

ECOSTATUS OF THE SABIE/SAND RIVER CATCHMENTS



Submitted to:

INCOMATI CATCHMENT MANAGEMENT AGENCY

Compiled by:

MPUMALANGA TOURISM AND PARKS AGENCY

Scientific Services: Aquatic & Herpetology



Date: August 2012

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1 INTRODUCTION

The ICMA appointed the MTPA as service provider to conduct biomonitoring within the Sabie/Sand River catchment on the 2011/2012 budget to determine the Present Ecstatus of this river system. Biomonitoring in the Sabie River was conducted during 2011, with the last formal biomonitoring on the Sabie River last being conducted during 1997 (Hill et al. (WRC report no.850/2/01)). During the 2011/12 survey thirty-eight sites were sampled in the Sabie River and its tributaries, including the Klein Sabie, Mac-Mac, Noord Sand, Sand, Marite and Sabana streams (Figure 1). Existing RQS 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 to October. The habitats of the upper reaches above the 1000m elevation were mostly high velocities over cobbles, the middle reaches 400-1000m elevation were medium to high velocities over boulders, and the lower reaches below 400m elevation were mostly low velocities over gravel and sand. The vegetation habitats were sparse due to the high water levels during the sampling period. Sedimentation increased in the upper reaches due to extensive forest fires in 2007.

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 Sabie/Sand River and trends in aquatic health over time, in order to inform management interventions required to address systemic and point specific impacts.

1.2 Background

The source of the Sabie River is on the Eastern slopes of the escarp, 2053m above sea level, and drops down to 120m above sea level where it enters the Coromana Dam in Mozambique, a distance of 175 km downstream. The difference in altitude influences the vegetation structure of the Sabie River from its source to Mozambique. Because of this, the Sabie catchment area was divided into 31 reaches (Table 1). Ten of the reaches were in altitudes between 2053-504m above sea level located in the zones (A-D) (Table 1).

- A:High Gradient Mountain Stream
- B:Mountain Stream
- C:Transitional
- D:Upper Foothills
- E:Lower Foothills

Zone A are affected by forestry and trout fishing. Most areas in these reaches are converted to commercial plantations of *Pinus* and *Eucalyptus* spp. The town Sabie also has a negative effect on environmental health due to unsustainable urban development and pollution from factories and sawmills. The Sabie sewerage works is also not operating properly. The reaches falling between Sabie and the Mac-Mac falls are furthermore impacted on by trout farming. The Inyaka Dam situated in these reaches also had an influence on the biodiversity of the river.

The other reaches are on altitudes between 504-120m, located in the zones (D-E). These reaches are affected by agriculture, eco-adventure tourism, irrigation, water abstraction and urban development. The reaches in the middle section of the Sabie catchment area from Hazyview to the borders of the Kruger National Park were heavily impacted due to urbanization and agriculture. Occasional flooding also had a huge influence on the river and changed the habitat structure of the river in these reaches significantly. The lower reaches of the Sabie catchment area is located in the protected areas of Sabie Sand, Mala Mala and the Kruger National Park. The impact in these reaches is limited because of protection in these areas, but up-stream impacts do have an influence on biodiversity in this reach. Rainfall varies between (2000mm-500mm) from the high altitude reaches at the source of the Sabie River in the Drakensburg Mountains to the lowveld areas where it flows into Mozambique respectively.

Natural vegetation types occurring in the upper reaches of the Sabie River catchment, according to Mucina &Rutherford (2006):

- Longtom Pass Montane Grassland
- Northern Escarp Dolomite Grassland
- Northern Escarp Quartzite Sourveld

Natural vegetation occurring in the middle reaches of the Sabie River catchment, according to Mucina &Rutherford (2006):

- Legogote Sour Bushveld
- Subtropical Afromontane Forests
- Pretoriuskop Sour Bushveld

Natural vegetation occurring in the lower reaches of the Sabie River catchment, according to Mucina & Rutherford (2006):

- Granite Lowveld
- Delagoa Lowveld
- Sweet Arid Basalt Lowveld
- Northern Lebombo Bushveld

Small gold mining operations occur close to Graskop and Sabie. According to the diaries of game rangers in the Kruger National Park, the Sabie River used to be sterile due to the effluent of one of these mines (pers. comm., Dr. Toll Pienaar).

2 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 Sabie River and to attempt to identify any sources and causes of impairment related to the catchment.

Aquatic biodiversity provide an integrative perspective of rivers as ecosystems by integrating pattern (structure) with process (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 was to use aspects of selected resident aquatic biodiversity to characterize the existence and severity of impairments in the Sabie River and to try and identify any sources and causes of impairment relating to catchment modifications. 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 1 and 2) (Kleynhans & Louw, 2008). Several of the aquatic species and taxa that have been recorded in the Sabie River are considered highly sensitive to changes in the above-mentioned physical drivers and are expected to respond rapidly to any changes.

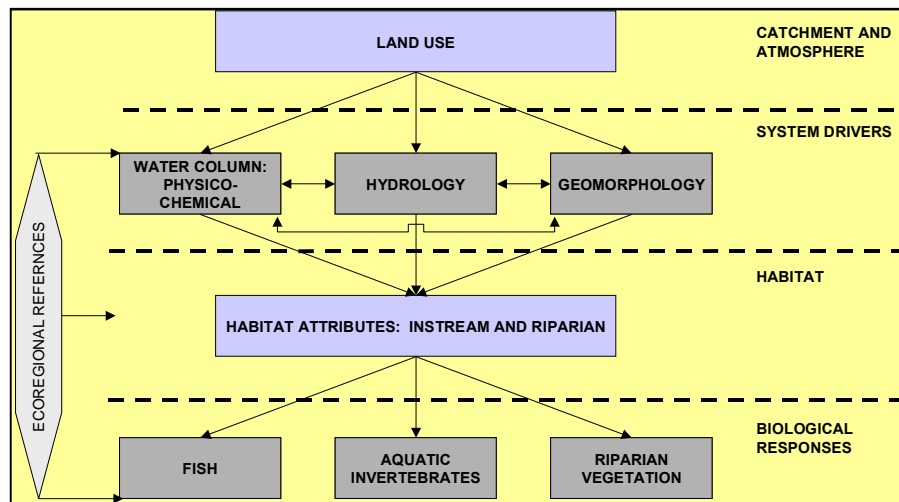


Figure 1: A simplified integration of influence of land use on physical driver determinants, habitats and the associated biological responses.

2.1 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 Sabie 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. Photos of the expected fish species attached in the Appendix.



2.1.1 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 was kept to about 30 minutes.

2.1.2 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.

All data and models are captured in an electronic appendix.

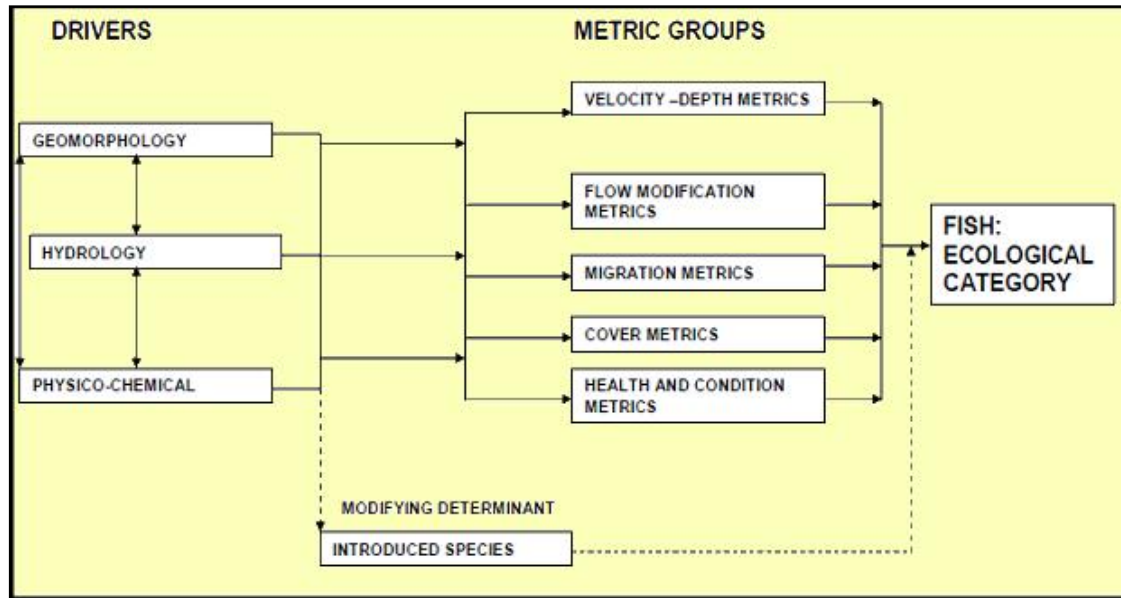


Figure 2: The relationship between ecological drivers, fish metric groups and Ecological Category



2.2 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.



Biomonitoring team at work in the Sabie River below the town of Sabie

2.2.1 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.



Dytiscidae - predacious diving beetle

2.2.2 Analysis

The interpretation of values can differ significantly for different eco-regions in the country. Dallas & Day (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.

2.3 Present Ecological Status



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 RESULTS

Thirty eight biomonitoring sites were selected in the Sabie and Sand River catchments to represent pre-defined reaches and were sampled during 2011 (Table 1) (Figure 3). Sampling was done during this period focussed primarily on some small tributaries high up in the catchment and main stem rivers up to the Mozambican border. At all these sampling sites the RHAM, FRAI and SASS were conducted. This information will be used to compile a comprehensive report on the eco-status of the Sabie – Sand River System.



Table 1: Biomonitoring sites selected in the Sabie and Sand River Reaches

SABI RIVER MAINSTEM						
	Reach	Site name	River	Latitude	Longitude	Elevation
1	X31A-799	X3SABI-OLIFA	SABIE	-25.1207	30.71732	1059 m
2	X31A-778	X3SABI-CASTLE	SABIE	-25.0933	30.76893	1000 m
3	X31B-757	X3SABI-RIOOL	SABIE	-25.0913	30.79376	953 m
4	X31B-757	X3SABI-BRUG	SABIE	-25.0657	30.85817	870 m
5	X31D-755	X3SABI-BRAND	SABIE	-25.0303	31.02602	510m
6	X3D-755	X3SABIE-AANDE	SABIE	-25.0286	31.05172	494m
7	X31K-752	X3SABI-SANBO	SABIE	-25.0238	31.16309	426 m
8	X31K-752	X3SABIE-HOXANE (Calcutta)	SABIE	-25.0191	31.20499	403m
9	X31K-752	SABIE TREINBRUG (Calcutta)	SABIE	-25.0184	31.24088	391m
10	X31K-715	X3SABI-SEKURUW	SABIE/KNP	-24.9895	31.28936	370m
11	X31M-747	X3SABIE-BUFFEL	SABIE/KNP	-24.9654	31.67756	234m
12	X33A-731	X3SABIE-ANTHO	SABIE/KNP	-24.968	31.7498	209m
13	X33B-804	X3SABIE-LUBEY	SABIE/KNP	-25.1	31.88563	150m
14	X33B-804	X3SABIE-LOWER	SABIE/KNP	-25.1221	31.92502	156m
15	X33D-811	SABI-BORDER	SABIE/KNP	-25.1852	32.03157	106m
SABI TRIBUTARIES: LONE CREEK TO NOORD SAND						
16	X31A-783	X3LONE CREEK	LONE CREEK	-25.1032	30.71144	1090 m
17	X31A-787	X3LONE CREEK	LONE CREEK	-25.1182	30.72414	1054 m
18	X31A-741	X3KSAB-KLEIN	KLEIN SABIE	-25.0635	30.79092	1070 m
19	X31D-773	X3SABA-BRAND	SABAAN	-25.0322	31.02255	512 m
20	X31C-683	X3MACM-PICNIC	MAC-MAC	-25.022	31.00064	542 m
21	X31C-683	X3MACM-VENUS	MAC MAC	-25.0086	30.92501	774 m
22	X31J-774	X3NSAN-SANBO	NOORD SAND	-25.0246	31.15843	436 m
SABI TRIBUTARIES:SAND RIVER AND TRIBUTARIES						
23	X32B-605	X3MOHL-ZOEKN	MUTLUMUVI	-24.7636	30.97547	709 m
24	X32B-605	X3MUTL-VIOLE	MUTLUMUVI	-24.7572	31.01151	628 m
25	X32G-565	X3SAND-ROLLE	SAND	-24.722	31.237	398 m
26	X32H-578	X3SAND-OTHAW	SAND	-24.768	31.406	416 m
27	X32H-578	X3SAND-LONDO	SAND	-24.7922	31.52279	302 m
28	X32H-602	X3SAND-MALA	SAND	-24.841	31.553	365 m
29	X32J-730	X3SAND-LOWFL	SAND/KNP	-24.9676	31.62546	235m
30	X32-B551	X3KSAN-ROOIBO	KLEIN SAND	-24.658	31.089	708 m
31	X32A-058	X3SAND-THULA	SAND	-24.715	31.204	396 m
SABI TRIBUTARIES: MARITE						
32	X31E-647	X3MARI-VERSA	MARITSANA	-24.8389	30.96116	887 m
33	X31G-647	X3MARI-MARIT	MARITE	-24.9608	31.10838	562 m
34	X31E-647	X3NGW-VERSA	NGWARITSANA	-24.9036	30.95053	817 m
35	X31E-647	X3MARI	MARITE	25.0159	31.11907	463 m
36	X31F-695	X3WATERHOUTB	WATERHOUTBOOM	-24.9551	30.90796	957 m
37	X32B-551	X3MOHL-WELGE	MOHLOMOBE	-24.7409	30.92343	918 m
38	X31H-819	X3UNSP-MARIT	UNSPECIFIED	-24.9316	30.92501	930 m

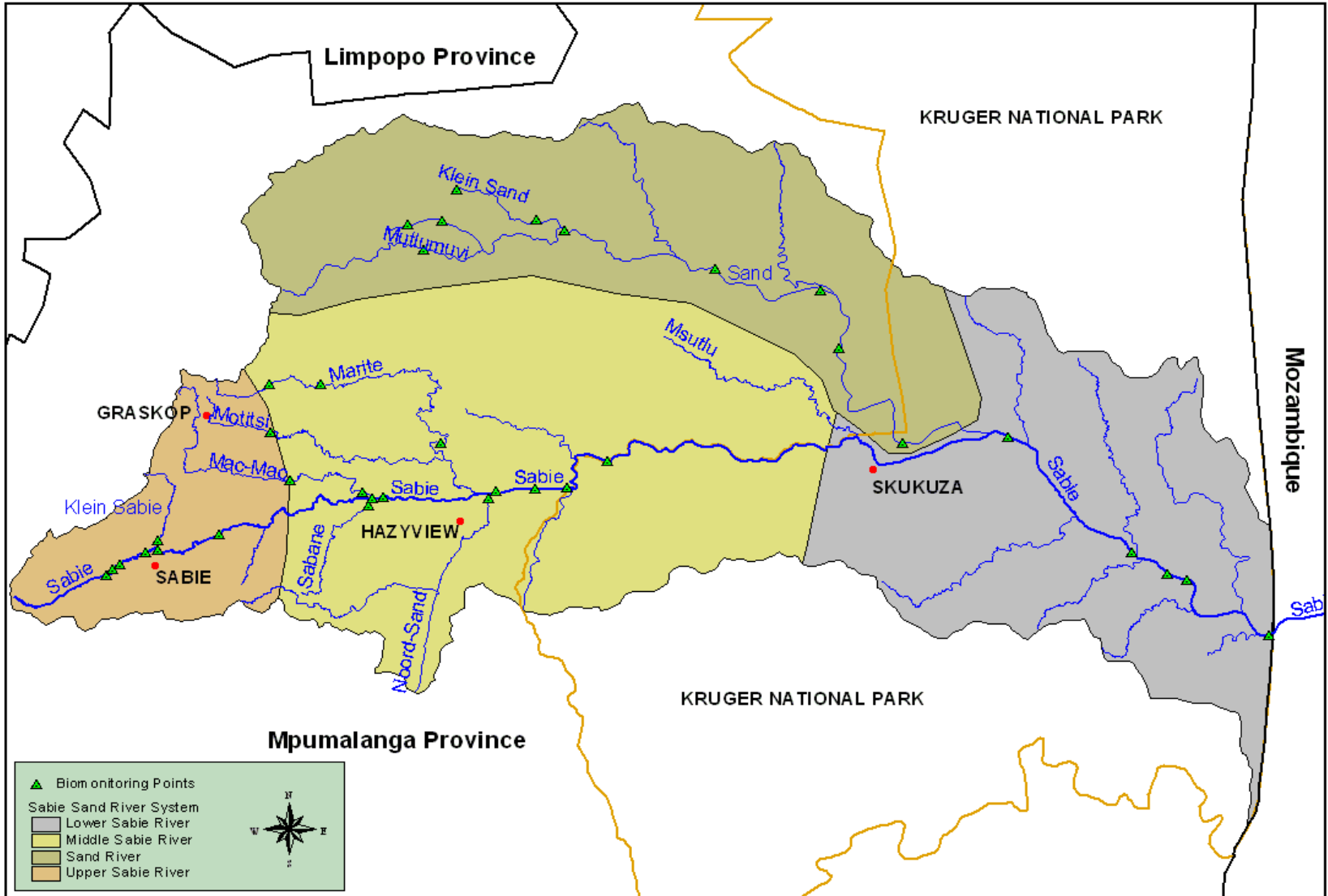
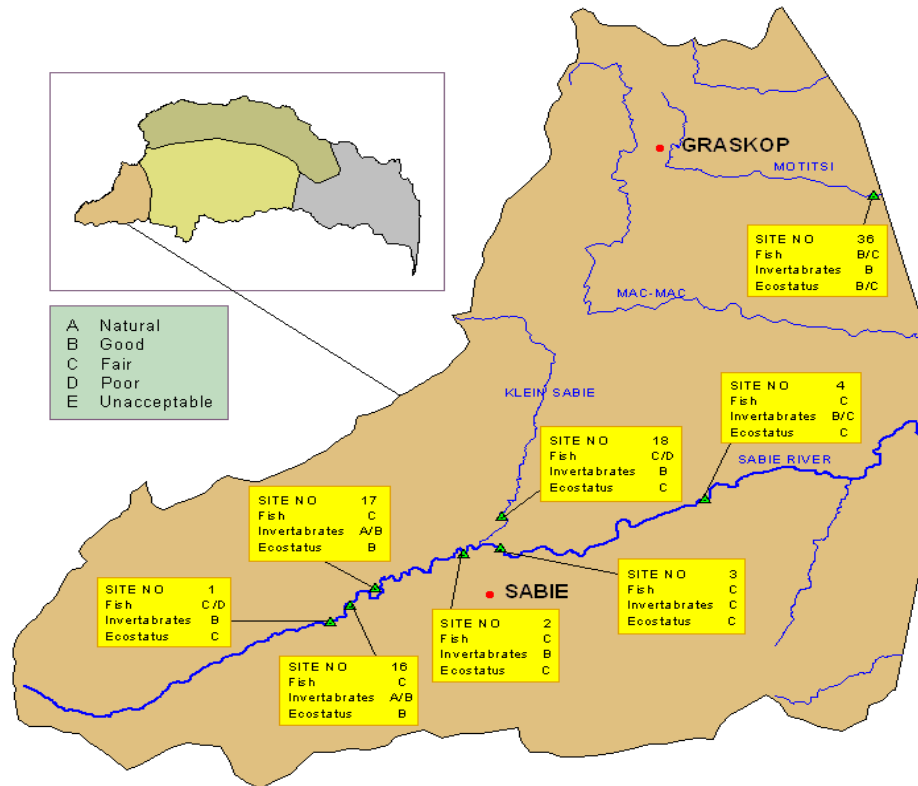


Figure 3: Map showing the positions of sampling sites in the Sabie and Sand River catchments

3.1 Pre-Defined Reaches in the Catchment

Different reaches for the Sabie- and Sand Rivers were defined based on physical aspects such as altitude, eco-region, geomorphic region, and geology. Representative sites were selected in these reaches and the results are discussed below.

3.2 Sabie River Main Stem Reaches



3.2.1 SQ REACH NUMBER X31A-799

SQ.reach (downstream-->)	SQ Reach	Fish sites	SASS sites	FRAI	MIRAI	In-stream ecostatus	Length km
X31A-799	Sabie	X3SABI-OLIFA	X3SABI-GROUB X3SABI-LTPAS (DIEDERICH SASS); X3SABI-LTPAS (DIEDERICH SASS); X3SABI-OLIFA	CD	B	C	12.76

General description

One monitoring site (X3SABI-OLIFA) was selected to represent this reach which is representative of the upper catchment High Gradient Mountain Stream, between 2054 and 1059 m.a.s.l., and characterised as small mountain streams with multiple riffles and small pools. The catchment has largely been transformed to monoculture forestry (pines) with sparsely developed riparian and moderate stands of alien invasive species.

Fish

The fish assemblage present in this reach was dominated by rainbow trout (*Oncorhynchus mykiss*), an introduced alien species, which are primarily stocked for recreational fishing. This reach is within the proclaimed fly fishing zone and stocking is regulated by provincial legislation. Three indigenous fish species were collected with low abundance and is listed in Appendix 1.

A Fish Response Assessment Index (FRAI) score of 60.4% was calculated for this reach based on all available information, placing this reach in an Ecological Class CD (Moderately to considerably impaired with a moderate diversity of taxa).

consisting mainly of tolerant taxa). The relative low ecological class (CD) can be related to excessive sedimentation and the presence of predatory introduced alien fish species rainbow trout (*Oncorhynchus mykiss*),

Invertebrates

The SASS (204) and ASPT (7.03) values recorded at this site during the review period is consistent with an Ecological Class B (Slightly impaired) with a high diversity of taxa. This is supported by the value obtained by the MIRAI value (B). A total of 29 taxa were recorded, indicating a relative high diversity of invertebrates. Highly sensitive taxa were recorded, including Perlidae, Heptagenidae, Tricorychidae and Athericidae. Only a small proportion of the taxa recorded were air breathers, which suggest that the river is well aerated.

In-stream Ecostatus

The Ecostatus for this reach was consistent with a Class C, suggesting a moderately impaired habitat. This low value is largely influenced by the relative low FRAI value which was influenced by alien invasive fish species rainbow trout (*Oncorhynchus mykiss*) and excessive sedimentation from a degraded catchment.



3.2.2 SQ REACH NUMBER X31A-778

SQ reach (downstream-->)	SQ Reach	Fish sites	SASS sites	FRAI	MIRAI	In-stream ecostatus	Length km
X31A-778	Sabie	X3SABI-CASTL	X3SABI-AMILL(DIEDERICHS SASS); X3SABI-SAWMI (DIEDERICHS SASS); X3SABI-CASTL	C	B	C	9.79

General description

One monitoring site (X3SABI-CASTL) was selected to represent this reach. This reach is representative of an upper foothill stream, below 1000 m.a.s.l. and characterised as relative small mountain streams with multiple riffles and runs with pools. The catchment has largely been transformed to monoculture forestry (pines) with sparsely developed riparian and moderate stands of alien invasive species.

Fish

The fish assemblage present in this reach was characterised by a low abundance and diversity. The fish assemblage is largely influenced by the presence of predatory exotic species (rainbow trout). This reach is within the proclaimed fly fishing zone and stocking is regulated by provincial legislation. Three indigenous fish species were collected dominated by rheophilic species and is listed in Appendix 1.

A Fish Response Assessment Index (FRAI) score of 64.8% 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

The SASS (222) and ASPT (6.94) values recorded at this site and represented an Ecological Class B (Slightly modified Impaired). This is supported by the value obtained by the MRAI value (B). A total of 32 taxa were recorded, indicating a high diversity of invertebrates. Highly sensitive taxa included Perlidae, Heptagenidae, Tricorychidae, Pyralidae and Athericidae was recorded at this site. Only a small proportion of the taxa recorded were air breathers, which suggest that the river is well aerated.

In-stream ecostatus

The Ecostatus for this reach was consistent with a Class C, suggesting a moderately impaired habitat. This low value is largely influenced by the relative low FRAI value that was influenced by alien invasive fish species and excessive sedimentation from a degraded catchment.

3.2.3 SQ REACH NUMBER X31B-757

SQ reach (downstream→)	SQ Reach	Fish sites	SASS sites	FRAI	MIRAI	In-stream ecostatus	Length km
X31B-757	Sabie	X3SABI-RIOOL; X3SABI-BRUG	X3SABI-RIOOL; X3SABI-SNOOK (DIEDERICH SASS); X3SABI-BERGV (DIEDERICH SASS); X3SABI-BRUG	C	C	C	16.32

General description

Two monitoring sites (X3SABI-RIOOL and X3SABI-BRUG) were selected to represent this relative long reach. This reach is representative of an upper foothill stream, below 1000 m.a.s.l. This stream is characterised as a moderate inclined mountain stream, dominated by In-stream boulders with increased flow velocities, and a high diversity of habitat types, which includes riffles and runs, cascades and pools. The catchment has largely been transformed to monoculture forestry (mainly eucalyptus) with a well-developed riparian zone which provide additional habitat such as overhanging vegetation with undercut banks with dense stands of alien invasive species.

Fish

The fish assemblage found in this reach consisted of four species with a low abundance largely influenced by a reduced water quality originating from Sabie Town and the sewage treatment works. Moderate siltation originating from degraded catchment still impacts the river in this reach. Four indigenous fish species were collected, dominated by rheophilic species and is listed in Appendix 1. Two adult longfin eel (*Anguilla mossambica*) were collected at the lower site during the present survey from all the surveys. This species is Catadromous meaning that they live for many years in freshwater before they migrate down to the marine environment to breed in the ocean near Madagascar. Eel larvae metamorphose into glass eels and then become elvers before they migrate upstream into freshwater (suitable rivers) by elvers migrating upstream to colonize the rivers until maturity before they migrate back to the sea to breed again. The presence of large dams downstream (Koromamano Dam in Mozambique) create largely unsurpassable barriers to the migrations of this species. Although infrequent records are still recorded in the Sabie River, it is doubtful that this species will be able to maintain populations in this river in future and still occur in any significant numbers in the Sabie River.

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 accumulated sediments and reduced water quality.

Invertebrates

The SASS (171 & 129) and ASPT (6.11 & 6.5) values recorded at these sites is consistent with an Ecological Class C (Moderately impaired with a moderate diversity of taxa). This is supported by the value obtained by the MRAI value (C). A total of 28 and 20 taxa were recorded respectively, indicating a moderate diversity of invertebrates. A lower diversity of sensitive taxa was recorded. Thirty percent of the taxa recorded were air breathers which suggest that the river has reduced oxygen levels, possibly as a result of the sewage effluent.

In-stream ecostatus

The Ecostatus for this reach was consistent with a Class C, suggesting a moderately impaired habitat. This low value is largely influenced by the relative low FRAI value that was influenced by accumulated sedimentation from a degraded catchment and reduced water quality.

3.2.4 SQ REACH NUMBER X31B-756

SQ reach (downstream-->)	SQ Reach	Fish sites	SASS sites	FRAI	MIRAI	In-stream ecostatus	Length km
X31B-756	Sabie		X3SABI-LUNSK (DIEDERICH SASS)	C	BC	C	18.09

General description

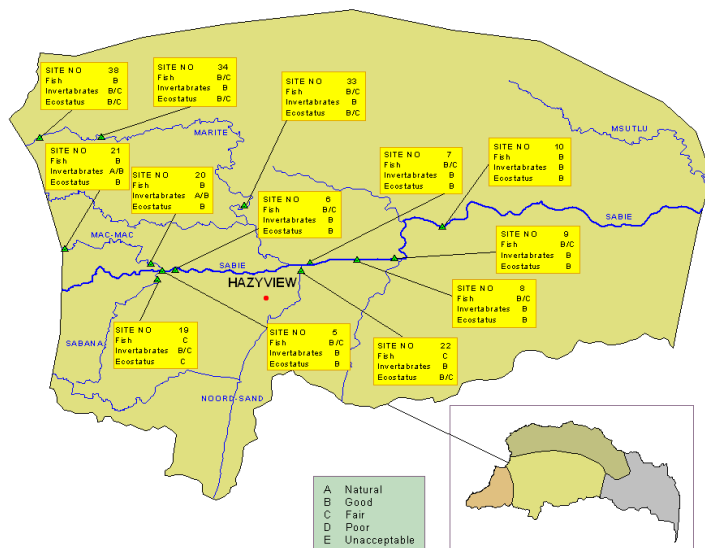
This reach is representative of a lower foothill stream, above 517 m.a.s.l. and characterised by a low gradient, moderate size stream with mainly runs and pools. The catchment has largely been transformed to monoculture forestry (Eucalyptus) with well-developed riparian and moderate stands of alien invasive species. The FRAI, MRAI and Ecostatus for this reach was derived and/or extrapolated from previous surveys and expert judgement.

3.2.5 SQ REACH NUMBER X31D-772

SQ reach (downstream-->)	SQ Reach	Fish sites	SASS sites	FRAI	MIRAI	In-stream ecostatus	Length km
X31D-772	Sabie			C	BC	C	0.30

General description

This reach is representative of lower foothill stream, above 517 m.a.s.l. and characterised by a low gradient, moderate sized stream with mainly runs and pools. The catchment has largely been transformed to monoculture forestry (Eucalyptus) with well-developed riparian and moderate stands of alien invasive species. The FRAI, MRAI and Ecostatus for this reach was derived and/or extrapolated from previous surveys and expert judgement and suggest 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 BC (slightly to moderately impaired with a moderate diversity of taxa).



3.2.6 SQ REACH NUMBER X31D - 755

SQ reach (downstream-->)	SQ Reach	Fish sites	SASS sites	FRAI	MIRAI	In-stream ecostatus	Length km
X31D-755	Sabie	X3SABI-BRAND; X3SABI-AANDE	X3SABI-BRAND; X3SABI-AANDE	BC	B	B	13.37

General description

Two monitoring sites (X3SABI-BRAND & X3SABI-AANDE) were selected to represent this reach. This reach is representative of the lower foothill stream, below 510 m.a.s.l. and characterised as a low inclined, single channelled stream with some anastomosing. Substratum is dominated by bedrock and contains multiple runs, some riffles and large pools. The catchment has largely been transformed to monoculture forestry (eucalyptus) and tropical fruit irrigation farming. The riparian vegetation is well-developed, consisting mainly of Mingerhout (*Breonadia microcephala*) providing additional habitat such as overhanging vegetation, rootwads and undercut banks, and creates habitat for habitat specialists such as the Mormyridae. Moderate stands of alien invasive species occur in the riparian vegetation.

Fish

The fish assemblage present in this reach was dominated by rheophylic fish species (flow dependent). Fourteen indigenous fish species were collected with higher abundance and is listed in Appendix 1. This reach can be considered as a transitional zone between temperate and more tropical fish species. Fish species unique to the area include *Opsaridium peringueyi*, *Labeobarbus polylepis*, *Barbus eutaenia* and the two Mormyrid fish species.

A Fish Response Assessment Index (FRAI) score of 78.2% was calculated for this reach based on all available information, placing this reach in an Ecological Class BC (slightly to moderately impaired with a high to moderate diversity and abundance of species). The relative high ecological class (BC) can be related to an increase in habitat diversity.

Invertebrates

The SASS (201 & 215) and ASPT (7.18 & 6.32) values recorded at this site during the review period fluctuate closely around the recommended eco-specification set for an Ecological Class B (Moderately impaired with a high diversity of taxa). This is supported by similar value obtained in the MIRAI model. A total of 28 and 34 taxa respectively were recorded, indicating a high diversity of invertebrates. Highly sensitive taxa recorded included Perlidae, Heptagenidae, Tricorychidae, Psephenidae, Dixidae and Athericidae. Less than 20% of the taxa recorded were air breathers, which suggest that the river is well aerated.

In-stream ecostatus

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

3.2.7 SQ REACH NUMBER X31K - 758

SQ reach (downstream-->)	SQ Reach	Fish sites	SASS sites	FRAI	MIRAI	In-stream ecostatus	Length km
X31K-758	Sabie			BC	BC	BC	2.41

General description

This reach is representative of lower foothill stream and characterised by a low gradient, moderate sized stream with mainly runs and pools. The catchment has largely been transformed to tropical fruit production. The riparian vegetation is well developed, creating anastomosing channels with extensive reed beds as a result of lower flow velocities. The FRAI, MIRAI and Ecstatus for this reach was derived and/or extrapolated from other surveys and expert judgement and indicate that the In-stream Ecstatus for the fish is a class BC (slightly to moderately impaired with moderately higher diversity of species) and for the invertebrates a class BC (Slightly to moderately impaired with a moderately high diversity of taxa).

3.2.8 SQ REACH NUMBER X31K - 752

SQ reach (downstream-->)	SQ Reach	Fish sites	SASS sites	FRAI	MIRAI	In-stream ecostatus	Length km
X31K-752	Sabie	X3SABI-SANBO; XSABI-CAL03; X3SABI-CAL01	X3SABI-SANBO; XSABI-CAL03; X3SABI-CAL01	BC	B	B	8.31



General description

Three monitoring sites (X3SABI-SANBO, X3SABI-CAL01, and X3SABI-CAL03) were selected to represent this reach. This reach is representative of the lower foothill stream, approximately 400 m.a.s.l. and is characterised as a low inclined anastomosing, sand dominated stream with multiple channels and sandy runs and large shallow pools. There is a notable absence of in-stream habitat in the form of riffles and runs with stones in current and cobbles. The catchment has largely been transformed to tropical fruit irrigation farming. The riparian vegetation is dominated by *Phragmites mauritianum* reedbeds as a result of the accumulation of sediments and nutrients.

Fish

This section of the river provides a low diversity of habitat types and consequently the diversity of fish species in this reach is low. The fish assemblage is dominated by more tolerant fish species. Ten indigenous fish species were collected with a relative low abundance and is listed in Appendix 1. This reach can be seen as a transitional zone between the temperate and cold water for certain fish species. These species include *Chiloglanis paratus* and *Chiloglanis sweirstrai*. The reason for the relative low abundance of fish species can be attributed to limited available habitat and that fish in this reach is harvested on a regular basis by extensive netting and poisoning.

A Fish Response Assessment Index (FRAI) score of 80% was calculated for this reach based on all available information, placing this reach in an Ecological Class BC (slightly impaired with a moderate diversity and abundance of species). The abundance and diversity of fish in this reach is strongly influenced by the available habitat and over utilisation of migrating fish, especially below weirs such as Hoxanne.

Invertebrates

The SASS scores (167, 178 & 161) and ASPT (6.29, 6.1 and 5.96) values recorded in this reach during the recent surveys suggest that the invertebrates is consistent with a class B (slightly impaired with a high diversity of taxa). This is supported by the value obtained by the MRAI value (B). A total ranging between 27 and 29 taxa were recorded indicating a moderate diversity of invertebrates. Highly sensitive taxa recorded included Perlidae, Heptagenidae, Prosopistomatidae, Dixidae and

Athericidae. Less than 30% of the taxa recorded were air breathers, which suggest that the river is still relatively well aerated.

In-stream ecostatus

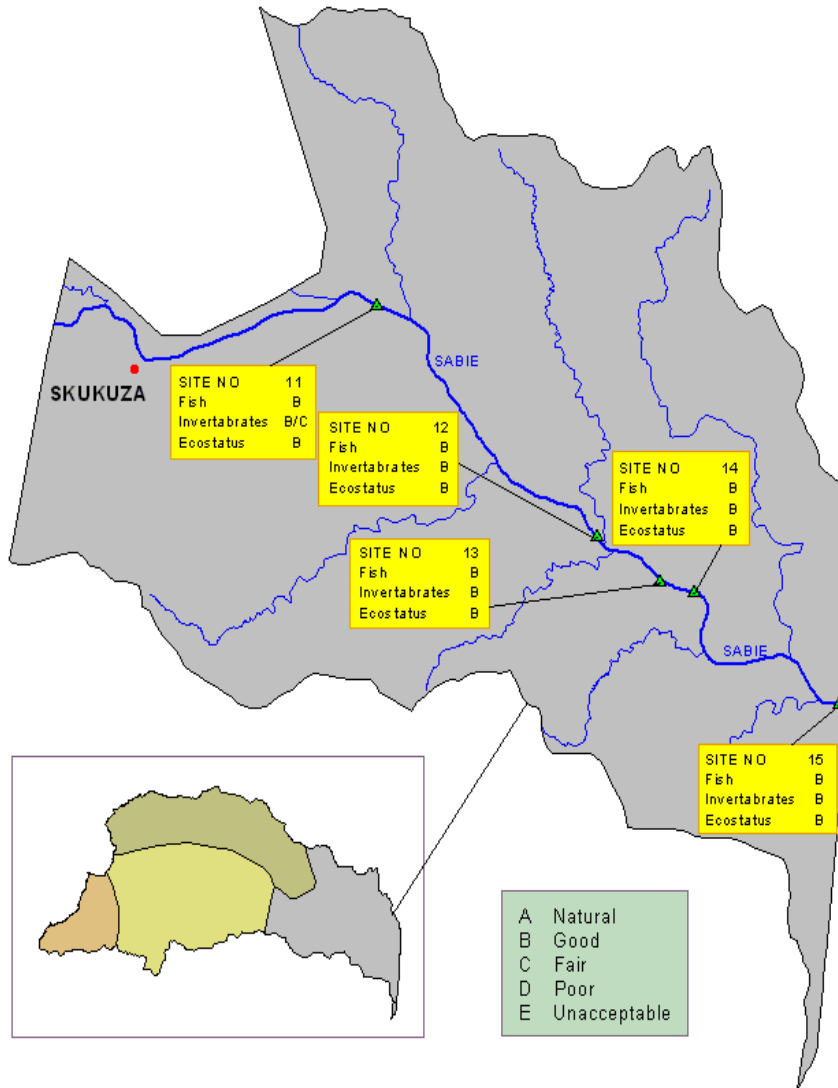
The high EC values obtained for invertebrates in this reach places the In-stream Ecostatus in a Class B, suggesting a slightly impaired habitat. This high value may reflect an overestimation of the In-stream Ecostatus as the riparian vegetation and geomorphology has been notably degraded.

3.2.9 SQ REACH NUMBER X31K - 750

SQ reach (downstream-->)	SQ Reach	Fish sites	SASS sites	FRAI	MIRAI	In-stream ecostatus	Length km
X31K-750	Sabie			BC	B	B	5.33

General description

The FRAI, MIRAI and Ecostatus for this reach were 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 moderately higher diversity of species) and for the invertebrates a class B (Slightly impaired with a high diversity of taxa).



3.2.10 SQ REACH NUMBER X31K - 715

SQ reach (downstream-->)	SQ Reach	Fish sites	SASS sites	FRAI	MIRAI	In-stream ecostatus	Length km
X31K-715	Sabie	X3SABI-SEKUR	X3SABI-SEKUR (SASS SITHOLE)	B	B	B	15.51

General description

One monitoring site (X3SABI-SEKUR) was selected to represent this reach. This reach is representative of a Lowveld Stream, approximately 370 m.a.s.l. and characterised as a low inclined, sandy stream interrupted by braided bedrock dominated sections with well-developed riparian vegetation dominated by Mingerhout (*Breonadia microcephala*) with multiple channels and riffles, runs and pools (Figure 4).



Figure 4: Braided bedrock dominated section within this reach (Sekuruwane).

Fish

Wade-able sections of the river provide a low diversity of habitat types and consequently the diversity of fish species collected in this reach was low. The fish assemblage is dominated by more tolerant lowveld fish species. Nine indigenous fish species were collected with a relative low abundance and is listed in Appendix 1.

A Fish Response Assessment Index (FRAI) score of 83.3% was calculated for this reach based on all available information, placing this reach in an Ecological Class BC (slightly to moderately impaired with a high diversity of species). The relative high ecological class (BC) can be related to an increase in habitat diversity.

Invertebrates

The MRAI for this reach was derived and/or extrapolated from previous surveys and expert judgement and suggest that the EC for invertebrates is a class B (Slightly impaired with a high diversity of taxa).

In-stream 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.

3.2.11 SQ REACH NUMBER X31M - 681

SQ reach (downstream-->)	SQ Reach	Fish sites	SASS sites	FRAI	MIRAI	In-stream ecostatus	Length km
X31M-681	Sabie		X3SABI-LISBO (SASS SITHOLE); X3SABI-GRAVE (SASS SITHOLE)	B	B	B	23.21

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 B (slightly impaired with a high diversity of species) and for the invertebrates a class B (Slightly impaired with a high diversity of taxa)

3.2.12 SQ REACH NUMBER X31M - 739

SQ reach (downstream-->)	SQ Reach	Fish sites	SASS sites	FRAI	MIRAI	In-stream Ecostatus	Length km
X31M-739	Sabie		X3SABI-SKUKU (SASS SITHOLE)	B	BC	B	4.43

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 B (slightly impaired with a high diversity of species) and for the invertebrates a class BC (Slightly to moderately impaired with a moderately high diversity of taxa).

3.2.13 SQ REACH NUMBER X31M - 747

SQ reach (downstream-->)	SQ Reach	Fish sites	SASS sites	FRAI	MIRAI	In-stream ecostatus	Length km
X31M-747	Sabie	X3SABI-BUFFE		B	BC	B	13.50

General description

One monitoring site (X3SABI-BUFFE) was selected to represent this reach. This reach is representative of a Lowveld Stream, approximately 234 m.a.s.l. and characterised as a low inclined anastomosing section of river with locally bedrock controlled sections within a sand dominated river. These controls create multi-channel islands and backwaters, providing excellent habitat for a wide variety of species. The riparian vegetation is well developed with multiple in-stream reed islands providing additional habitat such as overhanging vegetation, undercut banks and root wads.

Fish

This section of the river provides a moderately high diversity of habitat types and consequently the diversity of fish species collected in this reach was moderately high. The fish assemblage is dominated by more tolerant lowveld fish species, namely *Labeo cylindricus*, *Labeo molybdinus*, *Labeobarbus marequensis* and *Clarias gariepinus*. Eight indigenous fish species were collected with a relative low abundance and is listed in Appendix 1. 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 82.0% was calculated for this reach based on all available information, placing this reach in an Ecological Class B (slightly impaired with a high diversity of species). The relative high ecological class (B) can be related to habitat diversity.

Invertebrates

The MIRAI values (Class BC) were determined from SASS surveys conducted by SANPARKS within the Kruger National Park.

In-stream 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.

3.2.14 SQ REACH NUMBER X33A - 731

SQ reach (downstream-->)	SQ Reach	Fish sites	SASS sites	FRAI	MIRAI	In-stream ecostatus	Length km
X33A-731	Sabie	X3SABI-ANTHO	X3SABI-ANTHO	B	B	B	5.18

General description

One monitoring site (X3SABI-ANTHO) was selected to represent this reach. This reach is representative of a Lowveld Stream, approximately 209 m.a.s.l. and characterised as a low inclined braided, multi channelled, bedrock dominated stream with multiple channels and sandy runs, riffles and pools. The southern bank riparian vegetation is well developed, consisting of very large trees such as *Bretonia microcephala*, *Ficus sycamorus*, *Trichelia emetica*, *Diospyros mespiliformis* and *Syzygium cordatum*, providing additional habitat such as overhanging vegetation, undercut banks and rootwads. The northern bank consists of a braided bedrock controlled area with dense reed growth (*Phragmites mauritianum*) creating some additional cover.

Fish

This section of the river provides a high diversity of habitat types and consequently the diversity of fish species in this reach is high. The fish assemblage is dominated by *Labeobarbus marequensis*. Eighteen indigenous fish species were collected and is listed in Appendix 1. This high diversity of fish species is mainly due to the availability of habitat.

A Fish Response Assessment Index (FRAI) score of 81.1% was calculated for this reach based on all available information, placing this reach in an Ecological Class B (slightly impaired with a high diversity of species). The relative high ecological class (B) can be related to an increase in the available habitat diversity.

Invertebrates

The MIRAI values (Class B) were determined from SASS surveys conducted by SANPARKS within the Kruger National Park.

In-stream 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.

3.2.15 SQ REACH NUMBER X33A - 737

SQ reach (downstream-->)	SQ Reach	Fish sites	SASS sites	FRAI	MIRAI	In-stream ecostatus	Length km
X33A-737	Sabie			B	B	B	10.85

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 BC (slightly to moderately impaired with moderately higher diversity of species) and for the invertebrates a class BC (Slightly to moderately impaired with a moderately high diversity of taxa).

3.2.16 SQ REACH NUMBER X33B - 784

SQ reach (downstream-->)	SQ Reach	Fish sites	SASS sites	FRAI	MIRAI	In-stream ecostatus	Length km
X33B-784	Sabie		X3SABI-NWATI (SASS SITHOLE)	B	B	B	8.97

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 BC (slightly to moderately impaired with moderately higher diversity of species) and for the invertebrates a class BC (Slightly to moderately impaired with a moderately high diversity of taxa).

3.2.17 SQ REACH NUMBER X33B - 829

SQ reach (downstream-->)	SQ Reach	Fish sites	SASS sites	FRAI	MIRAI	In-stream ecostatus	Length km
X33B-829	Sabie			B	B	B	0.58

General description

The FRAI, MIRAI and Ecstatus for this reach was derived and/or extrapolated from previous surveys and expert judgement and indicate that the Ecstatus for the fish is a class B (slightly impaired with higher diversity of species) and for the invertebrates a class B (Slightly impaired with a high diversity of taxa).

3.2.18 SQ REACH NUMBER X33B - 804

SQ reach (downstream-->)	SQ Reach	Fish sites	SASS sites	FRAI	MIRAI	In-stream ecostatus	Length km
X33B-804	Sabie	X3SABI-LUBEY; X3SABI-LOWER	X3SABI-LUBEY (SASS SITHOLE)	B	B	B	10.41

General description

Two monitoring sites (X3SABI-LUBEY; X3SABI-LOWER) were selected to represent this reach. This reach is representative of a lowveld Stream, approximately 150 m.a.s.l. and characterised as a low inclined bedrock controlled section of the river with anastomosing, sand dominated stream with multiple channels including bedrock channels, sandy runs and large pools. There is a notable absence of In-stream habitat in the form of riffles and runs with stones in current and cobbles. The riparian vegetation is dominated by Phragmites reedbeds as a result of the accumulation of sediments

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. Nine indigenous fish species were collected with a relative low abundance and is listed in Appendix 1.

A Fish Response Assessment Index (FRAI) score of 82.5% was calculated for this reach based on all available information, placing this reach in an Ecological Class B (slightly impaired with a high diversity of species). The relative high ecological class (B) can be related to habitat diversity.

Invertebrates

The MIRAI values (Class B) were determined from SASS surveys conducted by SANPARKS within the Kruger National Park.

In-stream ecostatus

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

3.2.19 SQ REACH NUMBER X33D - 861

SQ reach (downstream-->)	SQ Reach	Fish sites	SASS sites	FRAI	MIRAI	In-stream ecostatus	Length km
X33D-861	Sabie			B	B	B	5.98

General description

The FRAI, MIRAI and Ecstatus for this reach were derived and/or extrapolated from previous surveys and expert judgement and indicate that the Ecstatus for the fish is a class B (slightly impaired with higher diversity of species) and for the invertebrates a class B (Slightly impaired with a high diversity of taxa).

3.2.20 SQ REACH NUMBER X33D - 811

SQ reach (downstream-->)	SQ Reach	Fish sites	SASS sites	FRAI	MIRAI	In-stream ecostatus	Length km
X33D-811	Sabie	X3SABI-BORDER	X3SABI-SPOOR (SASS SITHOLE)	B	B	B	3.29

General description

One monitoring site (X3SABI-BORDER) was selected to represent this reach. This reach is representative of a lowveld Stream, approximately 150 m.a.s.l. and characterised as a low inclined bedrock controlled section of the river with anastomosing, sand dominated stream and multiple channels and bedrock channels, sandy runs and large pools. The riparian vegetation is dominated by large trees and Phragmites reed beds as a result of the accumulation of sediments

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. Eleven indigenous fish species were collected with a relative low abundance and is listed in Appendix 1.

A Fish Response Assessment Index (FRAI) score of 82.1% was calculated for this reach based on all available information, placing this reach in an Ecological Class B (slightly impaired with a high diversity of species). The relative high ecological class (B) can be related to habitat diversity.

Invertebrates

The MIRAI values (Class B) were determined from SASS surveys conducted by SANPARKS within the Kruger National Park.

In-stream 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.

3.2.21 Summary of Sabie River Mainstem Reaches

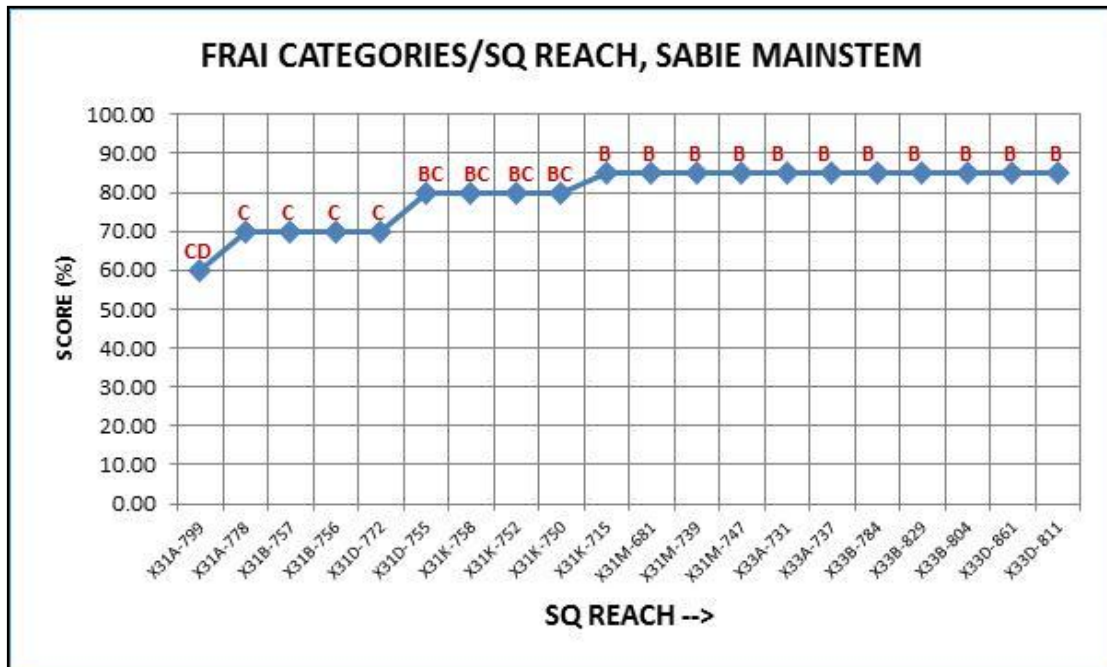


Figure 5: FRAI values observed for the different reaches within the Sabie River, starting at the source and moving downstream

The FRAI values (Figure 5) indicate that the upper Sabie River fish assemblage is moderately impaired upstream of the Mac Mac River after which it recovers significantly. This suggests that the fish assembly in the lower Sabie River is still in a relative good condition with a high species diversity and abundance. The upper reaches is largely modified by excessive sediment inputs due to land use practises {monoculture, pines} and impact of uncontrolled fires. Excessive sediments in the river cause embeddedness of habitats resulting in the loss of fish habitats.

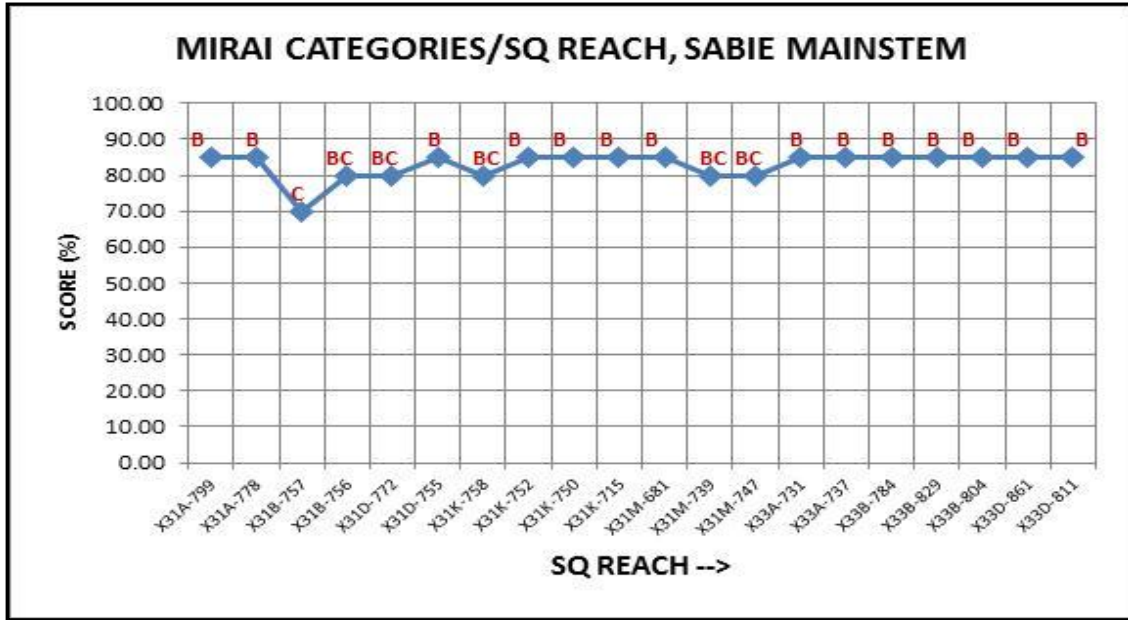


Figure 6: MIRAI values observed for the different reaches within the Sabie River, starting at the source and moving downstream.

The MIRAI values (Figure 6) indicate that the upper reaches of the Sabieriver still provide adequate habitat for macroinvertebrates. The influence of Sabie and the sewerage treatment facility is quite notable, indicating moderate impairment of this reach. The macroinvertebrates eco- class vary between a Class B and a BC, indicating local disturbance in a stretch of the river just upstream of the KNP, for example Hazyview and rural developments.

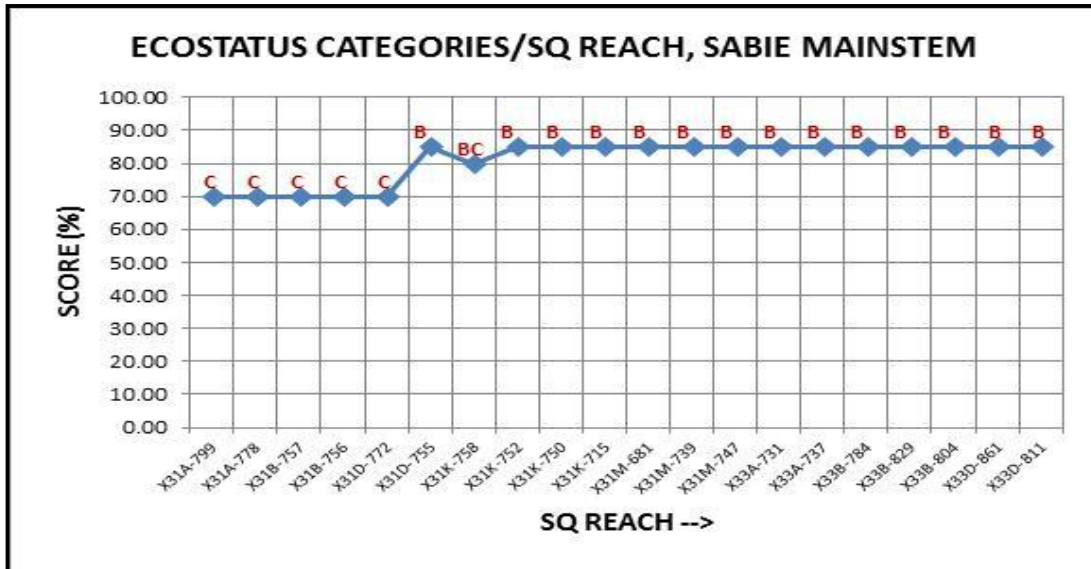


Figure 7: Ecstatus values observed for the different reaches within the Sabie River, starting at the source and moving downstream.

The In-stream Ecstatus values(Figure 7) indicate that the upper Sabie River is moderately impaired due to influx of sediments and the influence of predatory fish. The Sabie River notably recovers after its confluence with the Mac-Mac River, except where the Noord Sand River enters the Sabie River where the value is slightly reduced to a BC. The high Ecstatus values (B) obtained at certain reaches may be as a result of over estimation of the MIRAI values for these reaches.

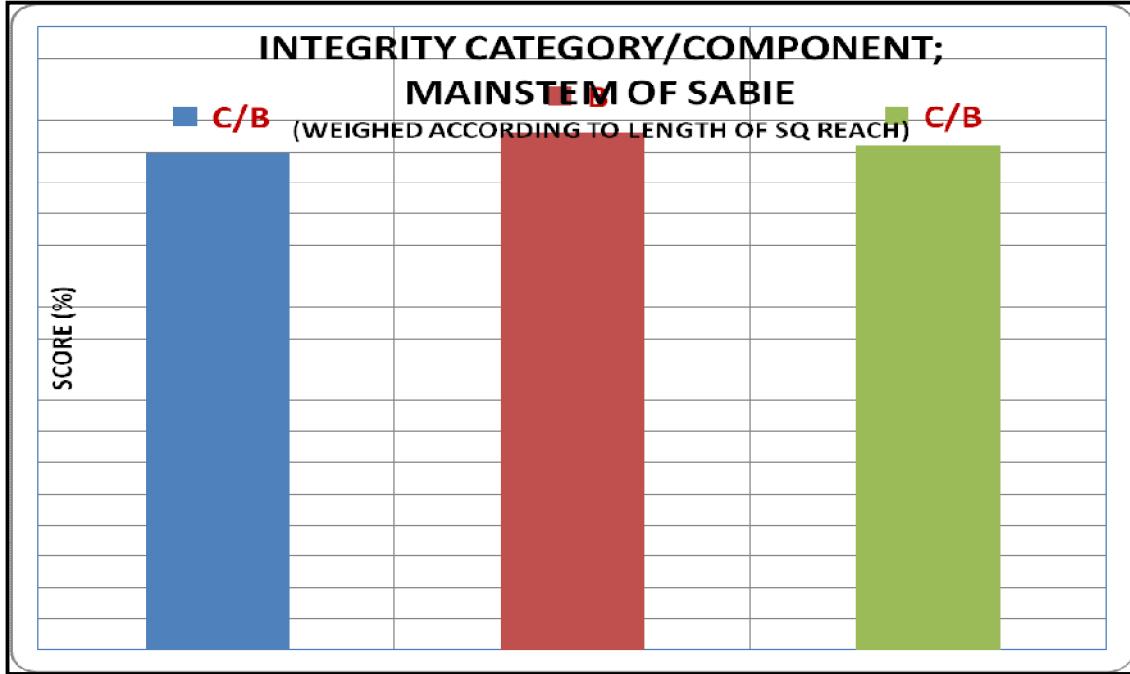


Figure 8: Integrity categories for FRAI, MIRAI and In-stream Ecstatus weighed according to the length of the reach

Figure 8 suggests that the FRAI is in a BC category for most of the Sabie River, while the MIRAI is a B and the Ecstatus is a BC.

3.3 Sabi Tributaries Lone Creek to Noord Sand Confluence

3.3.1 SQ REACH NUMBER X31A - 783

SQ reach (downstream-->)	SQ Reach	Fish sites	SASS sites	FRAI	MIRAI	In-stream ecostatus	Length km
X31A-783	LONE CREEK	LONE CREEK/X3LONE CREEK; LONE CREEK/X3LONE CREEK2	LONE CREEK/X3LONE CREEK; LONE CREEK/X3LONE CREEK2; X3LONE-CEYLO (DIEDERICH SASS)	C	AB	B	5.35

General description

Two monitoring sites (X3LONE CREEK; X3LONE CREEK2) were selected to represent this reach representing a mountain stream, approximately 1090 m.a.s.l. and characterised as a high inclined stream with a single channel and multiple riffles and runs with small pools. The catchment has largely been transformed to forestry (pines). The riparian vegetation is sparse and dominated by small shrubs (*Cliffortia spp.*).

Fish

This section of the river provides a low diversity of habitat types and consequently the diversity of fish species in this reach is low as is expected of a low order mountain stream. Two indigenous fish species were collected with a very low abundance and is listed in Appendix 1, namely *Barbus anoplus* and *Chiloglanis anoterus*. This is mainly due to the presence of the introduced alien species rainbow trout (*Oncorhynchus mykiss*), which are primarily stocked for recreational fishing. This reach is within the proclaimed fly fishing zone and stocking is regulated by provincial permitting.

A Fish Response Assessment Index (FRAI) score of 66.1% was calculated for this reach based on all available information, ranking this reach in an Ecological Class C (moderately impaired with a low diversity of species). 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. The relative low FRAI score can be related to the presence of the alien introduced predatory fish (rainbow trout).

Invertebrates

The SASS (201 & 215) and ASPT (7.18 & 6.32) values recorded at this site during the review period fluctuate closely around the recommended eco-specification set for an Ecological Class B (Moderately impaired with a high diversity of taxa). This is supported by the value obtained by the MRAI value (B). A total of 28 and 34 taxa were recorded indicating a high diversity of invertebrates. Highly sensitive taxa included Perlidae, Heptageniidae, Tricorychidae, Psephenidae, Dixidae and Athericidae which was recorded. Less than 20% of the taxa recorded were air breathers which suggest that the river is well aerated.

In-stream ecostatus

The Ecostatus for this reach was consistent with a Class B, suggesting a slightly impaired habitat. This high value may reflect as an over estimation of the MRAI as the In-stream habitat has been notably degraded due to In-stream siltation and sedimentation.

3.3.2 SQ REACH NUMBER X31A - 741

SQ reach (downstream-->)	SQ Reach	Fish sites	SASS sites	FRAI	MIRAI	In-stream ecostatus	Length km
X31A-741	Klein Sabie	X3KSAB-KLEIN	X3KSAB-LOGDE (DIEDERICKS SASS); X3KSAB-KLEIN	CD	B	C	14.61

General description

One monitoring site (X3SABI-KLEIN) was selected to represent this reach. This reach is representative of the lower foothill stream, approximately 1070 m.a.s.l. and characterised as a stream with a deep single channel with multiple runs, small pools and limited riffles. Large amounts of silt were observed in the pools and runs limiting the available fish habitat. The catchment has largely been transformed to forestry (pines) and numerous access roads contribute to the siltation of the stream. The riparian vegetation is well-developed, but dominated by alien and invasive plant species.

Fish

This section of the river provides a low diversity of habitat types and consequently the diversity of fish species in this reach is low. Only one indigenous fish species (*Chiloglanis anoterus*) of the six expected fish species (*Amphilius uranoscopus*, *Chiloglanis anoterus*, *Varicorhinus nelspruitensis*, *Tilapia sparrmanii*, *Pseudocrenilabrus philander* and *Barbus anoplus*) were collected with an extremely low abundance (Appendix 1). This is mainly due to reduced availability of fish habitat.

A Fish Response Assessment Index (FRAI) score of 57.5% was calculated for this reach based on all available information, ranking this reach in an Ecological Class CD (moderate to largely impaired with a low diversity of species). The relative low ecological class (CD) can be related to poor fish habitat diversity and predatory fish.

Invertebrates

The SASS scores were (232) and the ASPT (7.48) values recorded at this site suggest an Ecological Class B (Moderately impaired with a high diversity of taxa). This is supported by the value obtained by the MRAI value (B). A total of 31 taxa were recorded indicating a high diversity of invertebrates.

Highly sensitive taxa included Perlidae, Heptagenidae, Tricorychidae, Psephenidae, Dixidae and Athericidae which was recorded. Approximately 5% of the taxa recorded were air breathers which suggest that the river is well aerated.

In-stream ecostatus

The Ecostatus for this reach was consistent with a Class C, suggesting a moderately impaired habitat. This relative low value does not reflect the reference habitat conditions.

3.3.3 SQ REACH NUMBER X31D - 773

SQ reach (downstream-->)	SQ Reach	Fish sites	SASS sites	FRAI	MIRAI	In-stream ecostatus	Length km
X31D-773	Sabani	X3SABA-BRAND	X3SABA-BRAND	C	BC	C	19.79

General description

One monitoring site (X3SABI-BRAND) was selected to represent this reach. This monitoring site is situated in the lower reaches of the Sabaan River close to the confluence with the Sabie River. This reach is representative of the lower foothill stream, approximately 512 m.a.s.l. and characterised as a low inclined single bed-rock dominated channel with riffles, runs and pools. The riparian vegetation is dominated by *Breonadia microcephala*. The land use practise has largely transformed the natural habitat into tropical fruit production with increased water abstraction for irrigation.

Fish

The fish assemblage is dominated by more tolerant fish species namely *Pseudocrenilabrus philander*, *Tilapia sparrmanii* and *Clarias gariepinus*. In total eight indigenous fish species were collected with a relative low abundance and is listed in Appendix 1. The absence of the expected rheophilic fish species *Chiloglanis anoterus* can be ascribed to the loss of habitat resulting from excessive sedimentation, limiting interstitial spaces. The presence of the sensitive species *Opsaridium peringueyi* and *Barbus eutaenia* can be related to the close proximity of the Sabie main stem and the Mac-Mac stream confluence.

A Fish Response Assessment Index (FRAI) score of 65.7% was calculated for this reach based on all available information, ranking this reach in an Ecological Class C (moderately impaired with a low abundance of species). The relative low ecological class (C) can be related to a decrease in available fish habitat diversity and the impact of over-abstraction of water by the surrounding land use practices.

Invertebrates

The SASS (165) and ASPT (6.33) values recorded at this site during the review period indicate an Ecological Class BC (Moderately impaired with a high diversity of taxa). This is supported by the value obtained by the MRAI value (BC). A total of 27 taxa were recorded, indicating a high diversity of invertebrates. Highly sensitive taxa included Perlidae, Heptagenidae, Tricorychidae, Chlorocyphidae, Psephenidae, Dixidae and Athericidae. Less than 10% of the taxa recorded were air breathers which suggest that the river is well aerated.

In-stream ecostatus

The Ecostatus for this reach was consistent with a Class C suggesting a moderately impaired habitat. This relative low value does not reflect close to the reference habitat conditions.

3.3.4 SQ REACH NUMBER X31C - 683

SQ reach (downstream-->)	SQ Reach	Fish sites	SASS sites	FRAI	MIRAI	In-stream ecostatus	Length km
X31C-683	Mac-Mac	X3MACM-VENUS; X3MACM-PICNI	X3MACM-GRASK (DIEDERICKS SASS); X3MACM-FALLS (DIEDERICKS SASS); X3MACM-VENUS; X3MACM-PICNI	B	AB	B	46.82

General description

Two monitoring sites (X3MACM-VENUS; X3MACM-PICNI;) were selected to represent this reach. This reach is representative of the lower foothill stream, between 774 and 542 m.a.s.l. and characterised as a single channelled boulder dominated stream with multiple riffles, runs and small pools. The upper reaches of the catchment has largely been transformed to forestry (*Eucalyptus*). The well developed riparian vegetation provides ample habitat such as undercut banks, rood wads and overhanging vegetation.

Fish

This reach of the river provides a high diversity of habitat types and consequently the diversity of fish species in this reach is abundant. The fish assemblage is dominated by rheophilic species. Eight indigenous fish species were collected with a relative high abundance and is listed in Appendix 1. This is mainly due to a high diversity and availability of habitat types. The presence and high abundance of *Opsaridium peringueyi*, *Amphillius uranoscopus* and *Barbus eutaenia* is an indication of good water quality.

A Fish Response Assessment Index (FRAI) score of 72.9% was calculated for this reach based on all available information, ranking this reach in an Ecological Class B (slightly impaired with a high diversity of species). The relative high ecological class (B) can be related to a high diversity of habitat and good water quality.

Invertebrates

The SASS (210 & 167) and ASPT (7.2 & 7.3) values recorded at this site during the review period fluctuate closely around the recommended eco-specification set for an Ecological Class B (Moderately impaired with a high diversity of taxa). This is supported by the value obtained by the MRAI value (AB). A total of 23 and 29 taxa were recorded, indicating a high diversity of invertebrates. Highly sensitive taxa included Perlidae, Heptagenidae, Prosopistomatidae, Tricorychidae, Psephenidae, and Athericidae. Less than 30% of the taxa recorded were air breathers which suggest that the river is well aerated.

In-stream 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.

3.3.5 SQ REACH NUMBER X31J - 774

SQ reach (downstream-->)	SQ Reach	Fish sites	SASS sites	FRAI	MIRAI	In-stream ecostatus	Length km
X31J-774	Noord-Sand	X3NSAN-SANBO	X3NSAN-SANBO	C	B	BC	16.86

General description

One monitoring site (X3NSAN-SANBO) was selected to represent this reach. This reach is representative of the lower foothill stream, approximately 426 m.a.s.l. and characterised as a braided sharp inclined bedrock dominated stream providing a diversity of habitats which includes riffles, runs, pools and backwaters. The catchment has largely been transformed by rural developments and tropical fruit farming in the upper section of the reach. The riparian vegetation is well developed in the lower reaches, but excessive trampling of the river banks are evident in the upper section of the reach. The riparian vegetation consists of species closely associated with bedrock such as *Breonadia microcephala*. Some reed beds (*Phragmites maurietiana*) are present in this section of the river.

Fish

The lowest part of the reach can be described as a transitional zone between temperate and tropical fish species. This section of the river provides a high diversity of habitat types and consequently the diversity of fish species in this reach is expected to be high. However, due to trampling, siltation, over abstraction of water and poor water quality, deterioration of the available fish habitat is evident. The fish assemblage is dominated by more tolerant lowveld fish species. In total fourteen indigenous fish species were collected with a relative high abundance and is listed in Appendix 1. The presence of *Tilapia rendalli* and *Chiloglanis sweirstrai* within this reach indicate the transition to a tropical fish assemblage.

A Fish Response Assessment Index (FRAI) score of 75.2% was calculated for this reach based on all available information, ranking this reach in an Ecological Class C (moderately impaired with a high diversity of species). The moderate Ecological Class (C) can be related to a high diversity of impaired habitat and poor water quality.

Invertebrates

The SASS (215) and ASPT (6.7) values recorded at this site during the review period fluctuate closely around the recommended eco-specification set for an Ecological Class B (Moderately impaired with a high diversity of taxa). This is supported by the value obtained by the MRAI value (B). A total of 32 taxa were recorded, indicating a high diversity of invertebrates. Highly sensitive taxa included Perlidae, Heptageniidae, Prosopistomatidae, Chlorocyphidae, Pyralidae Psephenidae, and Athericidae which was recorded. Less than 30% of the taxa recorded were air breathers which suggest that the river is moderately well aerated.

In-stream ecostatus

The Ecostatus for this reach was consistent with a Class BC, suggesting a slightly to moderately impaired habitat. The Ecostatus of a Class BC river may reflect as an over estimation of the MRAI as the In-stream habitat alteration.

3.3.6 Summary of the Sabie Tributaries Lone Creek to Noord Sand

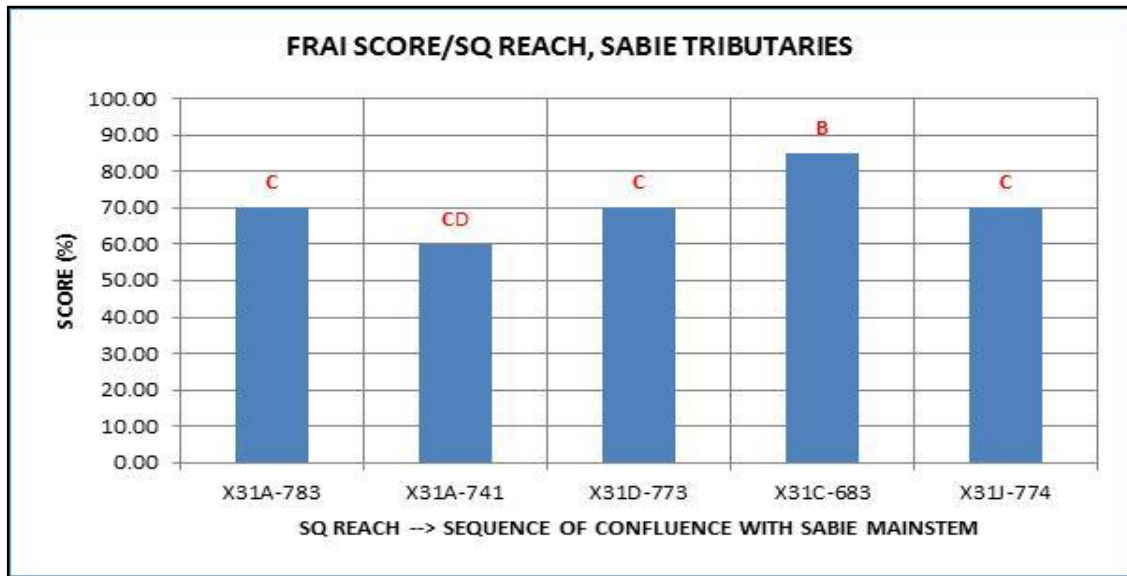


Figure 9 FRAI values observed for the different tributaries, starting at Lone Creek and moving downstream to Noord Sand.

The FRAI value (CD) (Figure 9) suggests that the Klein Sabie is largely impaired due to monoculture land use practises (pine plantations and industrial development close to the town of Sabie). The available fish habitat is largely restricted by sedimentation and reduced water quality. Lone Creek, Sabaan and Noord Sand Tributaries are moderately impaired due to catchment modifications, reducing available fish habitat. The Mac-Mac River is still in a relatively good condition, providing a habitat for a high diversity and abundance of sensitive species.

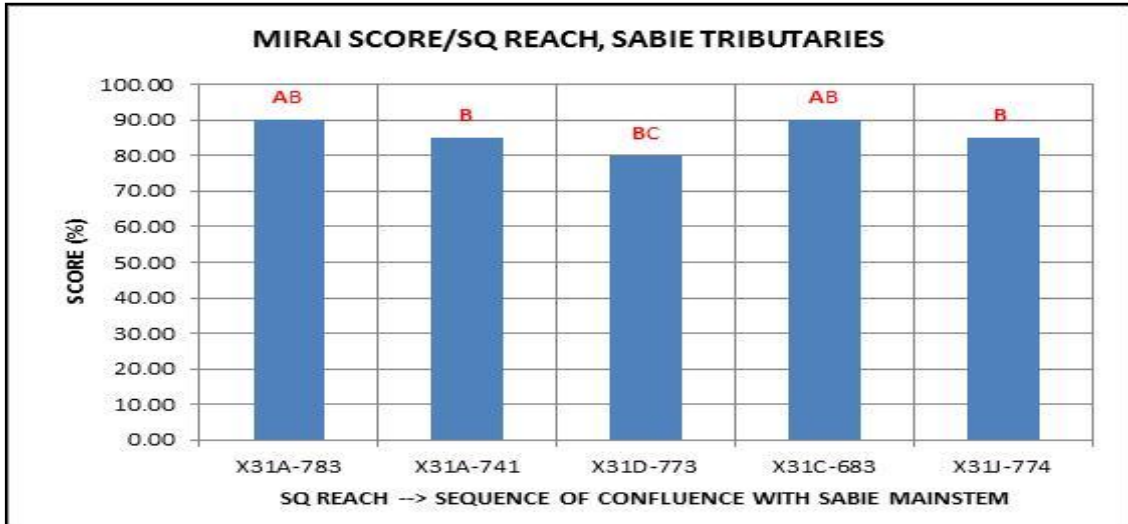


Figure 10 MIRAI values observed for the different Sabie River Tributaries, starting at Lone Creek and moving downstream towards the Noord Sand River.

The MIRAI value (Figure 10) suggests that Lone Creek and the Mac-Mac River are in a very good condition (AB) for macro-invertebrates, as well as the Klein Sabie and Noord Sand Rivers (B), while the Sabaan River is in a moderately impaired (BC) condition.

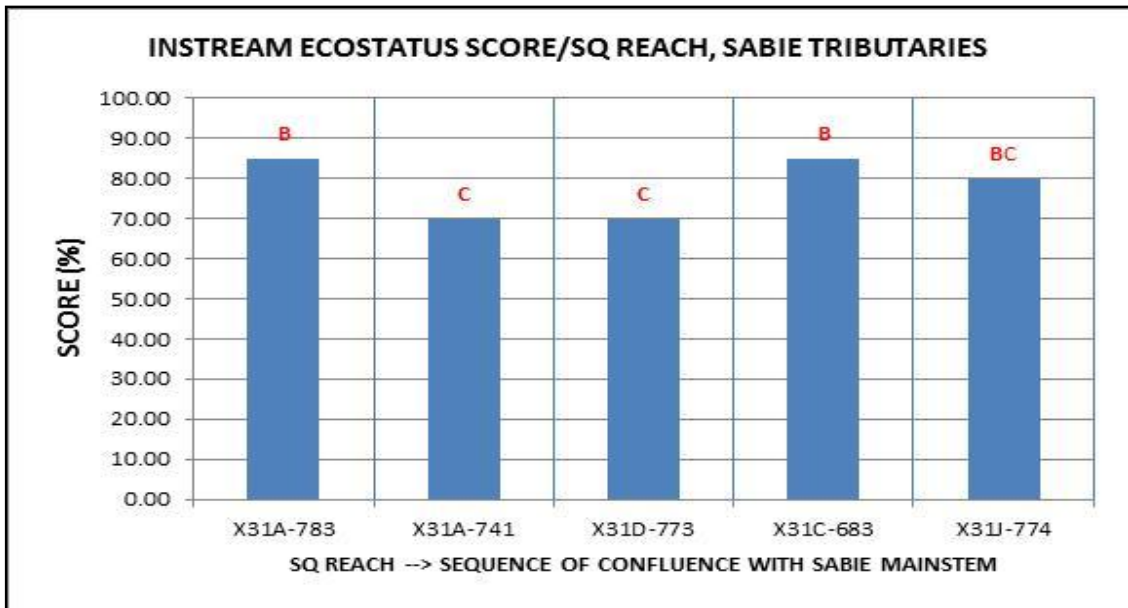


Figure 11 In stream Eco Status observed for the different Sabie River Tributaries, starting at the Lone Creek and moving downstream towards the Noord Sand River.

The Ecstatus values (Figure 11) obtained for these tributaries within the different reaches ranged from moderately to slightly impaired. The eco class of the fish assemblage in these reaches reduces the In-stream eco status. In certain reaches higher values can often be related to over-estimation of MIRAI values.

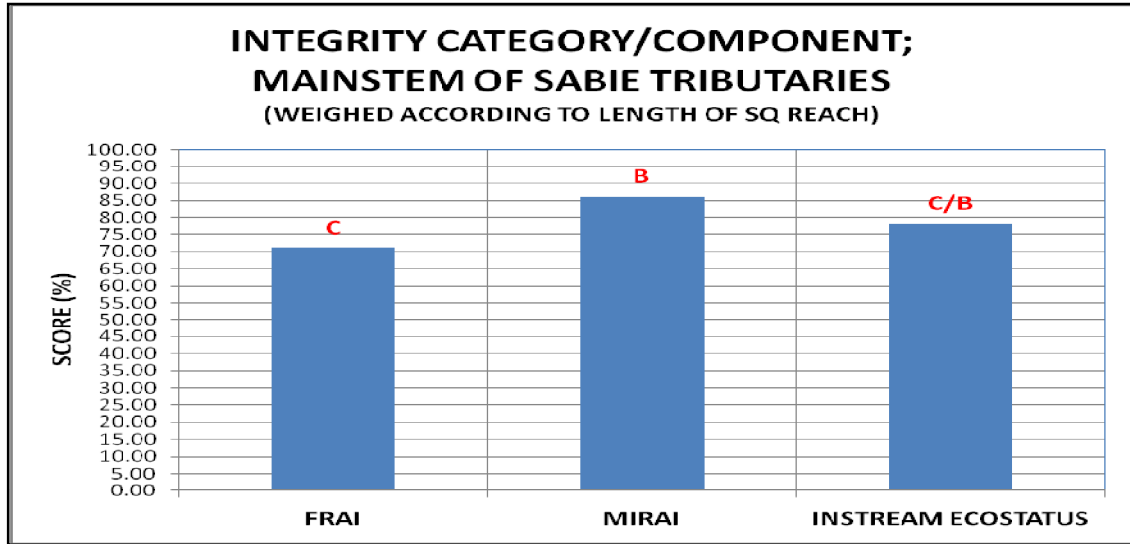
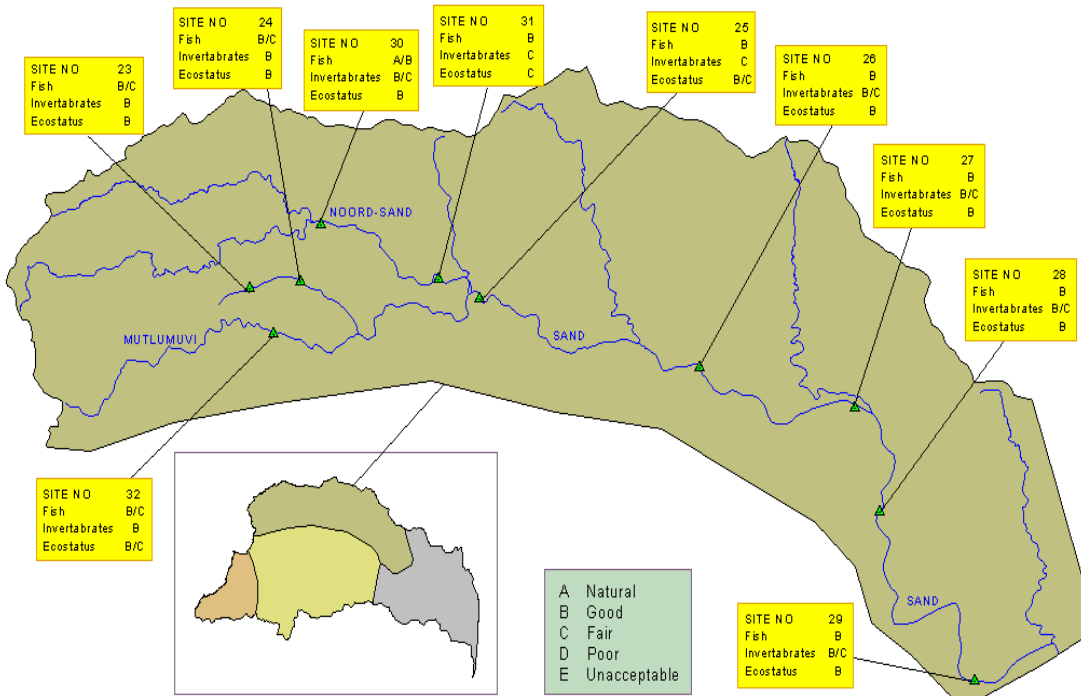


Figure 12 Integrity categories for FRAI, MIRAI and In-stream Ecstatus weighed according to the length of the reach.

Figure 12 indicates that the FRAI in the majority of the Sabie River Tributaries is consistent with a class C (moderately impaired) and for the MIRAI a class B (slightly impaired) with an overall In-stream eco status of CB (slight to moderately impaired).

3.4 Sabi Tributaries: Sand & Nwandlamuhari



3.4.1 SQ REACH NUMBER X32D - 605

SQ reach (downstream-->)	SQ Reach	Fish sites	SASS sites	FRAI	MIRAI	In-stream ecostatus	Length km
X32D-605	Mutlumuvi	X3MOHL-ZOEKN; X3MUTL-VIOLE	X3MOHL-ZOEKN; X3MUTL-VIOLE	BC	B	B	27.68

General description

Two monitoring sites (X3MOHL-ZOEKN & X3MUTL-VIOLE) were selected to represent this reach. This reach is representative of the lower foothill stream, varying between 709 to 628 m.a.s.l. and characterised as braided sharp inclined bedrock dominated. Here is a notable absence of In-stream habitat in the form of riffles and runs with stones in current and cobbles. The catchment has largely been transformed to tropical fruit irrigation farming. The riparian vegetation is dominated by Mingerhout

Fish

This section of the river provides a low diversity of habitat types and consequently the diversity of fish species in this reach is low. The fish assemblage is dominated by more tolerant lowveld fish species. Seven indigenous fish species were collected with a relative low abundance and is listed in Appendix 1. This is mainly due to a limited availability of habitat.

A Fish Response Assessment Index (FRAI) score of 78.5% was calculated for this reach based on all available information, ranking this reach in an Ecological Class BC (slightly to moderately impaired with a high diversity of species). The relative high ecological class (BC) can be related to an increase in habitat diversity.

Invertebrates

The SASS (162 & 176) and ASPT (7.0 & 6.8) values recorded at this site during the review period fluctuate closely around the recommended eco-specification set for an Ecological Class B (Moderately impaired with a high diversity of taxa). This is supported by the value obtained by the MIRAI value (B). A total of 24 and 25 taxa were recorded indicating a moderate diversity of invertebrates. Highly sensitive taxa included Perlidae, Prosopistomatidae, Psephenidae, Dixidae and Athericidae which was recorded. Less than 5% of the taxa recorded were air breathers which suggest that the river is well aerated.

In-stream 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.

3.4.2 SQ REACH NUMBER X32F -597

SQ reach (downstream-->)	SQ Reach	Fish sites	SASS sites	FRAI	MIRAI	In-stream ecostatus	Length km
X32F-597	Mutlumuvi			BC	BC	BC	15.35



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 BC (slightly to moderately impaired with a higher diversity of species) and for the invertebrates a class BC (Slightly to moderately impaired with a high diversity of taxa).

3.4.3 SQ REACH NUMBER 32G - 565

SQ reach (downstream-->)	SQ Reach	Fish sites	SASS sites	FRAI	MIRAI	In-stream ecostatus	Length km
X32G-565	Sand	X3SAND-ROLLE	X3SAND-ROLLE	B	C	BC	16.43

General description

One monitoring site (X3SAND-ROLLE) was selected to represent this reach. This reach is representative of the lowveld Stream, approximately 398 m.a.s.l. and characterised as a braided low inclined sand dominated stream with sandy runs, backwaters with a low abundance of In-stream habitat in the form of riffels and runs with stones in current and cobbles. The catchment has largely been transformed rural development and subsistence farming. The riparian vegetation is poorly developed and is dominated by reeds (Phragmites).

Fish

This section of the river provides a low diversity of habitat types and consequently the diversity of fish species in this reach is low. The fish assemblage is dominated by more tolerant lowveld fish species. Fourteen indigenous fish species were collected with a relative low abundance and is listed in Appendix 1. This is mainly due to a limited availability of habitat.

A Fish Response Assessment Index (FRAI) score of 83.5% was calculated for this reach based on all available information, ranking this reach in an Ecological Class B (slightly impaired with a high diversity of species). The relative high ecological class (B) can be related to an increase in habitat diversity.

Invertebrates

The SASS (131) and ASPT (4.9) values recorded at this site during the review period indicate for an Ecological Class C (Moderately impaired with a low diversity of taxa). This is supported by the value obtained by the MIRAI value (BC). A total of 27 taxa were recorded, indicating a high diversity of invertebrates. Highly sensitive taxa included Athericidae. Approximately 50% of the taxa recorded were air breathers, which suggest that the river is not well aerated.

In-stream ecostatus

The Ecstatus for this reach was consistent with a Class B, suggesting slightly impaired habitat conditions. This high value could largely reflect close to reference habitat conditions.

3.4.4 SQ REACH NUMBER X32H - 578

SQ reach (downstream-->)	SQ Reach	Fish sites	SASS sites	FRAI	MIRAI	In-stream ecostatus	Length km
X32H-578	Sand	X3SAND-OTHAW; X3SAND-LONDO	X3SAND-OTHAW; X3SAND-LONDO	B	BC	B	21.77

General description

Two monitoring sites (X3SAND-OTHAW & X3SAND-LONDO) were selected to represent this reach. This reach is representative of the lowveld stream, ranging between 416 and 302 m.a.s.l. and characterised as braided low inclined sand dominated stream. There is low abundance of In-stream habitat in the form of riffles and runs with stones in current and cobbles. The catchment largely falls within protected areas with a low impact on the stream. The riparian vegetation is poorly developed and is dominated by reed beds.

Fish

This section of the river provides a low diversity of habitat types and consequently the diversity of fish species in this reach is low. The fish assemblage is dominated by more tolerant lowveld fish species. Sixteen indigenous fish species were collected and is listed in Appendix 1. Large numbers of Mormyrids were collected at X3SAND-OTHAW. This is mainly due to limited availability of habitat.

A Fish Response Assessment Index (FRAI) score of 86.1% was calculated for this reach based on all available information, ranking this reach in an Ecological Class B (slightly impaired with a high diversity of species). The relative high ecological class (B) can be related to an increase in habitat diversity.

Invertebrates

The SASS (151 & 161) and ASPT (5.6 & 6.0) values recorded at this site during the review period fluctuate closely around the recommended eco-specification set for an Ecological Class C (Moderately impaired with a high diversity of taxa). This is supported by the value obtained by the MRAI value (BC). A total of 27 and 27 taxa were recorded respectively, indicating a high diversity of invertebrates. Highly sensitive taxa included Perlidae, Heptagenidae, and Athericidae. Less than 30% of the taxa recorded were air breathers which suggest that the river is well aerated.

In-stream 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.

3.4.5 SQ REACH NUMBER X32J - 602

SQ reach (downstream-->)	SQ Reach	Fish sites	SASS sites	FRAI	MIRAI	In-stream ecostatus	Length km
X32J-602	Sand	X3SAND-MALA	X3SAND-MALAM	B	BC	B	35.22

General description

One monitoring site (X3SAND-MALA) was selected to represent this reach. This reach is representative of the lowveld Stream, approximately 365 m.a.s.l.. There is low abundance of In-stream habitat in the form of riffles and runs with stones in current and cobbles. The catchment largely falls within protected areas with a low impact on the stream. The riparian vegetation is poorly developed and is dominated by reed beds.



Fish

This section of the river provides a low diversity of habitat types and consequently the diversity of fish species in this reach is low. The fish assemblage is dominated by more tolerant lowveld fish species. Twelve indigenous fish species were collected and is listed in Appendix 1. This is the only site where *Serranochromis meridianus* was collected. This is mainly due to a limited availability of habitat.

A Fish Response Assessment Index (FRAI) score of 86.6% was calculated for this reach based on all available information, ranking this reach in an Ecological Class B (slightly impaired with a high diversity of species). The relative high ecological class (B) can be related to an increase in habitat diversity.

Invertebrates

The SASS (119) and ASPT (5.7) values recorded at this site indicating an Ecological Class C (Moderately impaired with a moderate diversity of taxa). This is supported by the value obtained by the MRAI value (B). A total of 21 taxa were recorded indicating a moderate diversity of invertebrates. Highly sensitive taxa included Heptagenidae, and Athericidae. Less than 30% of the taxa recorded were air breathers which suggest that the river may be well aerated.

In-stream 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.

3.4.6 SQ REACH NUMBER X32J - 730

SQ reach (downstream-->)	SQ Reach	Fish sites	SASS sites	FRAI	MIRAI	In-stream ecostatus	Length km
X32J-730	Sand	X3 Sand-lowfl	SITHOLE KNP	B	BC	B	4.15

General description

One monitoring site (X3 SAND-LOWFL) was selected to represent this reach. This reach is representative of the lowveld Stream, approximately 235 m.a.s.l. There is low abundance of In-stream habitat in the form of riffles and runs with stones in current and cobbles. The catchment largely falls within protected areas with a low impact on the stream. The riparian vegetation is moderately well developed and is dominated by reed beds.

Fish

This section of the river provides a low diversity of habitat types and consequently the diversity of fish species in this reach is low. The fish assemblage is dominated by more tolerant lowveld fish species. Indigenous fish species were collected with a relative low abundance and is listed in Appendix 1. This is mainly due to a limited availability of habitat.

A Fish Response Assessment Index (FRAI) score of 86.5% was calculated for this reach based on all available information, ranking this reach in an Ecological Class B (slightly impaired with a high diversity of species). The relative high ecological class (B) can be related to an increase in habitat diversity.

Invertebrates

The SASS (119) and ASPT (5.7) values recorded at this site during the review period indicating an Ecological Class C (Moderately impaired with a moderate diversity of taxa). This is supported by the value obtained by the MIRAI value (B). A total of 21 taxa were recorded indicating a moderate diversity of invertebrates. Highly sensitive taxa included Heptagenidae, and Athericidae. Less than 30% of the taxa recorded were air breathers, which suggest that the river may be well aerated.

In-stream 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.

3.4.7 SQ REACH NUMBER X32-551

SQ reach (downstream-->)	SQ Reach	Fish sites	SASS sites	FRAI	MIRAI	In-stream ecostatus	Length km
X32B-551	Motlamogatsana	X3KSAN-ROOIB	X3KSAN-ROOIB	AB	BC	B	27.14

General description

One monitoring site (X3KSAN-ROOIB) was selected to represent this reach. This reach is representative of the lower foothill stream, approximately 708 m.a.s.l. and characterised as low inclined sand dominated stream. In certain sections boulders occur. Diverse habitat types including riffles, runs and pools are evident with a well-developed riparian zone. This provides adequate fish cover in the form of overhanging vegetation, undercut banks and rood wads. The catchment has largely been transformed by rural farming and settlements.

Fish

This section of the river provides a high diversity of habitat types and consequently the diversity of fish species in this reach is relatively high. The fish assemblage is dominated by more tolerant fish species such as *Barbus trimaculatus*, *Clarias*

gariepinus, *Pseudocrenilabrus philander* and *Labeo molybdinus*. Eleven indigenous fish species were collected with a relative high abundance and is listed in Appendix 1.

A Fish Response Assessment Index (FRAI) score of 86.2% was calculated for this reach based on all available information, ranking this reach in an Ecological Class B (slightly impaired with a high diversity of species). The relative high ecological class (B) can be related to a diversity of habitat types and good water quality.

Invertebrates

The SASS (201) and ASPT (7.18) values recorded at this site an Ecological Class B (Slightly impaired with a high diversity of taxa). This is supported by the value obtained by the MRAI value (BC). A total of 28 taxa were recorded, indicating a high diversity of invertebrates. Highly sensitive taxa included Perlidae, Heptagenidae, Psephenidae, and Athericidae which was recorded. Less than 20% of the taxa recorded were air breathers, which suggest that the river is well aerated.

In-stream 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.

3.4.8 SQ REACH NUMBER X32C - 558

SQ reach (downstream-->)	SQ Reach	Fish sites	SASS sites	FRAI	MIRAI	In-stream ecostatus	Length km
X32C-558	Nwandlamuhari	X3SAND-THULA	X3SAND-THULA	B	C	C	15.07

General description

This monitoring site (X3SAND-THULA) is representative of the lowveld streams and approximately 396 m.a.s.l. It is characterised as a low inclined braided, sand dominated stream with multiple channels with sandy runs and large pools. There is a notable absence of In-stream habitat in the form of riffles and runs with stones in current and cobbles. The catchment has largely been transformed to rural developments and subsistence farming. The riparian vegetation is dominated by Phragmites reed beds as a result of the accumulation of sediments and nutrients.

Fish

In total sixteen indigenous fish species were collected with a relative high abundance and is listed in Appendix 1. The fish assemblage was dominated by small barbus species that included *Barbus trimaculatus*, *Barbus unitaeniatus*, *Barbus viviparus*, *Barbus toppini*, *Barbus radiates* and *Barbus eutaenia*. This high abundance of species diversity can be attributed to congregation of fish in available habitat. This reach in general has low fish habitat type availability with large sections primarily consisting of shallow, sandy pools. The only fish cover recorded was at patches of *Phragmites mauritiana* where culverting roots create suitable fish cover.

A Fish Response Assessment Index (FRAI) score of 86.1% was calculated for this reach based on all available information, ranking this reach in an Ecological Class B (slightly impaired with a high diversity of species). The relative high ecological class (B) can be related to an increase in habitat availability in small sections of the reach.

Invertebrates

The SASS score (164) and ASPT (6.1) values recorded at this site suggesting an Ecological Class B (Moderately impaired with a high diversity of taxa). This is supported by the value obtained by the MRAI value (B). A total of 27 taxa were recorded indicating a high diversity of invertebrates. Highly sensitive taxa included Perlidae, Heptagenidae, Prosopistomatidae, and Athericidae. Less than 50% of the taxa recorded were air breathers which suggest that the river is possibly not as well aerated.

In-stream 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 in certain sections of the reach where fish habitat availability prevails.

3.4.9 SQ REACH NUMBER X32C - 606

SQ reach (downstream-->)	SQ Reach	Fish sites	SASS sites	FRAI	MIRAI	In-stream ecostatus	Length km
X32C-606	Nwandlamuhari			B	C	C	1.23

General description

The FRAI, MIRAI and Ecostatus for this reach were derived and/or extrapolated from previous surveys and expert judgement and indicate that the Ecostatus for the fish is a class B (Slightly impaired with a high diversity of species) and for the invertebrates a class C (Moderately impaired with a relative high diversity of taxa)

3.4.10 Summary of the Sand Tributaries: Sand to Nwandlamuhari

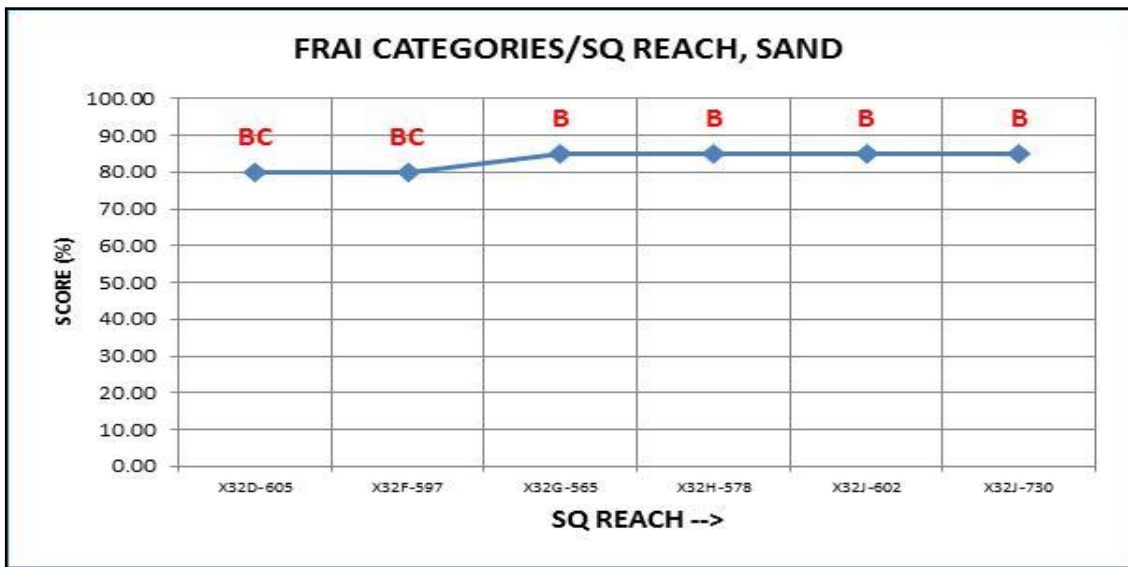


Figure 13 FRAI observed for the different Sand River reaches.

Figure 13 suggest that the fish assemblage for the upper Sand River reaches are largely in a moderately modified condition with the lower reaches within the protected areas being only slightly modified. This largely reflects the expected condition in a protected area.

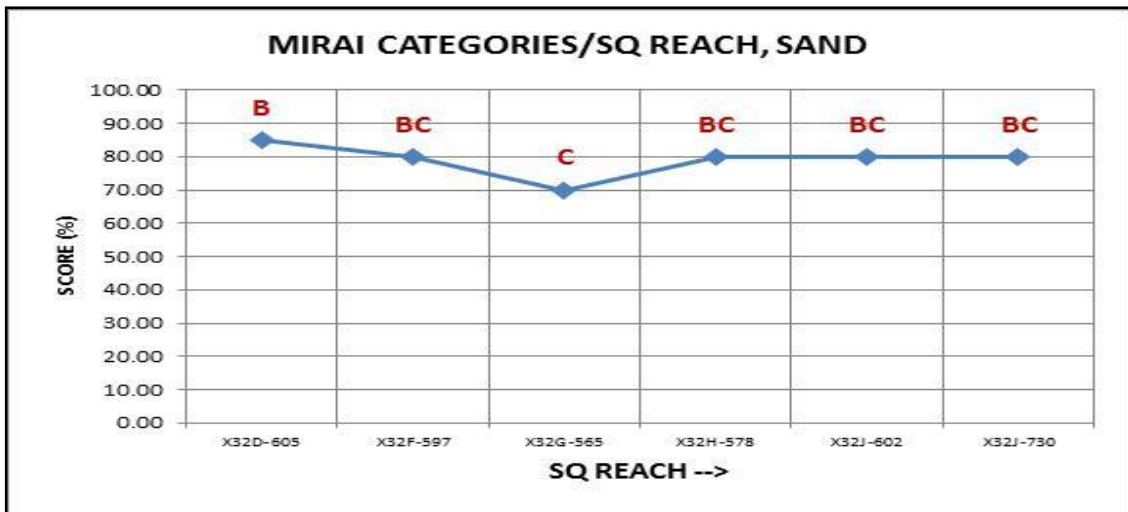


Figure 14 MIRAI observed for the different Sand River reaches.

Due to the low abundance of SASS biotopes and a lack of suitable habitats, SASS may be under estimated (Figure 14). The lower values obtained within the middle reaches probably reflects the impact of rural development and associated deterioration of water quality.

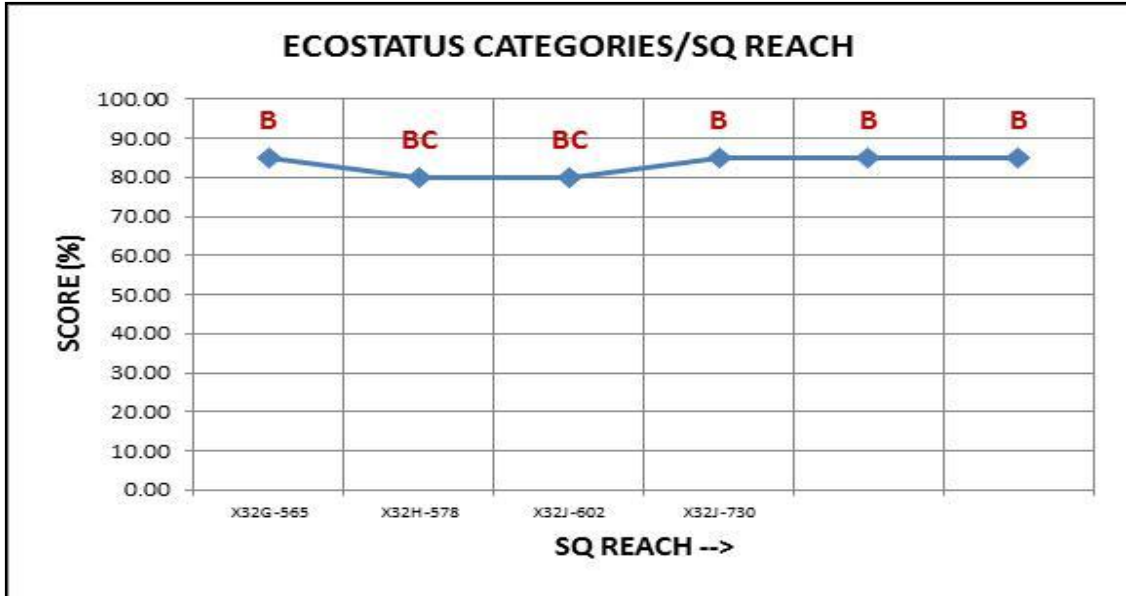


Figure 15 In-stream Eco Status observed for the different Sand River reaches.

Figure 15 suggest that the upper reaches of the Sand River is still in a good condition, but it deteriorates slightly due to the impact of rural settlements. However, the Sand River is still in a very good condition within the protected areas.

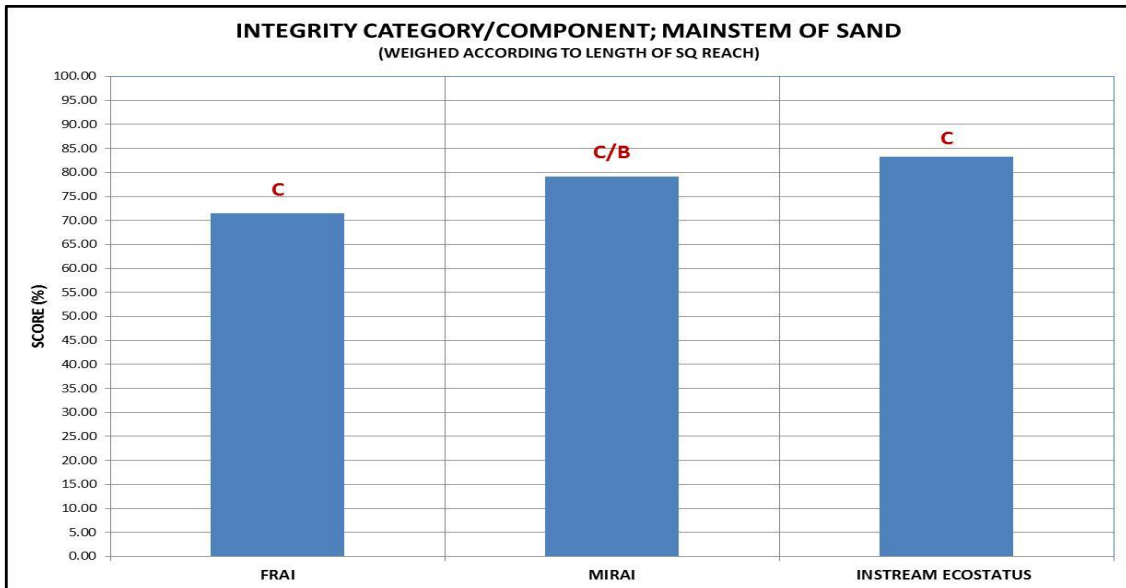


Figure 16 Integrity categories for FRAI, MIRAI and In-stream Ecstatus weighed according to the length of the reach

Figure 16 suggest that the FRAI value is largely in a class C (moderately modified) while the MIRAI reflects a class C/B (slightly to moderately modified) with an overall Ecstatus of a class C (moderately modified).

3.5 Sabi Tributaries : Marite

3.5.1 SQ REACH NUMBER X31E- 647

SQ reach (downstream-->)	Fish sites	SASS sites	FRAI	MIRAI	In-stream ecostatus	Length km
Marite	X3INGWA-VERSA; X3MARI-MARIT	X3INGWA-ROODE DIEDERICKS SASS); X3INGWA-VERSA; X3NWAR-VADER (DIEDERICKS SASS)	BC	B	BC	58.09

General description

Two monitoring sites (X3INGWA-VERSA, and X3MARI-MARIT) were selected to represent this reach. This reach is representative of the lower foothill Stream, ranging between 887 and 562 m.a.s.l and is characterised as a low inclined braided, sand dominated stream with multiple channels and sandy runs and large pools. There is a notable low abundance of In-stream habitat in the form of riffles and runs with stones in current and cobbles. The catchment has largely been transformed to rural settlements and subsistence farming. The riparian vegetation is dominated by Phragmites reed beds as a result of the accumulation of sediments and nutrients.

Fish

Six indigenous fish species were collected in this reach with a relative low abundance and is listed in Appendix 1. This section of the river provides a low diversity of habitat types and consequently the diversity of fish species in this reach is low. The fish assemblage is dominated by more tolerant fish species.

A Fish Response Assessment Index (FRAI) score of 78.3% was calculated for this reach based on all available information, ranking this reach in an Ecological Class BC (slightly to moderately impaired with a relative number of species). The relative high ecological class (BC) can be related to fish habitat availability.

Invertebrates

The SASS (155 & 183) and ASPT (7.0 & 5.9) values recorded at this site during the review period fluctuate closely around the recommended eco-specification set for an Ecological Class B (Moderately impaired with a moderate diversity of taxa). This is supported by the value obtained by the MIRAI value (B). A total of 22 and 31 taxa were recorded indicating a moderate diversity of invertebrates. Highly sensitive taxa included Perlidae, Heptagenidae, Tricorychidae, Polymitarcyidae and Athericidae. Less than 30% of the taxa recorded were air breathers which suggest that the river is well aerated.

In-stream ecostatus

The Ecostatus for this reach was consistent with a Class BC suggesting a slightly to moderately impaired habitat. This high value may reflect as an over estimation of the MIRAI as the In-stream habitat has been notably degraded due to In-stream siltation and sedimentation.

3.5.2 SQ REACH NUMBER X31F - 695

SQ reach (downstream-->)	Fish sites	SASS sites	FRAI	MIRAI	In-stream ecostatus	Length km
Motitsi	X3WATE-WATER	X3WATE-WATER; X3MOTI-ROODE; X3MOTI-DIEPD (DIEDERICKS SASS)	BC	B	BC	42.75

General description

One monitoring sites (X3WATE-WATER) was selected to represent this reach. This reach is representative of an upper foothill Stream, approximately 957 m.a.s.l and characterised as a high inclined single channel with a well developed riparian zone with riffles and runs with stones in current and cobbles. The catchment has largely been transformed to forestry (Pines). The riparian vegetation is dominated by grass species dense stands of alien plant species.

Fish

Four indigenous fish species were collected with high abundance and is listed in Appendix 1. Within this reach is the type locality of *Barbus brevipinus* which is listed as vulnerable due to being threatened by dams and introduced alien species. This section of the river provides a low diversity of habitat types and consequently the diversity of fish species in this reach is low. This is mainly due to a limited availability of habitat.

A Fish Response Assessment Index (FRAI) score of 80.4% was calculated for this reach based on all available information, ranking this reach in an Ecological Class BC (slightly to moderately impaired with a diversity of species). The relative high ecological class (BC) can be related to an increase in habitat diversity.

Invertebrates

The SASS (231) and ASPT (7.5) values recorded at this site suggest an Ecological Class B (Moderately impaired with a high diversity of taxa). This is supported by the value obtained by the MRAI value (B). A total of 31 taxa were recorded, indicating a high diversity of invertebrates. Highly sensitive taxa included Perlidae, Heptagenidae, Tricorychidae, Psephenidae, Dixidae and Athericidae which was recorded. Less than 10% of the taxa recorded were air breathers which suggest that the river is well aerated.

In-stream ecostatus

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

3.5.3 SQ REACH NUMBER X31F- 728

SQ reach (downstream-->)	Fish sites	SASS sites	FRAI	MRAI	In-stream ecostatus	Length km
X31E-647	X3MARI	X3MARI	B	BC	BC	7.99

General description

One monitoring site (X3MARI) was selected to represent this reach. This reach is representative of the upper foothill stream, approximately 463 m.a.s.l. and characterised as braided sharp inclined bedrock dominated stream providing a diversity of habitat types such as riffles, runs pools and backwaters. Riparian vegetation is well developed with some large trees providing additional fish habitat and cover.

Fish

This section of the river provides a low diversity of habitat types and consequently the diversity of fish species in this reach is low. The fish assemblage is dominated by more tolerant lowveld fish species. Nine indigenous fish species were collected with a relative low abundance and is listed in Appendix 1. This is mainly due to a limited availability of habitat.

A Fish Response Assessment Index (FRAI) score of 86.5% was calculated for this reach based on all available information, ranking this reach in an Ecological Class B (slightly impaired with a high diversity of species). The relative high ecological class (B) can be related to an increase in habitat diversity.

Invertebrates

The SASS (119) and ASPT (5.7) values recorded at this site indicating an Ecological Class C (Moderately impaired with a moderate diversity of taxa). This is supported by the value obtained by the MRAI value (B). A total of 21 taxa were recorded indicating a moderate diversity of invertebrates. Highly sensitive taxa included Heptagenidae, and Athericidae. more than 30% of the taxa recorded were air breathers which suggest that the river may not be well aerated.

In-stream ecostatus

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

3.5.4 Summary of the Sand Tributaries: Marite

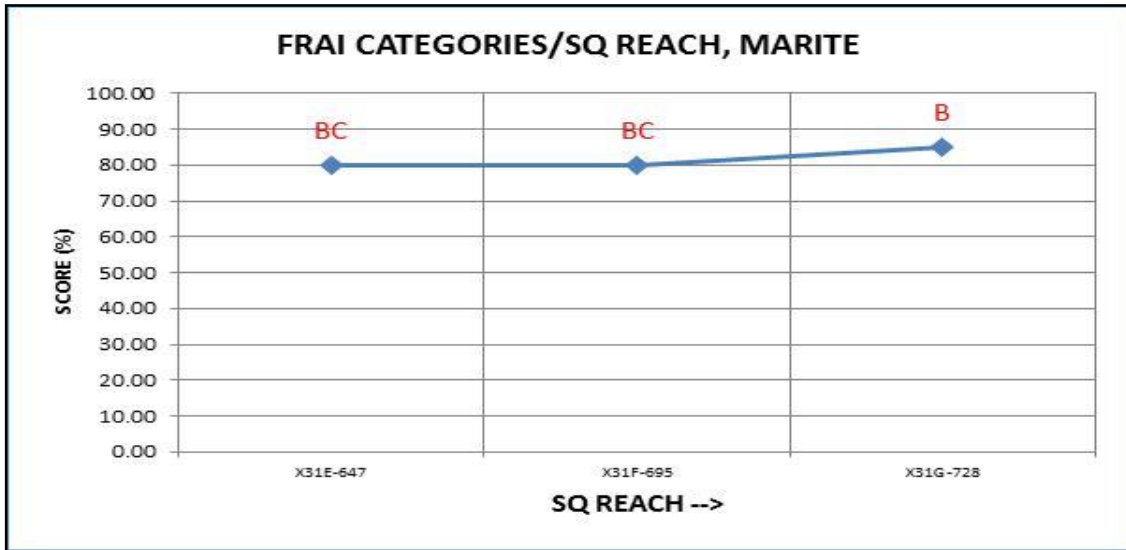


Figure 17 FRAI observed for the different Marite River reaches.

According to figure 17 the FRAI values indicate slightly to moderately impaired conditions for fish. This can be largely related to the impacts of forestry, primarily sedimentation from roads and catchment activities. The values obtained for the lower reaches indicate improved habitat conditions reflected by higher species diversity and abundance.

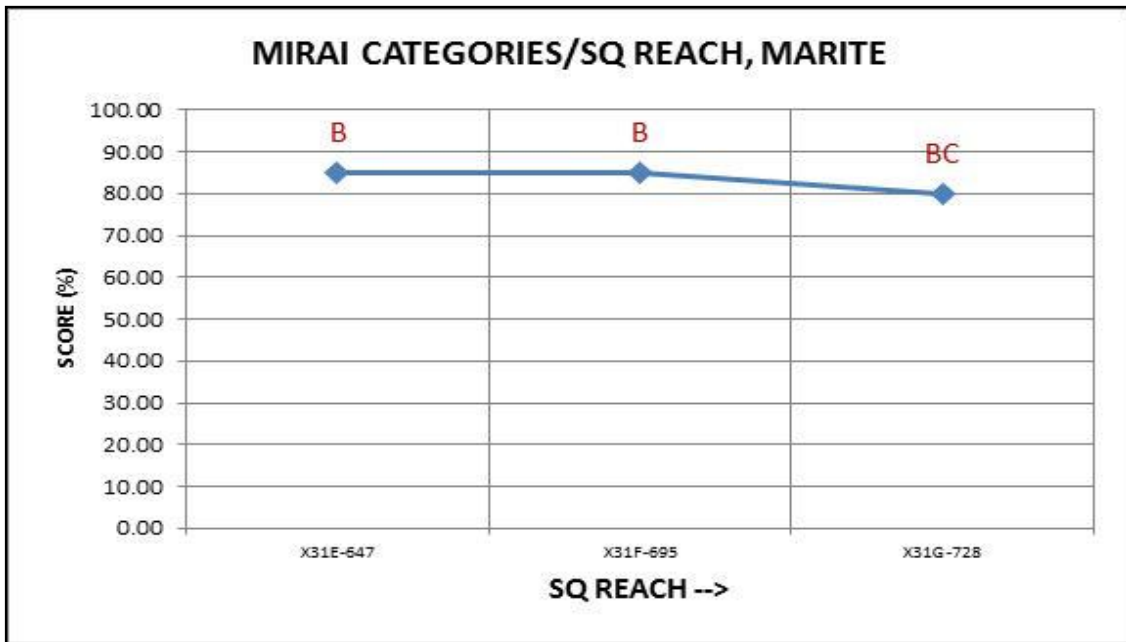


Figure 18 MIRAI observed for the different Marite River reaches.

Due to the low abundance of SASS biotopes and a lack of suitable habitats, SASS may be under estimated. The values obtained largely reflect a tendency for invertebrates in their longitudinal distribution within a river system.

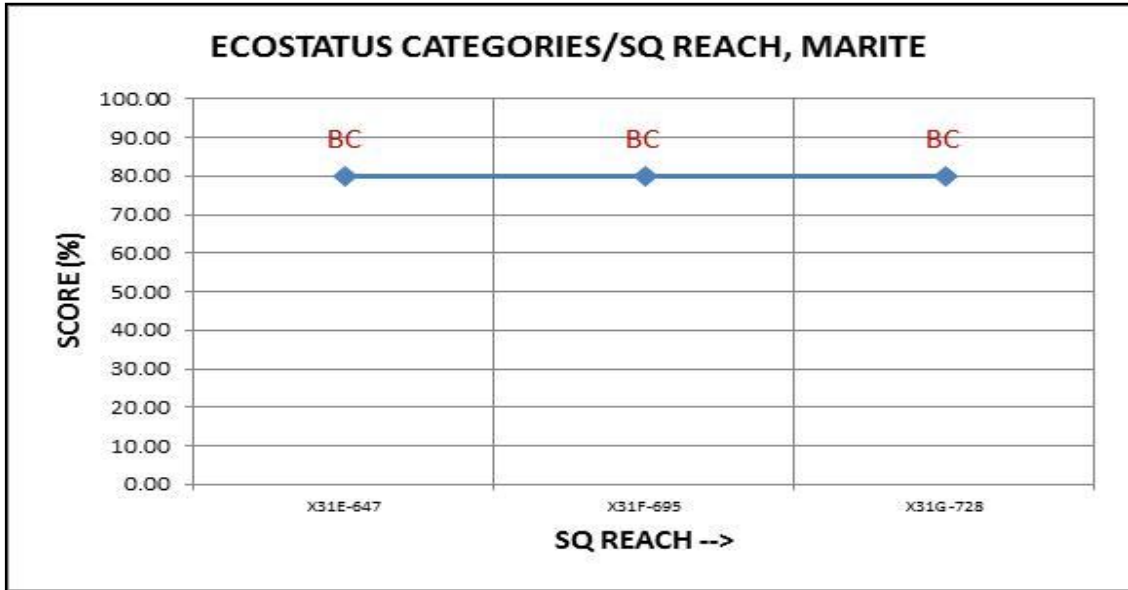


Figure 19 In-stream Eco Status observed for the different Marite River reaches.

Figure 19 shows that the Ecstatus for the Marite River is largely maintained within a slightly to moderately impaired habitat condition.

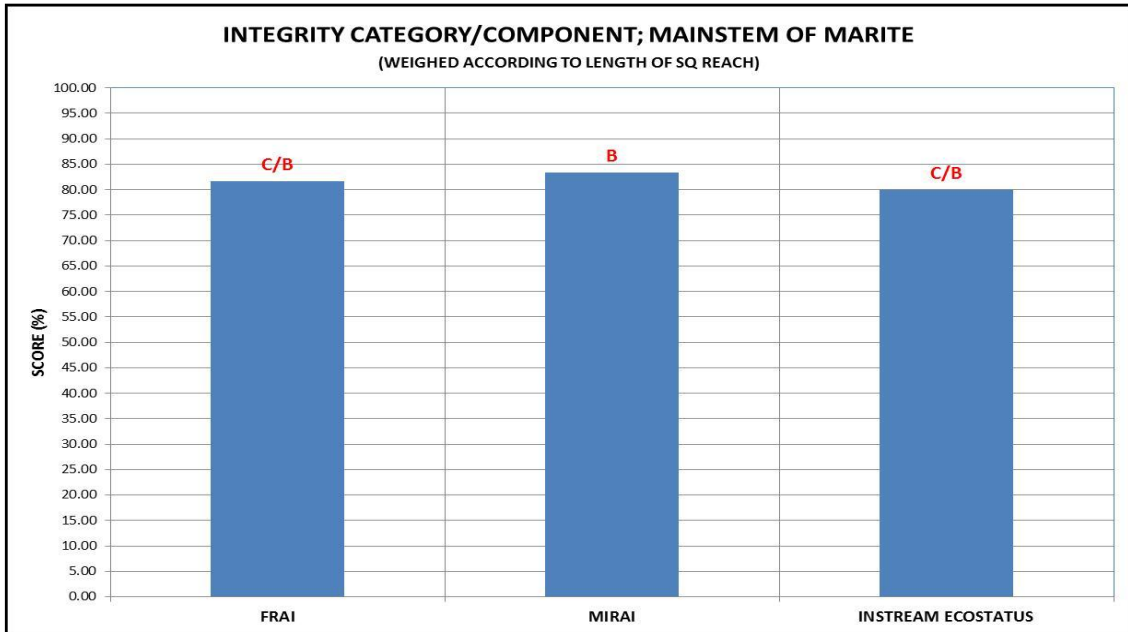


Figure 20 Integrity categories for Frai, Mirai and In-stream Ecstatus weighed according to the length of the reach

Figure 20 suggest that the FRAI value is largely in a class C/B (slightly to moderately modified) while the MIRAI reflects a class B (slightly modified) with an overall Ecstatus of a class C/B (slightly to moderately modified).

4 CONCLUSION

Thirty eight biomonitoring sites were selected and surveyed in the Sabie-Sand River Catchment during 2011. At all these sites biological indices were used to determine the overall ecstatus of the various reaches within the river. The combined graph of all the ecstatus values for all the reaches within the Sabie mainstem clearly indicates that the low values (class C – moderately modified) calculated within the upper reaches from the source to below the town of Sabie is of great concern. This would indicate that the various land use practices – forestry, industrial and urban development – and their related impacts have a serious influence on the on the aquatic biota. The most serious impacts appear to be sedimentation, siltation and reduced water qualities which reduce available in-stream habitat. The ecstatus further downstream changed to a class B status (largely unmodified – good state) after the confluence with the Mac-Mac River down to the Mozambican border. Fortunately large parts of the Sabie-Sand River System falls within conservation areas such as the Kruger National Park and Sabie-Sand Estates where the habitat is preserved to be largely natural. Thus the overall status for the Sabie-Sand River is a B/C – largely unmodified to moderately modified. In the Sabie River parts of the upper reaches are unacceptable where as certain parts downstream can be regarded as natural and in a good state.

Ecstatus values observed for the different reaches within the Sabie River, starting at the source and moving downstream to the Mozambican border.

Recommendations

Due to the low ecstatus values obtained for the Upper Sabie River region, this reach needs to be reflagged, indicate that further in-depth studies need to be conducted in this reach in order to incorporate and inform management interventions required to address systematic and point specific impacts.

Acknowledgements

Technical contributions:

- Dr Neels Kleynhans (RQS - DWA)
- Christa Thirion (RQS - DWA)
- Dr Andrew Deacon (SANParks)
- Hendrik Sithole (SANParks)
- Gerhard Diedericks (Environmental Biomonitoring)
- MTPA Scientific Services Biomonitoring Team
- Amanda Pontier (Student)
- Dr JS Engelbrecht (Aquaflex)

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6 APPENDIX

Appendix 1: Table indicating species collected at biomonitoring sites in the Sabi/Sand catchment

SQ REACH		X31A-783		X31A-741	X31D-773
ABRIV	SPECIES	LONE CREEK/X3LONE CREEK;	LONE CREEK/X3LONECREEK2	X3KSAB-KLEIN	X3SABA-BRAND
MMAC	Marcusenius macrolepidotus				X
PCAT	Petrocephalus wesselsi				
AMOS	Anguilla mossambica				
AMAR	Anguilla marmorata				
ALAB	Anguilla bengalensis labiata				
MBRE	Mesobola brevianalis				
OPER	Opsaridium peringueyi				X
BANO	Barbus anoplus	X	X		
BTRI	Barbus trimaculatus				
BANN	Barbus annectens				
BBRI	Barbus brevipinnis				
BUNI	Barbus unitaeniatus				
BVIV	Barbus viviparus				
BTOP	Barbus toppini				
BRAD	Barbus radiatus				
BEUT	Barbus eutaenia				X
BARG	Barbus argenteus				
BPAU	Barbus paludinosus				
BFRI	Barbus afrohamiltoni				
LROS	Labeo rosae				
LRUD	Labeo ruddi				
LCON	Labeo congoro				
LCYL	Labeo cylindricus				
LMOL	Labeo molybdinus				
BPOL	Labeobarbus polylepis				X
BMAR	Labeobarbus marequensis				X
VNEL	Varicorhinus nelspruitensis				
CCAR	Cyprinus carpio				
BIMB	Brycinus imberi				
MACU	Micralestes acutidens				
HVIT	Hydrocynus vittatus				
ANAT	Amphilius natalensis				
AURA	Amphilius uranoscopus				X
SINT	Schilbe intermedius				
CGAR	Clarias gariepinus				
CPAR	Chiloglanis paratus				
CSWI	Chiloglanis swierstrai				
CANO	Chiloglanis anoterus		X	X	X
SZAM	Synodontis zambezensis				
OMYK	Oncorhynchus mykiss	X	X		
PPHI	Pseudocrenilabrus philander				X
SMER	Serranochromis meridianus				
TSPA	Tilapia sparmanii				
TREN	Tilapia rendalli				
OMOS	Oreochromis mossambicus				
GGIU	Glossogobius giurus				

Ecostatus of Sabie-Sand River Catchment

SQ REACH		X31C-683		X31J-774	X31A-799	X31A-778
ABRIV	SPECIES	X3MACM- VENUS;	X3MACM- PICNI	X3NSAN- SANBO	X3SABI- OLIFA	X3SABI- CASTL
MMAC	Marcusenius macrolepidotus					
PCAT	Petrocephalus wesselsi					
AMOS	Anguilla mossambica					
AMAR	Anguilla marmorata					
ALAB	Anguilla bengalensis labiata					
MBRE	Mesobola brevianalis					
OPER	Opsaridium peringueyi		X	X		
BANO	Barbus anoplus				X	
BTRI	Barbus trimaculatus					
BANN	Barbus annectens					
BBRI	Barbus brevipinnis	X	X			
BUNI	Barbus unitaeniatus					
BVIV	Barbus viviparus			X		
BTOP	Barbus toppini					
BRAD	Barbus radiatus					
BEUT	Barbus eutaenia		X	X		
BARG	Barbus argenteus					
BPAU	Barbus paludinosus					
BFRI	Barbus afrohamiltoni					
LROS	Labeo rosae					
LRUD	Labeo ruddi					
LCON	Labeo congoro					
LCYL	Labeo cylindricus			X		
LMOL	Labeo molybdinus			X		
BPOL	Labeobarbus polylepis					
BMAR	Labeobarbus marequensis			X		
VNEL	Varicorhinus nelspruitensis	X		X		X
CCAR	Cyprinus carpio					
BIMB	Brycinus imberi					
MACU	Micralestes acutidens			X		
HVIT	Hydrocynus vittatus					
ANAT	Amphilius natalensis					
AURA	Amphilius uranoscopus	X	X		X	
SINT	Schilbe intermedius					
CGAR	Clarias gariepinus			X		
CPAR	Chiloglanis paratus					
CSWI	Chiloglanis swierstrai			X		
CANO	Chiloglanis anoterus	X	X	X		X
SZAM	Synodontis zambezensis					
OMYK	Oncorhynchus mykiss				X	
PPHI	Pseudocrenilabrus philander	X		X		X
SMER	Serranochromis meridianus					
TSPA	Tilapia sparrmanii			X	X	
TREN	Tilapia rendalli			X		
OMOS	Oreochromis mossambicus					
GGIU	Glossogobius giurus					

Ecstatus of Sabie-Sand River Catchment

SQ REACH		X31B-757		X31D-755	X31K-755	X31K-752
ABRIV	SPECIES	X3SABI-RIOOL;	X3SABI-BRUG	X3SABI-BRAND;	X3SABI-AANDE	X3SABI-SANBO; ;
MMAC	Marcusenius macrolepidotus			X		
PCAT	Petrocephalus wesselsi					
AMOS	Anguilla mossambica		X			
AMAR	Anguilla marmorata					
ALAB	Anguilla bengalensis labiata					
MBRE	Mesobola brevianalis					
OPER	Opsaridium peringueyi					
BANO	Barbus anoplus					
BTRI	Barbus trimaculatus					
BANN	Barbus annectens					
BBRI	Barbus brevipinnis					
BUNI	Barbus unitaeniatus			X		
BVIV	Barbus viviparus					
BTOP	Barbus toppini					
BRAD	Barbus radiatus					
BEUT	Barbus eutaenia			X	X	X
BARG	Barbus argenteus					
BPAU	Barbus paludinosus					
BFRI	Barbus afrohamiltoni					
LROS	Labeo rosae					
LRUD	Labeo ruddi					
LCON	Labeo congoro					
LCYL	Labeo cylindricus					
LMOL	Labeo molybdinus					X
BPOL	Labeobarbus polylepis			X	X	
BMAR	Labeobarbus marequensis			X	X	X
VNEL	Varicorhinus nelspruitensis	X	X			
CCAR	Cyprinus carpio					
BIMB	Brycinus imberi					
MACU	Micralestes acutidens					
HVIT	Hydrocynus vittatus					
ANAT	Amphilius natalensis					
AURA	Amphilius uranoscopus			X	X	
SINT	Schilbe intermedius					
CGAR	Clarias gariepinus					X
CPAR	Chiloglanis paratus					
CSWI	Chiloglanis swierstrai					
CANO	Chiloglanis anoterus	X	X		X	X
SZAM	Synodontis zambezensis					
OMYK	Oncorhynchus mykiss					
PPHI	Pseudocrenilabrus philander			X		X
SMER	Serranochromis meridianus					
TSPA	Tilapia sparrmanii	X				
TREN	Tilapia rendalli					
OMOS	Oreochromis mossambicus					
GGIU	Glossogobius giurus					

Ecstatus of Sabie-Sand River Catchment

SQ REACH				X31K-715	X31M-747	X33A-731
ABRIV	SPECIES	XSABI-CAL03	X3SABI-CAL01	X3SABI-SEKUR	X3SABI-BUFFE	X3SABI-ANTHO
MMAC	Marcusenius macrolepidotus			X	X	X
PCAT	Petrocephalus wesselsi			X		X
AMOS	Anguilla mossambica					
AMAR	Anguilla marmorata					
ALAB	Anguilla bengalensis labiata					
MBRE	Mesobola brevianalis					
OPER	Opsaridium peringueyi			X		X
BANO	Barbus anoplus					
BTRI	Barbus trimaculatus			X		X
BANN	Barbus annectens					
BBRI	Barbus brevipinnis					
BUNI	Barbus unitaeniatus					
BVIV	Barbus viviparus			X		X
BTOP	Barbus toppini					
BRAD	Barbus radiatus					X
BEUT	Barbus eutaenia	X		X		
BARG	Barbus argenteus					
BPAU	Barbus paludinosus					
BFRI	Barbus afrohamiltoni					X
LROS	Labeo rosae					
LRUD	Labeo ruddi					
LCON	Labeo congoro					
LCYL	Labeo cylindricus			X	X	X
LMOL	Labeo molybdinus	X		X	X	X
BPOL	Labeobarbus polylepis					
BMAR	Labeobarbus marequensis			X	X	X
VNEL	Varicorhinus nelspruitensis					
CCAR	Cyprinus carpio					
BIMB	Brycinus imberi					
MACU	Micralestes acutidens			X	X	X
HVIT	Hydrocynus vittatus					
ANAT	Amphilius natalensis					
AURA	Amphilius uranoscopus					
SINT	Schilbe intermedius					X
CGAR	Clarias gariepinus	X		X	X	X
CPAR	Chiloglanis paratus		X	X	X	X
CSWI	Chiloglanis swierstrai	X	X	X		X
CANO	Chiloglanis anoterus	X		X	X	
SZAM	Synodontis zambezensis					
OMYK	Oncorhynchus mykiss					
PPhi	Pseudocrenilabrus philander	X		X		X
SMER	Serranochromis meridianus					
TSPA	Tilapia sparmanii	X				
TREN	Tilapia rendalli					X
OMOS	Oreochromis mossambicus			X		X
GGIU	Glossogobius giurus					

Ecstatus of Sabie-Sand River Catchment

SQ REACH		X33B-804		X33D-811	X32D-605		X32G-565
ABRIV	SPECIES	X3SABI-LUBEY;	X3SABI-LOWER	X3SABI-BORDER	X3MOHL-ZOEKN;	X3MUTL-VIOLE	X3SAND-ROLLE
MMAC	Marcusenius macrolepidotus						
PCAT	Petrocephalus wesselsi						
AMOS	Anguilla mossambica						
AMAR	Anguilla marmorata						
ALAB	Anguilla bengalensis labiata						
MBRE	Mesobola brevianalis						X
OPER	Opsaridium peringueyi						
BANO	Barbus anoplus				X	X	
BTRI	Barbus trimaculatus				X	X	X
BANN	Barbus annectens	X					
BBRI	Barbus brevipinnis						
BUNI	Barbus unitaeniatus						X
BVIV	Barbus viviparus	X	X	X			X
BTOP	Barbus toppini						X
BRAD	Barbus radiatus						X
BEUT	Barbus eutaenia				X	X	X
BARG	Barbus argenteus						X
BPAU	Barbus paludinosus						
BFRI	Barbus afrohamiltoni						
LROS	Labeo rosae						
LRUD	Labeo ruddi						
LCON	Labeo congoro						
LCYL	Labeo cylindricus	X					
LMOL	Labeo molybdinus	X	X	X			
BPOL	Labeobarbus polylepis						
BMAR	Labeobarbus marequensis	X	X	X	X	X	X
VNEL	Varicorhinus nelspruitensis						
CCAR	Cyprinus carpio						
BIMB	Brycinus imberi			X			
MACU	Micralestes acutidens	X		X			X
HVIT	Hydrocynus vittatus	X		X			
ANAT	Amphilius natalensis						
AURA	Amphilius uranoscopus				X	X	
SINT	Schilbe intermedius						
CGAR	Clarias gariepinus	X	X	X	X		
CPAR	Chiloglanis paratus						
CSWI	Chiloglanis swierstrai	X		X			
CANO	Chiloglanis anoterus				X	X	X
SZAM	Synodontis zambezensis						
OMYK	Oncorhynchus mykiss						
PPHI	Pseudocrenilabrus philander						X
SMER	Serranochromis meridianus						
TSPA	Tilapia sparrmanii						
TREN	Tilapia rendalli		X	X			
OMOS	Oreochromis mossambicus	X	X	X			X
GGIU	Glossogobius giurus		X	X			X













Ecstatus of Sabie-Sand River Catchment




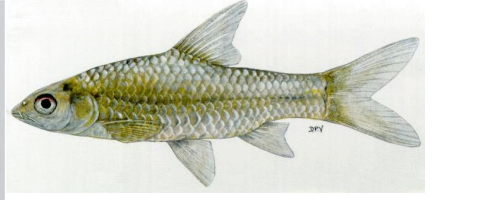







SQ REACH		X32H-578		X32J-602	X32J-730	X31E-647	X31E-647
ABRIV	SPECIES	X3SAND-OTHAW;	X3SAND-LONDO	X3SAND-MALAM	LOW FLOW BRIDGE	Ngw-Versa	Mari-Marite
MMAC	Marcusenius macrolepidotus	X			X		
PCAT	Petrocephalus wesselsi	X			X		
AMOS	Anguilla mossambica						
AMAR	Anguilla marmorata						
ALAB	Anguilla bengalensis labiata						
MBRE	Mesobola brevianalis		X				
OPER	Opsaridium peringueyi						
BANO	Barbus anoplus					X	
BTRI	Barbus trimaculatus	X	X	X	X		
BANN	Barbus annectens						
BBRI	Barbus brevipinnis						
BUNI	Barbus unitaeniatus	X	X	X			
BVIV	Barbus viviparus	X	X		X		
BTOP	Barbus toppini	X	X	X			
BRAD	Barbus radiatus				X		
BEUT	Barbus eutaenia						X
BARG	Barbus argenteus						
BPAU	Barbus paludinosus						
BFRI	Barbus afrohamiltoni			X	X		
LROS	Labeo rosae						
LRUD	Labeo ruddi						
LCON	Labeo congoro						
LCYL	Labeo cylindricus				X		X
LMOL	Labeo molybdinus	X	X				
BPOL	Labeobarbus polylepis						
BMAR	Labeobarbus marequensis	X	X	X	X		
VNEL	Varicorhinus nelspruitensis						
CCAR	Cyprinus carpio						
BIMB	Brycinus imberi						
MACU	Micralestes acutidens		X	X	X		
HVIT	Hydrocynus vittatus						
ANAT	Amphilius natalensis					X	
AURA	Amphilius uranoscopus						X
SINT	Schilbe intermedius	X			X		
CGAR	Clarias gariepinus		X		X		X
CPAR	Chiloglanis paratus	X	X	X	X		
CSWI	Chiloglanis swierstrai	X	X	X	X		X
CANO	Chiloglanis anoterus					X	X
SZAM	Synodontis zambezensis						
OMYK	Oncorhynchus mykiss						
PPHI	Pseudocrenilabrus philander			X	X		
SMER	Serranochromis meridianus			X			
TSPA	Tilapia sparrmanii						
TREN	Tilapia rendalli		X	X	X		
OMOS	Oreochromis mossambicus	X		X	X		
GGIU	Glossogobius giurus				X		

Ecstatus of Sabie-Sand River Catchment

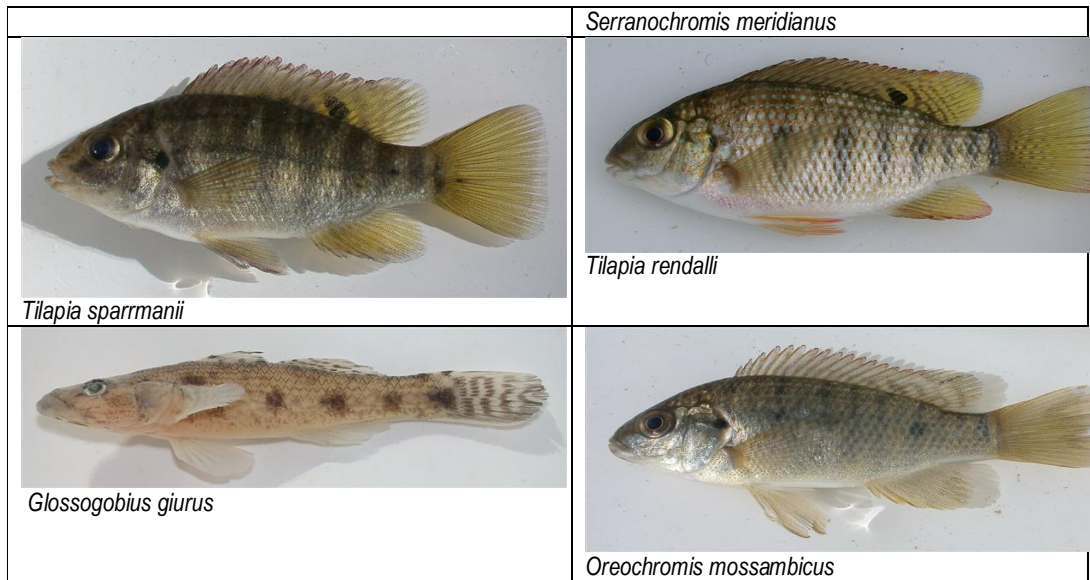
SQ REACH		X31E-647	X31F-695	X32A-058	X32B-551	X32B-551		X31E-647
ABRIV	SPECIES	Mari-Versa	Waterhoutboom	X3sand-Thula	X3MOHL-WELGE	Rooiboklaagte	X3SEKG-FORES	X3MARITES05
MMAC	Marcusenius macrolepidotus			X		X		X
PCAT	Petrocephalus wesselsi							
AMOS	Anguilla mossambica							
AMAR	Anguilla marmorata							
ALAB	Anguilla bengalensis labiata							
MBRE	Mesobola brevianalis					X		
OPER	Opsaridium peringueyi							X
BANO	Barbus anoplus							
BTRI	Barbus trimaculatus			X		X		
BANN	Barbus annectens							
BBRI	Barbus brevipinnis	X	X				X	
BUNI	Barbus unitaeniatus			X		X		X
BVIV	Barbus viviparus			X				
BTOP	Barbus toppini			X				
BRAD	Barbus radiatus			X				
BEUT	Barbus eutaenia			X		X		X
BARG	Barbus argenteus	X	X					
BPAU	Barbus paludinosus							
BFRI	Barbus afrohamiltoni							
LROS	Labeo rosae							
LRUD	Labeo ruddi							
LCON	Labeo congoro							
LCYL	Labeo cylindricus			X				
LMOL	Labeo molybdinus			X		X		
BPOL	Labeobarbus polylepis							
BMAR	Labeobarbus marequensis			X		X		
VNEL	Varicorhinus nelspruitensis							
CCAR	Cyprinus carpio							
BIMB	Brycinus imberi							
MACU	Micralestes acutidens			X				X
HVIT	Hydrocynus vittatus							
ANAT	Amphilius natalensis	X	X					
AURA	Amphilius uranoscopus				X		X	
SINT	Schilbe intermedius							
CGAR	Clarias gariepinus			X		X		X
CPAR	Chiloglanis paratus			X				X
CSWI	Chiloglanis swierstrai			X				
CANO	Chiloglanis anoterus	X	X			X		
SZAM	Synodontis zambezensis							
OMYK	Oncorhynchus mykiss							
PPHI	Pseudocrenilabrus philander			X		X		
SMER	Serranochromis meridianus							
TSPA	Tilapia sparrmanii							X
TREN	Tilapia rendalli							
OMOS	Oreochromis mossambicus			X		X		
GGIU	Glossogobius giurus							

Appendix 2: Photographs of different fish species collected in the Sabi/Sand Catchment

EXAMPLES OF FISH SPECIES COLLECTED DURING THE SURVEY	
 <p><i>Marcusenius macrolepidotus</i></p>	 <p><i>Petrocephalus wesselsi</i></p>
 <p><i>Anguilla mossambica</i></p>	 <p><i>Mesobola brevianalis</i></p>
 <p><i>Opsaridium peringueyi</i></p>	 <p><i>Barbus anoplus</i></p>
 <p><i>Barbus trimaculatus</i></p>	 <p><i>Barbus brevipinnis</i></p>
 <p><i>Barbus unitaeniatus</i></p>	 <p><i>Barbus viviparus</i></p>
	

<p><i>Barbus toppini</i></p> 	<p><i>Barbus radiatus</i></p> 
<p><i>Barbus eutaenia</i></p> 	<p><i>Barbus argenteus</i></p> 
<p><i>Barbus paludinosus</i></p> 	<p><i>Barbus afrohamiltoni</i></p> 
<p><i>Labeo rosae</i></p> 	<p><i>Labeo ruddi</i></p> 
<p><i>Labeo cylindricus</i></p>	<p><i>Labeo molybdinus</i></p>
<p><i>Labeobarbus polylepis</i></p>	<p><i>Labeobarbus marequensis</i></p> 
<p><i>Varicorhinus nelspruitensis</i></p> 	<p><i>Cyprinus carpio</i></p> 





APPENDIX 3: Electronic appendix of all data collected during the biomonitoring of the Sabi/Sand River including Fish forms; FRAI models; SASS data; MIRAI models; RHAM recordings. This electronic appendix will be submitted in the CD format.