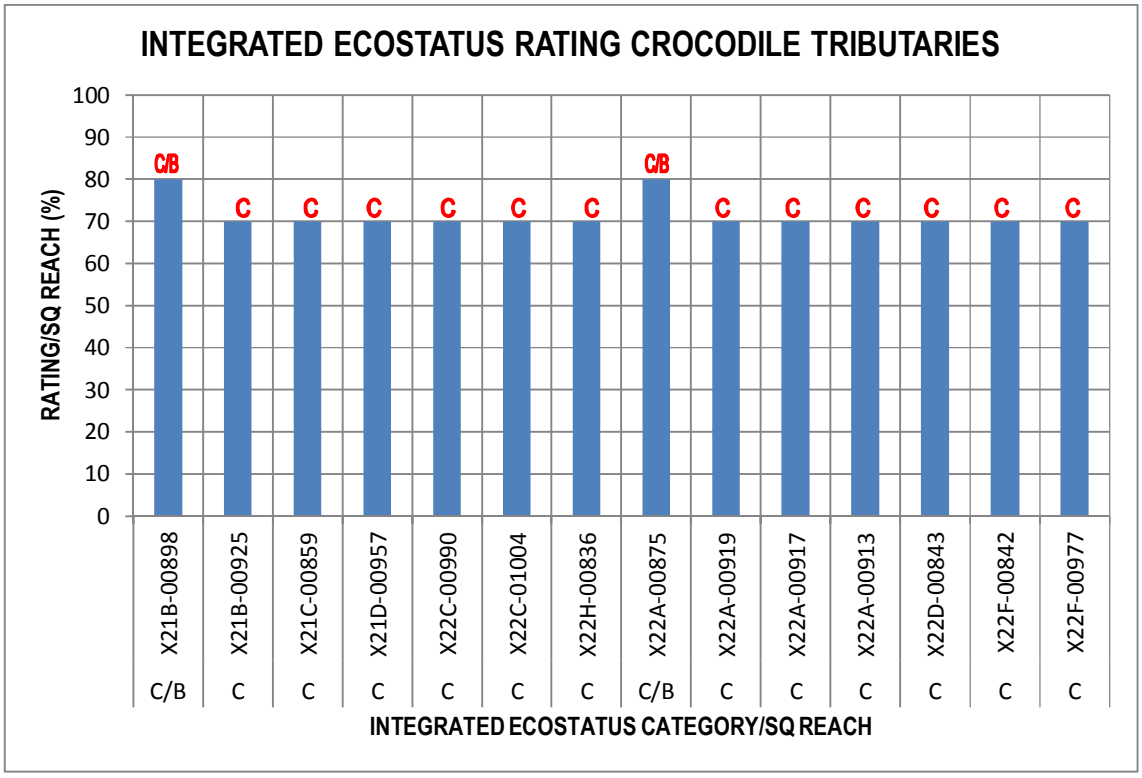


Figure 15: Integrated Ecostatus rating for the Crocodile River tributaries SQ reaches.

PES Categories

For the PES rating most of the rivers is rated within a C class – moderately modified, however the Lunsklip and the Nelsriver is within a Class D, which would indicate a largely modified reach. The Whiteriver is further reduced to a class E – seriously and critically modified.

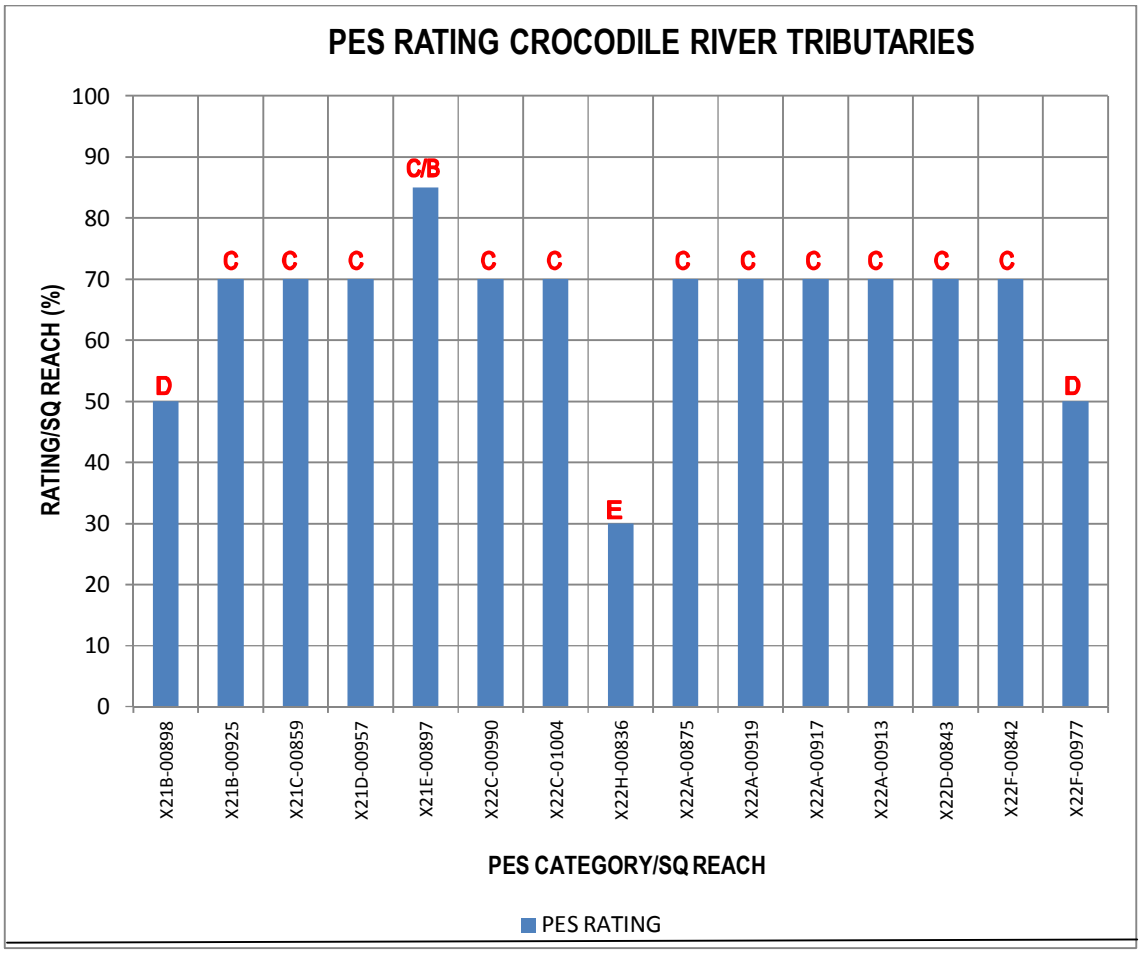


Figure 16: PES rating for the Crocodile River tributaries SQ reaches.

Elands River Mainstem Reaches and Tributaries

SQ REACH NUMBER X21F-01046

SQ Reach (downstream-->)	SQR Name	Fish sites	SASS sites	FRAI	MIRAI	Instream ecostatus	PES Category	Riparian PES	Length km
X21F-01046	Elands			C	AB	B	C	C	33.38

General description

The Elands River rises on grassland plateau as a narrow channel with no definite riparian zone at an altitude in the region of 1910 metres above sea level. Numerous small farm dams stocked with trout are typical of this reach.

The FRAI, MIRAI and Ecostatus for this reach was derived and/or extrapolated from previous surveys and expert judgement and indicate that the Ecostatus for the fish is a class C (moderately impaired with a moderate diversity and abundance of species) The relative low ecological class (C) can be related to excessive sedimentation and the presence of predatory introduced alien fish species (Rainbow trout). The Ecostatus for the invertebrates is a much higher class B (diversity of taxa).

SQ REACH NUMBER X21F-01081

SQ Reach (downstream-->)	SQR Name	Fish sites	SASS sites	FRAI	MIRAI	Instream ecostatus	PES Category	Riparian PES	Length km
X21F-01081	Elands			C	AB	BC	C	C	2.49

General description

This short reach is just downstream from the town Machadodorp.

The FRAI, MIRAI and Ecostatus for this reach was derived and/or extrapolated from previous surveys and expert judgement and indicate that the Ecostatus for the fish is a class C (moderately impaired with a moderate diversity and abundance of species) and for the invertebrates a class AB (diversity of taxa).

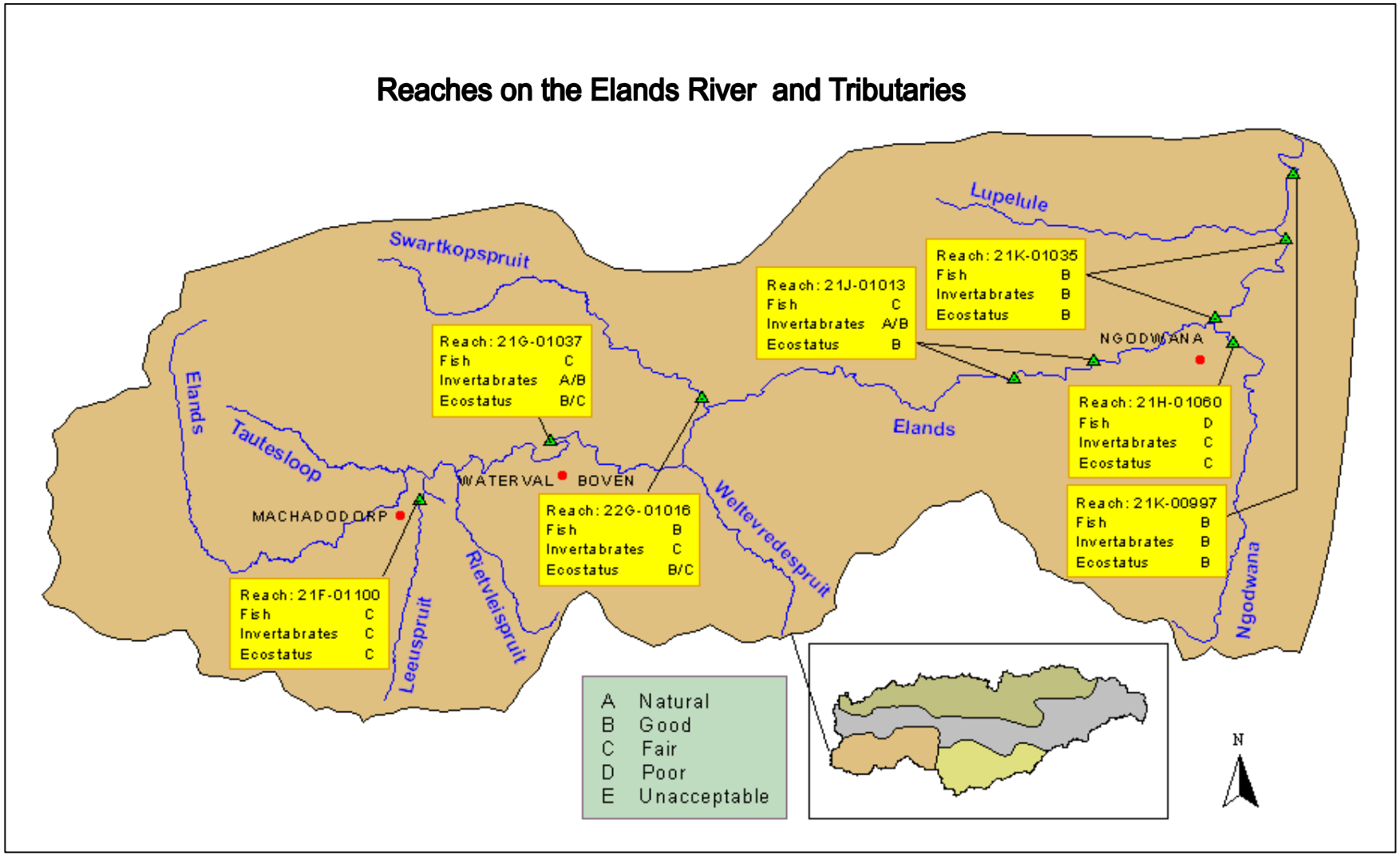


Figure 17: Elands River and tributaries indicating Fish, Invertebrates and Ecostatus ratings for each reach

SQ REACH NUMBER X21G-01037

SQ Reach (downstream-->)	SQR Name	Fish sites	SASS sites	FRAI	MIRAI	Instream ecostatus	PES Category	Riparian PES	Length km
X21G-01037	Elands	X2ELAN-DOORN	X2ELAN-DOORN	C	BC	D	D	C	19.72

General description

The elevation in this reach ranges from 1 505 m a.s.l. at the Rietvleispruit confluence to 1 200 m a.s.l. at the Weltevredespruit confluence. High relief and steep slopes results in a 19.7 km long reach, characterised by excellent riffle and rapid habitat. The reach falls withing the Great Escarpment Mountains aquatic ecoregion.
Encroachment by alien trees such as eucalypts and wattles are evident and results in the modification of the riparian habitat.

Fish

The habitat is dominated by riffles and rapids and a waterfall in this reach forms a natural physical barrier to the upstream migration of fish. The fish assemblage found in this reach consisted of three species and is listed in Appendix A. Nine indigenous fish species were expected and *Amphilius uranoscopus* is the only one of three flow dependent species expected whereas *Chiloglanis bifurcus* and *Chiloglanis pretoriae* were absent. Two tolerant species, *Pseudocrenilabrus philander* and *Tilapia sparrmanii* were collected in backwater habitat.
A Fish Response Assessment Index (FRAI) score of 72% was calculated for this reach based on all available information, placing this reach in an Ecological Class C (moderately impaired with a moderate diversity and low abundance).

Invertebrates

This reach is in the upper reach of the Elands River a medium size tributary of the Crocodile River, upstream of the town of Machadodorp. The bio-monitoring point sampled in this reach was, X2ELAN-DOORN. The in-stream habitat is dominated by, cobbles, bedrock, vegetation and sand-mud. Based on the 2012 SASS5 results, the reach was categorised overall as A/B, which represents marginal modified conditions. These modified conditions are linked to modifications in flow and water quality. Impacts are mainly due to agricultural activities and human settlements up stream. A total of 29 taxa were recorded respectively, indicating a high diversity of invertebrates. Highly sensitive taxa included Beatidae, Heptagenidae, and Prosopistomatidae. Although the taxa were present in the samples, it was noted that the abundance of these taxa were low.

Instream ecostatus

The Ecostatus for this reach was consistent with a Class C suggesting a moderately impaired habitat.

SQ REACH NUMBER X21F-01073

SQ Reach (downstream-->)	SQR Name	Fish sites	SASS sites	FRAI	MIRAI	Instream ecostatus	PES Category	Riparian PES	Length km
X21F-01073	Elands			C	AB	B	C	C	3.62

General description

The FRAI, MIRAI and Ecostatus for this reach was derived and/or extrapolated from previous surveys and expert judgement and indicate that the Ecostatus for the fish is a class C (moderately impaired with a moderate diversity and abundance of species) and for the invertebrates a class AB (moderately to slightly impaired with a moderate diversity of taxa).

SQ REACH NUMBER X21J-01013

SQ Reach (downstream-->)	SQR Name	Fish sites	SASS sites	FRAI	MIRAI	Instream ecostatus	PES Category	Riparian PES	Length km
X21J-01013	Elands	X2ELAN-GELUK; X2ELAN-HELML	X2ELAN-GELUK; X2ELAN-HELML	C	AB	B	C	D	35.01

General description

The elevation in this reach ranges from 1 167 m a.s.l. at the Swartkoppiesspruit confluence to 903 m a.s.l. at the Ngodwana River confluence. Monitoring points sampled in the Elands River within this reach included X2ELAN-GELUK and X2ELAN-HELML. Fast deep and shallow habitats with substrate and water column as cover, is dominant in this reach. The reach falls withing the Great Escarpment Mountains aquatic ecoregion.

Monitoring points sampled in the Elands River within this reach included X2ELAN-GELUK and X2ELAN-HELML. Fast deep and shallow habitats with substrate and water column as cover, is dominant in this reach.

Fish

This reach is characterised by all fish velocity depth classes with an abundance of cover present which is the reason that six of the nine expected fish species were collected (Appendix A). Of concern is the absence of the critically endangered red data species *Chiloglanis bifurcus* which is endemic to the Crocodile – Incomati River systems. The rheophilic *Labeobarbus polylepis* was recorded together with the flow dependant *Chiloglanis pretoriae* and *Amphilius uranoscopus.* The small barbus typical of the Elands River, *Barbus argenteus*, was collected in large numbers of all age classes indicating successful breeding of this species at present.

A Fish Response Assessment Index (FRAI) score of 82.3% was calculated for this reach based on all available information, placing this reach in an Ecological Class B (slightly impaired with a high diversity and abundance of species).

Invertebrates

This is in the upper reach of the Elands River a medium size tributary of the Crocodile River, downstream of the town of Machadodorp. The bio-monitoring points sampled in this reach were, X2ELAN-HELMLO and X2ELAN-GELUK.The in-stream habitat is dominated by, cobbles, bedrock, vegetation and sand-mud. Based on the 2012 SASS5 results, the reach was categorised overall as A/B, which represents marginal modified conditions. These modified conditions are linked to modifications in flow, water quality and sedimentation. Impacts are mainly due to agricultural activities and human settlements up stream. A total of 24 taxa were recorded respectively at the Geluk monitoring site and 29 taxa at the Hemlo site, indicating a high diversity of invertebrates. Highly sensitive taxa included Beatidae, Heptagenidae, and Perlidae. Although the taxa were present in the samples, it was noted that the abundance of the taxa present were not high.

Instream Ecostatus

The Ecostatus for this reach was consistent with a Class C, suggesting a moderately impaired habitat.

SQ REACH NUMBER X21K-01035

SQ Reach (downstream-->)	SQR Name	Fish sites	SASS sites	FRAI	MIRAI	Instream ecostatus	PES Category	Riparian PES	Length km
X21K-01035	Elands	X2ELAN-HOUT; X2ELAN-ROODE	X2ELAN-HOUT; X2ELAN-ROODE	B	B	B	D	D	9.41

General description

Two monitoring sites (X2ELAN-HOUT & X2ELAN-ROODE) were selected to represent this reach.

The elevation in the reach ranges from 903 m a.s.l. at the Ngodwana River confluence to 860 m a.s.l. at the Lupelule River confluence. The reach falls withing the Great Escarpment Mountains aquatic ecoregion.

The Sappi Ngodwana paper mill is just upstream from this reach. In September 1989 part of the Ngodwana, Elands and Crocodile rivers in Mpumalanga were polluted by an effluent spill from the Sappi Kraft pulp and papermill at Ngodwana which resulted in large mortalities of fish and aquatic insects. According to various surveys conducted subsequently to the spill, some eighteen species of indigenous fish and three species of exotic fish were affected. The Incomati rock catlet/ suckermouth (*Chiloglanis bifurcus*) critically endangered red data specie, was most seriously affected being eradicated over 38% of its natural range.

Fish

At these two biomonitoring sites habitat diversity was excellent and was dominated by fast deep and fast shallow fish velocity depth classes with riffles and runs, as well as good cover. The instream habitat was however impacted by eutrophication and reduced water quality as excessive filamentous algae were observed. Furthermore, siltation resulted in a loss of available fish habitat. Six of the expected nine species were recorded which included *Chiloglanis bifurcus, Chiloglanis pretoriae, Amphillius uranoscopus, Barbus argenteus, Labeobarbus polylepis and Tilapia sparrmanii.* This is the only reach of the mainstem Elands River where the vulnerable endemic Incomati suckermouth (*Chiloglanis bifurcus*) was sampled. Of concern is that only three specimens were collected, one at the monitoring site X2ELAN-HOUT and two at X2ELAN-ROODE.

These low abundances were not only recorded in *Chiloglanis bifurcus*, but were also reflected in the other reophilic species confirming the loss of available fish habitat.

A Fish Response Assessment Index (FRAI) score of 82.7% was calculated for this reach based on all available information, placing this reach in an Ecological Class B (slightly impaired with a high diversity and abundance of species).

Invertebrates

This is in the middle reach of the Elands River a medium size tributary of the Crocodile River, downstream of the SAPPI paper mill at Ngodwana. The bio-monitoring points sampled in this reach were, X2ELAN-ROODE and X2ELAN-GOEDG.The in-stream habitat is dominated by, cobbles, bedrock, vegetation and sand-mud. Based on the 2012 SASS5 results, the reach was categorised overall as C, which represents significant modified conditions. These modified conditions are linked to modifications in flow, water quality and sedimentation. Impacts are mainly due to industrial activities up stream at Ngodwana and the town of Ngodwana. Exotic vegetation on the banks of the river were present. A total of 36 and 29 taxa were recorded respectively at the Hout and Roode monitoring sites, indicating a high diversity of invertebrates. Highly sensitive taxa included Beatidae, Heptagenidae, Hydropscychidae and Perlidae. Beside the abundance of the sensitive species the abundance of the rest of the taxa were low.

Instream ecostatus

The Ecostatus for this reach was consistent with a Class B suggesting a slightly impaired habitat.

SQ REACH NUMBER X21K-00997

SQ Reach (downstream-->)	SQR Name	Fish sites	SASS sites	FRAI	MIRAI	Instream ecostatus	PES Category	Riparian PES	Length km
X21K-00997	Elands	X2ELAN-LINDE	X2ELAN-LINDE	B	B	B	C	C	10.95

General description

A steep gradient with bedrock and boulders with fast deep habitat is typical of this reach.

The elevation in the reach ranges from 860 m a.s.l. at the Lupelule River confluence to 772 m a.s.l. where it merges with the Crocodile River. A steep gradient with bedrock and boulders with fast deep habitat is typical of this reach. The reach falls into the Great Escarpment Mountains aquatic ecoregion. Changes in the riparian vegetation are a result from exploitation for firewood. The lower 5 Km of the reach is characterised by large riparian trees and shrubs in excellent condition.

Fish

All of the velocity depth classes with excellent cover were present at this reach with fast deep habitat dominant.

One of the small barbs, *Barbus paludinosus* (Straightfin barb), was sampled although not expected to occur. Nine fish species were expected which includes the flow dependant *Chiloglanis bifurcus, Chiloglanis pretoriae*, and *Amphilius uranoscopus.* Only the latter two flow dependant species were collected. The species collected is listed in Appendix A. Seven species were collected, but it includes the one which were not expected.

A Fish Response Assessment Index (FRAI) score of 84% was calculated for this reach based on all available information, placing this reach in an Ecological Class B (slightly impaired with a low diversity and abundance of species).

Invertebrates

This is in the bottom reach of the Elands River not far from the confluence with the Crocodile River. The bio-monitoring point sampled in this reach was, X2ELAN-LINDE. The in-stream habitat is dominated by, cobbles, bedrock, vegetation and sand-mud. Based on the 2012 SASS5 results, the reach was categorised overall as B, which represents slight modified conditions. These modified conditions are linked to modifications in flow, water quality and sedimentation. Impacts are mainly due to agricultural and human settlements in that area, sand mining takes place at the sampling point and may have long term effect on the macro invertebrates. A total of 36 taxa were recorded, indicating a high diversity of invertebrates. Highly sensitive taxa included Beatidae, Heptagenidae, Hydropscychidae and Perlidae. Although these taxa were present in the samples, it was noted that the abundance of the taxa were low.

Instream ecostatus

The Ecostatus for this reach was consistent with a Class B suggesting a slightly impaired habitat.

SQ REACH NUMBER X21F-01092

SQ Reach (downstream-->)	SQR Name	Fish sites	SASS sites	FRAI	MIRAI	Instream ecostatus	PES Category	Riparian PES	Length km
X21F-01092	Leeuspruit			C	C	C	D	C	1.04

General description

The FRAI, MIRAI and Ecostatus for this reach was derived and/or extrapolated from previous surveys and expert judgement and indicate that the Ecostatus for the fish is a class C (moderately impaired with a moderate diversity and abundance of species) The relative low ecological class (C) can be related to excessive sedimentation and the presence of predatory introduced alien fish species (Rainbow trout). The Ecostatus for the invertebrates is also in a class C.

SQ REACH NUMBER X21F-01100

SQ Reach (downstream-->)	SQR Name	Fish sites	SASS sites	FRAI	MIRAI	Instream ecostatus	PES Category	Riparian PES	Length km
X21F-01100	Leeuspruit	X2LEEU-GELUK	X2LEEU-GELUK	C	C	C	C	C	12.89

General description

The Leeuspruit, a tributary of the Elands River, rises about 13km south from Machadodorp on grassland plateau as a narrow channel with no definite riparian zone at an altitude in the region of 1910 metres above sea level. Numerous small farm dams stocked with trout are typical of this reachwhich falls within the Great Escarpment Mountains ecoregion. The malfunctioning Machadodorp sewerage works is positioned upstream of this biomonitoring reach.

Fish

Five indigenous fish species were expected to occur in this reach with only one flow dependant species, *Amphilius uranoscopus*, which were collected together with *Tilapia sparrmanii*. Water quality may be a reason that only two species in low abundance were collected.

A Fish Response Assessment Index (FRAI) score of 75.8% was calculated for this reach based on all available information, placing this reach in an Ecological Class C (moderately impaired with a low diversity and abundance of species). The relative low ecological class (C) can be related to excessive sedimentation and the presence of predatory introduced alien fish species (Rainbow trout).

Invertebrates

This reach is in the upper reach of the Leeuspruit a small tributary of the Elands River, downstream of the town of Machadodorp. The bio-monitoring point sampled in this reach was, X2-LEEU-GELUK. The in-stream habitat is dominated by, cobbles, bedrock, vegetation and sand-mud. Based on the 2012 SASS5 results, the reach was categorised overall as A/B, which represents marginal modified conditions. These modified conditions are linked to modifications in flow and water quality. Impacts are mainly due to agricultural activities and human settlements up stream. Exotic in-stream vegetation was present. The poor state of the Leeuwspruit can be attributed to a combination of agricultural activities (flow modification as result of water diversion and construction of several weirs, and modification of the riparian zone) and pollution from domestic origin (solid waste and effluent entering the stream in the Machadodorp vicinity). The presence of sewerage in rivers generally lowers the oxygen levels in the water, favouring low oxygen tolerant taxa such as Diptera from this and five out of the 29 taxa found at this site was of Diptera. The High oxygen tolerant taxa such as Heptagenidae and Perlidae does not benefit from the low oxygen levels and were absent.

Instream ecostatus

The Ecostatus for this reach was consistent with a Class C suggesting a moderately impaired habitat.

SQ REACH NUMBER X21G-01016

SQ Reach (downstream-->)	SQR Name	Fish sites	SASS sites	FRAI	MIRAI	Instream ecostatus	PES Category	Riparian PES	Length km
X21G-01016	Swartkoppiespruit	X2SWAR-KINDE	X2SWAR-KINDE	B	C	BC	C	C	28.30

General description

The Swartkoppiesspruit falls within the Great Escarpment Mountains ecoregion with elevation ranges from 1,766 above Roodekrans to 1,200 m a.s.l., at the Elands-Lunsklip confluence. This reach is dominated by varous weirs and instream structures created to provide habitat to the alien and invasive trout species. Three trout syndicates are known to operate on this reach.

Fish

A high diversity of slow and fast habitat types which includes riffles and runs, cascades and pools with cover types such as undercut banks and rootwads, overhang vegetation and substrate are present in this reach. It is of concern that only four indigenous fish species were collected from ten expected species. Of special interest is the eel, *Anguilla mossambica*, which was collected. This catadromous species breed in the ocean, enters rivers

as larvae and migrate upstream as far as they can go where they develop into adults. Adult eels return to the ocean at some stage to breed. Four flow dependent fish species were expected and only *Amphilius uranoscopus* and *Chiloglanis pretoriae* were collected. The relative low species diversity recorded could be related to the impact of the regular stocking of the alien and invasive species trout.

A Fish Response Assessment Index (FRAI) score of 84.1% was calculated for this reach based on all available information, placing this reach in an Ecological Class B (slightly impaired with a low diversity and abundance of species). The relative high Class B may be because of the excellent fish habitat present in this reach.

Invertebrates

This reach is in the upper reach of the Swartkoppie-spruit a small tributary of the Elands River. The bio-monitoring point sampled in this reach was, X2-SWAR-KINDE. The in-stream habitat is dominated by, cobbles, bedrock, vegetation and sand-mud. Based on the 2012 SASS5 results, the reach was categorised overall as C, which represents significant modified conditions. These modified conditions are linked to modifications in flow and water quality. Impacts are mainly due to forestry activities. 23 taxa were present, lower than the rest of the sample sites. Highly sensitive taxa included Beatidae, Heptagenidae, the taxa Diptera was absent on the sample date.

Instream ecostatus

The Ecostatus for this reach was consistent with a Class C suggesting a moderately impaired habitat.

SQ REACH NUMBER X21H-01060

SQ Reach (downstream-->)	SQR Name	Fish sites	SASS sites	FRAI	MIRAI	Instream ecostatus	PES Category	Riparian PES	Length km
X21H-01060	Ngodwana	X2NGOD-GROOT	X2NGOD-GROOT	D	C	C	C	C	25.36

General description

The Ngodwana River is a tributary of the Elands River at an altitude ranging between 940 and 960 m.a.s.l. Its confluence with the Elands River is at the Ngodwana Sappi Papermill with the lower reaches impounded for water usage by the mill.

Fish

Eight indigenous fish species were expected to occur, but no fish was collected. The only fish velocity depth classes present at the site were slow deep and slow shallow with very little cover present. The impoundment and controlled releases from it will have a detrimental effect on the fish species present.

A Fish Response Assessment Index (FRAI) score of 57.4% was calculated for this reach based on all available information, placing this reach in an Ecological Class D (largely impaired with a low diversity and abundance of species).

Invertebrates

This reach includes the Ngodwana River, a small perennial stream, a tributary of the Elands River, above the Sappy paper mill at Ngodwana. The bio-monitoring point sampled in this reach was, X2NGOD-GROOT. The in-stream habitat is dominated by, gravel, vegetation and sand-mud. Because of the sandy substrate boulders and bedrock are limited. Based on the 2012 SASS5 results, the reach was categorised overall as C, which represents significant modified conditions. These modified conditions are linked to modifications in flow, water quality and sediment deposition. Impacts are mainly due to industrial activities and are situated just below a fairly high dam wall; the water levels were unnaturally low due to the proximity of the dam, which stops stream flow in the dry season. Taxa present at this site were 22, only one highly sensitive taxa, Beatidae were present, all taxa had a low abundance.

Instream ecostatus

The Ecostatus for this reach was consistent with a Class C suggesting a modified habitat.

Summary Elands River Mainstem and Tributaries Indices

FRAI Categories

Figure 18 recapitulate the FRAI categories of the 11 SQ reaches. The upper reaches of the mainstem Elands River has an overall FRAI category of a Class C with the lower reaches a Class B. Most of the tributaries are in a Class C with the lowest Class recorded in the Ngodwana River (Class D).

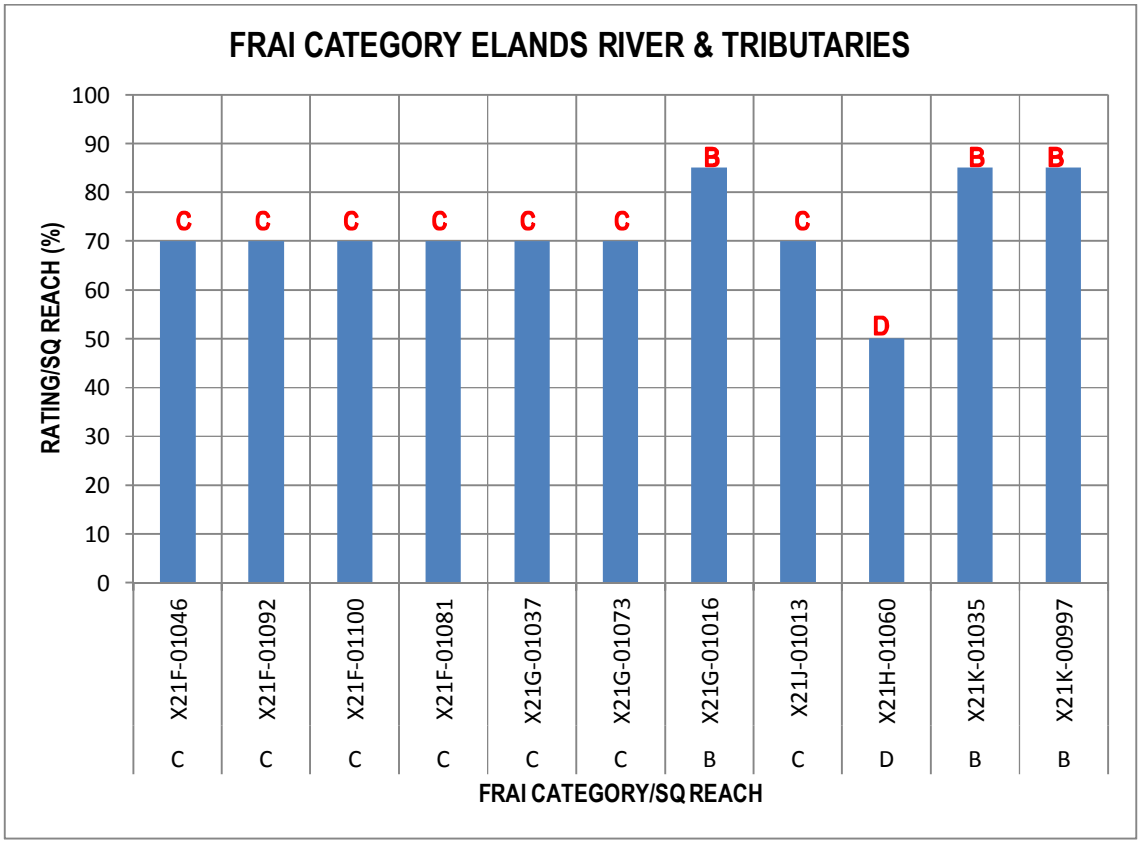


Figure 18: FRAI category for the Elands River and tributaries SQ reaches.

MIRAI Categories

Based on the aquatic invertebrate community, the Elands River mainstem is categorised as slightly impaired (A-B class). In the headwaters of the tributaries (Leeuspruit, Swartkoppies and Ngodwana) a MIRAI rating of a C Class (moderately impaired) were recorded. The area around Ngodwana and Ngodwana River deteriorates to a C Class (moderately impaired). The condition of the river steadily improves to a (B-Class) before the confluence with the Crocodile River.

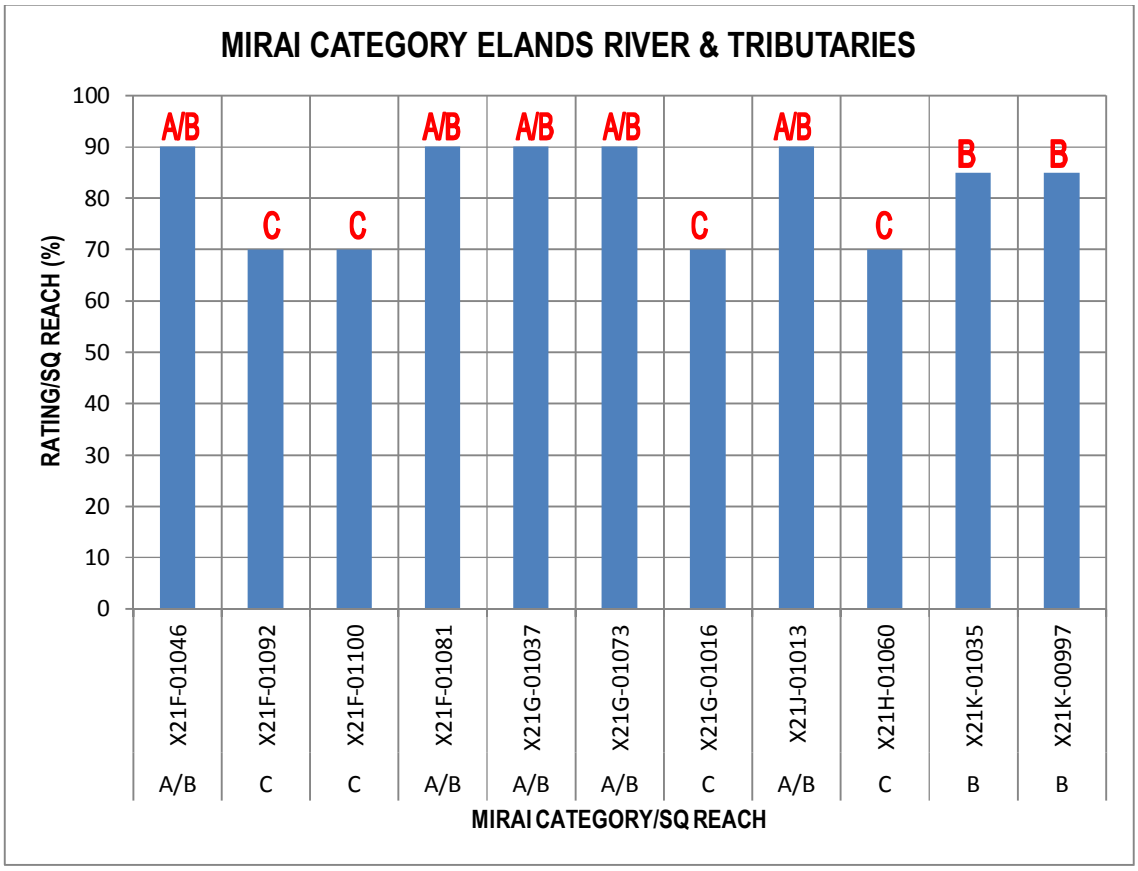


Figure 19: MIRAI category for the Elands River and tributaries SQ reaches.

Instream and Integrated Ecostatus Rating

The Instream Ecostatus Rating is derived from the fish assemblage (FRAI) and the macro-invertebrate assemblage (MIRAI). From Figure 20 it is evident that the Instream Ecostatus Rating is ranging from a Class B to a Class C, with an overall Instream Ecostatus of C/B. The Integrated Ecostatus Rating is derived from the fish (FRAI) and macro-invertebrates (MIRAI) assemblages and riparian index (VEGRAI) and is fairly consistent with the Instream Ecostatus Rating, Class C/B (Figure 21).

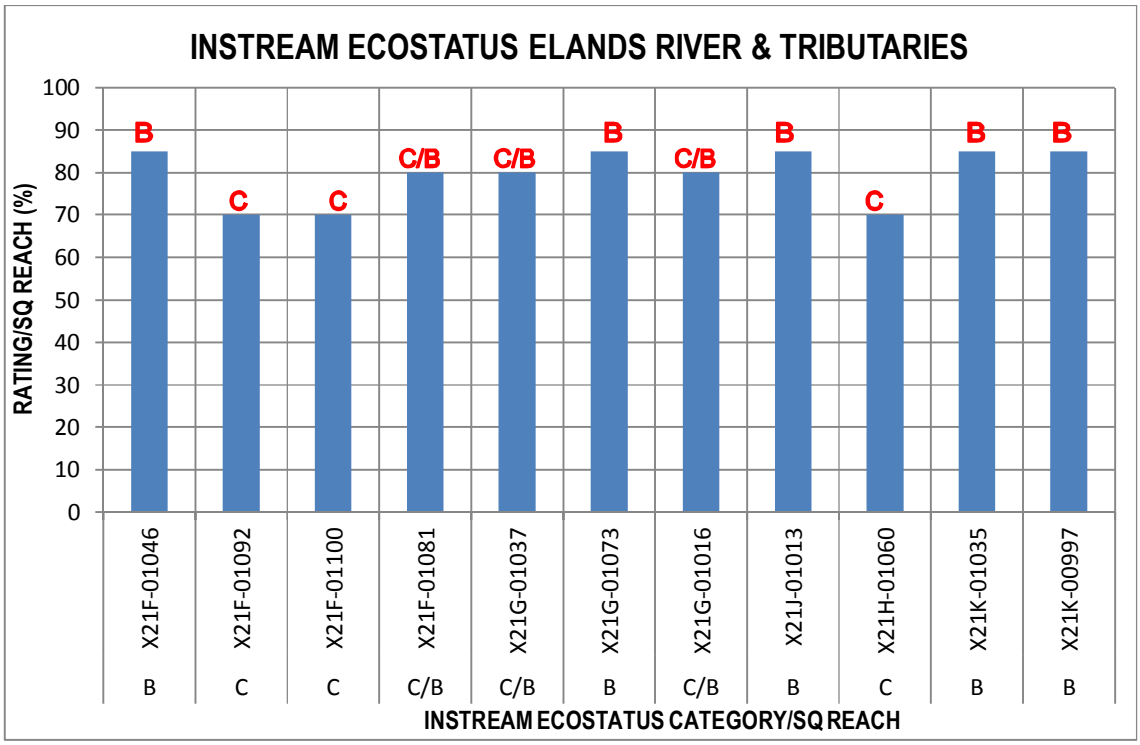


Figure 20: Instream Ecostatus rating for the Elands River and tributaries SQ reaches.

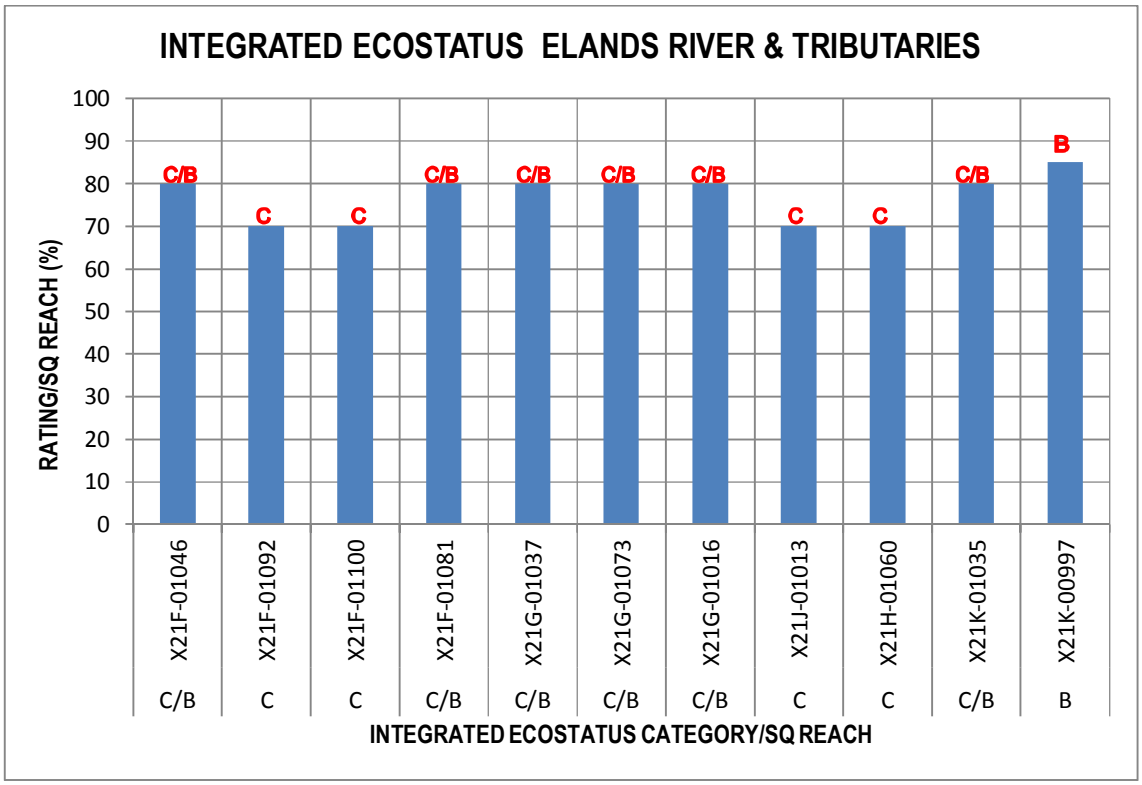


Figure 21: Integrated Ecostatus ratings for the Elands River and tributaries SQ reaches

PES Categories

For the PES rating (Present Ecological Status) which is a desktop study derived from the PES EIS it can be seen that the overall PES rating is a Class C, moderately modified, although three reaches, in the Sappi mill area, Elandsdoornhoek and Leeuwspruit are a Class D, largely modified (Figure 22).

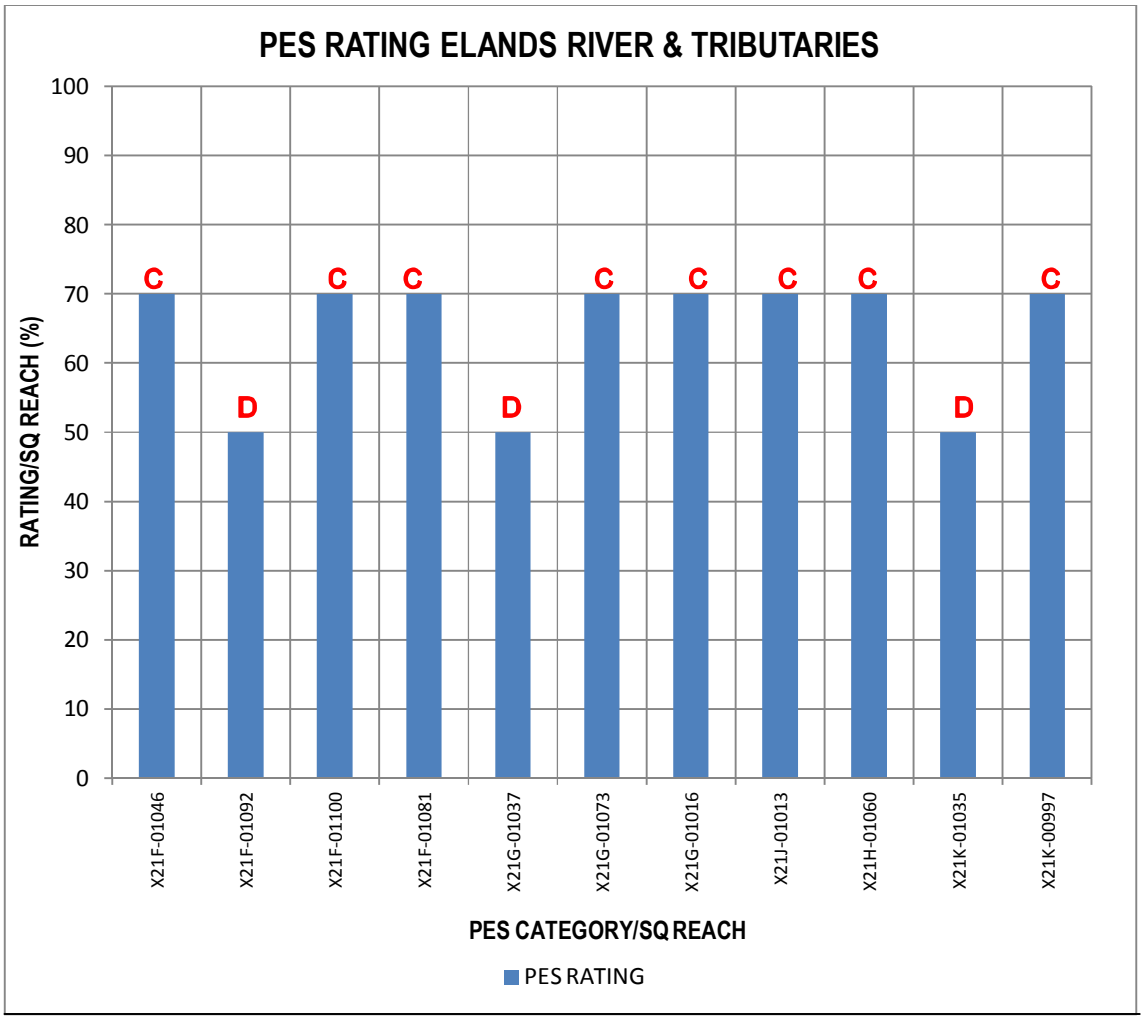


Figure 22: PES rating for the Elands River and tributaries SQ reaches.

Kaap River and Tributaries

The Kaap River sub-catchment is divided into two main tributaries the Noord-Kaap River and the Suid-Kaap River with the Queens River a tributary of the Suid-Kaap River.This sub-catchment are impacted on by forestry and smallholding faming pracises and has been intensively mined for minerals and the impact of these mining operations are still reflected in the water quality within streams and rivers in this sub-catchment.

SQ REACH NUMBER X23E-01154

SQ Reach (downstream-->)	SQR Name	Fish sites	SASS sites	FRAI	MIRAI	Instream ecostatus	PES Category	Riparian PES	Length km
X23E-01154	Queens	X2QUEE-HILVE-		C	C	C	C	D	43.44

General description

The Queens River originates at an elevation of 1 520 m a.s.l. and flows just north of the town of Baberton to the confluence with the SuidKaap River at an elevation of 630 m a.s.l. The instream habitat of the upper part of the reach is dominated by bedrock and boulders. The lower part of the reach is dominated by pools fringed by reeds. The reach falls withing the Great Escarpment Mountains and Lowveld aquatic ecoregions.

Fish

The river was in flood and only a few slower flowing areas on the side of the main river channel could be sampled. The two flow dependant fish species, *Amphilius uranoscopus* and *Chiloglanis pretoriae*, were the only two species sampled in very low numbers of a possible expected 22 species. These include both coldwater fish species and temperate fish species.

A Fish Response Assessment Index (FRAI) score of 68.6% was calculated for this reach based on all available information, placing this reach in an Ecological Class C (moderately impaired with a low diversity and abundance of species).

Invertebrates

Not done in 2013 due to high levels of water.

Instream ecostatus

The Ecostatus for this reach was consistent with a Class C suggesting a moderately impaired habitat.

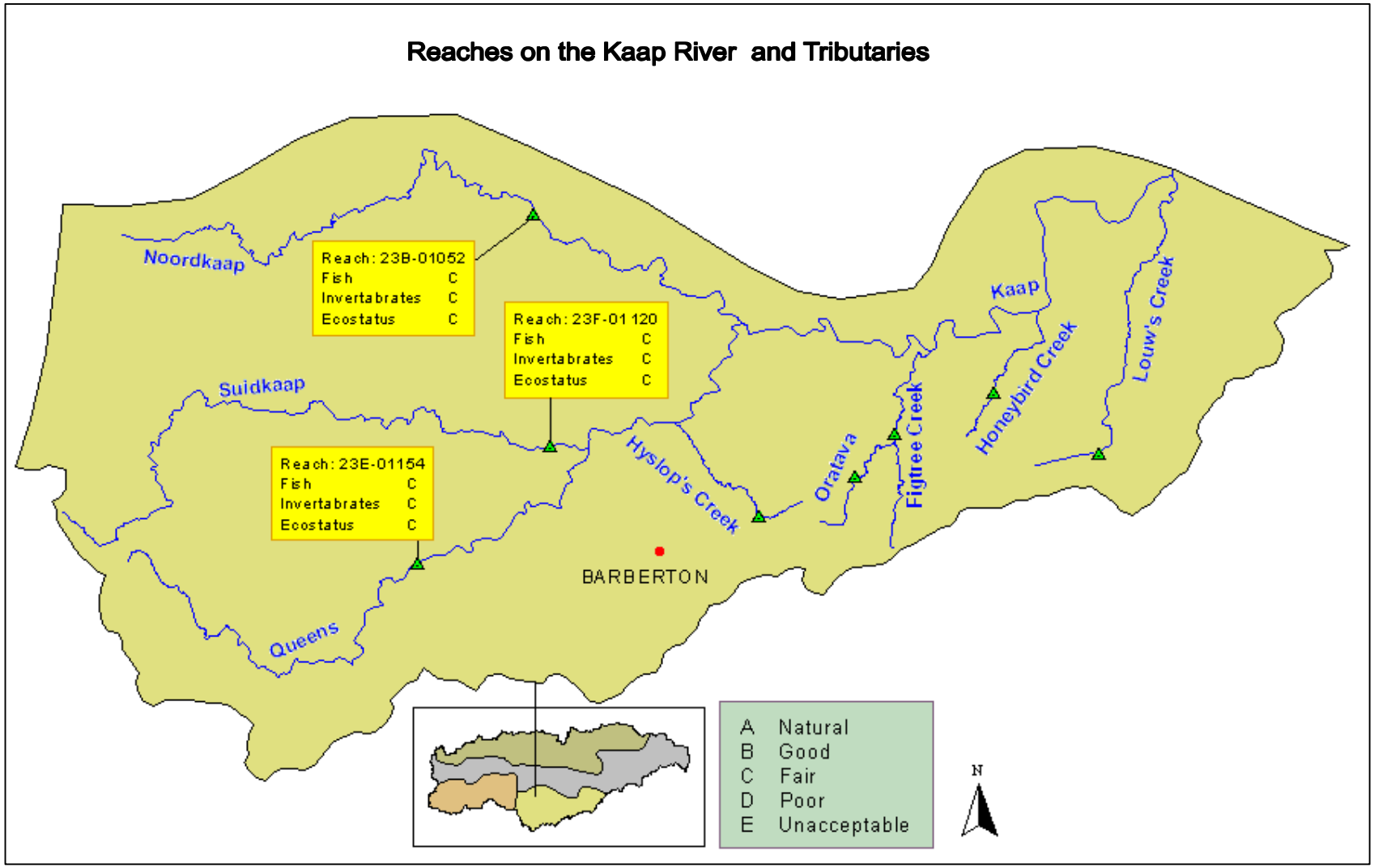


Figure 23: Kaap River and tributaries indicating Fish, Invertebrates and Ecostatus ratings for each reach

SQ REACH NUMBER X23F-01120

SQ Reach (downstream-->)	SQR Name	Fish sites	SASS sites	FRAI	MIRAI	Instream ecostatus	PES Category	Riparian PES	Length km
X23F-01120	Suid Kaap	X2SUID-DAISY		C	C	C	C	C	15.46

General description

The Suid-Kaap originates at an elevation of 1 645 m a.s.l. and joins up with the Noord-Kaap River at an elevation of 574 m a.s.l. The reach falls within the Great Escarpment Mountains ecoregion. This reach is mainly impacted on by small holding agricultural practises. Water hyacinth (*Eichornia crassipes*) occurs abundantly in this reach.

Fish

The river was in flood and only slower flowing side channels could be sampled. Only five of an expected 21 indigenous species were sampled. Three of the smaller barbs species, *Barbus trimaculatus, Barbus unitaeniatus and Barbus eutaenia* as well as the large *Labeobarbus marequensis* were recorded with the cichlid *Pseudocrenilabrus philander.*

A Fish Response Assessment Index (FRAI) score of 74.2% was calculated for this reach based on all available information, placing this reach in an Ecological Class C (moderately impaired with a low diversity and abundance of species).

Invertebrates

The MIRAI for this reach was derived and/or extrapolated from previous surveys and expert judgement and indicate that for the invertebrates a class C (moderately impaired with a low diversity and abundance of taxa).

Instream ecostatus

The Ecostatus for this reach was consistent with a Class C suggesting a moderately impaired habitat.

SQ REACH NUMBER X23C-01098

SQ Reach (downstream-->)	SQR Name	Fish sites	SASS sites	FRAI	MIRAI	Instream ecostatus	PES Category	Riparian PES	Length km
X23C-01098	Suid Kaap			C	C	C	D	D	44.28

General description

The FRAI, MRAI and Ecostatus for this reach was derived and/or extrapolated from previous surveys and expert judgement and indicate that the Ecostatus for the fish is a class C (moderately impaired with a moderate diversity and abundance of species) and for the invertebrates a class C (Moderately impaired with a moderate diversity of taxa consisting mainly of tolerant taxa).

SQ REACH NUMBER X23B-01052

SQ Reach (downstream-->)	SQR Name	Fish sites	SASS sites	FRAI	MIRAI	Instream ecostatus	PES Category	Riparian PES	Length km
X23B-01052	Noord Kaap	X2NOOR-RIVER	X2NOOR-RIVER	C	C	C	D	D	53.83

General description

The NoordKaap originates as a small mountain stream at an elevation of 1 620 m a.s.l. The habitat is dominated by fast deep and fast shallow velocities over. The river flows for a great part through the Barberton Nature Reserve and joins the Suid-Kaap River at and elevation of 574m a.s.l. to form the Kaap River. The 58.83km long reach falls within the Great Escarpment Mountains ecoregion.

Fish

Five of a possible 23 indigenous fish species were recorded. These included two flow dependant species, *Amphillius uranoscopus* and *Chiloglanis pretoriae*, with *Chiloglanis pretoriae* in high abundance.

A Fish Response Assessment Index (FRAI) score of 65.4% was calculated for this reach based on all available information, placing this reach in an Ecological Class C (moderately impaired with a low diversity and abundance of species).

Invertebrates

This reach consists of a small mountain stream a tributary of the Kaap River, between the town of Barberton and Nelspruit. The bio-monitoring point sampled in this reach was X2NOOR-RIVIER.The in-stream habitat is

dominated by, cobbles, sand-mud, bedrock and vegetation. Based on the 2012 SASS5 results, the reach was categorised overall as C, which represents significant modified conditions. These modified conditions are linked to modifications in flow, water quality and sediment deposition. The not common genera oligoneuridae in the Ephemeroptera taxa were present in low abundance. Impacts are due to agricultural activities, cattle grazing and human settlements. There is a highway bridge over the river creating an artificial channel on only one side of the river. 26 taxa were present and highly sensitive taxa included Beatidae, Heptagenidae, Hydropscychidae, Perlidae and Oligoneuridae.

Instream ecostatus

The Ecostatus for this reach was consistent with a Class C suggesting a moderately impaired habitat.

Summary Kaap River and Tributaries Indices

FRAI Categories

In Figure 24 the FRAI categories of the four SQ reaches done for the Kaap River catchment is reflected. The FRAI is constant in a Class C which is moderately impaired with a moderate diversity and low abundance of species.

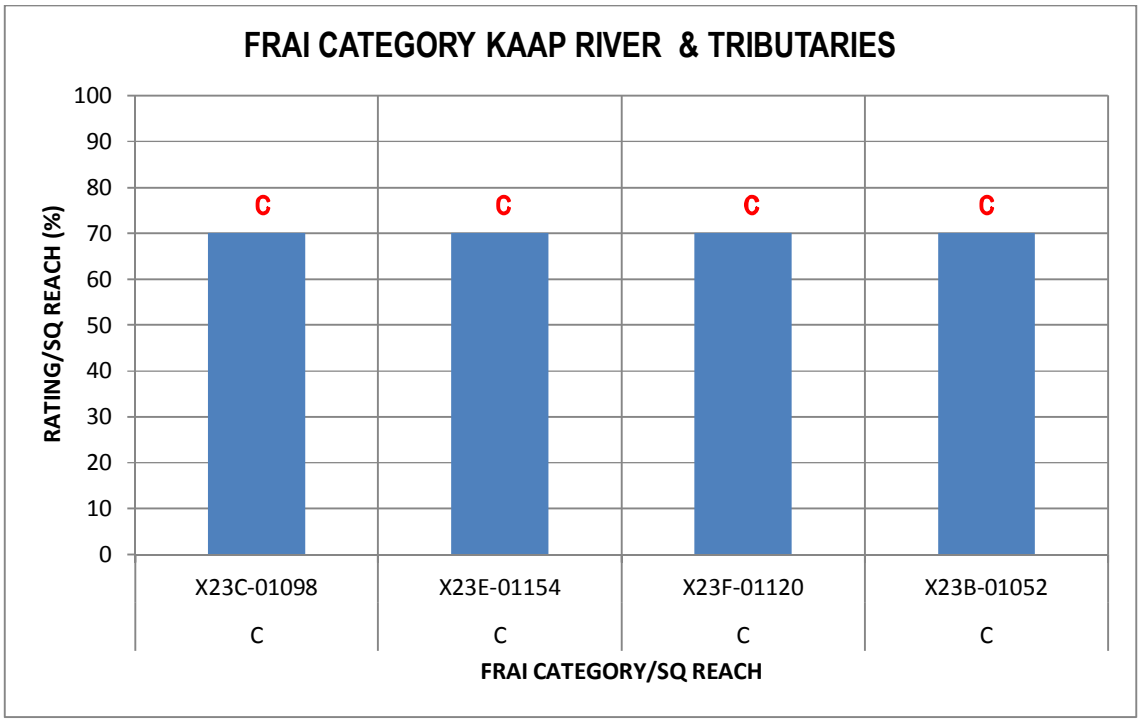


Figure 24: FRAI category for the Kaap River and tributaries SQ reaches.

MIRAI Categories

Based on the aquatic invertebrate community, the Kaap River and tributaries is categorised as moderately impaired (C-class). The conditions stay relatively constant (C-class), with localised impacts occurring downstream until the confluence with the Crocodile River.

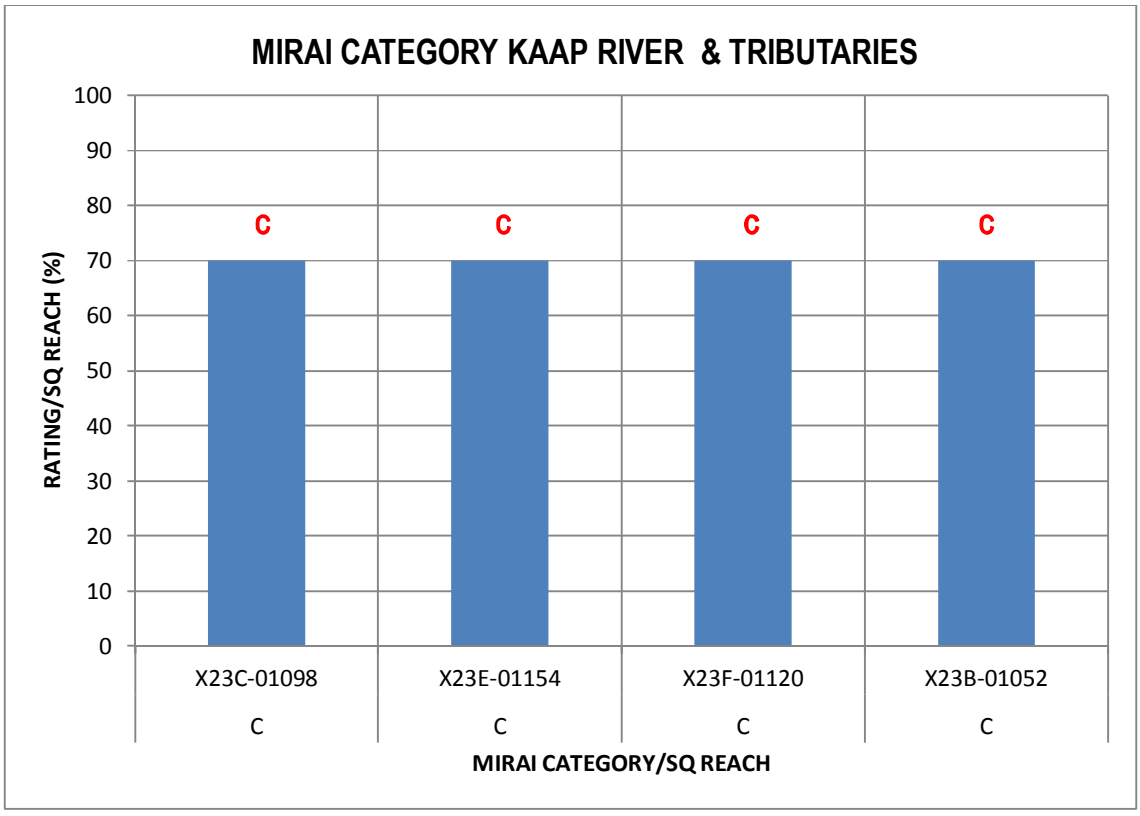


Figure 25: MIRAI category for the Kaap River and tributaries SQ reaches

Instream and Integrated Ecostatus Rating

The Instream Ecostatus Rating is derived from the fish assemblage (FRAI) and the macro-invertebrate assemblage (MIRAI). From Table it is evident that the Instream Ecostatus Rating is consistent throughout the Kaap River tributaries (Class C). The Integrated Ecostatus Rating is derived from the fish (FRAI) and macro-invertebrates (MIRAI) assemblages and riparian index (VEGRAI) and is fairly consistent with the Instream Ecostatus Rating (Class C) see (Figure 26 & 27).

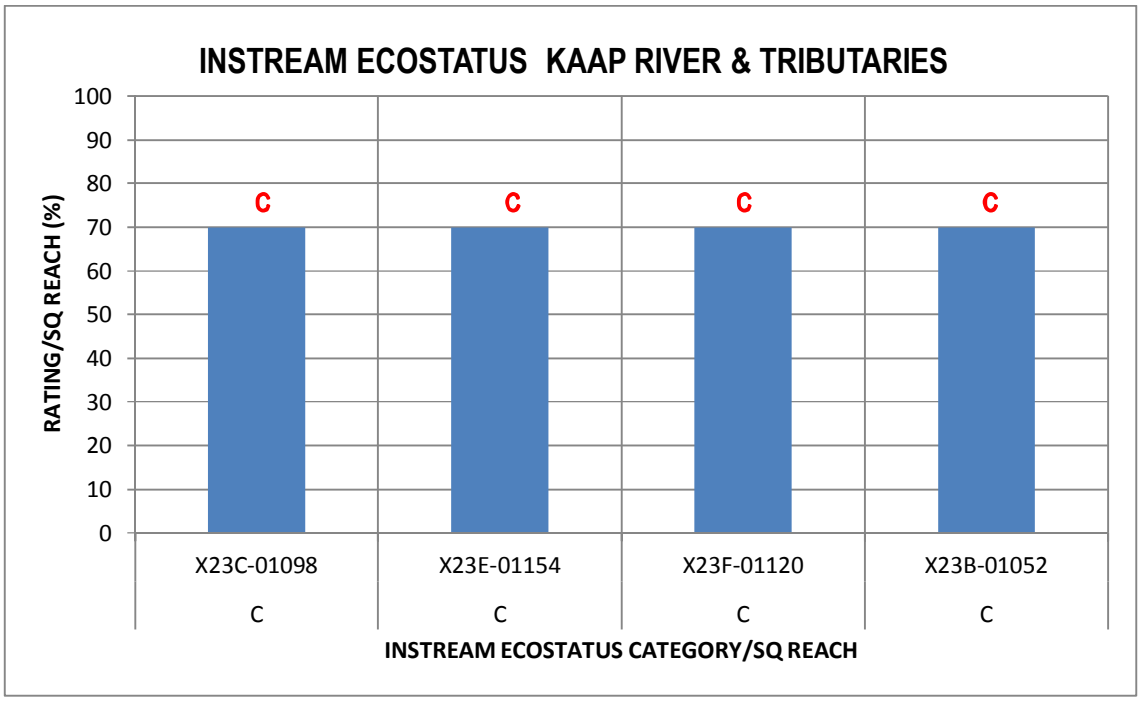


Figure 26: Instream Ecostatus rating for the Kaap River and tributaries SQ reaches

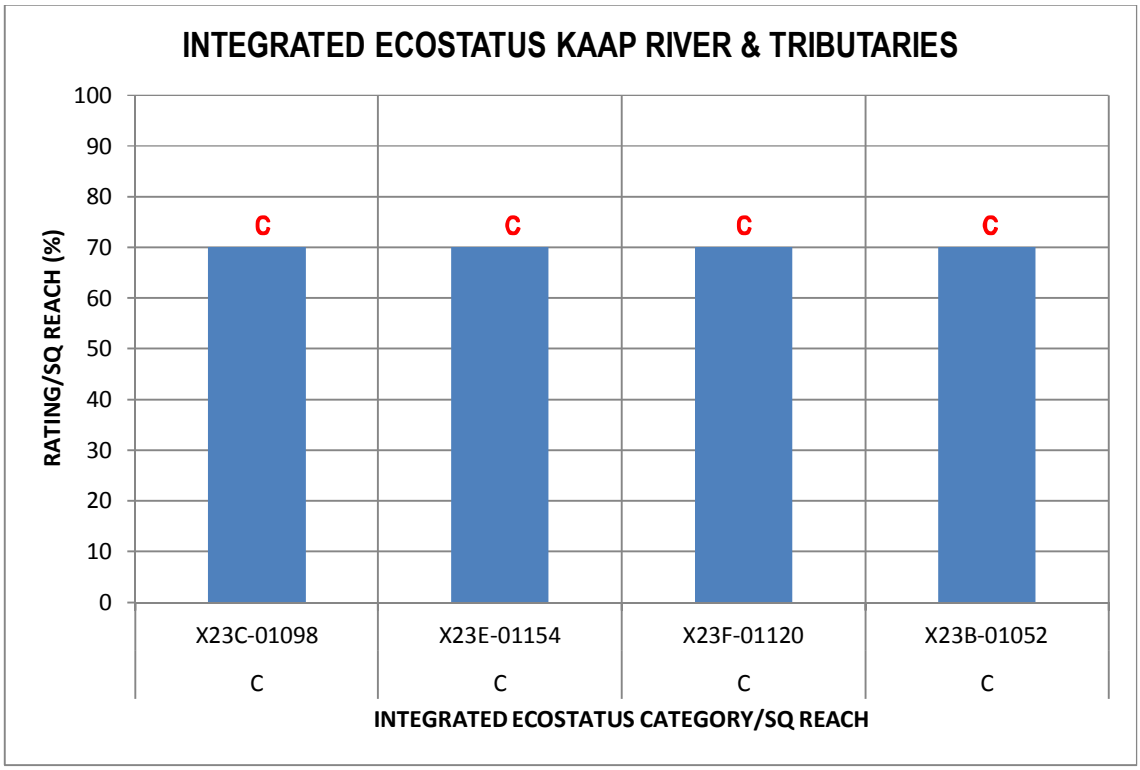


Figure 27: Integrated Ecostatus rating for the Kaap River and tributaries SQ reaches

PES Categories

For the PES rating (Present Ecological Status) which is a desktop study derived from the PES EIS it can be seen that the overall PES rating is a Class C/D, moderately to largely modified for Kaap River and tributaries (Figure 28).

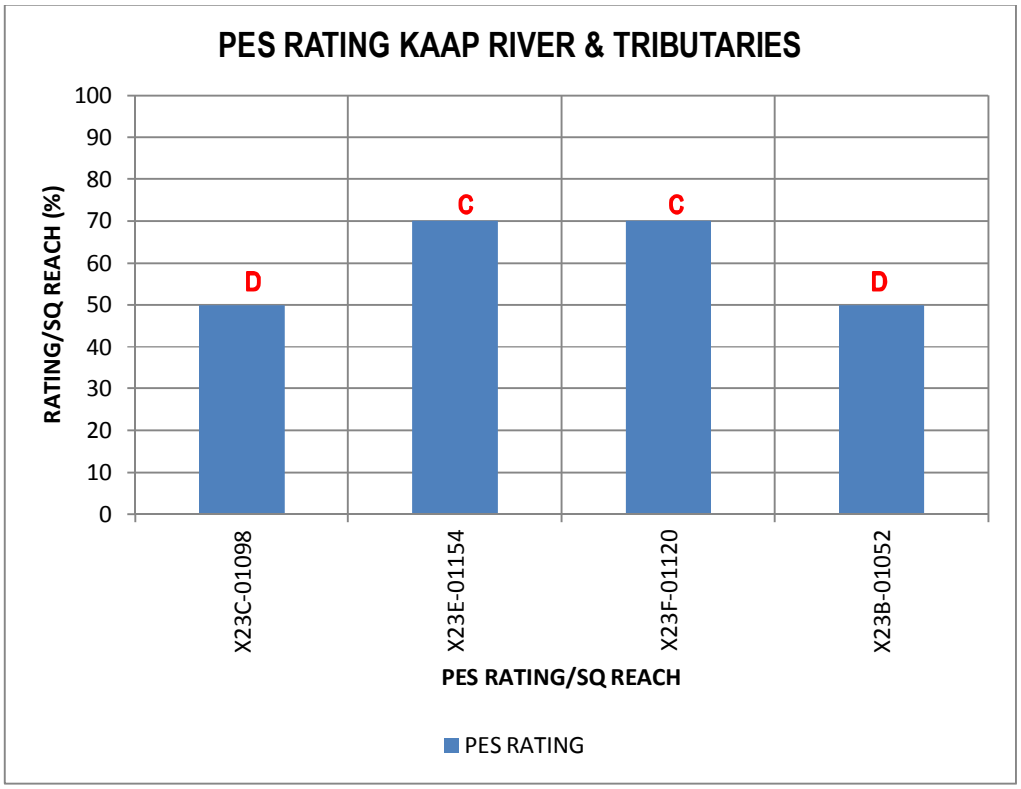


Figure 28: PES rating for the Kaap River and tributaries SQ reaches

Biomonitoring points for Crocodile River Tributaries not on the SQ reach cover for the PESEIS.

These monitoring points was done additionally and is not on the X2 reaches. They were incorporated to determine the status of the newly described species *Kneria kwena* which is endemic to the Crocodile River tributaries in the Badfontein area.

X2WILG-WILG1

General description

The Wilgekraalspruit is a small tributary that flows into the Lunsklip River before its confluence with the Crocodile River. The high upper reaches of this river is a high gradient mountain stream with the lower reaches at a lower gradient in the Badfontein area. This reach in the Wilgekraalspruit is at an altitude of 1300 m a.s.l. and can be characterised as a clear mountain steam with abundant habitat diversity. Within this reach a large tourism development was established, with illegal dams and weirs constructed with the Wilgekraalspruit.

Fish

The habitat assessed consisted of slow shallow fish velocity depth class which included slow shallow pools and fast shallow riffles and runs. On this reach five species were recorded at low abundances. The species include *Amphilius uranoscopus, Barbus anoplus, Barbus neefi , Chiloglanis pretoriae* and *Kneria kwena*. Their relative low abundance can be ascribed to high levels of siltation and sedimentation resulting from the upstream development, in particular the construction of illegal dams and weirs, as well as high levels of road networking and river crossings. In addition to this, reports indicate that these dams were stocked illegally with the alien and invasive species trout (*Oncorhynchus mykiss* and *Salmo trutta*) and large mouth bass (*Micropterus salmoides*). The impact of these alien and invasive species on indigenous fish species and their negative impact on endemic species are well documented. These impacts could result in the disappearance of the newly described endemic species *Kneria kwena* from this reach.

A Fish Response Assessment Index (FRAI) was calculated for this reach based on all available information, placing this reach in an Ecological Class C/D(moderately to largely impaired with a low diversity and abundance of species).

Invertebrates

Instream habitat is generally good. The sampling site in this reach is located towards the lower end of the reach. Taxon diversity during 2012 is moderately high (25 taxa) compared to the earlier SASS4 surveys when a maximum of 29 taxa (36 taxa in total) were recorded. There were three high scoring taxa recorded Perlidae, Heptageniidae and >2 spp Baetidae) compared to the 7 expected under reference conditions. There seems to

have been a decline in the number of moderately sensitive taxa in 2012 (5 taxa) compared with the 1999 SASS4 surveys when a total of 11 moderately sensitive taxa were collected. Based on the 2012 SASS5 results, the reach was categorised overall as a C, which represents moderately modified conditions. These modified conditions are mostly linked to modifications in water quality. Causes for these modifications are linked to small farm dams and agricultural activities in the reach

Instream Ecostatus

The Ecostatus for this reach was consistent with a Class C suggesting a moderately impaired habitat.

X2STER-R538B and X2JUNG-MOOIP

General description

The Sterkspruit and the Junglespruit are two tributaries of the Crocodile River originating in the Schoemanskloof area. Both these mountain streams are at an altitude of 1100 m.a.s.l. and therefore high gradient streams with a high diversity of habitat types. Habitat types include slow shallow and fast shallow flow velocity depth classes with pools followed by riffles and runs. Both these streams originate in the SAPPI plantations from where they flow through farmland with an intact riparian zone. In both streams where the N4 cross these streams, fishways have been constructed to facilitate migration of the different fish species occurring within these reaches.

Fish

Within these two streams three different fish species were recorded at relative high abundances, namely *Barbus anoplus, Barbus argenteus and Kneria kwena.* These sensitive species occur in small riffle streams with pools and slow flowing sections. The substrate consists mainly of stones and pebbles and is usually covered with "aufwuchs". The temperatures of these streams ranges from 9 ˚C in the winter to 26˚C in the summer time. Associated fish species in these streams include *Barbus anoplus, Amphilius natalensis* and *Barbus argenteus*. Shoals of these fish occur in small pools with clear and silt free water. *Kneria kwena* is reported to breath air and climb over damp rocks and up the sides of rapids during migration. Adult fish scrapes diatoms, algae and detritus from rock surfaces and also take small aquatic insects such as mayfly nymphs and midge larva. The absence of *Amphillius natalensis* is of concern and could possibly be related to the impact of upstream forestry related activities. The impacts noted were excessive siltation and sedimentation resulting in decreased interstitial spaces and loss of habitat.

A Fish Response Assessment Index (FRAI) was calculated for this reach based on all available information, placing this reach in an Ecological Class C/B(slightly to moderately impaired).

Invertebrates

Instream habitat for the **Sterkspruit** is generally good. The sampling site in this reach is located towards the lower end of the reach. Taxon diversity during 2012 is moderately high (21 taxa) compared to the earlier SASS4 surveys when a maximum of 19 taxa (27 taxa in total) were recorded. There were two high scoring taxa recorded Helodidae and >2 spp Hydropsychidae) compared to the 10 expected under reference conditions. The only high scoring taxan previously recorded that were not recorded in 2012 is the flat headed mayfly, Heptageniidae. There seems to have been a decline in the number of moderately sensitive taxa in 2012 (6 taxa) compared with the 1999 SASS4 surveys when a total of 9 moderately sensitive taxa were collected. Based on the 2012 SASS5 results, the reach was categorised overall as a BC, which represents moderately modified conditions. These modified conditions are mostly linked to modifications in water quality. Causes for these modifications are land use activities in the reach

Instream habitat is for the **Junglespruit** is generally good. The sampling site in this reach is located towards the lower end of the reach. There were no historical SASS data available for this site, but the Junglespruit is close to the Sterkspruit and the habitat and impacts in the two catchments are very similar. Taxon diversity during 2012 is moderately high (19 taxa) compared to the 21 taxa recorded in the Sterkspruit. There were three high scoring taxa recorded Helodidae, >2 spp Baetidae and >2 spp Hydropsychidae) compared to the 10 expected under reference conditions. There seems to have been a greater impact on the number of moderately sensitive taxa in 2012 (5 taxa) compared with the 23 taxa expected under reference conditions. Based on the 2012 SASS5 results, the reach was categorised overall as a BC, which represents moderately modified conditions. These modified conditions are mostly linked to modifications in water quality. Causes for these modifications are land use activities in the reach.

Instream Ecostatus

The Ecostatus for this reach was consistent with a Class B/C suggesting a slightly to moderately impaired habitat.

Biomonitoring points for Elands River not on the SQ reach cover for the PESEIS.

X2TAUT-WINNA

General Description

Reach X21F: Tautesloop

The Tautesloop Spruit, a small stream, tributary of the Elands River, a few kilometres upstream from the town of Machadodorp, rises on grassland plateau as a narrow channel with no definite riparian zone at an altitude in the region of 1910 metres above sea level. Numerous small farm dams stocked with trout are typical of this reach.

Fish

Only a single *Pseudocrenilabrus philander* was collected. Four indigenous fish species were expected with no flow dependant species. The very low abundance of fish and species can be ascribed to the presence of the alien and invasive trout species, *Oncorhynchus mykiss*. Largemouth bass (*Micropterus salmoides*) may also be present, but could not be confirmed. The negative impact of these alien and invasive piscivorous species on indigenous fish species is well known.

A Fish Response Assessment Index (FRAI) was calculated for this reach based on all available information, placing this reach in an Ecological Class D (largely impaired with a low diversity and abundance of species).

Invertebrates

The Tautesloop Spruit, a small stream, tributary of the Elands River, a few kilometres upstream from the town of Machadodorp, does not fall within a reach. The in-stream habitat is dominated by vegetation and sand-mud. The bio-monitoring point sampled was, X2TAUT-WINNA. Based on the 2012 SASS5 results, the reach was categorised overall as B/C, which represents some modified conditions. These modified conditions are linked to modifications in flow and water quality. Impacts are mainly due to agricultural activities and trout farming up stream. Sediment quantities in pool areas are surprisingly high. A broken dam wall is close to the monitoring site as well as a small bridge. Bank erosion is visible.

Instream Ecostatus

The Ecostatus for this reach was consistent with a Class C suggesting a moderately impaired habitat.

Biomonitoring points for Kaap River and Tributaries not on the SQ reach cover for the PESEIS.

X2HYSL-DYCED

Reach X23F:-Hyslop's Creek

General description

This stream originates at about 1050 m a.s.l. in the Baberton Mountainlands Nature Reserve and flows in a north westerly direction to join with the Suid-Kaap River at about 613 m a.s.l. The habitat is dominated in the upper reach by sequences of shallow riffle pool habitats with more small pools present than riffles. Mining and small holding agricultural activities have a serious impact on this stream, especially in the lower third just before it joins with the Suid-Kaap River.

Fish

Two species were recorded for this stream, the flow sensitive *Amphilius uranoscopus* and one of the smaller barbs, *Barbus trimaculatus*. A shallow pooldominated habitat is probably the reason why *Chiloglanis pretoriae* was not recorded.

A Fish Response Assessment Index (FRAI) was calculated for this reach based on all available information, placing this reach in a Fish Ecological Class B (slightly impaired with a low diversity and abundance of species).

Invertebrates

This reach consists of a small mountain stream a tributary of the Suidkaap River, above the town of Barberton. The bio-monitoring point sampled in this reach was X2HYSL-DYCED.The in-stream habitat is dominated by, cobbles, sand-mud, bedrock and vegetation. There were modified conditions linked to modifications in flow, water quality and sediment deposition. Impacts were limited, but there are impacts on the water quality due to historical mining activities. A total of 26 taxa were recorded, indicating a high diversity of invertebrates. Highly sensitive taxa included Beatidae and Perlidae

Instream Ecostatus

The Ecostatus for this stream was consistent with a Class B suggesting a slightly impaired habitat.

X2ORAT-MOUNT

Reach X23G: Oratawa Creek

General description

The Oratawa Creek is a small tributary of the Fig Tree Creek. This mountain stream originates at about 1240 m a.s.l. and joins up with Fig Tree Creek at about 650 m a.s.l. The habitat is dominated by rocky substrate with fast shallow water.

Fish

No fish could be found, although a local resident informed us of an eel he saw in the stream between the rocks, which most probably was a Longfin eel (Anguilla mossambica).

A Fish Response Assessment Index (FRAI) was calculated for this reach based on all available information, placing this reach in a Fish Ecological Class C (moderately impaired with a low diversity and abundance of species).

Invertebrates

This reach consists of a small mountain stream, a tributary of the Suidkaap River, east of the town of Barberton. The bio-monitoring point sampled in this reach was X2ORAT-MOUNT.The in-stream habitat is dominated by, cobbles, sand-mud, bedrock and vegetation. There were modified conditions present, linked to modifications in flow, water quality and sediment deposition. Impacts were limited, but there are impacts on the water quality due to historical mining activities. A total of 31 taxa were recorded, indicating a high diversity of invertebrates. Highly sensitive taxa included Beatidae, Heptagenidae, Hydropscychidae and Perlidae.

Instream Ecostatus

The Ecostatus for this stream was consistent with a Class B/C suggesting a slightly to moderately impaired habitat.

X2FIGT-COVIN

General description

Reach 23G: Fig Tree Creek

The Fig Tree Creek, a tributary of the Kaap River, is named after the sedimentary rock formation known as the Fig Tree Group found in the Baberton Greenstone Belt. It originates in the Baberton Mountainlands Nature Reserve at an elevation of about 1120 m a.s.l. and flows in a northerly direction to join up with the Kaap River at an elevation of about 525 m a.s.l. Impacts are mining and agriculture, but the stream is still largely natural.

Fish

A total of eight indigenous fish species from an expected eleven species were recorded from the sampling site on the lower reaches of the stream. Flow sensitive species, *Amphilius uranoscopus* and *Chiloglanis pretoriae* were found in abundance in all age classes. The rheophilic *Labeobarbus marequensis* was also recorded as well as the catadromous, *Anguilla mossambica*. This stream is an important refuge area for the Kaap catchment. A Fish Response Assessment Index (FRAI) was calculated for this reach based on all available information, placing this reach in a Fish Ecological Class B (slightly impaired with a low diversity and abundance of species).

Invertebrates

This reach consists of a small mountain stream a tributary of the Suidkaap River, east of the town of Barberton. The bio-monitoring point sampled in this reach was X2FIGT-COVIN.The in-stream habitat is dominated by, cobbles, sand-mud, bedrock and vegetation. There were modified conditions present, linked to modifications in flow, water quality and sediment deposition. Impacts are due to agricultural activities, cattle grazing and human settlements. A total of 26 taxa were recorded, indicating a high diversity of invertebrates. Highly sensitive taxa included Beatidae, Heptagenidae, Hydropscychidae and Perlidae.

Instream Ecostatus

The Ecostatus for this stream was consistent with a Class B suggesting a slightly impaired habitat.

X2HONE-LANCE

General description

Honeybird Creek

This small mountain stream is a tributary of the Kaap River and originates high up in the Baberton Mountain at an elevation of about 1200 m a.s.l. and joins up with the Kaap River at 475 m a.s.l. Very shallow sandy habitat dominates the area. Sedimentation from excessive over-grazing resulting in erosion is the main driver for the habitat present.

Fish

The flow dependant *Amphilius uranoscopus* and two of the smaller barbs, *Barbus trimaculatus* and *B. eutaenia* were sampled at this site in very low abundance.

A Fish Response Assessment Index (FRAI) was calculated for this reach based on all available information, placing this reach in a Fish Ecological Class C (moderately impaired with a low diversity and abundance of species).

Invertebrates

No data collected and non previous data available.

Instream ecostatus

The Ecostatus for this stream was consistent with a Class C suggesting a moderately impaired habitat.

X2LOUW-STATE

Reach 23H: Louw's Creek

General description

Louw's Creek originates high up in the Baberton Mountains at an elevation of 985 m a.s.l. It flows northwards to meet the Kaap River at an elevation of 375 m a.s.l. Main impacts on this stream are from the small town, Sincobile, next to it. Small scale agricultural activities and mining have also negative impacts on this stream. Water from the Shiyalongubu Dam is pumped over the watershed to a diverted Louw's Creek.

Fish

High flows were the reason for being able to sample only two species of fish in very low numbers. The species recorded were *Amphilius uranoscopus* and *Barbus eutaenia*. The lack of a range of habitats is also a reason for the low abundance of fish.

A Fish Response Assessment Index (FRAI) was calculated for this reach based on all available information, placing this reach in a Fish Ecological Class B (slightly impaired with a low diversity and abundance of species).

Invertebrates

This reach consists of a small mountain stream a tributary of the Suidkaap River, east of the town of Barberton. The bio-monitoring point sampled in this reach was X2LOUW-STATE.The in-stream habitat is dominated by, cobbles, sand-mud, bedrock and vegetation, although limited. There is definitely modified conditions that are linked to modifications in flow, water quality and sediment deposition. Impacts were extensive up stream due to historical mining activities, human settlements and the Barbrook mine, which is still active. A pipeline diverts the water directly from the Shiyalongubu dam, where a section of the Low's creek is diverted. A total of 16 taxa were recorded, indicating a low diversity of invertebrates. Highly sensitive taxa included Beatidae, Heptagenidae and Hydropscychidae, in low abundance.

Instream ecostatus

The Ecostatus for this stream was consistent with a Class B/C suggesting a slightly to moderately impaired habitat.

5. SUMMARY AND CONCLUSION

The main issues highlighted during the 2012/12013 biomonitoring of the Crocodile-Inkomati water catchment are briefly discussed.

CROCODILE MAINSTEM

Fish

In the main stem Crocodile River a total of 18 reaches were assessed as part of the determination of the ecological status of the Crocodile River. A total of 24 sites were sampled within these 18 SQ reaches, representing a total river length of 326 km (Table 23). The actual biomonitoring results indicated a C-class status for both the fish (FRAI) and aquatic macro-invertebrates (MIRAI). The instream ecostatus, which is derived from a combination of the data collected for fish and aquatic macro-invertebrates, was also categorised as a C-class (moderately modified). The PES value, which is a desktop study[2] derived from the PES-EIS, was also categorised as a lower C-class. The PES class indicates that the present condition of the river is more modified than expected.

Low fish species diversity and abundance were recorded in certain reaches, particularly in the headwaters (above Kwena Dam). The headwaters are characterised by a high density of farm dams and weirs, mostly stocked with trout. Fast flowing mountain streams were altered to lentic habitats, creating ideal conditions for alien fish species. The dams and weirs are linked to flow regulation, water quality changes, physical changes and increased sedimentation. Eutrophication associated with artificial feeding in the dams are evident in the downstream river.These listed impacts are considered to be the main causes for deterioration. The impact of alien trout on indigenous fish species is well documented (Cucherousset & Olden 2011; Davies & Day 1998; Mitchell & Knouft 2008). Local knowledge and results of the 2012/12013 survey indicate no viable populations of wild trout occurring within the upper reaches. These observations could be related to the increase water temperature and related habitat and water quality impacts

Flow regulation and timing of flow releases (dam operating rules) is the biggest cause for impaired conditions below Kwena Dam. The impacts of large dams on downstream communities are well documented. Fish species historically recorded prior to the construction of impoundment is no longer present in the Crocodile main stem, and where present in low abundance. Tributaries in the affected reach act as critically important refuges for the survival of these species. These flow sensitive species which is intolerant to habitat and water quality changes include *Kneria kwena*, *Chiloglanis bifurcus*, and *Opsaridium peringueyi*. The species *C. bifurcus* is categorised globally as endangered, *O. peringueyi* as threatened, and *K. kwena* is endemic to the upper reaches of the Crocodile River.

[2]Experts in their related fields determine expected presence of aquatic species within each river reach,

Aquatic Invertebrates

Aquatic macro-invertebrate communities are affected mainly by sedimentation and eutrophication. Flow regulation and changes in water temperature will also have a negative impact on instream communities. Ephemeroptera families recorded in 1967 are absent since monitoring was initiated in 1991.

Aquatic macro-invertebrate communities in the upper reaches of the Crocodile River main stem are relatively comparable to expected conditions, with flow regulation affecting communities downstream from the Kwena Dam. The conditions, based on the aquatic macro-invertebrates improves as it merges with the Elands and Houtbosloop upstream from Nelspruit, but deteriorates considerably downstream from Nelspruit. Several sensitive taxa that were frequently recorded prior to 1996 are absent from subsequent records, or if present, at very low abundance. Some of the sensitive Ephemeroptera families recorded in the Matthew (1968) study were not recorded again in recent years. In these lower reaches the Philopotamid caddisflies have not been found since 1996. The presence-absence of taxa in the lower reaches of the Crocodile River is of grave concern, and should be investigated further.

Ecostatus

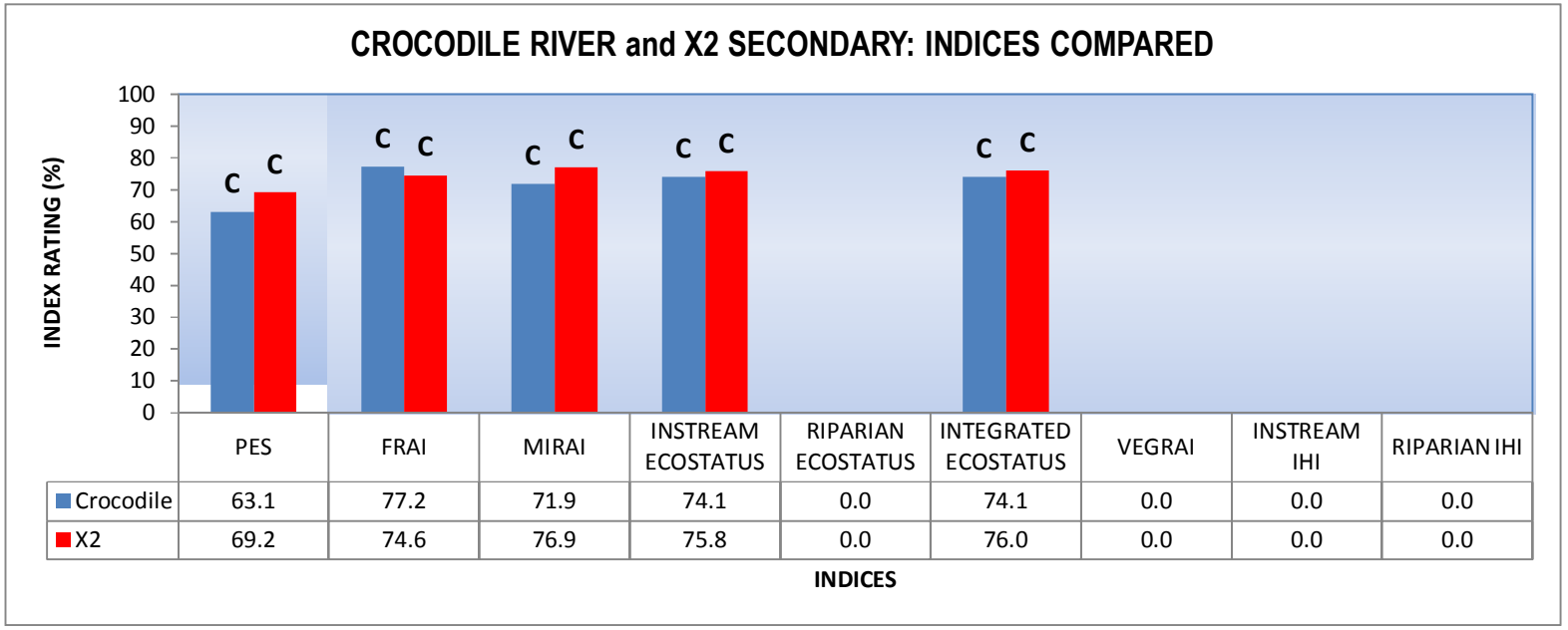
Where the Crocodile River merge with the Houtbosloop and Elands River, the Instream Ecostatus improves slightly, but deteriorates downstream from Nelspruit. The deterioration is linked to reduced water quality. Downstream from the Crocodile to where it enters Mozambique, the Instream Ecostatus is consistently categorised as moderately modified (C-class). This reduced value is mainly related to over abstraction and river regulation and habitat degradation.

X2 TRIBUTARIES

The X2 tributaries refer to all Crocodile River tributaries including the two major sub-catchments namely the Elands River and the Kaap River. Within the X2 secondary rivers a total of 50 reaches were assessed as part of the determination of the Ecological Status of the X2 secondary rivers. A total of 32 sites were sampled within these 50 reaches representing a total length of 1062.93km. The overall biomonitoring results indicate a Class C status for both the fish (FRAI: 74.6%) and aquatic macro-invertebrates (MIRAI: 76.95%). The Instream Ecostatus (75.8%) as well as the PES value (69.2%) was also categorised as a Class C (moderately modified) (Table 23). The X2 secondary tributaries of concern are the Lunsklip, Houtbosloop and Ngodwana rivers, where the PES – Present and Ecological status - classes indicate that these rivers are more impacted than expected.

Table 3: Summary of indices rated and comparison between Crocodile River and X2 Secondary

Crocodile River	PES	FRAI	MIRAI	INSTREAM ECOSTATUS	INTEGRATED ECOSTATUS
NR OF SQ REACHES ASSESSED	18	18	18	18	18
TOTAL LENGTH OF SQ REACHES ASSESSED	326.03	326.03	326.03	326.03	326.03
OVERALL RATING	63.1	77.2	71.9	74.1	74.1
OVERALL CATEGORY	C	C	C	C	C
X2	**PES**	**FRAI**	**MIRAI**	**INSTREAM ECOSTATUS**	**INTEGRATED ECOSTATUS**
NR OF SQREACHES ASSESSED	83	48	50	50	47
TOTAL LENGTH OF SQ REACHES ASSESSED	1583.42	1014.65	1062.93	1062.93	1013.47
OVERALL RATING	69.2	74.6	76.9	75.8	76.0
OVERALL CATEGORY	C	C	C	C	C



6. RECOMMENDATIONS

The status of the Crocodile River, especially in the upper reaches is of concern. Based on the impacts observed and discussed above, the following recommendationsare included:

- Water Temperature: Temperature related changes in the upper reaches of the Crocodile River, and its impact on the resident and downstream aquatic communities needs further investigation.
- Kwena Dam: Develop and implement dam release strategies with operating rules.
- Red-listed Fish Species: A comprehensive fish species survey in the Crocodile Catchment to determine the status and distribution of *Chiloglains bifurcus* and *Kneria kwena.*
- Implementation of the ecological reserve and frequent monitoring to track changes and trends, and to determine whether the reserve objectives are met.

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8. APPENDIX

Fish species collected per reach

ABREV	SPECIES	X21A-930			X21B-962			X21D-938	X21E-943				X22B-888	X22C-946	
		X2CROC-VERLO	X2CROC-EHOEK	X2CROC-VALY1	X2CROC-ROODE	X2CROC-DONKE	X2CROC-GOEDE	X2CROC-DOORN	X2CROC-STER1	X2CROC-RIETV	X2CROC-INDEM	X2CROC-MONTR	X2CROC-RIVUL	X2CROC-STRKS	X2CROC-HALLS
ANAT	*Amphilius natalensis*						X								
AURA	*Amphilius uranoscopus*								X	X	X	X	X		
AMOS	*Anguilla mossambica*														
BFRI	*Barbus afrohamiltoni*														
BANN	*Barbus annectens*														
BANO	*Barbus anoplus*	X	X	X	X	X									
BARG	*Barbus argenteus*								X	X	X	X			
BEUT	*Barbus eutaenia*														
BNEE	*Barbus neefi*						X								
BPAU	*Barbus paludinosus*														
BRAD	*Barbus radiatus*														
BTOP	*Barbus toppini*														
BTRI	*Barbus trimaculatus*														
BUNI	*Barbus unitaeniatus*														
BVIV	*Barbus viviparus*														
BIMB	*Brycinus imberi*														
CBIF	*Chiloglanis bifurcus*												X		
CPAR	*Chiloglanis paratus*														
CPRE	*Chiloglanis pretoriae*					X	X		X	X	X	X	X	X	X
CSWI	*Chiloglanis swierstrai*														
CGAR	*Clarias gariepinus*													X	X
GGIU	*Glossogobius giurus*														
HVIT	*Hydrocynus vittatus*														
KKWE	*Kneria kwena*														
LCON	*Labeo congoro*														
LCYL	*Labeo cylindricus*														
LMOL	*Labeo molybdinus*														
LROS	*Labeo rosae*														
LRUD	*Labeo ruddi*														
BMAR	*Labeobarbus marequensis*												X	X	X
BPOL	*Labeobarbus polylepis*														
MMAC	*Marcusenius macrolepidotus*														
MBRE	*Mesobola brevianalis*														
MACU	*Micralestes acutidens*														
MSAL	*Micropterus salmoides*														
OMYK	*Oncorhynchus mykiss*														
OPER	*Opsaridium peringueyi*														
OMOS	*Oreochromis mossambicus*													X	X
PCAT	*Petrocephalus wesselsi*														
PPHI	*Pseudocrenilabrus philander*				X		X		X	X	X	X	X	X	X
TREN	*Tilapia rendalli*														
TSPA	*Tilapia sparrmanii*				X										
VNEL	*Varicorhinus nelspruitensis*														

ABREV	SPECIES	X22J-958	X22K-1018		X24C-1033	X24D-994		X24E-982	X24H-888	X24H-934	X24H-953	X21G-1037	X21J-1013		X21K-1035	
		X2CROC-KAMAG	X2CROC-N4ROA	X2CROC-WELT1	X2CROC-KAAPM	X2CROC-MATJU	X2CROC-MALEL	X2CROC-RIVE1	X2CROC-MBYAM	X2CROC-TENBO	X2CROC-NKONG	X2ELAN-DOORN	X2ELAN-HELML	X2ELAN-GELUK	X2ELAN-ROODE	X2ELAN-GOEDG
ANAT	*Amphilius natalensis*															
AURA	*Amphilius uranoscopus*	X	X	X	X		X					X	X	X	X	X
AMOS	*Anguilla mossambica*															
BFRI	*Barbus afrohamiltoni*									X						
BANN	*Barbus annectens*															
BANO	*Barbus anoplus*															
BARG	*Barbus argenteus*												X	X	X	X
BEUT	*Barbus eutaenia*	X	X		X	X	X			X						
BNEE	*Barbus neefi*															
BPAU	*Barbus paludinosus*															
BRAD	*Barbus radiatus*							X		X						
BTOP	*Barbus toppini*															
BTRI	*Barbus trimaculatus*			X	X		X	X		X						
BUNI	*Barbus unitaeniatus*	X	X		X		X									
BVIV	*Barbus viviparus*								X	X	X					
BIMB	*Brycinus imberi*															
CBIF	*Chiloglanis bifurcus*														X	X
CPAR	*Chiloglanis paratus*			X	X		X	X	X	X	X					
CPRE	*Chiloglanis pretoriae*	X	X	X	X	X	X						X	X	X	X
CSWI	*Chiloglanis swierstrai*							X		X	X					
CGAR	*Clarias gariepinus*	X						X		X						
GGIU	*Glossogobius giurus*								X	X						
HVIT	*Hydrocynus vittatus*							X		X						
KKWE	*Kneria kwena*															
LCON	*Labeo congoro*									X						
LCYL	*Labeo cylindricus*				X	X	X	X		X	X					
LMOL	*Labeo molybdinus*		X		X		X	X								
LROS	*Labeo rosae*															
LRUD	*Labeo ruddi*															
BMAR	*Labeobarbus marequensis*	X	X			X	X	X	X	X	X					
BPOL	*Labeobarbus polylepis*												x			x
MMAC	*Marcusenius macrolepidotus*	X	X	X												
MBRE	*Mesobola brevianalis*															
MACU	*Micralestes acutidens*				X		X	X	X	X						
MSAL	*Micropterus salmoides*															
OMYK	*Oncorhynchus mykiss*															
OPER	*Opsaridium peringueyi*		X													
OMOS	*Oreochromis mossambicus*	X	X		X	X	X	X	X	X						
PCAT	*Petrocephalus wesselsi*															
PPHI	*Pseudocrenilabrus philander*	X	X		X	X	X	X	X			x	x			
TREN	*Tilapia rendalli*															
TSPA	*Tilapia sparrmanii*									x	x	x		x	x	
VNEL	*Varicorhinus nelspruitensis*															

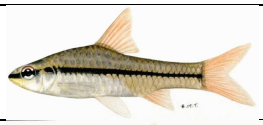
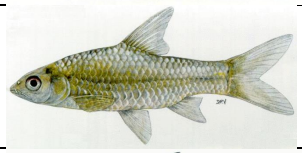
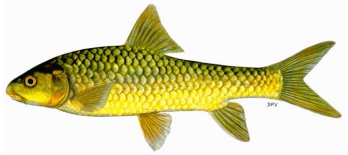
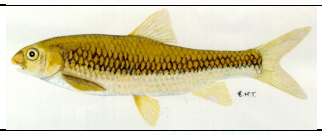
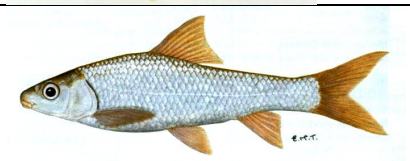
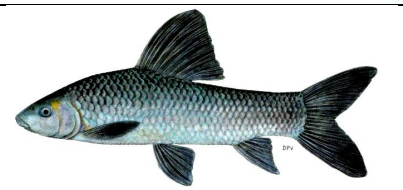
ABREV	SPECIES	X21K-997	X21B-898		X21B-925	X21C-859	X21D-957	X21F-1100	X21H-1060	X22A-913	X22C-990	X22C-1004	X22D-843	X22D-842	X22G-1016
		X2ELAN-LINDE	X2LUNS-UVERL	X2LUNS-VERLO	X2LUNS-UITWA	X2ALEX-RIETF	X2-BUFF-SOMER	X2LEEU-GELUK	X2NGOD-GROOT	X2HOUT-SUDWA	X2VISS-ALKMA	X2GLAD-HERMA	X2NELS-RHENO	X2NELS-SPITZ	X2SWAR-KINDE
ANAT	*Amphilius natalensis*														
AURA	*Amphilius uranoscopus*	X			X	X	X	X						X	X
AMOS	*Anguilla mossambica*														X
BFRI	*Barbus afrohamiltoni*														
BANN	*Barbus annectens*														
BANO	*Barbus anoplus*			X		X	X				X				X
BARG	*Barbus argenteus*	X								X		X			
BEUT	*Barbus eutaenia*														
BNEE	*Barbus neefi*				X	X	X								
BPAU	*Barbus paludinosus*	X													
BRAD	*Barbus radiatus*														
BTOP	*Barbus toppini*														
BTRI	*Barbus trimaculatus*										X				
BUNI	*Barbus unitaeniatus*														
BVIV	*Barbus viviparus*														
BIMB	*Brycinus imberi*														
CBIF	*Chiloglanis bifurcus*														
CPAR	*Chiloglanis paratus*														
CPRE	*Chiloglanis pretoriae*	X			X					X				X	X
CSWI	*Chiloglanis swierstrai*														
CGAR	*Clarias gariepinus*														
GGIU	*Glossogobius giurus*														
HVIT	*Hydrocynus vittatus*														
KKWE	*Kneria kwena*					X	X								
LCON	*Labeo congoro*														
LCYL	*Labeo cylindricus*														
LMOL	*Labeo molybdinus*														
LROS	*Labeo rosae*														
LRUD	*Labeo ruddi*														
BMAR	*Labeobarbus marequensis*										X				
BPOL	*Labeobarbus polylepis*	x													
MMAC	*Marcusenius macrolepidotus*														
MBRE	*Mesobola brevianalis*														
MACU	*Micralestes acutidens*														
MSAL	*Micropterus salmoides*														
OMYK	*Oncorhynchus mykiss*												X		
OPER	*Opsaridium peringueyi*														
OMOS	*Oreochromis mossambicus*														
PCAT	*Petrocephalus wesselsi*														
PPHI	*Pseudocrenilabrus philander*	x						X							
TREN	*Tilapia rendalli*														
TSPA	*Tilapia sparrmanii*					X								X	
VNEL	*Varicorhinus nelspruitensis*														

ABREV	SPECIES	X22H-836	X23B-1052	X23E-1154	X23F-1120	Not on reach								
		X2WITR-VALLE	X2NOOR-RIVER	X2QUEE-HILVE	X2SUID-DAISY	X2WILG-WILG1	X2STER-R538B	X2JUNG-MOOIP	X2TAUT-WINNA	X2HYSL-DYCED	X2ORAT-MOUNT	X2FIGT-COVIN	X2HONE-LANCE	X2LOUW-STATE
ANAT	*Amphilius natalensis*													
AURA	*Amphilius uranoscopus*		X	X		X	X		X	X		X	X	X
AMOS	*Anguilla mossambica*											X		
BFRI	*Barbus afrohamiltoni*													
BANN	*Barbus annectens*													
BANO	*Barbus anoplus*					X	X	X						
BARG	*Barbus argenteus*						X							
BEUT	*Barbus eutaenia*				X							X	X	X
BNEE	*Barbus neefi*					X								
BPAU	*Barbus paludinosus*													
BRAD	*Barbus radiatus*													
BTOP	*Barbus toppini*													
BTRI	*Barbus trimaculatus*				X					X		X	X	
BUNI	*Barbus unitaeniatus*				X									
BVIV	*Barbus viviparus*													
BIMB	*Brycinus imberi*													
CBIF	*Chiloglanis bifurcus*													
CPAR	*Chiloglanis paratus*													
CPRE	*Chiloglanis pretoriae*		X	X		X						X		
CSWI	*Chiloglanis swierstrai*													
CGAR	*Clarias gariepinus*	X										X		
GGIU	*Glossogobius giurus*													
HVIT	*Hydrocynus vittatus*													
KKWE	*Kneria kwena*					X	X	X						
LCON	*Labeo congoro*													
LCYL	*Labeo cylindricus*													
LMOL	*Labeo molybdinus*													
LROS	*Labeo rosae*													
LRUD	*Labeo ruddi*													
BMAR	*Labeobarbus marequensis*		X		X									
BPOL	*Labeobarbus polylepis*													
MMAC	*Marcusenius macrolepidotus*													
MBRE	*Mesobola brevianalis*													
MACU	*Micralestes acutidens*													
MSAL	*Micropterus salmoides*	X												
OMYK	*Oncorhynchus mykiss*													
OPER	*Opsaridium peringueyi*													
OMOS	*Oreochromis mossambicus*		X											
PCAT	*Petrocephalus wesselsi*													
PPHI	*Pseudocrenilabrus philander*	X	X		X				X					
TREN	*Tilapia rendalli*													
TSPA	*Tilapia sparrmanii*			X										
VNEL	*Varicorhinus nelspruitensis*		X											

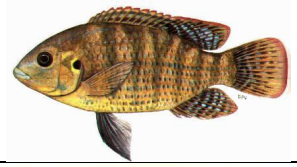
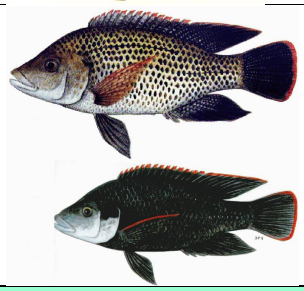
APPENDIX – Photo's of Fish species

Illustrations of fish species from the Atlas of Southern African Freshwater Species - SAIAB (Scott et al., 2004) recorded at all the sampling sites .

FAMILY MORMYRIDAE - SNOUTFISHES	
Marcusenius macrolepidotus Bulldog	
Petrocephalus catostoma (*wesselsi*) Northern churchill	
FAMILY ANGUILLIDAE - FRESH WATER EELS	
Anguilla mossambica Longfin eel	
FAMILY KNERIIDAE - KNERIAS	
Kneria auriculata (*kwena)* Southern kneria	
FAMILY CYPRINIDAE - BARBS, YELLOWFISH, LABEOS	
Mesobola brevianalis River sardine	
Barbus anoplus Chubbyhead barb	
Barbus annectens Broadstriped barb	
Barbus neefi Sidespot barb	
Barbus unitaeniatus Longbeard barb	
Barbus viviparus Bow stripe barb	
Barbus toppini East coast barb	

Barbus radiatus Beira barb	
Barbus trimaculatus Three spot barb	
Barbus eutaenia Orange fin barb	
Barbus argenteus Rose fin barb	
Barbus paludinosus Straight fin barb	
Barbus afrohamiltoni Plump barb	
Labeobarbus polylepis Bushveld small scale yellowfish	
Labeobarbus marequensis Lowveld large scale yellowfish	
Varicorhinus nelspruitensis Incomati chisel mouth	
Labeo ruddi Silver labeo	
Labeo congoro Purple labeo	
Labeo cylindricus Red eye labeo	

Labeo molybdinus Leaden labeo	
FAMILY CHARACIDAE - CHARACINS	
Brycinus imberi Imberi	
Micralestes acutidens Silver robber	
Hydrocynus vittatus Tigerfish	
FAMILY AMPHILIIDAE - MOUNTAIN CATFISHES	
Amphilius natalensis Natal mountain catfish	
Amphilius uranoscopus Common or stargazer mountain catfish	
FAMILY CLARIIDAE - AIR-BREATHING CATFISHES	
Clarias gariepinus Sharptooth catfish	
FAMILY MOCHOKIDAE - SQUEAKERS, SUCKERMOUTH CATLETS	
Chiloglanis bifurcus Incomati suckermouth or rock catlet	
Chiloglanis paratus Sawfin suckermouth or rock catlet	
Chiloglanis pretoriae Short spine suckermouth or rock catlet	
Chiloglanis swierstrai Lowveld suckermouth or rock catlet	
FAMILY SALMONIDAE - TROUTS	
Salmo trutta Brown trout	

Oncorhynchus mykiss Rainbow trout	
FAMILY CENTRARCHIDAE - BASSES AND SUNFISHES	
Micropterus salmoides Largemouth bass	
FAMILY CICHLIDAE - CICHLIDS	
Pseudocrenilabrus philander Southern mouth brooder	
Tilapia sparrmanii Banded tilapia	
Tilapia rendalli Red breast tilapia	
Oreochromis mossambicus Mozambique tilapia	
FAMILY GOBIIDAE - GOBIES	
Glossogobius giuris Tank goby	
ADDITIONAL SPECIES	
Opsaridium zambezense (perringuyei) Nothern barred minnow	

APPENDIX - Photo's of monitoring sites

CROCODILE RIVER MAINSTEM

REACH: X21A-00930	
X2CROC-VERLO	
	
Figure A-1: Upstream view of the Verlorenvlei site (X2CROC-VERLO) on the Crocodile River (19 September 2012, G Diedericks).	**Figure A-2:** Downstream view of the Verlorenvlei site (X2CROC-VERLO) on the Crocodile River (19 September 2012, G Diedericks).
X2CROC-EHOEK	
	
Figure A-3: Upstream view of the Elandshoek site (X2CROC-EHOEK) on the Crocodile River (18 September 2012, G Diedericks).	**Figure A-4:** Downstream view of the Elandshoek site (X2CROC-EHOEK) on the Crocodile River (18 September 2012, G Diedericks).
X2CROC-VALYS	
	
Figure A-5: Upstream view of the Valyspruit site (X2CROC-VALYS) on the Crocodile River (18 September 2012, G Diedericks).	**Figure A-6:** Downstream view of the Valyspruit site (X2CROC-VALYS) on the Crocodile River (18 September 2012, G Diedericks).

REACH: X21B-00898	
X2LUNS-UVERL	
	
Figure A-7: Upstream view of the Upper Verlorenvalei site (X2LUNS-UPPER) on the Lunsklip River (18 September 2012, G Diedericks).	**Figure A-8:** Downstream view of the Upper Verlorenvalei site (X2LUNS-UPPER) on the Lunsklip River (18 September 2012, G Diedericks).
X2LUNS-VERLO	
	
Figure A-9: Upstream view of the Verlorenvalei site (X2LUNS-VERLO) on the Lunsklip River (18 September 2012, G Diedericks).	**Figure A-10:** Downstream view of the Verlorenvalei site (X2LUNS-VERLO) on the Lunsklip River (18 September 2012, G Diedericks).

REACH: X21B-00962	
X2CROC-ROODE	
	
Figure A-11: Upstream view of the Roodekrans site (X2CROC-ROODE) on the Crocodile River (19 September 2012, G Diedericks).	**Figure A-12:** Downstream view of the Roodekrans site (X2CROC-ROODE) on the Crocodile River (19 September 2012, G Diedericks).
X2CROC-DONKE	

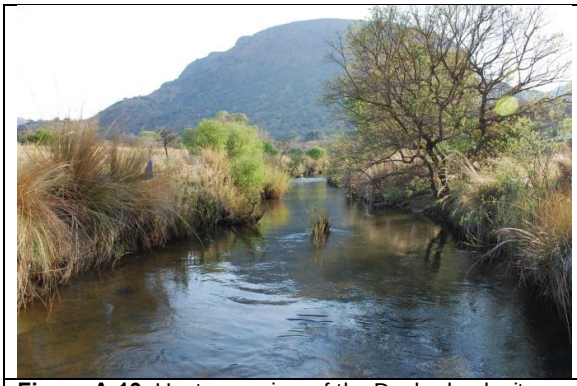


Figure A-13: Upstream view of the Donkerhoek site (X2CROC-DONKE) on the Crocodile River (19 September 2012, G Diedericks).

Figure A-14: Downstream view of the Donkerhoek site (X2CROC-DONKE) on the Crocodile River (19 September 2012, G Diedericks).

X2CROC-GOEDE

Figure A-15: Upstream view of the Goedehoop site (X2CROC-GOEDE) on the Crocodile River (09 October 2012, G Diedericks).

Figure A-16: Downstream view of the Goedehoop site (X2CROC-GOEDE) on the Crocodile River (09 October 2012, G Diedericks).

REACH: X21E-00943

X2CROC-STER1

Figure A-19: Upstream view of the Sterkspruit site (X2CROC-STER1) on the Crocodile River (28 September 2012, G Diedericks).

Figure A-20: Downstream view of the Sterkspruit site (X2CROC-STER1) on the Crocodile River (28 September 2012, G Diedericks).

X2CROC-RIETV	
	
Figure A-21: Upstream view of the Rietvlei site (X2CROC-RIETV) on the Crocodile River (28 September 2012, G Diedericks).	**Figure A-22:** Downstream view of the Rietvlei site (X2CROC-RIETV) on the Crocodile River (28 September 2012, G Diedericks).
X2CROC-INDEM	
	
Figure A-23: Upstream view of the Die Rots site (X2CROC-INDEM) on the Crocodile River (28 September 2012, G Diedericks).	**Figure A-24:** Downstream view of the Die Rots site (X2CROC-INDEM) on the Crocodile River (28 September 2012, G Diedericks).
X2CROC-MONTR	

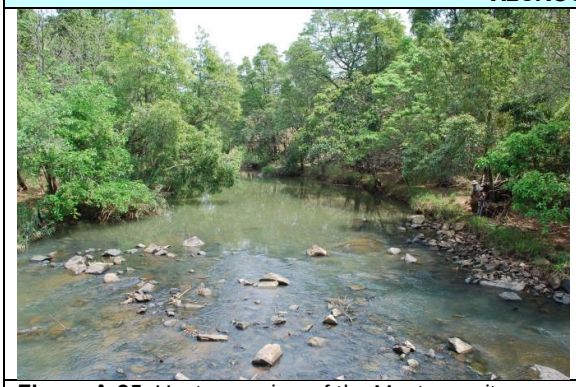
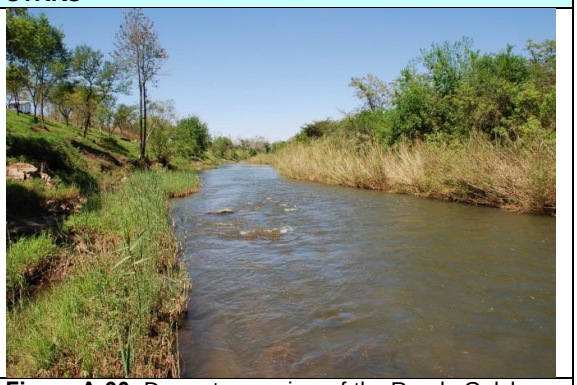



Figure A-25: Upstream view of the Montrose site (X2CROC-MONTR) on the Crocodile River (28 September 2012, G Diedericks).	**Figure A-26:** Downstream view of the Montrose site (X2CROC-MONTR) on the Crocodile River (28 September 2012, G Diedericks).

REACH: X22B-00888	
X2CROC-RIVUL	
	
Figure A-27: Upstream view of the Rivulets site (X2CROC-RIVUL) on the Crocodile River (29 September 2012, G Diedericks).	**Figure A-28:** Downstream view of the Rivulets site (X2CROC-RIVUL) on the Crocodile River (29 September 2012, G Diedericks).

REACH: X22C-00946	
X2CROC-STRKS	
	
Figure A-29: Upstream view of the Ronde Geluk site (X2CROC-STRKS) on the Crocodile River (29 September 2012, G Diedericks).	**Figure A-30:** Downstream view of the Ronde Geluk site (X2CROC-STRKS) on the Crocodile River (29 September 2012, G Diedericks).
X2CROC-HALLS	
	
Figure A-31: Upstream view from a side channel in the Crocodile River at the Halls site (X2CROC-HALLS) (29 September 2012, G Diedericks).	**Figure A-32:** Downstream view from a side channel in the Crocodile River at the Halls site (X2CROC-HALLS) (29 September 2012, G Diedericks).

REACH: X22JC-00958	
X2CROC-KHAMA	
	
Figure A-33: Upstream view of the Khamagugu site (X2CROC-KHAMA) on the Crocodile River (08 October 2012, G Diedericks).	**Figure A-34:** Downstream view of the Khamagugu site (X2CROC-KHAMA) on the Crocodile River (08 October 2012, G Diedericks).

REACH: X22K-01018	
X2CROC-N4ROA	
	
Figure A-35: Upstream view of the Kanyamazane site (X2CROC-N4ROA) on the Crocodile River (08October 2012, G Diedericks).	**Figure A-36:** Downstream view of the Kanyamazane site (X2CROC-N4ROA) on the Crocodile River (08 October 2012, G Diedericks).

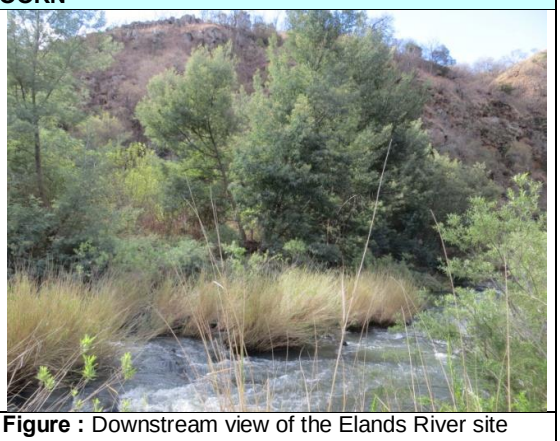
X24D-00994 – Crocodile River: Matjulu-Malelane

X24F-00953 – Crocodile River: Maroela

X24H-00880 – Crocodile River: Mbyamiti – Crocodile Bridge

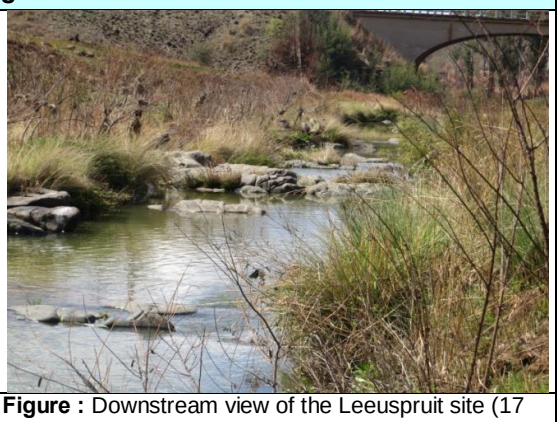
X24H-00934 – Crocodile River: Nkongoma

CROCODILE RIVER TRIBTARIES, ELANDS RIVER AND KAAP RIVER

REACH: X21G-01037	
X2ELAN-DOORN	
	
Figure : Upstream view of the Elands River site (27 March 2012, H. Marais).	**Figure :** Downstream view of the Elands River site (27 March 2012, H.Marais).

REACH: X21J-01013	
X2ELAN-HEML	
	
Figure: Upstream view of the Elands River site (19 September 2012, H. Marais).	**Figure:** Upstream view of the Elands River site (19 September 2012, H.Marais).
X21K-01035	
X2ELANDS-ROODE	
	
Figure: Upstream view of the Elands-Roode site (19 September 2012, H.Marais).	**Figure:** Downstream view of the Elands-Roode site (19 September 2012, H.Marais).

REACH: X21K-01035	
X2ELAN-HOUT	
	
Figure : Upstream view of the Eland-Hout site (19 September 2012, H.Marais).	**Figure :** Downstream view of the Eland-Hout site (19 September 2012, H.Marais).
REACH: X21K-00997	
X2ELAN-LINDE	
	
Figure : Upwnstream view of the Eland-Linde site (19 September 2012, H.Marais).	**Figure :** Downstream view of the Eland-Linde site (19 September 2012, H.Marais).

REACH: X21F-01100	
X2LEEU-	
	
Figure : Upstream view of the Leeuspruit site (17 September 2012, H.Marais).	**Figure :** Downstream view of the Leeuspruit site (17 Sept 2012, H.Marais).

REACH: X21H-01060	
X2NGOD-GROOT	
	
Figure: Upstream view of the Ngodwana River site (19 September 2012, H.Marais).	**Figure: Down**stream view of the Ngodwana River site (19 September 2012, H.Marais).
REACH: X22G-01016	
X2SWAR-KINDE	
	
Figure: Upstream view of the Swartkoppies spruit site (25 September 2012, H.Marais).	**Figure:** Downstream view of the Swartkoppies spruit site (25 September 2012, H.Marais).
REACH: X22A-00913	
X2HOUT-SUDWA-	
	
Figure: Upstream view of the Houtbosloop site (12 Sept 2012, H.Marais).	**Figure:** Downstream view of the Houtbosloop site (12 Sept 2012, H.Marais).

REACH: X22C-00990	
X2VISS-ALKMA	
	
Figure: Cross section of the Visspruit site (14 Sept 2012, H.Marais).	**Figure:** Downstream view of the Visspruit site(14 Sept 2012, H.Marais).
REACH: X22D-00843	
X2NELS-RHENO	
	
Figure : Upstream view of the Nels River site (26 September 2012, H.Marais).	**Figure :** Downstream view of the Nels River site (26 September 2012, H.Marais).
REACH: X22D-00842	
X2NELS-SPITS	
	
Figure : Downstream view of the Nels River Spitskop site (26 September 2012, H.Marais).	**Figure :** Downstream view of the Nels River Spitskop site (26 September 2012, H.Marais).

REACH: X22C-01004	
X2GLAD-HERMA	
	
Figure: Upstream view of the Gladdespruit site (27 March 2013, H.Marais).	**Figure:** Downstream view of the Gladdespruit site (27 March 2013, H.Marais).
REACH: X22H-00836	
X2WITR-VALLE	
	
Figure : Upstream view of the White River site (12November 2012, H.Marais).	**Figure :** Downstream view of the White River site (12November 2012, H.Marais).
REACH: X23E-01154	
X2QUEE-HILV	
	
Figure : Upstream view of the Queens River site (27 March 2012, H.Marais).	**Figure :** Downstream view of the Queens River site (27 March 2012, H.Marais).

REACH: X23F-01120	
X2SUID-DAISY	
	
Figure : Upstream view of the Suidkaap River site (27 March 2012, H.Marais).	**Figure :** Downstream view of the Suidkaap River site (27 March 2012, H.Marais).

NOT IN REACH	
X2TAUT-WINNA	
	
Figure: Upstream view of the Tautesloop site (27 March 2012, H.Marais).	**Figure:** Downstream view of the Tautesloop site (27 March 2012, H.Marais).

NOT IN REACH	
X2HYSL-DYCED	
	
Figure: Upstream view of the Hyslopôs Creek site (13 November 2012, H.Marais).	**Figure:** Downstream view of the Hyslopôs Creek site (13 November 2012, H.Marais).

NOT IN REACH X2ORAT-MOUNT	
	
Figure : Upstream view of the Oratawa Creek (14 November 2012, H.Marais).	**Figure :** Downstream view of the Oratawa Creek (14 November 2012, H.Marais).

NOT IN REACH X2LOUW-STATE	
	
Figure: Upstream view of the Lows Creek site (14 November 2012, H.Marais).	**Figure:** Downstream view of the Lows Creek site (14 November 2012, H.Marais).